IFORS 2026

The 24th Conference of the International Federation of Operational Research Societies

12-17 JULY
VIENNA, AUSTRIA

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Faculty of Business, Economics and Statistics

CONFERENCE BOOKLET

Decision Support for a Sustainable World



12 - 17 July, 2026

Vienna, Austria

Gurobi® hexaly

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WELCOME & KEY INFORMATION

On behalf of the organizing committee, it is our great pleasure to welcome you to IFORS 2026 in Vienna.

This conference brings together the global operations research community to exchange ideas, advance knowledge, and address the complex challenges of our world through analytics and innovation.

We hope you find the program inspiring, the discussions enriching, and your time in Vienna both productive and memorable.

> **Together, we turn ideas into insights — and insights into decisions for a sustainable future.**
>
> - IFORS 2026

Program

Registration Desk
Universitätsring 1, 1010 Vienna

Sunday, 12 July: 15:00-20:00

Monday, 13 July: 07:30-18:00, **Tuesday**, 14 July: 07:30-18:00

Wednesday, 15 July: 08:00-15:00

Thursday, 16 July: 08:00-17:00, **Friday**, 17 July: 08:30-15:00

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Your Time in Vienna

Here's everything you need for a smooth, rewarding, and memorable experience in Vienna.



Daily Highlights

Explore the program, plenary sessions, and special events each day.

Collaborate & Collect

Engage in inspiring sessions and meet colleagues from around the world.

Evening Together

Welcome and Farewell start and end the conference together.

Useful Contacts

Information Desk
Main Foyer - Main Building (Hauptgebäude)
E-mail: ifors2026@univie.ac.at
Phone: 0043 1 4277 37039

First Aid
Opposite SR5 (lower ground floor) in the Hauptgebäude HG (main building)

Taxi Service
Nearest Station: Schottengasse 9
Uber, Bolt etc are also available

WiFi
Login with eduroam or the Wifi password given to you at the registration

Discover Vienna

From historic landmarks to modern hotspots, explore the best of Vienna during your stay.

Scan to explore

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Program Highlights

A week of inspiring ideas, meaningful connections, and memorable experiences in the heart of Vienna.

SUN JULY 12

Welcome Reception

Kick off IFORS 2026 with an informal evening of networking and Viennese hospitality. Registration starts at 15:00.

18:00 - 21:00
Arkadenhof
Hauptgebäude (HG)

MON JULY 13

Opening & Plenary 1

Official opening and keynote address from a leading voice in operations research.

8:15 - 10:00
Audimax
Hauptgebäude (HG)

TUE JULY 14

IFORS Ceremony & GLOW

Announcement of the new IFORS Hall of Fame inductees.

A panel discussion on Global Leadership in Operations Research for Women.

8:15 Ceremony
Audimax
Hauptgebäude (HG)

10:30 GLOW
HS 1 (Lecture hall 1)
Hauptgebäude (HG)

WED JULY 15

Excursions

Explore the latest research and discover Vienna and its surroundings through our afternoon side events. Ticket is in your conference material.

from 12:30
Hauptgebäude (HG)

THU JULY 16

IFORS Awards & Conference Banquet

Announcement of the new IFORS fellows and EJOR Best Paper Awards

Celebrate connections and collaboration at a memorable evening in Vienna. At extra cost - tickets are available at registration.

08:15 - 09:00
Audimax
Hauptgebäude (HG)

18:30 - 23:00
Hilton Vienna Park
Am Stadtpark 1

FR JULY 17

Closing ceremony & Farewell party

Join the Closing Ceremony to celebrate the conference highlights, followed by a farewell party to end the week in a relaxed atmosphere.

14:30 - 19:00
Audimax
Hauptgebäude (HG)

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Stay Connected

Follow IFORS 2026 on Instagram and Linkedin for conference news, behind-the-scenes impressions and community highlights from Vienna.

#IFORS2026 **Share your moments**

Instagram
@ifors.vienna
Stories, photos and live impressions from the conference week.

LinkedIn
IFORS Vienna
Updates, speaker highlights and networking insights from the OR community.

Scan to follow

Conference Web App

Access the Web App to explore the programme, find sessions, and build your personal schedule.

Save it to your home screen for quick access during IFORS 2026.

Scan for program

Tag us and use #IFORS2026
We look forward to seeing your conference moments from Vienna.

Conference Banquet & Social Side Events

Celebrate, connect, and discover Vienna beyond the conference sessions.



Excursion - July 15, afternoon

Explore Vienna and its surroundings through our curated social activities. One Exursion is included in the conference fee.

- Klosterneuburg - Abbey Tour
- Klosterneuburg - Wine Tour
- Panorama of Vienna
- Schloss Hof
- Schönbrunn Palace
- Tablet Rallye
- Top Golf
- Walking Tour of the Old Town
- Wien Museum



Conference Banquet July 16, 18:30

Join us for a memorable evening of networking, dinner, and Viennese hospitality. Enjoy live entertainment and capture memorable moments at our photobooth.

Visit registration desk for last minute tickets - optional 150€

Hilton Vienna Park (Am Stadtpark 1, 1030 Vienna)

Important Information

Columbus Reisen, the official excursion partner, will be on site July 14 and on July 15 with a service desk in the entrance area of the Main Building (Hauptgebäude) until the excursions begin. **Participants may visit the desk for assistance, meeting point information, and last-minute excursion bookings, subject to availability.**

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Conference Venues

IFORS 2026 takes place across three iconic buildings in the heart of Vienna.
All venues are within easy walking distance of each other.



1 Hauptgebäude (HG)
University of Vienna
Main Building

Universitätsring 1
1010 Vienna, Austria

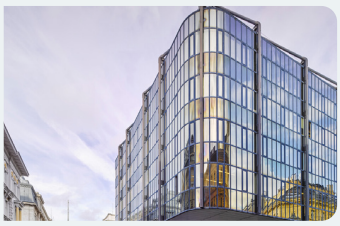
Plenaries

Registration

Exhibition &
Coffee Breaks

Sessions, Plenaries, Keynotes, Welcome Ceremony, Opening, Closing





2 Juridicum (JUR)
University of Vienna

Schottenbastei 10-16
1010 Vienna, Austria

Coffee Breaks

Sessions, Keynotes, EURO DISS. Award



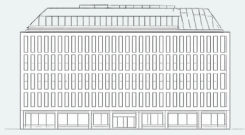


3 Kolingasse (KOL)
University of Vienna

Kolingasse 14-16
1090 Vienna, Austria

Coffee Breaks

Sessions



Each lecture room is equipped with a laptop.

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Getting Around

The three venues are located in the center of Vienna and well connected by foot and public transport.



Scan to explore essential locations surrounding the conference venue.

Open the interactive Google Map and save it to your phone for quick access throughout the conference week.

Scan to explore

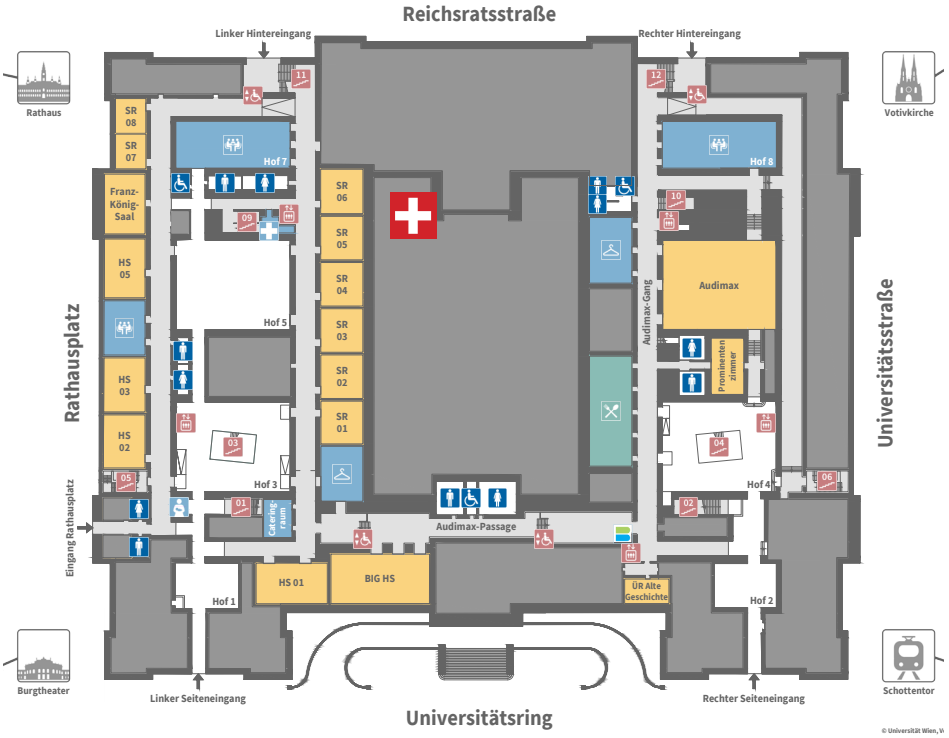
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Floor Map - Hauptgebäude (HG)

Tiefparterre - Lower Ground Floor

Main Building - Hauptgebäude (Universitätsring 1)

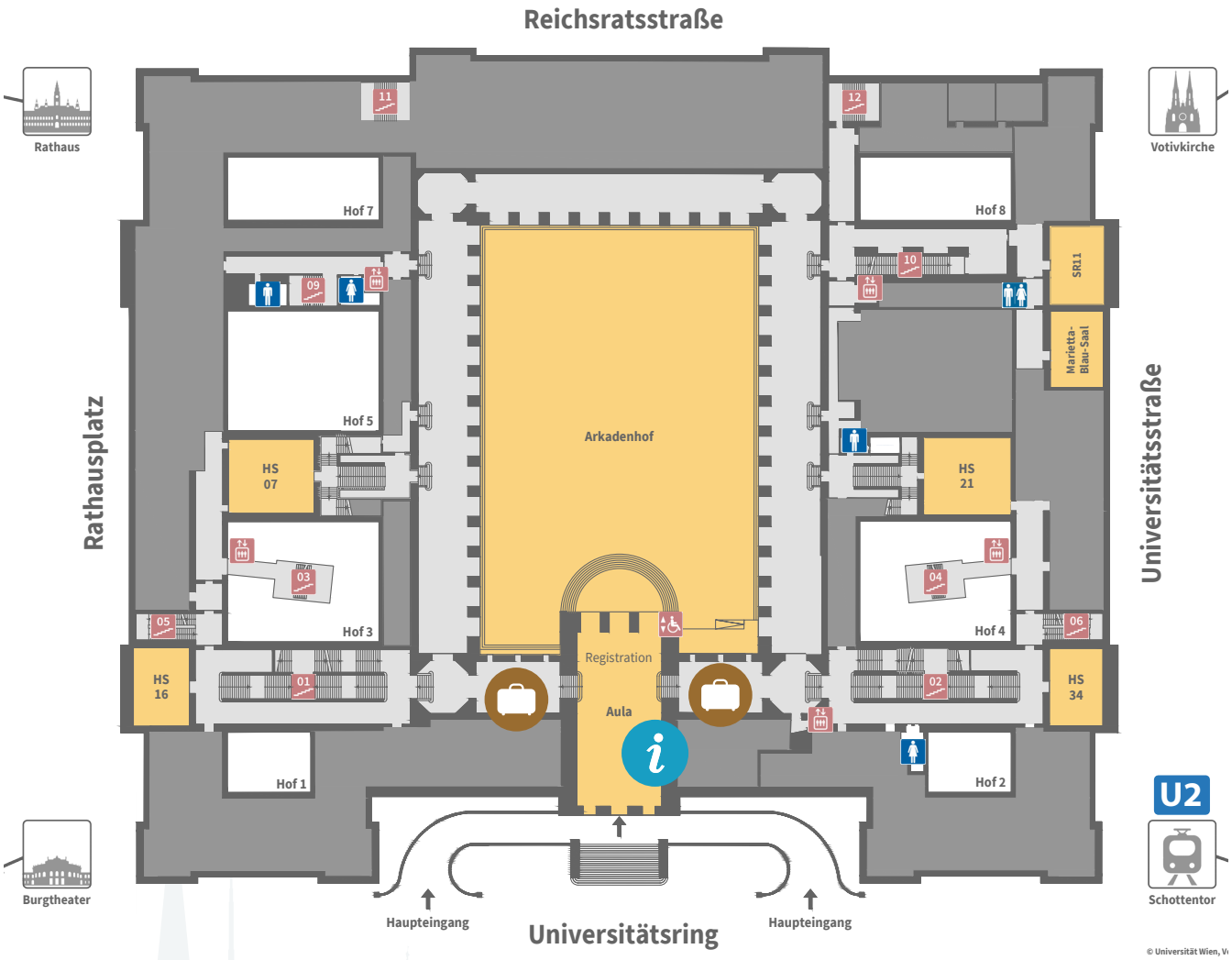


U2

Floor Map - Hauptgebäude (HG)

Hochparterre - Raised Ground Floor

Main Building - Hauptgebäude (Universitätsring 1)



Luggage storage is available **on the last day, Friday, from 8:00 to 19:00**.
Please place your luggage to the left or right of the registration desk.

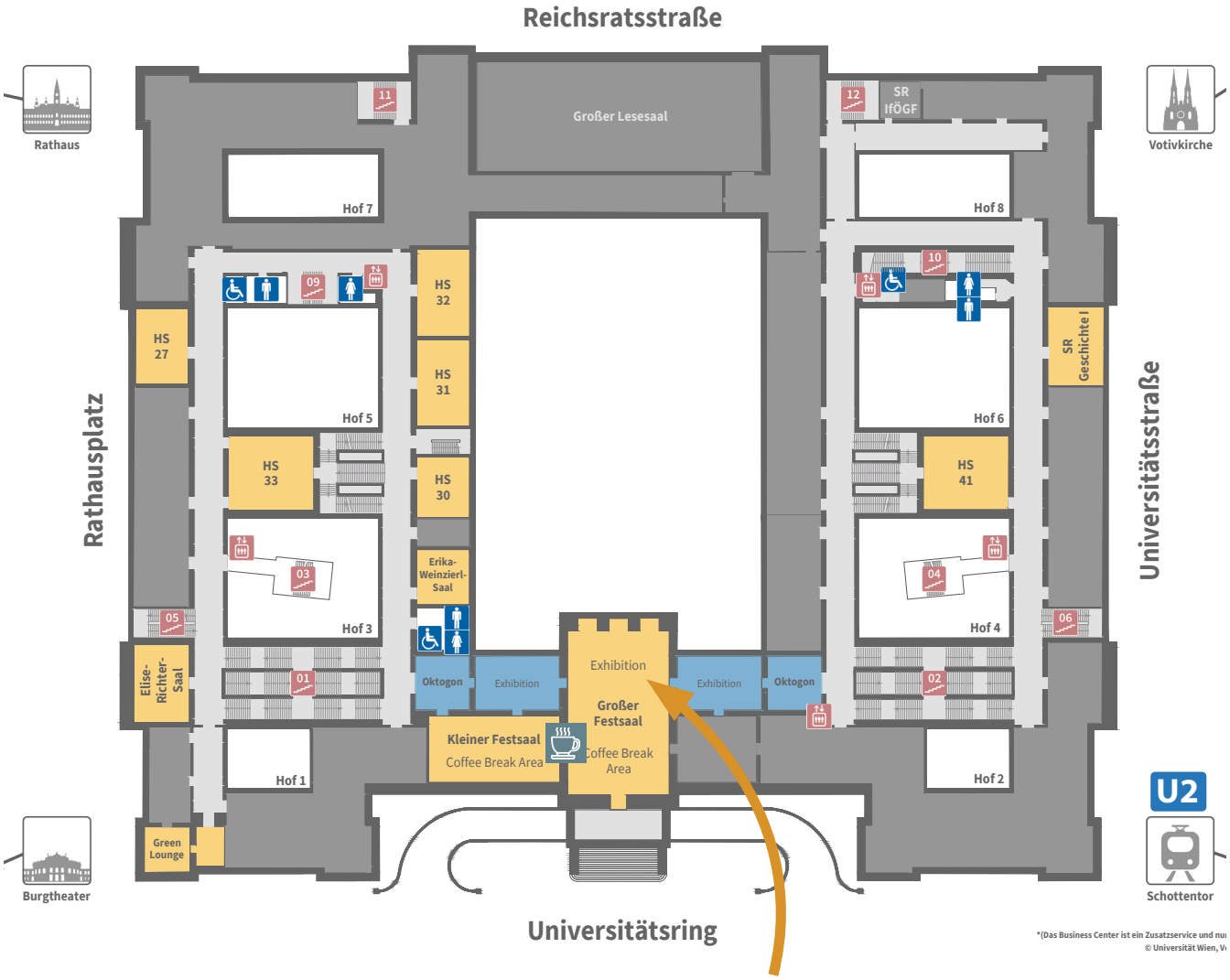
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Floor Map - Hauptgebäude (HG)

1. Obergeschoß - First Floor

Main Building - Hauptgebäude (Universitätsring 1)



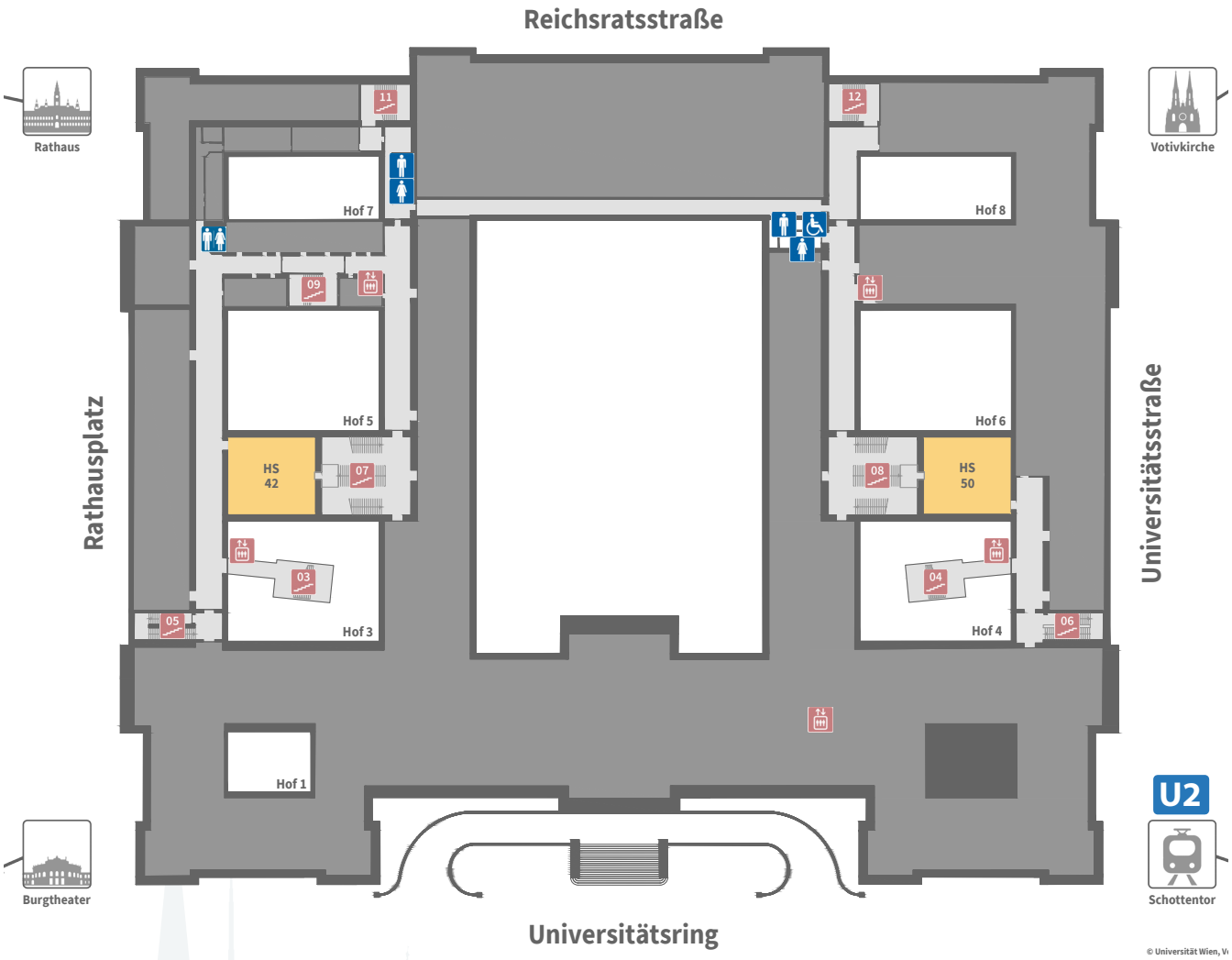
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Floor Map - Hauptgebäude (HG)

2. Obergeschoß - 2nd Floor

Main Building - Hauptgebäude (Universitätsring 1)



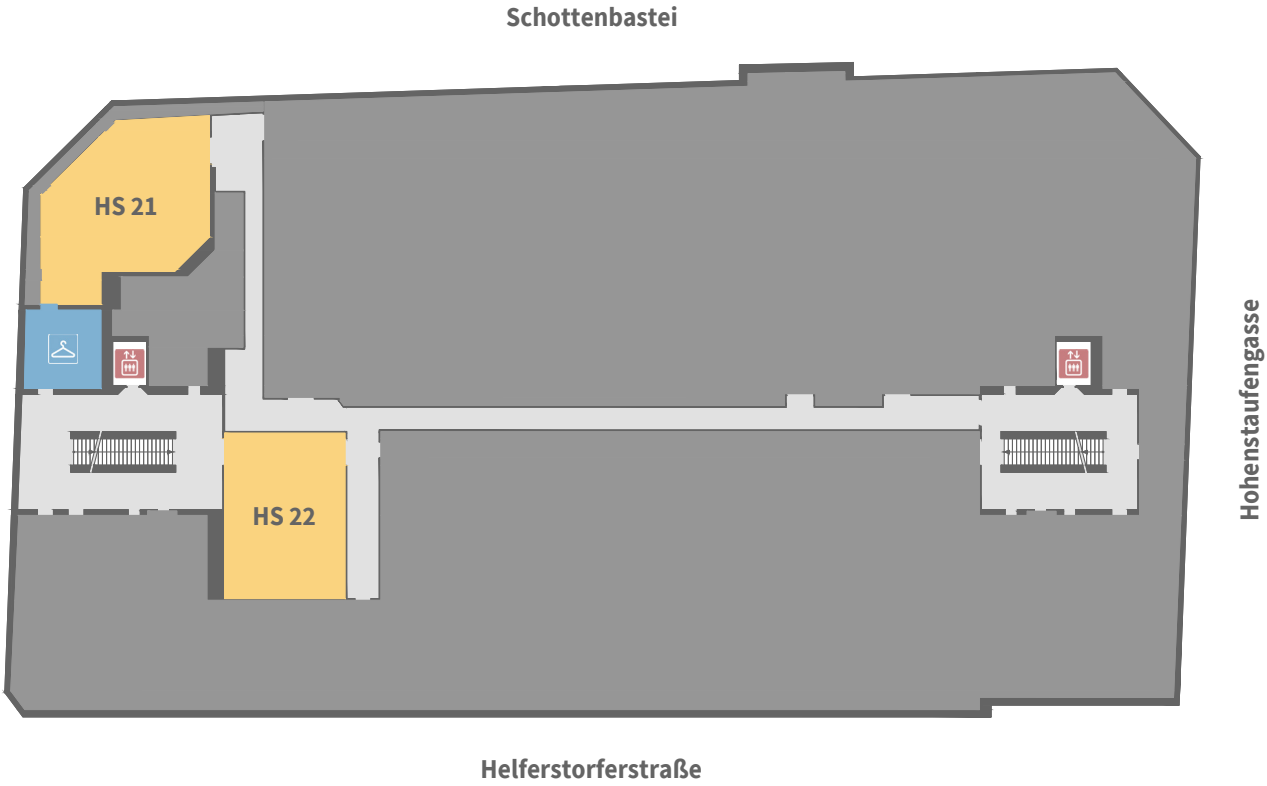
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Floor Map - Juridicum (JUR)

2. Untergeschoss - Basement Level 2

Juridicum - Schottenbastei 10-16



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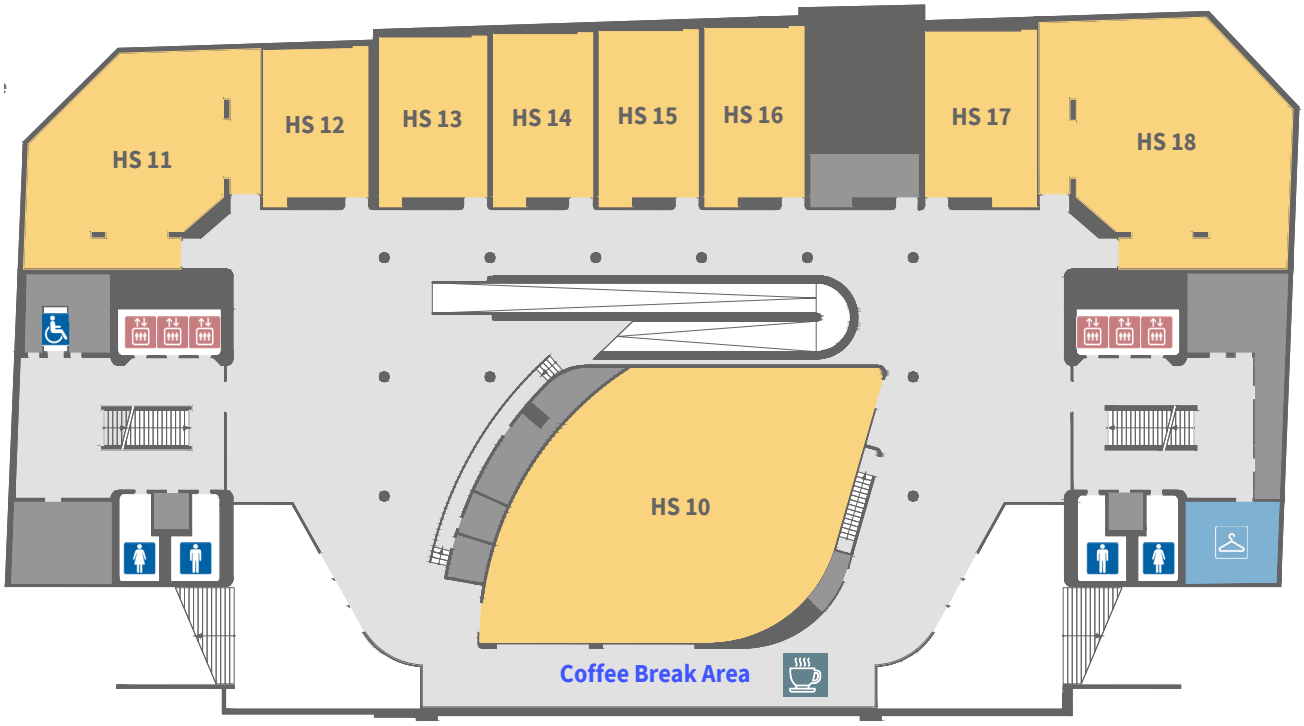
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Floor Map - Juridicum (JUR)

1. Untergeschoss - Basement Level 1

Juridicum - Schottenbastei 10-16



Helferstorferstraße

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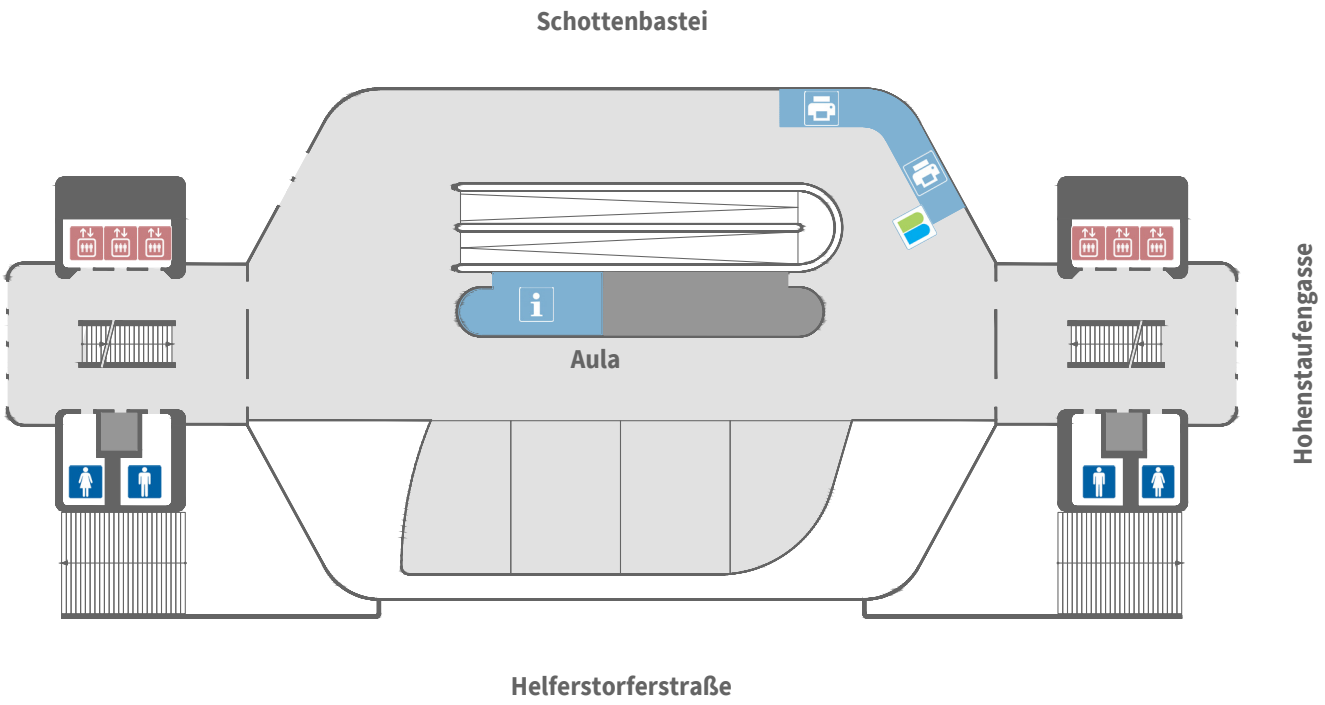
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Floor Map - Juridicum (JUR)

Erdgeschoß - Ground floor

Juridicum - Schottenbastei 10-16



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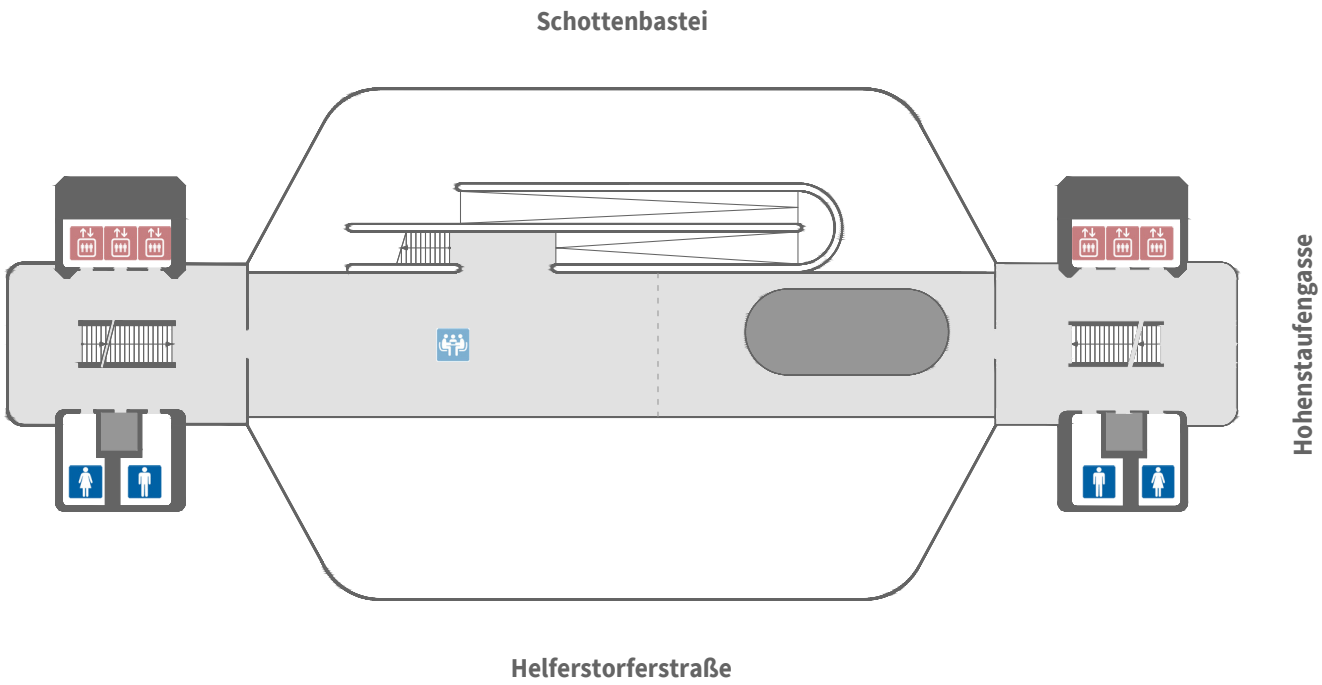
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Floor Map - Juridicum (JUR)

Zwischengeschoß - Mezzanine level

Juridicum - Schottenbastei 10-16



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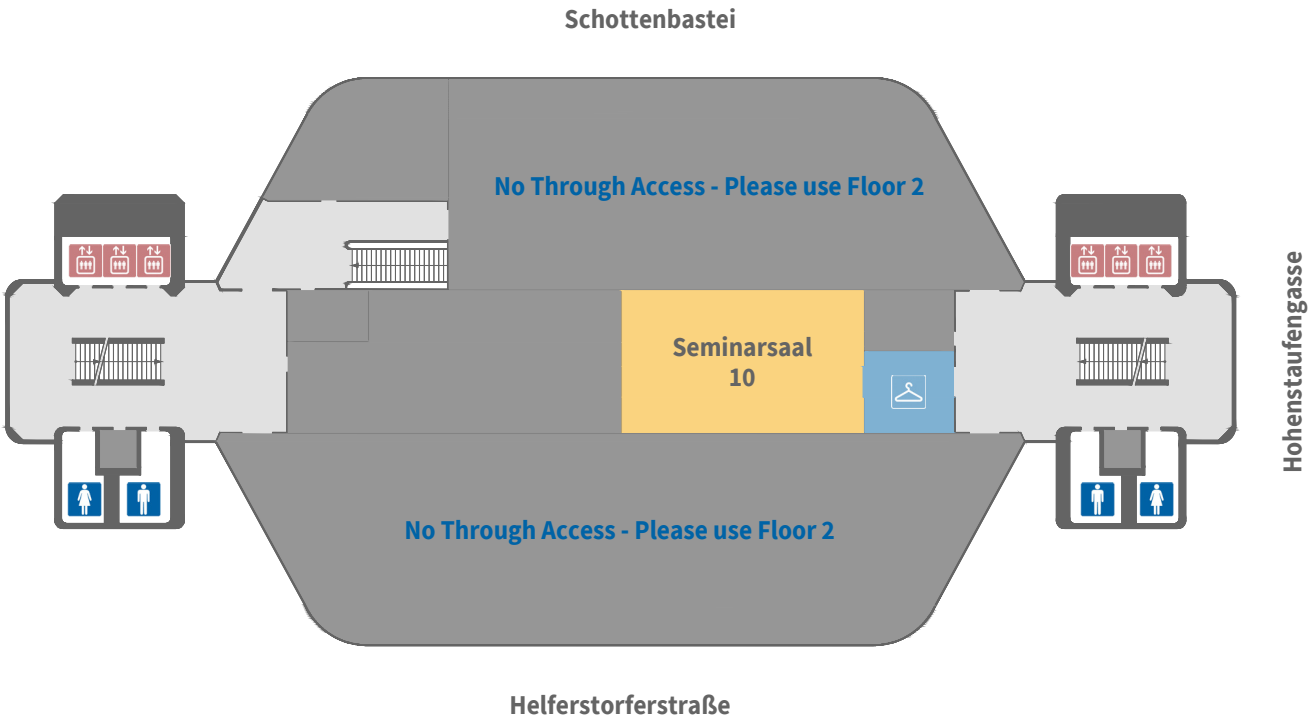
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Floor Map - Juridicum (JUR)

1. Obergeschoß - First floor

Juridicum - Schottenbastei 10-16



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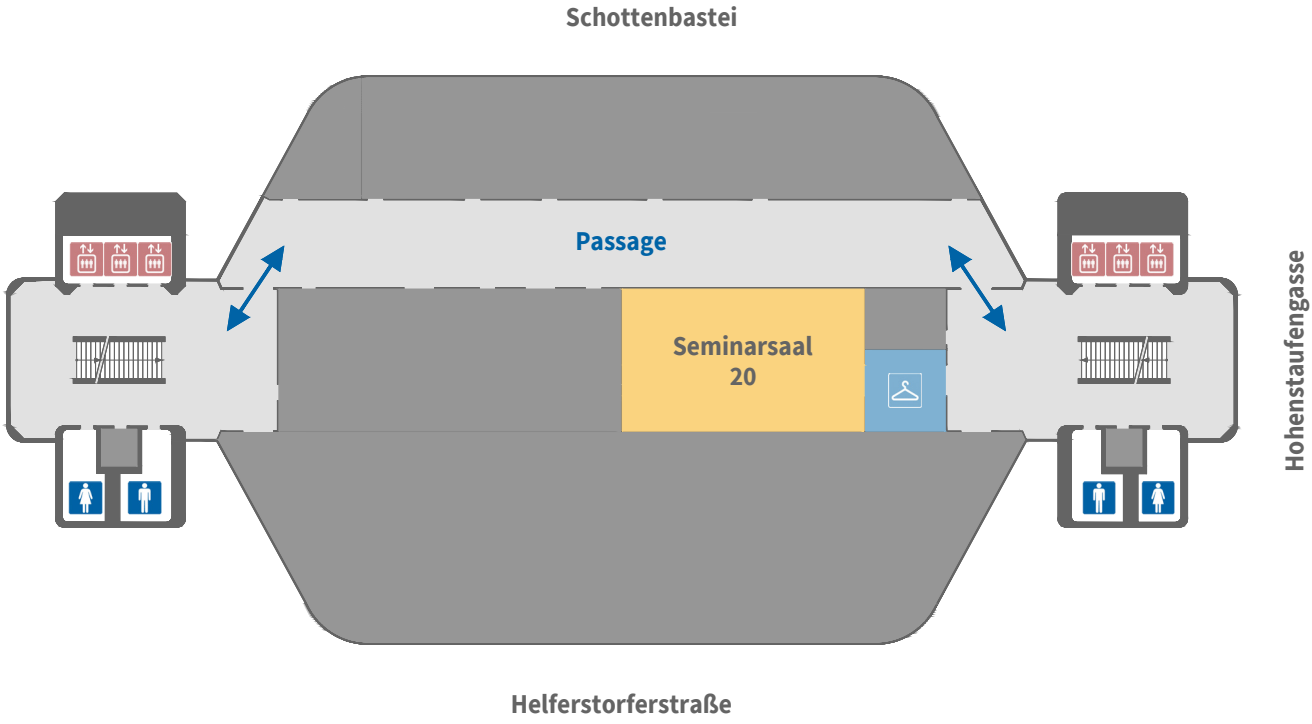
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Floor Map - Juridicum (JUR)

2. Obergeschoß - 2nd Floor

Juridicum - Schottenbastei 10-16

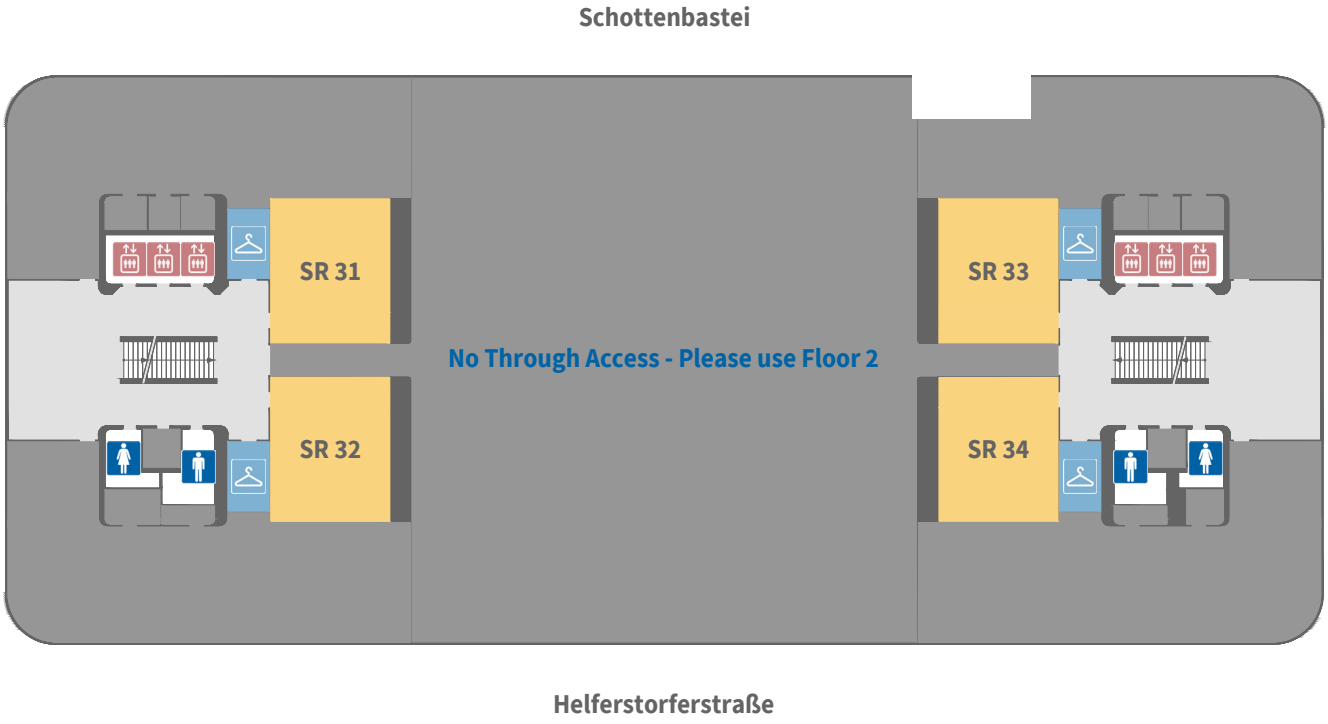


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Floor Map - Juridicum (JUR)

3. Obergeschoß - 3rd Floor

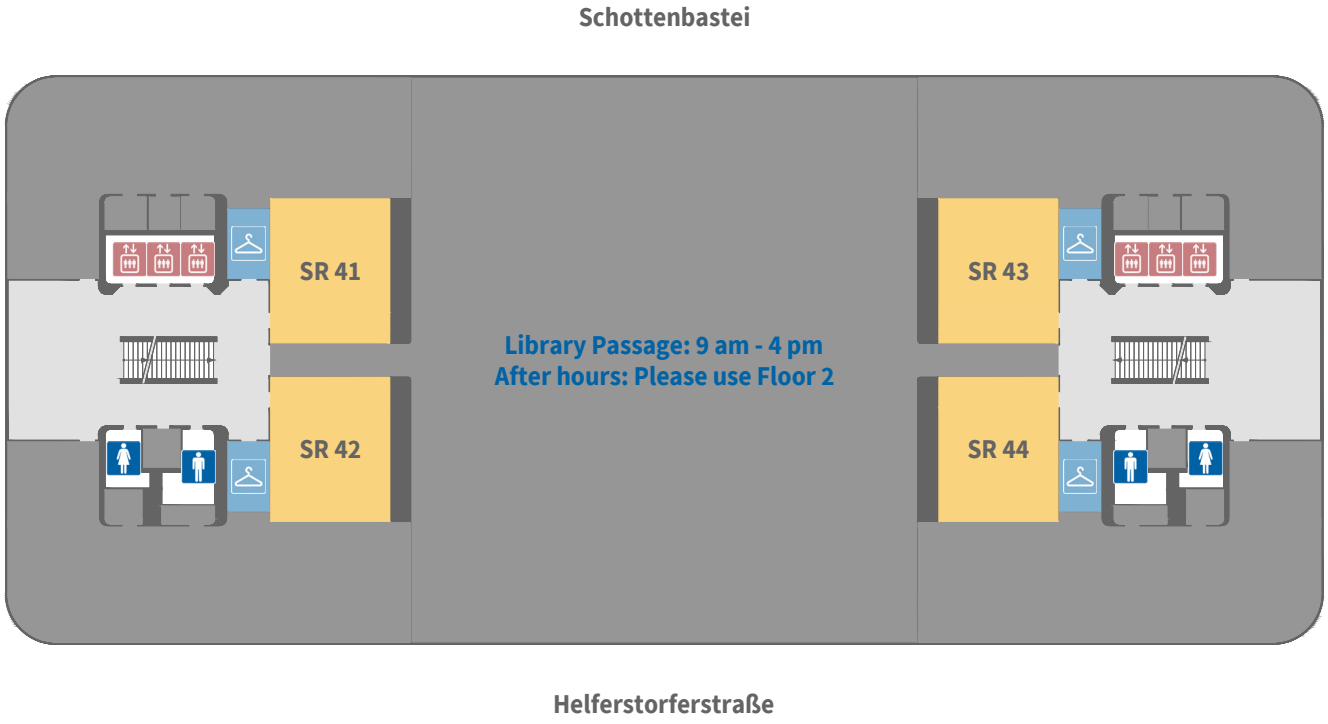
Juridicum - Schottenbastei 10-16



Floor Map - Juridicum (JUR)

4. Obergeschoß - 4th Floor

Juridicum - Schottenbastei 10-16



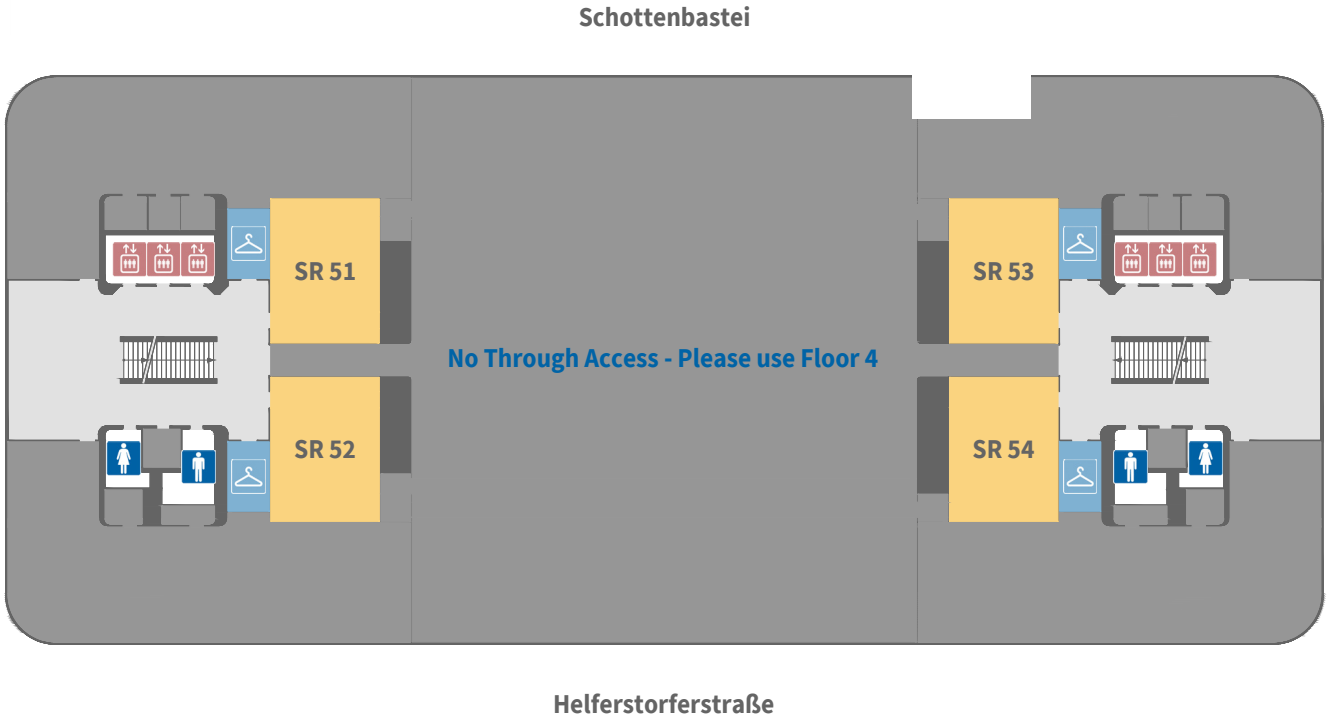
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Floor Map - Juridicum (JUR)

5. Obergeschoß - 5th Floor

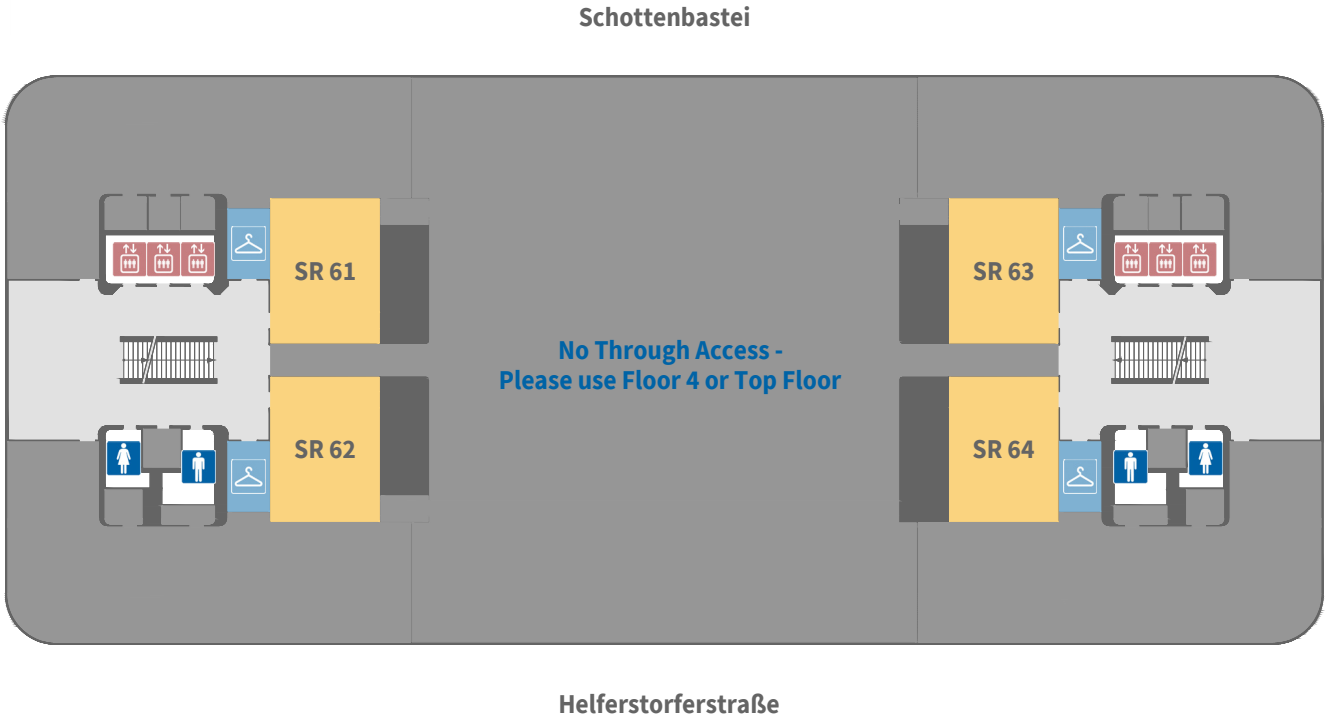
Juridicum - Schottenbastei 10-16



Floor Map - Juridicum (JUR)

6. Obergeschoß - 6th Floor

Juridicum - Schottenbastei 10-16



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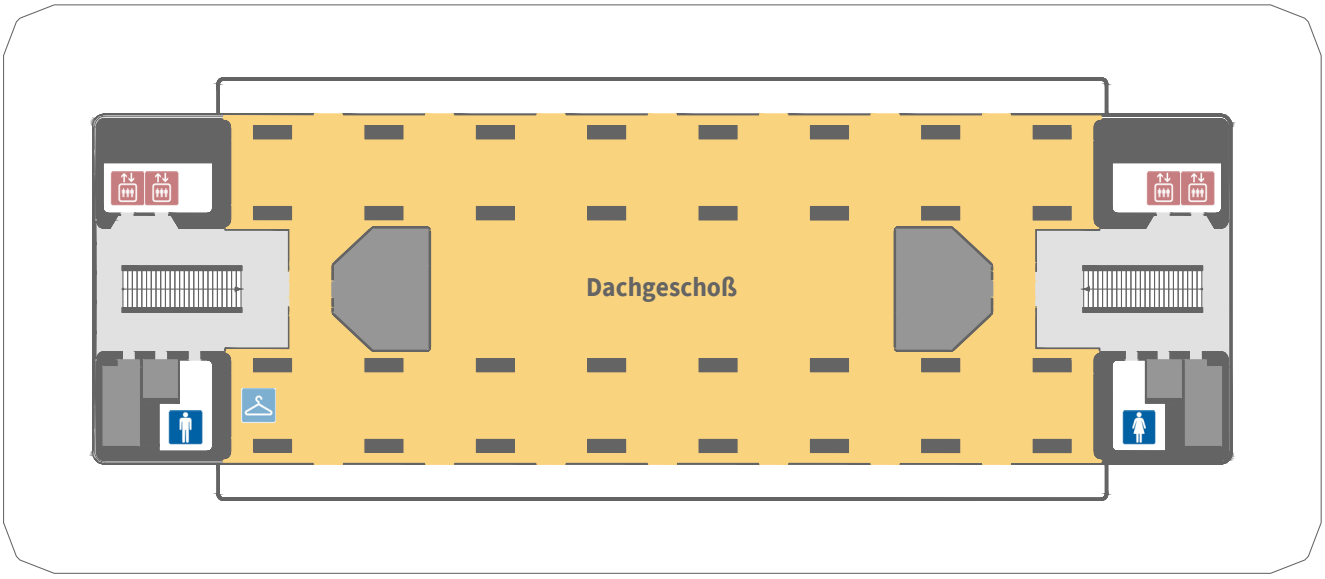
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Floor Map - Juridicum (JUR)

Dachgeschoß - Top Floor

Juridicum - Schottenbastei 10-16

Schottenbastei



Helferstorferstraße

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Floor Map - Kolingasse (KOL)

Erdgeschoß - Ground Floor

Kolingasse 14-16



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Floor Map - Kolingasse (KOL)

1. Obergeschoß - First Floor

Kolingasse 14-16



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Floor Map - Kolingasse (KOL)

2. Obergeschoß - 2nd Floor

Kolingasse 14-16



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Our sponsors can be found in the exhibition area in the Main Building (Hauptgebäude HG).

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Stadt Wien



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Starting points for the excursions:

1. **Walking Tour of the Old Town**
   Meeting Point 13:00 BIG
   Hauptgebäude (HG), Main Building

2. **Wien Museum with Walking Tour (not shown on the map)**
   Meeting Point 13:00
   Main entrance Wien Museum,
   Karlsplatz 8, 1040 Vienna

3. **Schönbrunn Palace Tour**
   Meeting Point 12:15 Audimax - Hauptgebäude HG, you need a ticket for public transport
   or 13:00 Ehrenhofbrunnen - the fountain in the large courtyard in front of Schönbrunn Palace

4. **Tablet Rallye**
   Meeting Point 13:00 HS 1 (lecture hall 1)
   Hauptgebäude (HG), Main Building

5. **Panorama of Vienna**
   Meeting Point 14:00
   Josef-Meinrad-Platz, 1010 Vienna

6. **Klosterneuburg - Abbey Tour**
   Meeting Point 12:30 and 14:30
   Rathausplatz 5, 1010 Vienna

7. **Klosterneuburg - Wine Tour**
   Meeting Point 12:30 and 14:30
   Rathausplatz 5, 1010 Vienna

8. **Top Golf**
   Meeting Point 14:00
   Rathausplatz 5, 1010 Vienna

9. **Schloss Hof Tour**
   Meeting Point 13:00
   Rathausplatz 5, 1010 Vienna

Scan for the exact location

Supported by

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ÖGOR

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Stadt Wien

www.ifors2026.at

Follow IFORS Vienna on Instagram and LinkedIn for updates and highlights.

Monday, 8:15-9:00

■ MA-01

Monday, 8:15-9:00 - Room: HG - Audimax

Welcome Ceremony

Stream: Special Sessions
Plenary session
Chair: *Karl Doerner*

Monday, 9:00-10:00

■ MB-01

Monday, 9:00-10:00 - Room: HG - Audimax

Plenary Miguel Anjos

Stream: Plenaries
Plenary session
Chair: *Frits Spieksma*

1 - Operational research for a sustainable energy transition
Miguel Anjos

Our life and survival depend on energy. Energy is fundamental for meeting society's need for heating and cooling, communications, health care, transportation, agriculture, manufacturing, and almost every other realm of human endeavour. There are dramatic economic, health and safety consequences when supply fails, as evidenced for example by the April 2025 blackout in the Iberian peninsula. At the same time, energy acquisition and use impact our natural environment. In particular, air pollution is the cause of millions of deaths each year, and the main culprit is the emission of small particles from power plants, factories, vehicle exhausts, and burning coal and wood. Another well-known concern are the global energy-related CO2 emissions. Increasing the use of electricity to meet our various needs is key to achieving major reductions of these emissions. Electric energy thus plays a fundamental role in our contemporary energy systems. As we aim to reduce the environmental impact of human activity, a historical energy transition is under way. Two simultaneous trends in this transition are: 1. more and more electricity is sourced from renewable sources and 2. the demand for electricity increases as it replaces the use of fossil fuels. This transition raises several major challenges for electric power systems. We will provide an overview of energy systems, highlight successful uses of OR in practice for system operations and policy-making, and review some of the main challenges currently being addressed by OR researchers.

Monday, 10:30-12:00

■ MC-01

Monday, 10:30-12:00 - Room: HG - Audimax

Tutorial Georg Pflug

Stream: Tutorials
Tutorial session
Chair: *David Wozabal*

1 - Including model error in financial optimization and insurance design
Georg Pflug, Alois Pichler

Optimal decision making in finance and insurance includes a statistical part (estimation of the random scenario process), a modeling part (designing the decision objective and the constraints) and an algorithmic part (mathematical optimization). It is evident that errors in the statistical part lead directly to errors in the decision found in the optimization part. In order to incorporate the model uncertainty into the whole decision process, we define confidence regions for the distribution of the estimated scenario process by methods of nonparametric statistics and find minimax (i.e. saddle point solutions) for the final decisons, which are good compromises between optimality and distributional robustness. We define the quantities: costs for ambiguity (COA) and reward for distributional robustness (RDR), which caracterize the quality of the decision making and extend the notions of expected value of perfect information (EVPI) and value of stochastic solution. We illustrate the presented concepts giving examples from financial management, pension fund managenent and insurance contract design.

■ MC-04

Monday, 10:30-12:00 - Room: HG - BIG-Hörsaal (Building: HG)

Healthcare logistics

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Melanie Reuter-Oppermann*

1 - Mobile Clinic Planning in Long-Term, Capacity-Scarce Settings: From Distance Minimization to Equitable Locality Selection
Angel Ruiz, Julia Isabel Serrato Fonseca, Ana María Anaya-Arenas

Most Mobile Clinic (MC) studies address short planning horizons or assume that capacity exceeds demand. In such settings, the problem focuses on efficiency, typically minimizing travel distance or costs. In contrast, when planning over long horizons, and demand persistently exceeds MC capacity, planning shifts to selecting which localities to visit and when. We propose a formulation with a time dependent prioritization mechanism that increases the urgency of localities left unserved for multiple periods and penalizes delayed first visits, enforcing an equitable distribution of visits.

2 - A Simulation Study of Capacity-Constrained HTA: Optimizing for Adaptive HTA Assessments
Christina Andrea Ibarra, Jamaica Briones, Jing Lou, Euan Barlow, Alec Morton

In resource-limited settings, limited health technology assessment (HTA) capacity can delay evaluation of new technologies & restrict patient access. We simulate capacity-constrained adaptive HTA triage workflows where technologies are routed to full HTA or adaptive HTA (less capacity-intensive but higher uncertainty), using weighted scoring & threshold rules based on expected decision risk and budget impact. Preliminary results suggest adaptive triage can improve system-level evaluation coverage & net monetary benefit (NMB), when adaptive HTA resource use is low.

3 - A Gender Perspective on OR Healthcare Applications
Melanie Reuter-Oppermann, Eda Yücel, Paula Carroll

Within healthcare Operations Research (OR), to date, no analysis of results or recommendations from a gender perspective has been conducted to assess the impacts of these decisions on gender equality. In this study, we address how to include gender aspects in OR healthcare models and algorithms, and what impact gender concerns have on the solution recommendations. We identify gender dimensions of OR healthcare research and propose a framework to include gender concerns in healthcare applications. We demonstrate the framework on sample healthcare applications including screening services.

■ MC-07

Monday, 10:30-12:00 - Room: HG - Hörsaal 21 (Building: HG)

Electricity Market Design

Stream: Auctions and Market Design
Invited session
Chair: *Bernhard Kasberger*
Chair: *Simon Finster*

1 - Revenue equivalence between energy-only and uplift electricity market designs with non-convex costs.
Pär Holmberg, Frank Wolak

We develop an auction-theoretic model of electricity markets where each producer has a perfectly divisible unit with start-up costs; an extension adds minimum-output constraints. Producers observe independent private signals informative about their own costs. We compare the European energy-only design with a centralized U.S. design, in which units submit separate bids for energy and start-up costs, and make-whole (uplift) payments ensure cost recovery for partially dispatched units. We solve for symmetric equilibria and show that the two designs are revenue-equivalent for producers.

2 - The Cost of Fairness in Electricity Markets
Daniel Linnenbrink

European policymakers argue that bidding zones with uniform prices ensure fairness in electricity markets. Since the result of such a fair spot market is often infeasible due to network constraints, a second stage is needed: the redispatch. This paper uses mechanism design theory to show that even a minimal fairness restriction on the first stage strictly increases procurement costs for asymmetric dispatches. In detail, I analyze a market-based redispatch mechanism where inc-dec gaming creates arbitrage profits for those producers that benefit the network the least.

3 - On the Design of Stochastic Electricity Auctions
Thomas Hübner

Electricity is traded in day-ahead auctions because many decisions in power systems must be made in advance. However, day-ahead trading requires wind and solar generators to sell power under uncertainty about their actual production. Because the current auction design does not allow them to communicate these uncertain preferences, renewable energy is used inefficiently, and system decisions become suboptimal. We show how the theory of equilibrium under uncertainty and optimal quantization can be applied to this problem to provide recommendations for day-ahead auction design.

4 - Auctions for RES with Pre-commitment
Bert Willems, Silvester Van Koten

This paper examines the design of renewable energy auctions, where the non-completion of awarded projects remains a concern. We extend the standard second-price auction model to include post-award cost shocks and introduce a combination of pre-qualification requirements and performance bonds. Pre-qualification requires all bidders to incur part of their investment costs before entering the auction, while performance bonds penalize only the winning bidder if the project is not completed. Both instruments impose costs on bidders, reduce entry, and lower competition, which leads to higher markups

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■ MC-08

Monday, 10:30-12:00 - Room: HG - Hörsaal 41 (Building: HG)

Competitive Location and Stackelberg Games

Stream: Location Analysis
Invited session
Chair: *Vladimir Marianov*

1 - A Leader-Follower Competitive Facility Location Game with Deterministic Allocation of Customers
Julius Hoffmann, Stefan Nickel

We study a leader-follower competitive facility-location problem where each customer is assigned to the facility and hence, the player, that yields the highest utility for that customer. Both players are allowed to place facilities on a finite set of candidate locations and to adjust facility attributes that influence the utility perceived by the customers. To address this hierarchical decision process, we formulate a flexible bilevel optimization model and present a cutting-plane algorithm for the corresponding single-level reformulation which performed well in a computational experiment.

2 - Competitive Location With Dissimilar Objectives
Joyendu Bhadury, H.a. Eiselt

This paper studies a competitive location model on graphs in which one firm has a "public welfare maximization" objective that attempts to minimize the average distance to its own customers, while the other has a "profit/market share maximizing" objective that seeks to maximize the demand it serves. Nash Equilibrium pairs of locations are characterized for three classes of graphs: trees, cactus graphs and general graphs and it is shown that their existence can be determined in strongly polynomial time and that in the same time, all Nash Equilibria location pairs can also be determined.

3 - New Advances in Resources Location in Stackelberg Security Games
Francisco Temprano Garcia, Lina Mallozzi, Justo Puerto

Stackelberg Security games is a classic problem in Game theory, where two different type of players can be distinguished, attackers, that play the followers role, and defenders, the leaders. The case with one defender and multiple attackers to face has been deeply studied and analyzed in literature. In this talk, we consider two variants of the above problem. The first one consists of multiple defenders that can cooperate to increase their benefits, and the second one contemplates the possibility of limiting each attacker decision space depending on the decision of the remaining players.

4 - Competitive facility location under agglomeration
Vladimir Marianov, Gonzalo Mendez-Vogel, Armin Lüer-Villagra, H.a. Eiselt

Commercial competing facilities often cluster. Clusters facilitate product comparisons within a single trip, increasing stores' attraction and expanding stores' market. Consumers first select a cluster and then choose a store. We model this decision process using nested logit and introduce an accessibility factor that captures the benefits of agglomeration. We formulate a competitive location model in which a firm selects locations for multiple stores in a market with pre-existing clusters. Computational experiments and a real-world case study illustrate solution patterns.

■ MC-10

Monday, 10:30-12:00 - Room: HG - Hörsaal 31 (Building: HG)

Bilevel optimization problems: complexity analysis and algorithms

Stream: Combinatorial Optimization
Invited session
Chair: *James Orlin*

1 - Complexity of the Recoverable Robust Shortest Path problem under interval budgeted uncertainty
Marcel Jackiewicz, Adam Kasperski, Pawel Zielinski

We examine the Recoverable Robust Shortest Path problem with interval budgeted uncertainty. The problem is two-stage, with a path being chosen in the first stage and exchanged for the minimum cost path in its neighbourhood in the second stage. For discrete budget uncertainty we show that the problem is hard for the third level of polynomial hierarchy and the adversarial problem is hard for the second level. For continuous case, we show NP-hardness of the problem, together with inapproximability results for both continuous and discrete cases in acyclic digraphs.

2 - On a Variant of the Minimum Path Cover Problem in Acyclic Digraphs: Computational Complexity Results and Exact Method
Nour Elhouda Tellache, Roberto Baldacci

The Minimum Path Cover (MPC) problem seeks the smallest set of node-disjoint paths covering all nodes in a graph. We study a variant on directed acyclic graphs (DAGs) where each path must include at least one arc from a predefined subset. We prove that the feasibility problem is strongly NP-hard for general DAGs but polynomially solvable when the DAG is the transitive closure of a path. We propose two integer programming formulations, strengthen them with valid inequalities, and develop a branch-and-cut algorithm tested on benchmark and airline crew scheduling instances.

3 - The Strong Total Cover Problem: Algorithms and Complexity
Luca Ferrarini, Manuel Aprile

The Strong Total Cover Problem (STCP) is a novel covering problem on a graph where the goal is to find a minimum-size subset of vertices and edges that covers all elements of the graph. A vertex covers itself and all incident edges, while an edge covers itself and its two endpoints. In this talk, we present algorithmic and polyhedral results on STCP, highlighting connections with related combinatorial problems. We also discuss its computational complexity and identify graph classes for which the problem can be solved in polynomial time.

4 - Interdiction problems and 2-person sequential games: beyond NP-completeness
James Orlin, Lasse Wulf, Christoph Grüne

In the Interdiction Knapsack Problem (IKP), an adversary can block K items from being selected. The adversary's goal is to prevent the

decision maker from achieving a given target value of V. The Knapsack Problem is NP-complete. The IKP is one level harder than NP-complete. We have proved a meta-theorem which establishes that the IKP and hundreds of other interdiction problems based on NP-complete problems are all one level harder than NP-complete. We have proved similar meta-theorems for min max regret problems.

■ MC-11

Monday, 10:30-12:00 - Room: HG - Hörsaal 32 (Building: HG)

Discrete, continuous and hybrid stochastic optimal control in OR I

Stream: Combinatorial Optimization
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Januj Juneja*
Chair: *İsmail Özcan*

1 - Hidden Bilevel Structures in Graph Disconnection Problems
Fabio Furini, Marco Lübbecke, Fabio Ciccarelli, Christopher Hojny

Many fundamental graph disconnection problems hide an underlying bilevel structure that can be exploited for stronger formulations and algorithms. In this talk, we reveal and formalize this hidden structure for two key problems: the capacitated vertex separator and the k-vertex cut. Both are modeled as two-phase bilevel games, where a leader strategically deletes vertices and a follower reacts by optimizing over the disconnected graph. We present new integer programming formulations naturally capturing this bilevel interaction, supported by families of strengthening valid inequalities.

■ MC-13

Monday, 10:30-12:00 - Room: JUR - Seminar-Saal 20 (Building: JUR)

MIP Solvers

Stream: Software for Operations Research
Invited session
Chair: *Timo Berthold*

1 - What's New in FICO Xpress Solver
Timo Berthold

We will give an overview of the latest enhancements, the newest features, and the most recent performance improvements in the FICO Xpress Solver for mixed-integer linear and nonlinear optimization problems.

2 - What's new in Gurobi 13
Michael Winkler

In this presentation, we will give an overview of recent developments in Gurobi 13. In particular, we will talk about performance improvements, huge LPs, and improvements on nonlinear optimization.

3 - Recent Advances in the Cardinal Optimizer
Leon Eifler

The Cardinal Optimizer (COPT) is a mathematical optimization solver designed for large-scale problems, supporting LP, NLP, MIP, conic programming, and both convex and non-convex MIQCP. This talk presents recent algorithmic and software advances in the latest COPT release. We provide an empirical evaluation across all supported problem classes, including comparisons with previous COPT versions.

4 - MIP in HiGHS: An overview of recent developments
Mark Turner

In this talk we discuss the development process in HiGHS and go through selected features published in the past year. We will summarise which features worked, which didn't work, what motivated them, and dissect why they're important. For each feature, anecdotes from a developers perspective will be provided, and when relevant, approximate performance changes will be provided. In addition, we will discuss some larger design decisions as well as features on the HiGHS MIP road-map.

■ MC-14

Monday, 10:30-12:00 - Room: HG - Hörsaal 01 (Building: HG)

Robust and Data-Driven Optimization Models: Formulations and Solution Methods

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Nanari Wada*

1 - An Axiomatic Analysis of Distributionally Robust Optimization with q-Norm Ambiguity Sets for Probability Smoothing
Kota Kurihara, Yoichi Izunaga, Yuya Yamakawa

The "zero-frequency problem" often arises in probability estimation from finite data. The traditional approach, Laplace smoothing, is axiomatically characterized but relies on restrictive ratio preservation. To address this, we propose a smoothing method based on distributionally robust optimization with q-norm ambiguity sets (q-DRO). By reformulating q-DRO as conic optimization, we show the q-DRO estimator satisfies key axioms: positivity, symmetry, and order preservation. Finally, we show our model is equivalent to regularized empirical loss minimization, justifying its theoretical validity.

2 - Multi-Period Price Optimization under Demand Uncertainty and Reference Price Effects
Masato Inokuma, Shunnosuke Ikeda, Yuichi Takano

A multi-period price optimization method is proposed under demand uncertainty and reference price effects, where current prices influence not only present demand but also future demand. Demand is modeled by piecewise linear functions to enhance flexibility in representing demand behavior, and robust optimization is incorporated to derive pricing decisions under uncertainty. Numerical experiments suggest that moderate consideration of uncertainty can achieve higher profit than a deterministic model.

3 - Feature Selection Based on Cross-Validation Criterion and Least Squares Support Vector Machines
Masaharu Mori, Shunnosuke Ikeda, Ryuta Tamura, Yuichi Takano, Ryuhei Miyashiro

We propose a cross-validation-based feature selection method for support vector machines. We formulate a bilevel optimization model where the lower level trains least squares support vector machines (LS-SVMs) on training folds, and the upper level minimizes classification errors on validation folds. Exploiting LS-SVM optimality conditions, this optimization model is reformulated as a single-level mixed-integer linear optimization problem. Experiments show that our method achieves high accuracy for classification and feature selection.

4 - Safe Screening Rules for Cardinality-Constrained Portfolio Optimization
Nanari Wada, Shunnosuke Ikeda, Yuichi Takano

We focus on portfolio optimization problems with cardinality constraints that limit the number of invested assets. In this talk, we propose safe screening rules for such problems. Our method constructs a convex perspective relaxation and derives screening scores from its Fenchel dual. These scores provide theoretically guaranteed conditions for safely including or excluding assets. Computational experiments demonstrate significant acceleration in solving large-scale problems without sacrificing global optimality.

■ MC-16

Monday, 10:30-12:00 - Room: HG - Hörsaal 42 (Building: HG)

Sustainability and Resilience in Urban Environments

Stream: Location Analysis for Urban and Digital Infrastructure
Invited session
Chair: *Kaori Isawa*

1 - Toward an Economic-Modeling Framework for Historic Building Preservation under Opportunity Costs
Kaori Isawa

Many Japanese real-estate developers see demolition and redevelopment as more profitable than adaptive reuse, so conserving historic buildings can involve an opportunity cost. This study explores how monetary transfers can reduce that cost and where conflicts arise in decision-making. We model a three-actor transaction (developer, consumers, government) for acquiring and converting a historic building into a facility, and examine cost-sharing and public support schemes. This provides groundwork for later optimization analysis and complements empirical work such as hedonic valuation.

2 - Network Optimization of Cooling Spot Placement for Reducing Pedestrian Heat Risk
Hiroko Watanabe, Nobuki Adachi, Hiroyuki Hasada, Yudai Honma

Extreme heat poses increasing health risks to pedestrians in urban environments. Designing effective cooling interventions along walking routes has therefore become an important challenge. This study proposes a network optimization model to determine the optimal placement of cooling spots that reduce heat-related health risks during walking. The model incorporates nonlinear human thermoregulation dynamics to represent heat accumulation and recovery along pedestrian paths. The proposed framework provides new insights into mitigating pedestrian heat risks in urban environments.

3 - A DEA-Based Evaluation Framework for SDGs : Bottlenecks, Benchmarks, and Cooperation
Shu Nagata, Yudai Honma

This study proposes a DEA-based framework for evaluating each country's progress toward the SDGs. Whereas existing approaches tend to rely on ranking-based comparisons, the proposed framework clarifies what actions each country should take next. Using the Range Adjusted Measure (RAM) model, we identify bottlenecks through indicator-specific improvement potentials and, subsequently, employ a range-adjusted distance measure to identify benchmark countries and potential partners for cooperation. This framework helps clarify the directions in which each country should concentrate its efforts.

4 - Electrifying middle-mile freight networks under shipper emissions sensitivity
Gita Taherkhani

This paper studies planning for a motor carrier operating a fixed middle-mile hub network with shippers sensitive to GHG emissions. Shipments move from origins to destinations through hub-to-hub lanes with all-or-nothing service. The carrier decides which commodities to accept, how to route them, where to install EV charging, and how to deploy diesel versus battery-electric trucks on each lane to meet Scope 3 targets. We estimate well-to-wheel emissions using GLEC, develop a MILP, and test it on realistic instances to assess tractability and the network impacts of emissions constraints.

■ MC-20

Monday, 10:30-12:00 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Emergent routing problems in delivery and services

Stream: Vehicle Routing and related problems
Invited session
Chair: *Claudia Archetti*

1 - A partial duty formulation for crew scheduling
Remy Spliet, Twan Dollevoet, Bart van Rossum

We study a crew scheduling problem, subject to working time, duty length, and break regulations. Traditional integer programming approaches rely on formulations that include a variable for each duty, using column generation to compute LP bounds. Instead, we propose using partial duties, defined as the part of a duty that occurs either before or after the break, which simplifies the pricing problem. Because the LP bound becomes weaker, we introduce valid inequalities that repair the value of the LP relaxation. Computational experiments show improved computation times with our new formulation.

2 - Planning Shared Trips to Support After-School Activities
Georg Brandstätter, Pamela C. Nolz, Ulrike Ritzinger

In places with insufficiently available public transportation, children sometimes can't easily get to their after-school activities on their own. Thus, parents often drive their children to these activities. On these trips, they could pick up children from other friendly households that need to get to the same (or nearby) activities, but don't do so because of the required coordination effort. We present an optimization algorithm for planning shared trips between members of different households in order to balance the required effort and incentivize more sustainable modes of transportation.

3 - Real-World Vehicle Routing under Demand Uncertainty
Václav Sobotka, Hana Rudová

Rich deterministic vehicle routing problems (VRP) with hundreds of customers are routinely solved with state-of-the-art heuristics. Yet, works on stochastic VRPs with uncertain demands predominantly focus on the canonical problem variant, recourse modeling, and small-scale instances solved with exact methods. To fill this gap, we propose a modular method building on state-of-the-art heuristics and simulations. We demonstrate the method's capabilities on benchmark instances with up to 1,000 customers and a real-world problem with uncertain demands faced by the company Wereldo in practice.

4 - Multi-Objective Stochastic Time-Dependent Routing for Sustainable E-Grocery Cold Chains with Perishability
Esam Alhomaidi, Osamah Mohammed

The rapid growth of e-grocery intensifies pressure on cold-chain logistics to deliver perishables sustainably under uncertain demand and time-dependent congestion. This study proposes a stochastic, time-dependent MILP model with cold-storage hubs to jointly minimize economic cost, carbon emissions, and freshness loss. Demand uncertainty is modeled via multi-scenario programming and perishability through freshness decay. An Adaptive Large Neighborhood Search efficiently solves large-scale instances, producing near-optimal solutions and managerial insights for sustainable cold-chain design.

■ MC-21

Monday, 10:30-12:00 - Room: JUR - U 22 (Building: JUR)

INFORMS Journal on Data Science Papers Session

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Paul Brooks*

1 - Network Analytics for Anti-money Laundering—A Systematic Literature Review and Experimental Evaluation
Bruno Deprez, Toon Vanderschueren, Bart Baesens, Tim Verdonck, Wouter Verbeke

Money laundering poses a persistent global challenge, often involving complex networks of connected entities. This paper reviews 97 studies from Web of Science and Scopus, providing a taxonomy aligned with existing fraud analytics frameworks. We conclude that most research still relies on expert rules and manual feature engineering, though deep learning is gaining in popularity. We also provide experiments in a standardised set-up, which show that network analytics improve detection power, but we warn of challenges with graph neural networks, class imbalance, and reliability on synthetic data.

2 - Spatio-Temporal Time Series Forecasting Using an Iterative Kernel-Based Regression
Neta Rabin

Spatio-temporal time series analysis addresses tasks like forecasting, prediction, and clustering across domains such as epidemiology and economics. We propose a kernel-based iterative regression model that fuses data from multiple spatial locations to enhance forecasting accuracy. Using multiscale kernels combined as a convex average, the method effectively captures nonlinear relationships and spatial dependencies. Experiments on solar energy, epidemiology, and fire prediction demonstrate improved accuracy and robustness, making it a practical tool for decision-support systems.

3 - How to Purchase Labels? A Cost-Effective Approach Using Active Learning Markets
Xiwen Huang, Pierre Pinson

We introduce and analyze active learning markets as a way to purchase labels, in situations where analysts aim to acquire additional data to improve model fitting, or to better train models for predictive analytics applications. We focus on a single-buyer-multiple-seller setup and propose the use of two active learning strategies (variance based and query-by-committee based), paired with distinct pricing mechanisms. Our proposal comprises an easy-to-implement practical solution for optimizing data acquisition in resource-constrained environments.

4 - For Causal Decision Making with ML Models, Observational Data may be Better than Experimental Data
Foster Provost, Carlos Fernandez-Loria

Decisions supported by machine learning often aim to improve outcomes through intervention. Using observational data can introduce confounding bias. Although experimental data can mitigate confounding, it is costly. This paper presents theoretical and experimental results showing that models built with readily available but confounded data can yield decisions as good as or better than those based on experimental data. This can occur for example when larger effects are more likely to be overestimated or when the variance reduction of the larger data sets outweighs the bias from confounding.

■ MC-23

Monday, 10:30-12:00 - Room: HG - Hörsaal 02 (Building: HG)

Rethinking advances in stochastic and robust optimization

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Mengmeng Li*
Chair: *Sloan Nietert*
Chair: *Tobias Sutter*

1 - Optimal learning via Moderate Deviations Theory
Tobias Sutter

This paper develops a statistically optimal method to learn function values via confidence intervals across a wide range of models, including nonparametric stochastic programming and SDEs. Using a moderate deviation principle, we construct highly accurate intervals that achieve exponential accuracy, minimality, consistency, low mischaracterization probability, and eventual uniformly most accurate (UMA) optimality. The intervals are obtained as solutions to robust optimization problems defined by the induced rate function, with many cases admitting tractable finite convex reformulations.

2 - Asymptotic Optimality in Data-Driven Decision Making
Radek Salac, Tobias Sutter

We study how to make statistically optimal decisions given observations of a stochastic process, including heterogeneous or evolving sources. We propose a framework that selects decisions whose shifted regret risk decays at a prescribed exponential rate. The optimal decision solves a multi-objective problem based on asymptotic properties of the stochastic process, characterized by a Laplace-principle rate function. Our approach handles uncertain distributions, recovers results such as distributionally robust optimization, and balances risk decay with statistical consistency.

3 - Exact Solution Approach for Mixed-Integer Bilevel Stochastic Optimization Problems
Dmytro Matsypura, Tomas Lagos

We study a class of mixed-integer bilevel stochastic programs where the leader makes a first-stage decision before uncertainty is realized, and the follower solves a mixed-integer optimization problem in each scenario. We propose a value-function-based reformulation, a scenario-wise decomposition, and a stochastic subgradient cutting-plane method. We prove that, under mild assumptions, the algorithm converges finitely to an optimal solution and provides valid upper and lower bounds.

4 - When Does Wasserstein DRO Make Good Decisions?
Sloan Nietert

This work examines the excess risk of WDRO decisions when evaluated on a worst-case distribution within a W2 eps-ball of the nominal distribution. We show that the asymptotic complexity of robust decision-making in the eps->0 limit is measured by a problem-specific condition number. In this regime, WDRO achieves the instance-optimal rate. For fixed eps > 0, however, we show that WDRO only achieves the optimal rate for "low rank" problems. To fix this, we introduce a new condition number reduction algorithm that always achieves the optimal rate and admits tractable algorithms.

■ MC-25

Monday, 10:30-12:00 - Room: HG - Hörsaal 16 (Building: HG)

Sustainable and Generative AI in SCM for Emerging Economies

Stream: OR for Development
Invited session
Chair: *Bruno Kamdem*
Chair: *Sadia Samar Ali*

1 - XGNN-RCI: Explainable Graph Neural Networks with Regional Contagion Intelligence for Systemic Risk Prediction in South Asian Emerging Markets
Bushra Saeed, Wei Yin

Systemic crises propagate through interconnected regional networks. We introduce XGNN-RCI, an explainable graph neural network for systemic risk prediction in South Asian markets. Our Regional Contagion Index captures cross-border spillovers with 33% predictive importance. RCI-Attention dynamically adapts message passing, yielding 27% F1 improvements. Analyzing India, Pakistan, Bangladesh, Sri Lanka data achieves F1=0.816, AUC=0.946. Validated on 2022 Sri Lankan crisis with one-quarter advance detection. Deployment-ready for central banks.

2 - Optimizing the Middle Corridor: A Multi-Agent AI Approach
Bruno Kamdem, Nahid Jafari

Geopolitical volatility and the closure of the Strait of Hormuz have forced a critical shift toward the Middle Corridor or Trans-Caspian International Transport Route (TITR). This paper addresses the resulting coordination crisis between sovereign governments and private carriers using a Multi-Agent Deep Deterministic Policy Gradient (MADDPG) framework. We implement a Centralized Training, Decentralized Execution (CTDE) architecture to solve a high-dimensional stochastic differential game.

3 - Managing Supply Chain Disruptions in Multinational Corridors: A Stochastic Differential Game with Geopolitical Risk and Infrastructure Constraints
Bruno Kamdem, Nahid Jafari

The volatility of global commodity prices is increasingly exacerbated by regional instabilities. This crisis is forcing sovereign governments and private carriers into a complex strategic tug-of-war over revenue and survival. In this paper, we address the critical problem of maintaining corridor viability amidst such disruptions, motivated by the need for resilient infrastructure management during geopolitical shocks. We employ a stochastic differential game framework, utilizing Hamilton-Jacobi-Isaacs equations to derive a unique Feedback Nash Equilibrium for optimal tax and freight rates.

4 - Determinants of Energy Efficiency in Developing Regions: An Empirical Analysis using MARS and CMARS
Jinal Parikh, Gerhard-Wilhelm Weber, Yavuz Yilmaz

This study investigates the determinants of energy efficiency, reveals nonlinear responses and critical thresholds, and uncovers regional patterns across states by applying Multivariate Adaptive Regression Splines (MARS) to explain the TFEE scores obtained from SBM-DEA. TFEE serves as the dependent variable, while a set of economic, environmental, structural, and exogenous factors, including energy consumption, capital, labour, GSDP, GHG emissions, industrial structure indicators, energy system characteristics, climate variables, spatial coordinates and time effects are independent variables.

■ MC-26

Monday, 10:30-12:00 - Room: HG - Elise-Richter-Saal (Building: HG)

Omnichannel & Retail Distribution Network Design

Stream: Freight Network Design and related problems
Invited session
Chair: *Walid Klibi*
Chair: *Imen Ben Mohamed*

1 - Urban Fulfillment Network Design with Ship-from-Store Option under Uncertainty
Imen Ben Mohamed, Walid Klibi, Juan Carlos Pina Pardo

We introduce the urban fulfillment network design problem with a ship-from-store option under uncertainty. Stores serve as an intermediate layer in a two-echelon structure to fulfill online orders, with decisions on fulfillment setup and logistics service provider (LSP) selection accounting for fulfillment, delivery, and inventory costs. A two-stage stochastic mixed-integer program handles demand and capacity uncertainty, solved via an integer L-shaped decomposition with scenario sampling. Numerical experiments on a real-world retailer case validate the model and solution approach.

2 - Online Retail Network Design under Endogenous Demand Uncertainty
Linda Ben Ismail, Walid Klibi, Tianyuan Zhang, Zied Jemai

Designing e-commerce networks with home delivery and buy-online-pick-up-in-store (BOPS) options is challenging as customer demand across channels depends on service attributes set by network design. We develop an iterative predict-then-optimize framework for two-echelon network design under endogenous demand. Total demand is predicted and allocated across channels via discrete choice and embedded in a two-stage stochastic program. The approach captures demand endogeneity and identifies profit-maximizing designs. A cosmetics-sector case study shows the benefits over exogenous-demand models.

3 - Case-Pack Allocation for E-Commerce Retailers
Alejandro Toriello

We study case-breaking in e-commerce warehouses. Inbound goods in cases are "broken" into individual units to fulfill retail demand. Processing capacity prevents all cases from being broken; we must decide which cases to break and how to distribute individual units and intact cases. Given warehouse inventory and target retail stocks, we optimize a concave, non-decreasing objective capturing product urgency, current inventory and demand. We formulate an integer program and propose a column generation algorithm with efficient pricing heuristics.

■ MC-27

Monday, 10:30-12:00 - Room: JUR - Hörsaal 13 (Building: JUR)

Advances in Decision Support for Social Good

Stream: Humanitarian Logistics
Invited session
Chair: *Jessica Rodríguez-Pereira*

1 - A Decision-Support Model for Routing and Scheduling Mobile Health Units: A Case Study in Rural Africa
Sara Hatami, Jésica de Armas, Gaston Huber

Access to healthcare in rural areas is often limited by long distances, poor infrastructure, and scarce resources. Motivated by a real-world mobile healthcare program operated by a non-profit organization in rural Africa, this study develops a Mixed Integer Linear Programming model to optimize the routing and scheduling of mobile health units serving dispersed communities. The model maximizes vulnerability-weighted service coverage while minimizing travel distance and weekend operations under realistic logistical constraints. A user interface supports data management and operational planning.

2 - Robust Location-Routing for Search-and-Rescue Operations under Uncertainty
Kamran Sarmadi

This research studies a multi-period location-routing problem for disaster search-and-rescue operations under uncertain demand and travel times. We develop a distributionally robust optimization model that integrates facility location and routing decisions using joint chance constraints. A case study based on Santa Cruz County, California, demonstrates the effectiveness of the proposed approach. Results show that the model supports strategic facility placement and efficient routing of rescue teams, improving rescue outcomes under uncertainty.

3 - Drone-Enabled Early Diagnosis of Human Immunodeficiency Virus in Infants
Alborz Hassanzadeh, Laurent Alfandari

Every hour, 13 infants succumb to HIV, with over 81% of these deaths occurring in Sub-Saharan Africa. Accurate and early diagnosis is the first step in addressing this global health crisis, but operational challenges persist. We developed an integrated allocation-queue decision model with drone fleet sizing to address such challenges. A selective overview of our findings from Mozambique shows that drones offer a promising solution: assigning just one drone to 4% of the clinics results in a 2% increase in treatment initiation for HIV+ infants.

4 - Planning the Where and the How of Post-Disaster Field Assessments under Uncertainty
Jessica Rodríguez-Pereira, Asena Kaplan, Burcu Balcik, Marie-Ève Rancourt, Gilbert Laporte

After the 2023 Türkiye earthquakes, comprehensive rural field assessments were needed to capture evolving vulnerabilities and recovery capacities. We formulate an integrated optimization problem that jointly selects a representative sample of villages and designs field team routes under uncertainty in key-informant availability. A data-driven clustering procedure ensures sampling representativeness, while a matheuristic based on a set-partitioning model incorporates primary and backup sites. The model is validated through a case study using real data from the affected regions.

■ MC-28

Monday, 10:30-12:00 - Room: JUR - Hörsaal 17 (Building: JUR)

Green and Smart Maritime and Port Logistics

Stream: Maritime Logistics
Invited session
Chair: *Cagatay Iris*
Chair: *Yadong Wang*

1 - Energy efficient Stowage Planning
Line Reinhardt, Agnieszka Sivertsen, Rune Jensen

Stowage planning for large container vessels is extremely difficult due to among others the multiport and stability requirements. Therefore new heuristic frameworks addressing the complex and interwoven structure of these problem. We have developed an Strategic Large Neighborhood search (SLNS) framework which is an adaption of the LNS which can handle a very large number of neighborhoods and has a recovery which can repair deteriorated solutions so they may be accepted. The results show an improvement on the representative container stowage planning problem of up to 20%.

2 - Joint routing and scheduling for mothership-drone system in shore-to-ship delivery
Yadong Wang, Mengyan Yang

As vessel delays and port congestion intensify, shore-to-ship delivery becomes increasingly challenging. Although drones offer fast and flexible service, their payload and battery limits restrict independent operations. This study proposes a coordinated mothership-drone system in which the mothership supports drone takeoff, landing, and battery resupply, extending delivery range. An MILP model based on a time-expanded network optimizes routing and scheduling under operational constraints, which is solved by an ALNS algorithm. Results show reduced operating costs and improved service coverage.

3 - Decarbonisation in Port-Hinterland Freight Transport: A Systematic Review of Measures, Modelling Approaches, and Performance Indicators
Seyma Onal, Cagatay Iris, Dongping Song

Port-hinterland freight transport is critical for maritime decarbonisation but remains under-synthesised. This study presents a systematic literature review of quantitative research on decarbonisation in port-hinterland freight transport. It synthesises operational, technical, and market-based measures, along with the modelling approaches used to evaluate them. The review maps how these measures are assessed through performance indicators, revealing dominant modelling patterns, underexplored decision areas and gaps in effective decarbonisation strategies.

4 - Modelling a Multi-Fuel Bunkering Network for the Baltic Sea Region
Jan Simon Bischoff, Frank Meisel

In order to decarbonise the shipping industry, there is a growing shift towards renewable fuel alternatives. In the future, multiple fuel types, such as methanol and ammonia, will coexist within the shipping industry. Therefore, the maritime refuelling infrastructure will need to be redesigned. This study utilises a flow-refuelling location optimisation model to identify cost-effective sites for port-to-ship and ship-to-ship fuel supply operations. It also determines the optimal supply capacities for methanol and ammonia. The model is applied to AIS-based ship routes for the Baltic Sea region.

■ MC-29

Monday, 10:30-12:00 - Room: HG - Hörsaal 30 (Building: HG)

Scheduling problems

Stream: Combinatorial Optimization
Invited session
Chair: *Alberto Locatelli*

1 - New MIP formulation and BRKGA for the earliness-tardiness permutation flow shop scheduling problem with exact delays
Rafael Melo, Matheus Queiroz, Bruno Xavier, Mateus Silva, Vítor Barbosa, Mauricio Resende

We study the earliness-tardiness permutation flow shop problem with exact delays (ET-PFSP-ED). We prove its equivalence to the earliness-tardiness single-machine problem with sequence-dependent setup times (ET-SMSP-SDS). Based on this result, we develop a new MIP formulation, an exact two-phase greedy algorithm for the fixed-permutation case, and a BRKGA for the original problem. Preliminary computational results evaluate the proposed methods.

2 - Sugarcane Harvesting Front Scheduling Optimization with Multiple Plants
Pedro Peverari Di Lallo, Reinaldo Morabito, Willy Oliveira Soler

This study extends the Sugarcane Harvesting Front Scheduling Problem (SHFSP), which allocates harvesting fronts to sugarcane field plots (blocks) and sequences their visits over a planning horizon. As Brazil's sugarcane sector consolidates into large industrial groups, pre-allocating blocks to individual plants foregoes cross-plant collaboration. We propose a novel MIP model where blocks are sharable across plants, with realistic operational constraints validated by a domain expert. Experiments with realistic data confirm coordinated multi-plant planning outperforms independent solutions.

3 - Solving the Train Stop Scheduling Problem using a Branch-and-Price Framework
Sachin Jayaswal, Faiz Hamid, Ankit Pramod Meshram

We address the Train Stop Scheduling Problem in passenger rail planning, where train stopping patterns must satisfy origin-destination demand and capacity constraints while minimizing total stops. We propose an exact branch-and-price approach based on Dantzig-Wolfe decomposition and delayed column generation. A two-phase branching scheme, strengthened by a problem-specific primal heuristic, improves solution quality and search efficiency. Computational results show strong scalability and exact solution of realistic benchmark instances.

4 - A New Combinatorial Branch-and-Bound Algorithm for the Job Sequencing and Tool Switching Problem
Alberto Locatelli, Jean-François Côté, Leandro Coelho

The Job Sequencing and Tool Switching Problem (SSP) is a well-known combinatorial optimization problem arising in flexible manufacturing. Since the seminal article by Tang and Denardo (1988), SSP has received considerable attention, leading to numerous exact and heuristic approaches. Despite these efforts, several benchmark instances remain unsolved to proven optimality. In this work, we propose a branch-and-bound algorithm for the SSP with novel features. The proposed method outperforms the state of the art on a standard set of benchmark instances and solves several previously open instances.

■ MC-31

Monday, 10:30-12:00 - Room: JUR - Hörsaal 12 (Building: JUR)

Network design and line planning for public transport 1

Stream: Optimizing Transit
Invited session
Chair: *Maarten Wens*
Chair: *Pieter Vansteenwegen*

1 - The Joint Design On-Demand Bus Routing Problem
Shahrezad Fahmy, Lissa Melis, Tjark Vredeveld

While fixed bus routes are efficient in high-demand areas, they underperform under sparse or variable demand, where on-demand services offer flexibility at higher operational cost. This raises the question of how cities can redesign public transport systems to effectively balance both modes within a single integrated framework. We propose a unified multilevel heuristic that jointly optimizes line planning, frequency setting, hub location, and on-demand routing, improving system-wide performance.

2 - Network Design for Tourists
Maarten Wens, Pieter Vansteenwegen, Jan-Dirk Schmöcker

The network design problem consists of two parts: network design and passenger assignment. The latter usually considers the demand as a static OD-matrix. However, the actual demand also changes based on the transportation system. What happens if the assignment problem becomes an activity-based trip chain?

The tourist trip design problem, where tourists decide which attractions to visit, is used to build this trip chain. The objective of the network design is to disperse tourists and reduce congestion. The decision variables are the cost of transportation between tourist attractions.

■ MC-32

Monday, 10:30-12:00 - Room: JUR - Hörsaal 14 (Building: JUR)

Passenger and Freight Co-Modal Urban Logistics

Stream: City Logistics
Invited session
Chair: *Dongyang Xia*

1 - Jointly Optimizing Train Services and Freight Distribution in Metro Passenger and Cargo Systems: A Branch and Price Approach
Ni An

This paper addresses metro-based passenger-cargo co-transportation by developing a train-cargo interdependent spatiotemporal network and formulating an integer linear program that jointly optimizes timetabling, capacity allocation, and freight routing. propose a branch-and-price algorithm enhanced with improved label-setting, restricted master problem reduction, bound tightening, and tailored branching strategies for large scale instances. Computational experiments on real-world Beijing metro data demonstrate the algorithm's effectiveness and provide managerial insights.

2 - Operational Planning for Tram-Based Last-mile Freight Delivery
Inès Van de Weyer, Dilay Aktas Dejaegere, Pieter Vansteenwegen

As cities grow, urban last mile logistics face congestion, emissions, and access restrictions, while public transit operators have unused capacity during off-peak hours. This study examines a low-investment multi-modal system in which trams transport goods to the city center and e-cargo bikes unload the goods and complete the deliveries. We have developed a MILP model to optimize drop off choices and bike routes, and a tailored Large Neighborhood Search (LNS) metaheuristic. Results show the approach efficiently produces high quality solutions for operational planning.

3 - Redesigning urban intermodal transit for passenger and freight co-modal mobility: Metro line planning with integrated truck routing
Dongyang Xia, Yahan Lu, Patrick Stokkink, Shadi Sharif Azadeh

We study passenger and freight co-modal mobility in an inter-modal network combining urban rail transit and truck services. A path-based optimization model jointly determines line plans, service frequencies, and routing decisions under budget constraints. To solve large-scale instances, we develop a column generation algorithm with a two-phase diving procedure. We evaluate our approaches on both artificial instances and real-world case studies from the Rotterdam inter-modal network.

■ MC-33

Monday, 10:30-12:00 - Room: JUR - Hörsaal 15 (Building: JUR)

Satellite scheduling

Stream: OR in Space
Invited session
Chair: *Sushanta Nigudkar*

1 - A Hybrid Metaheuristic Framework for Remote Sensing Satellite Scheduling
Dung-Ying Lin

We develop an efficient heuristic framework for remote sensing satellite mission scheduling. The scheduler selects and sequences missions under tight windows and constraints on communication, ground contacts, visibility, memory, power, and safety. The problem is highly combinatorial, making exact optimization impractical. A hybrid metaheuristic (tabu search, GRASP, and simulated annealing), validated with constraint programming, delivers clear gains in solution quality and speed.

2 - Robust Multi-Period Satellite Constellation Reconfiguration Problem
Cansu Agrali, Gregoire Danoy

This paper introduces a modeling framework for the robust multi-period satellite constellation reconfiguration problem. Unlike deterministic scheduling reliant on exact point forecasts, we propose an optimization approach that maximizes worst-case observation coverage. By integrating a spatial uncertainty cone and a tunable risk budget, the framework determines maneuver strategies that guarantee observation quality under shifting storm trajectories. The model strictly adheres to orbital dynamics, propellant limits, and orbital perturbation constraints.

3 - Scheduling In-orbit services for mega-constellations
Sushanta Nigudkar, Christof Defryn

The recent rise in space asset deployments at debris-rich LEO altitudes has led to increasing interest in the planning and execution of on-orbit servicing missions (OOS). This work explores the on-orbit servicing of mega-constellations, which accounts for the largest fraction of satellites in LEO, using an orbital service depot that can dispatch service shuttles. The mission is formulated as a Vehicle Routing Problem (VRP) with the objective of minimising total propellant mass consumption. A Large Neighbourhood search is then used to solve the VRP.

■ MC-34

Monday, 10:30-12:00 - Room: JUR - Hörsaal 16 (Building: JUR)

Planning and scheduling picking operations in collaborative environments

Stream: Warehousing
Invited session
Chair: *Melih Celik*
Chair: *Sina Khodaee*

1 - Can We Have It All? Towards Stress-Aware and Efficient Human-Robot Collaboration in Robotic Mobile Fulfillment Systems
Suryakant Kumar, Tanmoy Kundu, Jiuh-Biing Sheu

This study develops a human-centric human-robot collaboration framework for Robotic Mobile Fulfillment Systems. By integrating stochastic optimal control with non-cooperative game theory, we enable Autonomous Mobile Robots (AMRs) to adapt to real-time picker stress. Using an Extended Kalman Filter for state estimation, the model dynamically adjusts AMRs movement rates based on Nash equilibria targets. Numerical analyses show stress reductions of up to 47% with minimal productivity loss, aligning warehouse operations with Industry 5.0.

2 - Human-Centered Coordination in Robotic Warehouses: Integrating Worker Preferences into Human-Robot Order Picking
Mahdi Ghorashi Khalilabadi, Debjit Roy, René de Koster

Autonomous mobile robots are increasingly used in warehouses to support human order picking. Most coordination models assume homogeneous workers, ignoring differences in worker preferences and their impact on performance. We study a human-robot collaborative order-picking system in which picker preferences over travel distance and item characteristics influence effective execution times. The problem is formulated as an integrated assignment and sequencing model with a dual objective balancing makespan and preference alignment, and solved using heuristic methods including adaptive large.

3 - Hop on/hop off: Cooperative order picking of an autonomous drive-on picking cart and a human order picker
Tobias Kroll, Nils Boysen, Stefan Bock

In workforce-shortage contexts, robotic collaboration can streamline order picking while retaining flexibility. Ride-on picking carts (cobots) transport drivers, letting the picker hop off, collect items, then deposit and hop on elsewhere. We model routing for picker-cobot tandems under various speed ratios and traffic rules. If cross-aisle walking is forbidden, we give a polynomial-time algorithm; otherwise, we use a decomposition heuristic. Experiments show efficiency gains depend on layout, speed relations, and regulations, pinpointing where human-cobot cooperation is beneficial.

4 - The impact of zoning policies on efficiency in collaborative picking systems with autonomous mobile robots
Sina Khodaee, Melih Celik, Vaggelis Giannikas, Nader Ghaffarinasab

We investigate the impact of zoning decisions in a collaborative order-picking system where autonomous mobile robots (AMRs) transport batches of orders and human pickers retrieve and load items onto the robots. The key decisions include batching orders for AMRs, assigning pickers to zones, and routing both robots and pickers. We study three coordination strategies: no zoning, static zoning, and dynamic zoning, and develop MIP models and solution heuristics for each. Computational results discuss the benefits of dynamic zoning showing a balance between performance and practical simplicity.

■ MC-35

Monday, 10:30-12:00 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Applications of AI meets Sustainability

Stream: Operations Research and Sustainability
Invited session
Chair: *Ismail Elbouknify*

1 - Towards Green AI in Finance: News Selection for Efficient Financial Market Prediction
Ismail Elbouknify

Financial news is valuable for market prediction, but ingesting thousands of daily headlines makes models costly, slow, and higher-carbon—and can amplify noisy patterns. We propose a Green-AI, budgeted news-selection approach that treats headlines as a constrained resource and picks a small, diverse, high-information subset via confidence filtering, clustering summarization, and diversity sampling. This maintains predictive value and improves trading outcomes (higher PnL and Sharpe ratio) while cutting compute, latency, and emissions by 98%.

2 - Disruptions in Critical Raw Material Markets: Evidence from Physical and Financial Lithium Markets
Kaiyu Xie, Marcos Machado, Laura Spierdijk, Devrim Murat Yazan

This paper examines how supply-side disruptions in critical raw materials are priced in physical and financial markets, using lithium as an empirical case. Combining spot prices and lithium-related equity indices, we find weak and unstable transmission after removing broad market effects. Financial spikes are more frequent and often expectation-driven. Using 22,000 news headlines and a two-layer LDA-BERTopic model, we show that spikes align with narratives of upstream supply risk and production uncertainty, highlighting episodic risk repricing in CRMs.

3 - Sustainable Semiconductor E-Waste Reverse Supply Chain Design under Decision-Dependent Quality Uncertainty
Arash Amirteimoori, Hao Chen, Devrim Murat Yazan, Mahak Sharma

This study develops a two-stage Distributionally Robust MILP for designing and operating a multi-echelon reverse supply chain for semiconductor e-waste. The model jointly optimizes facility location, technology choice, capacity, and material flows across collection, classification, and recovery. It captures decision-dependent quality uncertainty, hazardous contamination risk, and distributional ambiguity through CVaR and Wasserstein robustness. Parallel solution algorithms enable efficient optimization, supporting resilient and sustainable recovery infrastructure design.

4 - The Effects of Annual Reports on Volatility: A European Point of View
Fulvio Raddi

The paper aims to study the sentiment brought to the market by the emission of annual reports, and if and how this affects the local volatility (in terms of log-returns). We consider the companies forming the STOXX 50 index for which we extract the 2023 annual reports' sentiment scores using them as exogenous variables in two models: a local volatility regression model and a two-stage Exponential Generalized AutoRegressive Conditional Heteroskedasticity (EGARCH) model. Results show that the EGARCH approach is more efficient in assessing the impact of sentiment on market volatility.

■ MC-37

Monday, 10:30-12:00 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Optimization algorithms and applications 1

Stream: Nonlinear Optimization
Invited session
Chair: *Cong Sun*

1 - Stepsizes for the gradient method based on subspace approximations
Ya-xiang Yuan

The gradient method is the simpliest method for unconstrained optimization, as in each iteration, the next iteration point is obtained from the current one by moving along the gradient direction. Variations of the gradient methods, such as stochastic gradient algorithms are widely used for machine learning and other AI problems. In this talk, we give some new stepsizes for the gradient method based on subspace approximations, which presents a new approach for constructing gradient algorithms.

2 - Acceleration strategies for gradient methods
Anna De Magistris

Gradient methods are fundamental to large-scale optimization, yet acceleration remains a key challenge. This work moves beyond standard negative gradients by employing composite search directions. The first strategy executes a minimization process within low-dimensional affine subspaces, specifically targeting convex quadratic problems. The second adapts the "twin" concept from Kaczmarz iterations as a means of acceleration. Numerical experiments demonstrate that both strategies significantly enhance convergence and robustness.

3 - A Unified Decentralized Nonconvex Algorithm under Kurdyka-Lojasiewicz Condition
Liping Wang

In this paper, a unified decentralized nonconvex algorithmic framework is proposed which subsumes several state-of-the-art gradient tracking algorithms and quasi-Newton algorithms. We develop an analytical convergence of the unified algorithm under the Kurdyka-Lojasiewicz condition for nonconvex optimization problem. We also propose some quasi-Newton variants that fit into the proposed framework. The numerical results show that these newly developed algorithms are very efficient compared with other state-of-the-art algorithms for solving decentralized nonconvex smooth optimization problems.

4 - Nonconvex Optimization in Large-Scale Bibliometric Analysis
Thi Huong Vu

Clustering scientific publications in large-scale bibliometric datasets poses challenging nonconvex optimization problems. We first share practical experience with hard clustering via the Leiden algorithm, which recovers expert-aligned partitions but also reveals fragmented networks, reconnected using semantic similarity from large language models. We then address fuzzy clustering as a nonlinear optimization

problem, introducing GPU-parallel algorithms scalable to billions of citations and techniques using first- and second-order information to improve solution quality and stability.

■ MC-38

Monday, 10:30-12:00 - Room: JUR - Seminar-Raum 44 (Building: JUR)

OR Solutions and Practice: Lessons Around the World

Stream: The Practice of OR: Stories of Solutions, Setbacks, and Successes
Invited session
Chair: *Elise del Rosario*
Chair: *Gerhard-Wilhelm Weber*

1 - Impacting Society with OR tools
Andrés Weintraub

To be truly relevant,OR needs to impact different aspects of our society. Ideally, these applications should have several characteristics: a)be innovative,moving the boundaries of knowledge b)have significant economic and social impact,changing the way industry and other institutions operate c)Remain in time,renewing itself periodically. In this talk I present the work our group has carried out in areas including forest management, mine planning, ship container logistics, oil distribution, sports scheduling, fighting forest fires, while pointing out setbacks and successes met along the way.

2 - The Decision Making Environment and the OR Analyst
Elise del Rosario

Decision-making environments in organizations are far more complex than the formal models used to support them. Analysts must navigate misaligned objectives, political constraints, data ambiguity, and communication gaps that shape how models are interpreted and used. This presentation examines the reality of the analyst-decision maker interface and proposes a framework for understanding how organizational context influences the adoption and impact of OR tools. The goal is to bridge the gap between modeling assumptions and real-world decision processes.

3 - Data Collection on the Front Lines
James (Jim) Cochran

Data Collection on the Front Lines

Data is the lifeblood of every real application of operations research, statistics, or analytics. Missteps in data collection can lead to disastrous results. In this talk, we consider data collection challenges we faced in projects in The Central African Republic, Somalia, and Tigray. We discuss ways we overcame these challenges - or failed at o do so - and offer some advice for others facing data collection challenges.

4 - Why do OR projects fail, and what does an OR Team need to do to succeed?
Karla Hoffman

OR has the opportunity to play a decisive role in shaping strategy, building trust in data-driven decision-making, and providing measurable value to organizations. However, without careful attention to the human, system, and data issues, OR projects often fail. This talk includes examples of how non-mathematical modeling issues determined whether a data-driven model succeeded or failed. Specifically, this talk provides directions for handling ambiguity and unexpected changes to the system. It will also discuss human-behavior processes, such as setting expectations and building user trust.

■ MC-45

Monday, 10:30-12:00 - Room: HG - Seminar-Raum 01 (Building: HG)

Decision-Focused Optimization

Stream: Prescriptive Analytics in Operations Management
Invited session
Chair: *Tu Ni*
Chair: *Hailong Sun*

1 - Revisiting Assortment Optimization Through A MINLP Lens
Taotao He

In this talk, we show how a simple idea in MINLP can be used to exactly solve assortment optimization under various multinomial logit (MNL) based choice models. For the standard MNL model, a compact linear program (LP) can be derived whenever the feasible set itself admits a compact LP representation. For the mixture of MNLs, we obtain a finite sequence of LPs that converges to the optimal revenue, with the first LP yielding an integer programming formulation capable of solving instances with 1,000 products and 100 segments within minutes. We also discuss extensions to multi-purchase MNL.

2 - Learning Correlated Preferences via Inverse Optimization
Hailong Sun

We study the problem of learning correlated preferences from aggregate choice data. Our focus is on the Cross Moment Model (CMM), a flexible choice model that captures rich correlation patterns among alternatives. We develop an estimation method based on inverse optimization, and develop and alternative minimization algorithm to solve the estimation problem. We establish the convergence of the algorithm, and the statistical properties of the estimator. Numerical results demonstrate the strong performance of the method. Applications in data-driven bundle pricing is discussed.

3 - Decision Analytics of Switchback Experiments: A Robust Optimization Approach
Tu Ni

Digital platforms use switchback experiments to prevent user interference, but small sample sizes make classical p-values hard to act on. This paper proposes a robust optimization approach to decide whether to roll out changes. By treating unobserved outcomes as unknowns and minimizing "worst-case regret," the method uses temporal structure and Lipschitz continuity to outperform standard tests. It handles carryover effects and requires no distributional assumptions. For managers, it provides a faster, clearer "go/no-go" filter, saving resources for high-impact innovations.

4 - Policy Optimization for Multi-Product Inventory Systems with Demand Substitution via Differentiable Simulators
Saied Farham-Nia

Toward reliable and scalable application of deep reinforcement learning in inventory control, we study an infinite-horizon multi-product inventory system with partial demand substitution and partial lost sales under stock-out conditions. Our model-based approach constructs a differentiable simulator from historical or synthetic data and applies stochastic gradient descent via direct backpropagation for policy optimization. Benchmarking against value iteration and standard inventory heuristics, it shows strong convergence, low optimality gaps, and superior performance.

■ MC-46

Monday, 10:30-12:00 - Room: HG - Seminar-Raum 02 (Building: HG)

Challenges in scheduling

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Baruch Mor*

1 - Priority queues with discretionary services
Royi Jacobovic
Consider a single-server non-preemptive priority queue such that once a customer enters the service position, he decides when to quit. Furthermore, each customer benefits from the consumption of service-time. In the current work, under extremely general conditions, we solve the planner's problem using nonparametric optimization and derive a price function that makes the customers behave consistently with the socially optimal solution. Furthermore, we develop a c-mu rule for this model and discuss the case when the priority classes are unobservable. This is a joint work with Yuval Gat.

2 - Scheduling theory in light of lean manufacturing
Baruch Mor
Classic deterministic scheduling assumes machines produce perfectly with zero waste. We challenge this by integrating Zero Waste Manufacturing (ZWM) and Zero Defect Manufacturing (ZDM), acknowledging real-world waste and defects. We study single-machine scheduling with performance deterioration, requiring Calibration and Preventive Maintenance (CPMA). Each job incurs waste cost; we minimize makespan or weighted completion time under waste/repair cost limits, proposing DP algorithms for NP-hard problems and mapping Pareto-optimal solutions.

3 - Auction-Based Mechanisms for Strategic Single-Machine Scheduling
Shani Alkoby, Baruch Mor
This paper integrates classical single-machine scheduling with auction-based mechanism design to address decentralized environments with self-interested agents. Jobs compete for execution slots through sequential second-price auctions, ensuring incentive compatibility and individual rationality. The framework accommodates makespan, total completion time, and total weighted completion time objectives. By embedding efficiency penalties aligned with classical scheduling rules, the mechanism balances strategic behavior with system performance while generating non-negative revenue for the scheduler

4 - Admission control for service systems with impatient customers: Value of information
Wensi Zhang, Ivo Adan, Vidyadhar G. Kulkarni
We study admission control in service systems with impatient customers modeled as an M/M/s+G queue. Customers abandon if waiting exceeds their patience time. We compare optimal policies under partial information (queue length) and full information (virtual queueing time, VQT), which relates to scheduling and resource allocation decisions. For constant impatience, a VQT-threshold policy is optimal. Numerical and simulation results show that the value of full information is limited and that queue-length policies from an equivalent from an equivalent M/M/s+M model provide accurate approximations.

■ MC-47

Monday, 10:30-12:00 - Room: HG - Seminar-Raum 03 (Building: HG)

Stochastic methods for routing and service network design

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Janosch Ortmann*

1 - Managing Uncertain Vehicle Availability in Production Routing: Reformulation and Decomposition Methods
Michel Gendreau, Luis Rocha, Alena Otto, Jorge E. Mendoza, Walter Rei
Uncertain driver availability can severely disrupt supply chain operations. We study this in the context of the production routing problem (PRP) and propose the stochastic PRP with uncertain vehicle availability (SPRP-V). We derive a novel deterministic reformulation, HetPRP, that embeds expected recourse costs into first-stage routing decisions, eliminating the need for stochastic decomposition. Computational results show that HetPRP significantly outperforms both the extensive form formulation and a tailored Benders decomposition that exploits the integrality of second-stage subproblems.

2 - Coping with Uncertainty in Green EV Charging Infrastructure Planning: A Stochastic Behavioral Optimization approach
Maria Elena Bruni, Haoqi Xie
Designing sustainable electric vehicle charging networks requires addressing demand uncertainty while integrating renewable energy and user behavior. We introduce the green charging station network design problem, formulating it as a two-stage stochastic MILP with embedded discrete choice models to capture heterogeneous user preferences under uncertain charging demand. The framework jointly optimizes station location, technology selection and renewable energy sizing. Experiments on a real network reveal that environmental awareness significantly shapes optimal network configuration.

3 - Tactical Planning in an Integrated Multi-stakeholder Freight Transport System under Uncertainty in Demand and Supply
Janosch Ortmann
The transportation sector is evolving to meet growing demands for efficiency, profitability, and reduced environmental impact. Two-sided logistics platforms such as Uber Freight facilitate interactions between shippers and carriers. We study a digital freight platform where the demand of many shippers is matched with the capacity of many carriers through a centralised decision-support entity, forming a Many-to-One-to-Many (M1M) system. This setting leads to a large-scale stochastic optimisation model for tactical planning under uncertainty in demand volumes and service capacity.

4 - Service Network Design with Uncertainty on Water Levels for Intermodal River Transport
Walter Rei
Barge transport offers a sustainable alternative to other modes but is increasingly affected by drought-induced low water levels that restrict navigation and vessel capacity. This presentation introduces an integrated modelling framework for tactical planning in consolidation-based barge freight transportation. Two stochastic Water-Level-Constrained Scheduled Service Network Design models capturing uncertainty in resource capacities due to water level variations are presented, and computational experiments evaluate different tactical adjustment strategies.

■ MC-48

Monday, 10:30-12:00 - Room: HG - Seminar-Raum 04 (Building: HG)

Supply chain risk management

Stream: Data-driven Operations Research
Invited session
Chair: *Piyal Sarkar*

1 - A Reinforcement Learning Approach for Real-Time Data-Driven Supply Chain Optimization under Demand Uncertainty
Yogesh Kumar Jain

In this study, a reinforcement learning (RL) method is developed for real-time data-driven supply chain optimization, considering demand uncertainty. Unlike other static approaches, the presented method dynamically responds to inventory, production, and distribution decisions through continuous feedback from dynamic demand patterns. The performance of the presented method has been evaluated empirically, indicating its superiority over other conventional approaches. The presented method has shown promising results for RL in supply chain management.

2 - Temporal Multiplex Graph Learning for Weak Signal Detection and Systemic Risk Propagation in Supply Chain Networks
Mohamed Saâd El Harrab, Abdelmouaiz Tebjou

Supply networks exhibit systemic vulnerability patterns preceding disruptions by weeks, undetected by static risk scoring. Modeled as multiplex networks, they encode physical, financial, geographic, and operational interdependencies evolving over time. Weak signals combine internal indicators (delivery reliability, quality, financial stress) with external geopolitical, commodity, and regulatory streams. Propagation dynamics support worst-case exposure quantification and proactive decision support, with scenario interpretation grounded in language models constrained to quantitative outputs.

3 - Managing multi-period production capacities hedging under exchange rate risk
Piyal Sarkar

This paper presents a method to hedge the exchange rate risk by using put options and capacity allocation for a firm under multi-period production with known demand. The firm sells goods in both domestic and foreign markets and produces the product at a domestic facility. As a consequence of this arrangement, the exchange rate plays a vital role in the firm's financial risk and overall profit. Thus, a global firm facing exchange rate risk can benefit by integrating flexible manufacturing practices and financial risk hedging.

■ MC-49

Monday, 10:30-12:00 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management in Transportation and Mobility 1

Stream: Data-Driven Demand Management
Invited session
Chair: *Katrin Waßmuth*

1 - Capacity Allocation: Balancing Contract Commitments and Spot Market Opportunities
Benny Mantin, Rishikesh Parma, Çağıl Koçyiğit

We study the capacity allocation problem for freight shipping faced by a maritime firm who allocates vessel capacity through contracts and the spot market under demand uncertainty. We formulate this problem as an integer program aiming to maximize a concave revenue function representing the total expected revenue from contracts and the spot market. Solving a convex relaxation of this problem, we characterize its optimality conditions. We then propose an easy-to-interpret and computationally efficient algorithm. Our real-data experiments demonstrate consistent revenue improvements.

2 - Delivery Profiles in Attended Home Delivery: Integrating Demand Management and Vehicle Routing Problems with Delivery Options
Kilian Hein, Matthias Soppert, Claudius Steinhardt

We analyze an attended home delivery setting in which customers choose delivery profiles, consisting of sets of delivery options, each defined by a time slot and a delivery location. To incentivize customers to choose profiles for which the provider obtains more flixibility in the routing, we optimize the profiles' prices. We formulate a static mixed-integer programming model and use scenarios to incorporate customers' choices. We show that our approach can reduce operational costs for the provider compared to classical attended home delivery without delivery profiles.

3 - Incorporating Deep and Machine Learning Approaches into Rehabilitation Transportation Service Management in Rural Area
Yu-syuan Wu, Yu Sin Liao, Cheng-Chieg Chen

Many previous studies tend to solve the routing and scheduling problems with given demand information, but rarely analyzing demand recurrence characteristics based on the historic dispatching data. This study initially analyzes the rehabilitation transportation service database, to explore the features and linkages of demand frequency, distributions of time and space, and short-term to long-term demand prediction mechanisms, so as to alleviate the operational challenges of the rehabilitation transportation service providers in rural area.

4 - Time Window Assortment Design with Stochastic Demand: The Value of Overlapping Time Windows
Katrin Waßmuth

Online grocery deliveries require customers to be present, making time window design crucial. While research on time window assortments is growing, the benefits of overlapping windows are not well understood. Extending an established model, we incorporate demand variability across windows and analyze how overlaps can reduce inefficiencies from demand peaks. We derive conditions under which overlapping time windows lower delivery costs and support our insights with Monte Carlo simulations.

■ MC-50

Monday, 10:30-12:00 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Sector-Coupled Multi-Energy Systems I

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Nicolò Zatta*

1 - A Strong MIP Formulation for Multi-State Units: An Application to Power-to-Hydrogen
Ali Nikseresht, Jehum Cho, Yashar Ghiassi-Farrokhfal, Derek Bunn

We propose a strong mixed-integer formulation for multi-state units with transition-dependent delays using backward-looking time-window constraints. Under state-conditional operating assumptions, the formulation is ideal and yields a compact convex hull description. We apply it to integrated electricity-hydrogen dispatch in a national-scale Netherlands case and show that explicit three-state electrolyzer modeling improves computational performance by more than fifteen-fold and increases hydrogen-side net profit by 31.31 percent relative to a two-state benchmark.

2 - Control of a gas turbine-battery hybrid power plant providing an ancillary service
Přemysl Šůcha, Petr Stejskal

The growing penetration of renewable energy increases the need for ancillary services. This paper studies the control of a real-world hybrid power plant consisting of fast aeroderivative gas turbines and a battery energy storage system. We present a feasibility study showing how forecasting of automatic frequency restoration reserve (aFRR) activation can improve plant economics. The control is formulated as an optimization problem, while machine learning supports better unit commitment decisions. We focus on aFRR provision, which is challenging due to strict response times.

3 - Re-optimazion of Battery Energy Storage Systems scheduling in continuous markets
Enrico Brambilla, Renata Mansini, Maria Teresa Vespucci

Following the European Clean Energy Package, Italy's shift to a 15-minute settlement has increased market volatility. This rolling horizon framework optimizes Battery Energy Storage Systems (BESS) within the Single Intraday Coupling (SIDC), using continuous reoptimization to respond to shifting prices. Constraints include power limits, efficiency, and degradation-linked throughput caps. Notably, the model accounts for BESS integration within broader energy systems and pre-existing market positions, enabling both arbitrage and portfolio rebalancing in a volatile environment.

4 - MILP-based optimal scheduling of residential heat pumps with temperature-dependent efficiency and building thermal inertia
Nicolò Zatta, Francesco Ceccanti, Andrea Baccioli, Aldo Bischi

This work presents a mixed-integer linear programming model for the day-ahead scheduling of a residential heat pump. The formulation combines a multi-node building thermal model with a piecewise linear representation of heat pump performance depending on supply temperature and load. Simulations over a 24-hour horizon show that simplified efficiency assumptions can overestimate electricity consumption by up to 35 percent. The model exploits building thermal inertia to shift heating demand and reduce operating costs while maintaining comfort.

■ MC-51

Monday, 10:30-12:00 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Optimization for Interpretable and/or Fair AI//ML

Stream: Mathematical Optimization for Transparent and Fair Decision Making
Invited session
Chair: *Craig Larson*

1 - Interpretable Machine Learning for Bicycle Safety Risk Prioritization
Farnaz Farzadnia, Dolores Romero Morales

Cycling is central to sustainable urban mobility, yet safety concerns still deter many potential riders. We propose an interpretable machine-learning framework that estimates segment-level crash probability for bicycle crashes and uses SHapley Additive exPlanations (SHAP) to reveal the key infrastructure and traffic factors driving risk, including how their importance varies across Level of Traffic Stress classes.

2 - Feature Selection through Cooperative Games with Robust Egalitarian Rankings
Marco Piazza, Antonio Consolo, Chiara Mariani, Mauro Passacantando, Enza Messina

Cooperative game-theoretic models for feature selection are attracting growing interest in machine learning. While popular approaches rely on the Shapley value or the Banzhaf index, which quantify marginal feature contributions, we propose new approaches based on minimizing the L1 and L norms of the coalition excess vector, allowing more robust and equitable assessment of feature contributions. Experiments on 20 classification datasets (26-450 features) with logistic regression and random forests show comparable or superior test performance, especially on larger datasets.

3 - Modeling "local" in Local Interpretable Model-agnostic Explanations
Dolores Romero Morales, Emilio Carrizosa, Cristina Molero-Río

Local Interpretable Model-agnostic Explanations (LIME) is a popular technique in XAI that locally approximates a black-box model by an interpretable surrogate. In this talk, we revisit the concept of locality in LIME. The goal of our approach is to choose an interpretable local sample and train a generalized linear model as an interpretable surrogate that effectively performs locally. This problem can be formulated as an MINLO model. The very same methodology allows us to handle tabular data across different prediction tasks, and numerical illustrations of this will be provided.

4 - Conjecturing for Discovery of Patterns in Data
Craig Larson, Paul Brooks

We introduce algorithms for automated discovery of nonlinear and boolean patterns typically hidden by machine learning methods. The first identifies a top-k set of expressions by minimizing an objective function that captures the tradeoff between error and complexity. A second algorithm leverages reinforcement learning to minimize error, complexity, and redundancy to ensure a diverse set of expressions for further investigation. These methods bridge the gap between predictive power and human-readable insights, facilitating the discovery of fundamental relationships within complex datasets.

■ MC-52

Monday, 10:30-12:00 - Room: KOL - PC Raum 1 (Building: KOL)

Power System Planning and Operation

Stream: Energy Markets & Systems
Invited session
Chair: *Ramteen Sioshansi*
Chair: *Enzo Sauma*

1 - Stable and Fair Uniform Price Allocations of Community Aggregation Gains in Retail Electricity Markets
Shmuel Oren, Tomas Valencia Zuluaga

We propose a mechanism to distribute collective savings in a community of residential customers with local energy resources . We exploit the strong duality of Linear Programs to prove that stable imputations in a desired class, the uniform price core, are guaranteed to exist and can be found efficiently, overcoming scalability issues. Looking for fair distributions however, may come at the cost of computational intractability for large problem instances; to overcome this challenge, we propose a sampling methodology that returns imputations in an acceptable relaxation of the uniform price core.

2 - Full-EU Nodal Investment Planning for Renewable Auction Bid Selection
Anthony Papavasiliou

We propose a full-EU algorithm for renewable capacity auction bids with nodal network constraints. The problem is formulated as a two-stage stochastic capacity expansion model with renewable integration targets, high temporal resolution, and climate uncertainty. To solve this large-scale problem, we use a stabilized Benders' decomposition with adaptive level-set updates designed for high-performance computing. The full-EU monolithic model would approximately contain about 1492 million constraints and 761 million variables.

3 - Impact of hydrogen production flexibility on power system operation and expansion planning
Enzo Sauma, Andrés Pereira

Hydrogen production can provide some flexibility to the power system. This work examines the impact of hydrogen-production inter-seasonal flexibility on power system expansion planning and operation. We conduct a case study of the Chilean power system, evaluating three levels of inter-annual hydrogen demand flexibility. Our results indicate that increasing hydrogen demand flexibility leads to reductions in total system costs and investment levels in both power generation and transmission infrastructure. Furthermore, the value of flexibility increases as hydrogen demand level decreases.

4 - Leveraging Operational Flexibility of Water Desalination to Reduce the Cost Electricity-System Decarbonization
Ramteen Sioshansi

Electricity-system decarbonization is costly due to challenge of maintaining reliable electricity supply during all times. In this work, we examine the extent to which water desalination, which is energy intensive and has inherent operational flexibility, can be used to reduce the cost of electricity-system decarbonization.

■ MC-53

Monday, 10:30-12:00 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Multi-Objective Optimization for Sustainable and Resilient Systems

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Banafsheh Khosravi*

1 - A Multi-Objective Optimization Framework for Large-Scale Linear Programs: An Application in Resilient Energy System Planning
Aileen Homey, Suzanne Le Bihan

We present a general-purpose Multi-Objective Optimization (MOO) framework applied to the large-scale energy system model REMix, integrating raw material supply risk. We jointly minimize system costs and geopolitical criticality for Europe's technology expansion until 2050. To efficiently tackle computational challenges arising from integrating MOO with large-scale Linear Programs (LPs), we explore methods like Augmented Epsilon Constraint and Sandwiching. Results show prioritizing supply risk shifts the optimal technology mix, proving MOO's critical value in resilient energy planning.

2 - A Multi-Objective Mathematical Model for Long-Term Fair Carpooling under Hybrid Work Schedules
Ezgi Kıran, Banu Icmen Erdem

Increasing traffic congestion, rising fuel costs, and environmental concerns have increased the importance of carpooling as a sustainable transportation solution. This study proposes a multi-objective carpooling model incorporating hybrid work schedules and emphasizing long-term planning and fairness. The mixed-integer programming model minimizes total travel distance while improving employees' departure times and balancing vehicle usage across days. Alternative pick-up points are defined for each employee to create a flexible network structure. The model is solved using the Gurobi solver.

3 - A Multi-Stage Stochastic Model for a European Hydrogen Infrastructure: Balancing Cost and Risk
Julia Erdmann

Uncertain future technology cost development complicates the deployment of a European hydrogen infrastructure. To support long-term planning, we propose a multi-stage, bi-objective stochastic framework for risk-aware hydrogen supply chain design. By simultaneously minimizing expected total cost and Conditional Value-at-Risk, our model evaluates the trade-off between economic efficiency and financial risk. We apply the proposed model to a large-scale European case study, enabling analysis of robust infrastructure pathways and the impact of risk on technology choice and deployment timing.

4 - Enhancing Safety for Critical Undersea Infrastucture
Banafsheh Khosravi, Dylan Jones, Tsz Yu Suen, Ashraf Labib, Negar Akbari, Mario Gonzalez, David Cassimiro, Andressa Santiso

This seminar presents initial results from a Lloyd's Register Foundation funded project for enhancing the safety of critical undersea infrastructure. Prototype multiple objective optimisation algorithms for surveillance scheduling for incident detection and resource allocation for incident response are detailed. Case studies from Brazil and the UK are given, involving offshore wind farm undersea infrastructures. Maritime stakeholder mapping, training and involvement is discussed, including the results of a recent Brazilian stakeholder workshop.

■ MC-57

Monday, 10:30-12:00 - Room: HG - Seminar-Raum 07 (Building: HG)

OR Education 1

Stream: OR Education
Invited session
Chair: *Arne Heinold*
Chair: *Graeme Warren*

1 - A Behavioral Pedagogical Framework for Structuring Unstructured B2B E-Commerce Decisions
Pin-Rui Hwang

Traditional B2B e-commerce courses often prioritize enterprise needs over students, lowering motivation. We propose a behavioral pedagogical framework using the Fogg Behavior Model to structure unstructured B2B problems. By decomposing projects into weekly challenges, we reduce cognitive load and use industry mentors for timely prompts. Thematic analysis of 387 statements from 12 students revealed that mentor guidance, role identity, and confidence building directly drive engagement. Data shows a shift towards proactive learning and problem-solving, bridging the academic-industry gap.

2 - IBIS-inspired Problem Structuring for trustworthy and ethical AI: exploring the TEA platform
Katharina Burger

The rapid adoption of generative AI creates new challenges for governance and decision-making under conditions of uncertainty. This paper examines how IBIS-inspired problem structuring can support the teaching of AI assurance in an executive education context. Using the Trustworthy and Ethical Assurance (TEA) Platform, participants explored the development of assurance cases for real-world GenAI applications. Reflections indicate that the process supported collaborative analysis, structured discussion, and deeper learning about responsible AI governance.

3 - What Is an Operations Analyst? "Same as a Normal Analyst, Just Much Cooler": Identity-making at the Swedish Defence Research Agency
Nika Rasmussen

Drawing on interviews and insider participant observation, the paper examines how the operations analyst role is formed at the Agency. While practice was previously dominated by modelling and simulation, methods and perspectives have diversified with recruitment, contributing to the role's ongoing definition. Analysts—often embedded in the Swedish Armed Forces—gradually develop competence and professional identity through situated learning in a community of practice, participating in everyday analytical work and professional development while negotiating and reshaping the role.

4 - Modeling Littlefield Technologies: Simulation Insights and Cognitive Biases in Operations Management Education
Graeme Warren, Uday Venkatadri

Littlefield Technologies is a popular simulation game for teaching operations management. We develop an AnyLogic model to analyze optimal strategies for capacity investment, inventory reorder points, and contract selection. We also examine cognitive biases—anchoring, recency bias, overconfidence, and sunk cost fallacy—that impair student performance. Pedagogical framings are proposed to help students recognize these biases. We evaluate the game's value as an experiential learning tool and offer recommendations for classroom integration.

■ MC-58

Monday, 10:30-12:00 - Room: HG - Seminar-Raum 08 (Building: HG)

Managing the Supply Chain

Stream: Integrated Planning in Manufacturing
Invited session
Chair: *Olga Ismailov*

1 - Network Flexibility Design Under Endogenous Uncertainty
Soroush Fatemi-Anaraki, Martin Grunow, Giovanni Pantuso, Stefan Weltge

We extend the chaining approach to address supply network design problems with endogenous uncertainty, in which the network design shapes supply and demand distributions. Enabling multiple plants to produce a product improves network robustness but incurs efficiency losses. Sourcing locations of products affect the demand via tariffs and country-of-origin effects. We propose a two-stage stochastic program and a decomposition scheme, and derive distribution-free formulations to speed it up. We show the trade-off between endogenous effects and explain their impact on the optimal design.

2 - A Bayesian Approach for Stochastic Workload Balancing of Automotive Part Dispatchers
Timur Wohlleber, Jan-Niklas Doerr, Martin Grunow

At an automotive plant, a dispatcher monitors the supply of parts. Workload increases when part shortages require additional attention. Balancing the workload between dispatchers must hence account for part shortage uncertainty. We use Bayesian updating to estimate shortage distributions used in a stochastic assignment model, which periodically reassigns suppliers to dispatchers to improve fairness. We evaluate our approach in an industry case study, based on a German OEM.

3 - Comparative analysis of semiconductor equipment assembly modes
Olga Ismailov, Margaretha Gansterer

Semiconductor machine production is concentrated in the hands of a few manufacturers. Depending on country-specific conditions, the production of these machines can be carried out in different ways. In practice, semiconductor equipment manufacturers typically rely on one assembly mode and avoid combining different ones within the same manufacturing site. As a result, the efficiency of alternative assembly modes is rarely compared. We generate a system dynamics simulation framework in order to evaluate sequential and simultaneous manufacturing modes based on real-world data.

■ MC-59

Monday, 10:30-12:00 - Room: KOL - Seminar-Raum 9 (Building: KOL)

Multicriteria sorting

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Milosz Kadzinski*

1 - Strategic Preference Manipulation in Multiple Criteria Sorting: Taxonomy of Targets, Difficulty of Manipulation, and Optimization Models
Jerzy Łukaszewicz, Milosz Kadzinski

Strategic manipulation of preferences in MCDA involves deliberately altering preference parameters to steer the recommendation. We propose a framework for multi-criteria sorting that formalizes what it means to reach a target and quantifies the difficulty of doing so. First, we propose a taxonomy of manipulation targets tailored to sorting. Second, we introduce complementary measures of manipulation difficulty. Third, we demonstrate the use of the proposed framework on a real-world problem of national research assessment.

2 - Neural Architectures for Value-Based Multiple Criteria Sorting
Michał Fredrych, Milosz Kadzinski

We propose neural network architectures for value-based preference learning, enhancing models robustness and adaptability. The approach reinterprets the UTADIS method using neural models, including a Multi-Layer Perceptron implementation and an adaptation of Kolmogorov-Arnold Networks, a well-recognized alternative in the ML field for MLP models. The study investigates the dissimilarities between neural and traditional linear-programming formulations. Experimental results indicate that neural formulations provide improved flexibility and stronger generalization in complex decision settings.

3 - Multi-Criteria Decision Aid Methodological Framework for guidelines and protocols in Medicine. The case of Cardiopulmonary Resuscitation and First Aid.
Athanasios Spyridakos, Nikolaos Nikolaou, Nikos Tsotsolas

Cardiovascular and Cardiopulmonary Resuscitation and First Aid guidelines and protocols are derived by the ILCOR through a thorough, time-consuming and many agents process based on the GRADE

methodology. In this research work the MCDA UTA DIS approach is exploited in order to analyze existing recommendations made by ILCOR in order to: a) identify the evaluation structures; b) assess a multicriteria classification additive value system; c) identify areas of interventions in the process followed and d) develop a decision aiding tool for supporting the process of issuing recommendation.

4 - Application of the novel variant of Dominance-based Rough Set Approach for explaining and shaping public acceptance of wind farms in Austria
Weronika Mrozek, Milosz Kadzinski, River Huang

Wind power is vital for Austria's decarbonization, but success hinges on local acceptance. We analyze survey data from 500+ residents in Styria using a tailored Dominance-based Rough Set Approach (DRSA). Transparent decision rules are induced via DOMLEM and ranked by a composite interestingness index to ensure reliability. We quantify factor importance through rule, structure, and prediction-based weights. Finally, we derive prescriptive insights via minimal-change scenarios and system-wide levers to help policymakers and developers build durable support for wind energy.

■ MC-61

Monday, 10:30-12:00 - Room: KOL - Seminar-Raum 18 (Building: KOL)

Sports Scheduling

Stream: OR in Sports
Invited session
Chair: *David Winkelmann*

1 - Scheduling sports tournaments with two court types
Melissa Koch, Sigrid Knust, Xuan Thanh Le

Balanced tournament designs are a well-studied topic in sports league scheduling, particularly with regard to assigning courts to matches in a fair and uniform way. Usually, every court is treated uniquely. We introduce a novel variant of the problem where courts of two different types are considered. Our objective is to construct a schedule for a single round-robin tournament where the distribution of matches on the two court types is as balanced as possible. After outlining fundamental observations, we present efficient construction methods that yield optimal solutions in various settings.

2 - Fair Incomplete Round-Robin Tournaments
Sten Wessel, Frits Spieksma

In the popular round-robin tournament format, it is often not possible that teams play all other teams, as this requires too many matches. The incomplete round robin (iRR) variant every team still plays the same number of matches, however, not against all other teams. With varying team strengths, the question arises: is the iRR fair? We consider fairness of an iRR draw using the difference between the strongest and weakest opponent sets. We do a computational analysis, and theoretically analyze the computational complexity of finding a fair iRR where every opponent set is of equal strength.

3 - Betting Against Integrity: Identifying Match-Fixing Through In-Play Market Dynamics
David Winkelmann, Maya Vienken, Christian Deutscher, Roland Langrock

Match-fixing undermines sporting integrity and public trust, posing severe risks to football's commercial and social value. Using second-by-second live-betting data from the Italian SerieB, this study applies a state-space modelling approach to detect anomalies in betting volumes. The results highlight how real-time data can help identify suspicious behaviour and strengthen match integrity.

■ MC-65

Monday, 10:30-12:00 - Room: HG - Hörsaal 27 (Building: HG)

Machine Learning Applications

Stream: Analytics
Invited session
Chair: *Carla Vairetti*
Chair: *Sebastian Maldonado*

1 - Predictive Maintenance for Industrial Cinema Projectors using Machine Learning
Subhamoy Dam, Kristof Coussement

For cinema projector manufacturers, reliability is a critical differentiator; unplanned failures disrupt operations and inflate costs. While predictive maintenance (PdM) is established in other sectors, its application in cinema remains unexplored. In collaboration with a leading manufacturer, this study develops a PdM framework for Laser Driver Modules. Using telemetry from 130+ sensors, we benchmark ML and DL architectures across multi-time horizons. This system-level approach identifies failures via 24-hour runtime windows, providing empirical insights for specialized equipment monitoring.

2 - Automated Routing of Industrial Projects in Environmental Impact Systems via Deep Learning
Carla Vairetti, Sebastian Maldonado

This study introduces a deep learning framework to optimize the initial phase of Environmental Impact Assessments. By utilizing transformers like RoBERTa, the system automates the assignment of industrial projects to competent state agencies, replacing manual triage. Applied to the Chilean environmental system, the model handles 14-class multilabel scenarios to predict agency involvement. Results show an F1 score of 0.87, showing that AI can reduce administrative bottlenecks and accelerate project approval timelines by streamlining the coordination between regulators and developers.

3 - Automated Evaluation of Contact Center Agents Using Deep Learning Transformers for Enhanced Performance and Customer Satisfaction
Juan Pablo Karmy, Sebastian Maldonado, Carla Vairetti, Ignacio Mayer

To address the inefficiencies of manual quality monitoring in contact centers, this project introduces an automated evaluation system using deep learning transformers (BERT, ELECTRA, and RoBERTa). By analyzing agent performance and interaction patterns, the system provides objective, scalable insights. All models achieved over 94% performance in dialogue tasks, with RoBERTa delivering the best results. Using a Weighted-Sum Model, the system yielded an average AQM-Score of 57.5% for 2023 data, offering a reliable methodology to enhance service and decision-making.

4 - Fuzzy Individualized Treatment Effects: Enhancing Prescriptive Analytics using OWA Operators
Sebastian Maldonado, Catalina Sánchez, Carla Vairetti

Standard uplift modeling often struggles with "noise" from customers whose behaviors are deterministic regardless of intervention. We propose Fuzzy Individualized Treatment Effect (FITE), a framework using Linguistic Quantifiers to assign continuous relevance scores to samples. FITE utilizes soft computing to downweight non-persuadable segments like "Sure Things." Results indicate that this fuzzy weighting mechanism achieves superior predictive performance over traditional methods, offering a more stable and nuanced decision-support tool for optimizing resource allocation in marketing.

■ MC-66

Monday, 10:30-12:00 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Quantum Algorithms for Multi-objective Optimization

Stream: Quantum Optimization
Invited session
Chair: *Pascal Halffmann*

1 - Combining QAOA with Classical Multi-Objective Optimization Methods
Stephanie Riedmüller

We present a hybrid quantum-classical approach for multi-objective optimization based on the Quantum Approximate Optimization Algorithm (QAOA). It combines low-depth QAOA circuits with classical techniques, particularly the weighted sum method. The performance is evaluated on multi-objective weighted Max-Cut problems using matrix product state simulations and experiments on an IBM Quantum computer. QAOA parameters are obtained via parameter transfer. The hybrid method identifies unsupported solutions not found by classical weighted sum and indicates potential to outperform classical methods.

2 - Large-scale quantum optimization via low-energy state sampling
Pablo Diez-Valle, Mateo Alonso

We present a hybrid algorithm for large combinatorial optimization on quantum devices with limited resources, and outline its extension to multi objective problems. The method avoids variational tuning and exploits low energy sampling in QAOA type circuits, approximating problems with N>=q variables using q qubits. This opens a path for the practical use of near term quantum computers, while leveraging future hardware improvements. We validate the approach through simulations and experiments on IBM quantum hardware.

3 - A Rigorous Quantum Framework for Inequality-Constrained and Multi-Objective Binary Optimization
Alexander Mandl

Combinatorial optimization algorithms on quantum computers encode optimal solutions as ground states of Hamiltonian operators. Although numerous works study these encodings in the unconstrained regime, many applications require the handling of equality and inequality constraints. In this work, we present the Multi-Objective Quantum Approximation (MOQA) framework, which reduces the problem to an optimization task over multiple objectives that is compatible with current ground state solvers. We explore the theoretical foundation of MOQA and showcase the encoding process for example applications.

4 - Population-Based Training of Variational Quantum Algorithms for Multiobjective Optimization
Pascal Halffmann, Ivica Turkalj

Recently, variational quantum algorithms (VQAs) have shown promising results for tackling multiobjective optimization problems. We enhance an existing approach by introducing classical population-based heuristics for parameter training. Instead of optimizing the hypervolume of the sample set we adapt genetic operators as present in NSGA-II. This population-based training guides the algorithm toward improved approximations of the Pareto front, as our numerical experiments demonstrate. We outline future research directions on combining VQAs with evolutionary heuristics.

Monday, 13:00-14:00

■ MD-01

Monday, 13:00-14:00 - Room: HG - Audimax

Keynote Stefan Pickl

Stream: Keynotes
Keynote session
Chair: *Richard Hartl*

1 - Club of Rome Lecture Emissions Trading „Cap and Trade" and Operations Research
Stefan Wolfgang Pickl

This special Club of Rome lecture presents a survey on designing, modeling, and optimizing Emissions Trading Systems (ETS) to achieve significant, cost-effective sustainable emission reductions. By utilizing mathematical programming, simulation, and game theory, these systems ensure environmental goals are met with optimal economic behavior. The focus will be on the central question "How can Operations Research help in complex Emission Trading (Cap and Trade-) Systems to monitor, verify and optimization an innovative certificate market?".

■ MD-02

Monday, 13:00-14:00 - Room: JUR - Hörsaal 10 (Building: JUR)

Keynote Radhika Kulkarni

Stream: Keynotes
Keynote session
Chair: *Rina Schneur*

1 - From Models to Smarter Decisions: Harnessing OR + AI
Radhika Kulkarni

In 1987, Nobel laureate Herbert Simon envisioned artificial intelligence and operations research working together to make better decisions. Nearly forty years later, machine learning tools and AI platforms have proliferated across industries—from healthcare to finance to manufacturing. Practitioners are increasingly integrating AI and OR in real-world implementations. Is Simon's vision finally becoming reality?

Simon recommended to OR researchers and practitioners that "we should aspire to increase the impact of MS/OR by incorporating the AI toolkit that can be applied to ill-structured, knowledge-rich, nonquantitative decision domains that characterize the work of top management and the great policy decisions that face our society." Has the OR community succeeded in realizing this vision? In this presentation, Kulkarni will review current applications where practitioners have successfully combined data-driven AI methods with model-driven OR approaches. She will then discuss opportunities and challenges in interdisciplinary collaboration between the AI and OR communities, describing recent efforts such as AI-OR joint workshops / sessions / papers to promote greater collaboration between AI and OR researchers and practitioners to combine the best of both approaches.

The presentation will address critical questions: What are the most successful areas where AI-OR collaboration has resulted in innovations that neither field could have achieved alone? What challenges remain in developing real-world implementations that are trustworthy, unbiased, and explainable?

Monday, 14:15-15:45

■ ME-01

Monday, 14:15-15:45 - Room: HG - Audimax

Tutorial Andres Gomez

Stream: Tutorials
Tutorial session
Chair: *Andrea Seidl*

1 - Convexification and solution of mixed-integer nonlinear optimization problems
Andres Gomez

The pace of innovation for mixed-integer nonlinear optimization technology has sped up over the past decade, driven by modern applications in finance, statistics, control, energy, among others. The improvements have led to astonishing progress in certain settings, with practical problems that can be solved comfortably at large scales, but has been lackluster in other areas. In this talk we review the state-of-the-art of practical mixed-integer nonlinear optimization, present recent improvements but also discuss major challenges hampering the widespread implementation of successful mixed-integer nonlinear optimization solvers.

■ ME-04

Monday, 14:15-15:45 - Room: HG - BIG-Hörsaal (Building: HG)

Machine learning in healthcare

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Joana Matos Dias*

1 - A Meta-Analysis of Resistance to Medical AI: Strategies for Enhancing Acceptance
Chen Yang

Medical AI reduces doctors' workloads and improves healthcare access in remote areas. Despite its efficiency, consumer resistance to AI healthcare persists. This study identifies 11 moderators of consumer acceptance, grouped into AI characteristics, medical context, and personal traits. Analyzing 244 effect sizes from 40 studies, results show moderate resistance, with higher acceptance when AI acts as a supporter and shows humanlike communication. Design implications suggest positioning AI as a support tool and enhancing humanlike interaction.

2 - Predictors of Hospital Mortality in Severe Community-Acquired Pneumonia patients: A Brazilian ICU Cohort of 10,104 Patients
Igor Tona Peres, Gabriel Césari de Almeida Fonte

Severe community-acquired pneumonia (sCAP) presents high mortality in low-and-middle-income countries. This retrospective cohort study evaluated 10,104 sCAP patients requiring ventilatory support in Brazilian ICUs from 2022 to 2024. We used a mixed-effects logistic regression to identify factors associated with hospital mortality. Hospital mortality was 20% overall and 52% for mechanically ventilated patients. Older age, poor performance status, and organ support (MV, vasopressors, RRT) were independently associated with mortality , highlighting the need for tailored interventions.

3 - Metaheuristics for Healthcare Optimisation with Machine Learning based Objective function
Joana Matos Dias, Rodrigo Viana, Humberto Rocha

This work illustrates how metaheuristics can be effectively integrated with machine-learning-based health outcome prediction models to support decision-making optimisation in healthcare. Metaheuristics enable efficient exploration of large and complex decision spaces and can optimise objective functions defined implicitly through ML predictions rather than explicit mathematical formulations. The proposed framework is demonstrated in the context of radiotherapy treatment planning optimisation, where treatment parameters are adjusted to improve predicted patient outcomes.

■ ME-06

Monday, 14:15-15:45 - Room: HG - Hörsaal 07 (Building: HG)

Warehouse and Logistics Operations in Retail

Stream: Retail Operations
Invited session
Chair: *Heinrich Kuhn*

1 - Capacity expansion in online grocery retail
Jan K. Strackbein, Niels Agatz, Moritz Fleischmann

Home grocery delivery faces persistent profitability challenges. Efficient scaling is critical, yet expanding into new service regions requires time to grow demand and achieve economies of scale. We develop a budget-constrained capacity expansion model for retailers navigating demand growth across multiple service regions, capturing strategic trade-offs in allocating investments within and between regions. Our numerical experiments assess the conditions for retailers to achieve profitability.

2 - Determining the best storage locations for items in a large-scale warehouse
Mert Parçaoğlu, Betül Ahat, Ahmet Çınar

In B2C e-commerce warehouses employing multi-location policies, the Storage Location Assignment Problem (SLAP) significantly impacts picking efficiency. This research introduces a mathematical programming model designed to minimize travel distances while strictly adhering to physical capacity constraints. By integrating item order rates, co-order frequencies, and volumetric limits, the model ensures that all assignments remain spatially feasible. Results demonstrate substantial improvements in storage configuration and operational workflow optimization.

3 - Mobile stores and early product diffusion: An agent-based simulation study
Florian Cramer, Christian Fikar

We examine how mobile retail formats affect early product diffusion when availability is limited. Using an agent-based simulation of grocery retailing, we compare stationary and mobile stores across coverage levels, relocation policies, and customer dispersion patterns. Results indicate that mobile retail can accelerate early adoption and enhance spatial access equity, especially in highly dispersed and clustered markets. Coverage has a greater impact than relocation frequency on long-term diffusion and repeat purchases.

4 - Same-day or next-day? Transparent time-dependent shipment pricing for e-fulfillment
Uta Mohring, Melvin Drent, Ivo Adan, Willem van Jaarsveld

Fulfilling online orders quickly is vital in e-commerce, with many firms offering same-day shipment. Firms risk overpromising when shipment options and fees are not aligned with their fulfillment capacity. Therefore, shipment options and fees should be adapted based on the time remaining to collect and ship these orders.We model such a system as a periodic Markov chain. We provide structural insights—the optimal policy includes a cutoff point and monotonically increasing fees—and a polynomial-time optimization algorithm. We also study a simple policy that achieves near-optimal performance.

■ ME-07

Monday, 14:15-15:45 - Room: HG - Hörsaal 21 (Building: HG)

Fairness in Market Design

Stream: Auctions and Market Design
Invited session
Chair: *Bernhard Kasberger*
Chair: *Simon Finster*

1 - The Price of Opportunity Fairness in Matroid Allocation Problems
Simon Mauras

We consider matroid allocation problems under opportunity fairness constraints: resources need to be allocated to a set of agents under matroid constraints (which include classical problems such as bipartite matching). Agents are divided into C groups according to a sensitive attribute, and an allocation is opportunity-fair if each group receives the same share proportional to the maximum feasible allocation it could achieve in isolation. We study the Price of Fairness (PoF), i.e., the ratio between maximum size allocations and maximum size opportunity-fair allocations.

2 - Equitable Auctions
Simon Finster, Patrick Loiseau, Simon Mauras, Mathieu Molina, Bary Pradelski

We study how auction design affects surplus division among bidders. We propose a parsimonious equity measure and apply it to standard auctions for homogeneous goods. The uniform price auction is equity-optimal iff bidders have a common value. With private values, pay-as-bid is preferred under a common regularity condition, but not in general. For price mixing between pay-as-bid and uniform prices, we provide prior-free bounds on equity-preferred pricing. We also characterize direct mechanisms achieving ex-post surplus parity that interpolate between efficient and fair allocations.

3 - Decentralized Trading Networks: Equilibria and Fairness
Matilde Tullii, Simon Finster, Edwin Lock

We explore stability and fairness considerations in decentralized networked markets with bilateral contracts. In our trading network game, we show that a well-defined subset of Nash equilibria can be supported as competitive equilibria. Considering an offer-based trading dynamic as well as a stochastic price clock market, we prove new convergence results to Nash equilibrium and competitive equilibrium. Finally we prove several negative results about fairness: inessential agents always receive zero utility in any core outcome, and even essential ones can get zero utility in all core outcomes.

■ ME-08

Monday, 14:15-15:45 - Room: HG - Hörsaal 41 (Building: HG)

Advances in Location Analysis

Stream: Location Analysis
Invited session
Chair: *Hatice Calik*

1 - Valid Inequalities for the Generalized Maximal Covering Location Problem
Sachin Jayaswal, Shreyas Bhowmik, Guneshwar Anand

We study the Generalized Maximal Covering Location Problem (GMCLP), which generalizes the well-known maximal covering location problem (MCLP) by allowing negative weights for a subset of the customer nodes. GMCLP is known to suffer from a weak LP bound. We generalize the so-called two-customer inequalities proposed in the literature to n-customer inequalities and evaluate their impact. While 2-customer inequalities reduce the average LP gap from 45.34% to 2.77%, the addition of 3-customer inequalities further reduces it to 1.45%, allowing us to solve 326 of the 400 instances at the root node.

2 - An Evaluation of Linear Approximation Techniques of Euclidean Distances: Tests with Mixed-Integer Linear Programs for the Weber Problem
Fabian Wilschewski, Alf Kimms, Christin Münch

Euclidean distances are part of various optimization problems, but due to the non-linearity of Euclidean distances, direct application of mixed-integer linear programming (MILP) may not be possible. Approximation techniques can serve as an alternative to non-linear models or tailor-made algorithms. We present different approximation techniques that enable the use of MILPs. We evaluate their performance by solving the Weber problem, which is finding the weighted geometric median of given points in the plane.

3 - Clustering Offshore Wind Farms and Connecting Them to Onshore Grids
Hatice Calik, Wout Stockman, Dirk Van Hertem

The offshore wind capacity in the North Sea is planned to reach at least 300GW by 2050. Connecting the offshore wind farms to the onshore grid is challenging since it requires a trade off among multiple objectives. We develop a multi-step decision-making framework for tackling this design challenge. The framework first clusters the offshore wind farms, then connects the cluster centers to the onshore grid by solving a minimum weight matching, and finally, solves the optimal power flow problem on the grid expanded with the offshore connections considering renewable and demand uncertainty.

4 - Reliable Facility Location under Time-Dependent Problem Parameters
Megha Sharma

The conventional Reliable Facility Location Problems (RFLP) consider problem parameters and facility failure probabilities to remain constant over the lifetime of the facilities. However, many real-life facility failures and problem parameters exhibit temporal dependence, in particular, seasonality. Therefore, in this paper, we generalize RFLP to account for time dependent problem parameters. We determine the value of incorporating time dependence in RFLP. We also present a local-search based heuristic for this problem and share our computational experience.

■ ME-10

Monday, 14:15-15:45 - Room: HG - Hörsaal 31 (Building: HG)

Exact algorithms for combinatorial optimization problems

Stream: Combinatorial Optimization
Invited session
Chair: *Luigi Di Puglia Pugliese*

1 - InnOpTEM: Optimizing Topology and Redispatch for German Transmission System Operators using Benders Decomposition
Tim Donkiewicz, Oliver Gaul, Marco Lübbecke

The InnOpTEM project addresses integrating topology switching into day-ahead congestion management of German transmission system operators. We formulate security-constrained optimal transmission switching with N-1 robustness and solve it via Branch-and-Benders-Cut. This talk focuses on subproblem selection, cut filtering and sequential warm-starting as key enhancements for solving real-world instances within operational time limits. We report on challenges and lessons learned from a field test with four German TSOs, where operators confirmed practical feasibility of proposed measures.

2 - Optimal path planning under the Chebyshev distance: a branch-and-bound approach
Jeroen Laarman, Michael Dienstknecht, Kees Jan Roodbergen

Given a three-dimensional space with polyhedral obstacles, we consider the problem of finding the shortest, collision-free path between a given source and sink point. The length of a path is evaluated by the Chebyshev distance, a metric that is commonly used in applications with simultaneous movement along all three axes such as crane operations. We propose a branch-and-bound algorithm built on a free-space decomposition that solves this problem to optimality while existing methods rely on heuristics.

3 - A lifting-based strengthening method for Chvátal-Gomory inequalities for binary integer programs
Junyoung Kim, Kyungsik Lee

We propose a novel method to strengthen Chvátal-Gomory (CG) inequalities for general binary integer programs (BIP). Given a CG inequality, we construct a binary knapsack set defined in an extended variable space and show that the CG inequality can be derived from a lifted cover inequality for this set. By applying a lifting method, we obtain a stronger lifted cover inequality, which induces a valid inequality for the original BIP that dominates the CG inequality. Theoretical and computational results demonstrate the effectiveness of the proposed method in enhancing the LP relaxations of BIPs.

4 - Optimal solution approach based on decomposition strategy to solve the resource-constrained covering tour problem
Luigi Di Puglia Pugliese, Marcello Sammarra, Giusy Macrina, Francesca Guerriero

We address the Resource-Constrained Covering Tour Problem (RC-CTP), inspired by wireless power transfer applications where an unmanned vehicle must recharge smart devices. Some devices are visited directly, while others can be served remotely within a coverage radius. Both travel and charging consume a limited resource. We propose an exact solution approach based on Benders decomposition. Computational results show competitive performance compared with state-of-the-art methods.

■ ME-11

Monday, 14:15-15:45 - Room: HG - Hörsaal 32 (Building: HG)

Discrete, continuous and hybrid stochastic optimal control in OR II

Stream: Combinatorial Optimization
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Noam Goldberg*

1 - Restless bandits with imperfect binary observations: a computational PCL-indexability approach
José Niño-Mora

We study belief-state restless bandits with imperfect binary observations, motivated by opportunistic spectrum access with sensing errors. We develop a computational approach based on partial conservation laws, a deterministic skeleton, renewal decompositions and combinatorics on words to evaluate the Whittle index and performance metrics. The method yields closed forms in tractable regimes, supports numerical verification of indexability over broad parameter ranges, and yields an index policy that outperforms standard benchmarks.

2 - Structure-Aware Heuristic Improvement via Policy Iteration
Ties Schalij, Cristian Dobre, Juan Vera

Heuristics in combinatorial optimization are usually blind to specific characteristics of instance classes, offering an opportunity to enhance performance. To exploit this, we propose a framework based on modeling these problems as Markov Decision Processes (MDPs) and treating heuristics as policies. By integrating instance-class information into the MDP and applying Policy Iteration, we develop a heuristic tailored to the instance class, with proven improved solution quality. Our method is illustrated on the greedy heuristic for the Knapsack Problem across various instance classes.

3 - Robust Extensible Bin Packing and Revisiting the Convex Knapsack Problem
Noam Goldberg, Michael Poss

We study a robust extensible bin packing problem with budgeted uncertainty. We propose a scenario generation algorithm for this problem, which alternates between solving a master robust bin packing problem with a finite uncertainty set and solving a separation problem. We first show that continuous separation is strongly NP-hard. Then, focusing on the separation problem for the integer master problem, we show that this problem reduces to an NP-hard special case, for which we develop a pseudo-polynomial dynamic program (DP) and an approximation scheme.

■ ME-12

Monday, 14:15-15:45 - Room: JUR - Hörsaal 11 (Building: JUR)

Health Care Logistics of Patient Transport

Stream: Health Care Logistics
Invited session
Chair: *Yu Ogasawara*
Chair: *Ito Mari*

1 - A mathematical programming model for planning a mass transportation of patients
Shungo Koichi

When a long power outage occurs, it becomes necessary to transfer patients from an affected hospital to other hospitals. In that case, due to the number of available beds and necessary medical equipment, a large-scale hospital often temporarily accepts a not small number of patients. However, since the receiving hospital also needs time to prepare, transfers must be planned in the consideration of, e.g., the number of prepared beds, to ensure a smooth transition to medical care at the receiving hospital. This study proposes a simple mathematical programming model to address this problem.

2 - The Impact of High-Speed Helicopters on Changes in HEMS Base Locations
Takamori Ukai, Shigeki Toriumi

The transport of patients by aircraft is expected to improve patient outcomes by reducing transport time. In many countries, rotorcraft—which have few restrictions on takeoff and landing sites—are used and provided as HEMS (Helicopter Emergency Medical Services). Currently, technological development is underway to improve the cruising speed of rotorcraft. In this presentation, we use a mathematical model to analyze how the deployment of HEMS bases will be affected when high-speed aircraft become available.

3 - Impact of Surgery Duration Prediction Accuracy on Operating Room Allocation and Costs
Yusuke Nakata, Ito Mari, Daijiro Kabata, Kazuma Yunoki

Quantitative evaluation of operating room-related costs helps identify areas where operational efficiency should be improved. Uncertainty in surgery duration significantly affects operating room scheduling. Previous studies have estimated surgery duration using machine learning. However, the impact of prediction accuracy on scheduling remains unclear. This study investigates how prediction accuracy affects surgery allocation and operating room-related costs using a Monte Carlo optimization model. The findings provide insights for supporting operating room management decisions.

■ ME-13

Monday, 14:15-15:45 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Nonlinear Solvers

Stream: Software for Operations Research
Invited session
Chair: *Julien Darlay*

1 - What's New for the Linear and Nonlinear Optimization Capabilities in FICO Xpress
Tristan Gally

This talk discusses the latest updates to the linear programming capabilities for both CPU and GPU within FICO Xpress Solver as well as the recent improvements to our nonlinear optimization solvers, in particular the global optimization capability.

2 - Latest developments in Artelys Knitro
Hugo Chareyre

In this talk, we will present the latest developments in Artelys Knitro 16.0, including new features and performance enhancements.

Artelys Knitro is a powerful solver for mathematical optimization problems. It supports linear, quadratic, nonlinear, and black-box functions, offering a wide range of algorithms to tackle convex or nonconvex, continuous or discrete problems.

3 - Solving MINLP polynomial problems to global optimality: Recent developments in RAPOSa
Julio González-Díaz, Brais González Rodríguez, Iria Rodríguez-Acevedo, Alejandro Barros-González, Marta Cean-Romero, Iago Fernández-Perlo

This talk presents recent developments in RAPOSa, a global solver for polynomial optimization problems. We discuss the impact of several algorithmic improvements on the solver's performance, focusing on enhancements in some of RAPOSa's core elements such as SDP-cuts, bound-tightening, and reformulations for products of binary variables.

We also plan to cover ongoing work aimed at extending RAPOSa to broader classes of problems, including polynomial optimization problems defined on unbounded domains and models that combine polynomial and conic constraints.

4 - Solving nonlinear continuous optimization problems with Hexaly
Julien Darlay

Hexaly is a model-and-run global optimization solver. In this talk, we present the heuristic and exact components used to address continuous nonlinear problems. Constraints and objectives are represented using an expression graph. Hexaly 14.5 introduces new components to improve the resolution of such problems, including structure detection, a new modular interior-point algorithm, and a branch-and-reduce algorithm with cut generation. This new version has been benchmarked against open-source implementations on three benchmarks: pooling, portfolio optimization, and the CUTEst library.

■ ME-14

Monday, 14:15-15:45 - Room: HG - Hörsaal 01 (Building: HG)

Stochastic programming for Portfolio Optimization

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Milos Kopa*

1 - Mean-CVaR portfolio optimization with decision-dependent copulas
Erik Kočandrle, Milos Kopa

Portfolio optimization problems include a stochastic element in the form of asset losses. Their probability distribution is generally considered to be fixed, but there are cases where decision dependent (endogenous) randomness occurs. Provided that the investor's budget is large enough relative to the size of considered companies, a significant investment can influence the loss distribution. We propose a modified Mean-CVaR model where significant investments influence the dependence structure between asset losses. The dependence structure is described using suitable types of copulas.

2 - Measures of SSD Portfolio Inefficiency
Monika Hendrych, Milos Kopa

This paper studies optimization models with feasibility conditions ensuring second-order stochastic dominance (SSD) efficiency, allowing only non-dominated portfolios. Rebalancing an SSD-inefficient portfolio under proportional transaction costs yields a bilevel stochastic model: the lower level enforces SSD efficiency, the upper level minimizes transaction costs. The minimal costs define an SSD portfolio inefficiency measure. We introduce reasonable axioms for measures of SSD portfolio inefficiency in general, discuss them in this case, and illustrate the approach with US industry portfolios.

3 - Multicriteria Portfolio Optimization of Cryptocurrencies
Milos Kopa, Karel Kozmík, Audrius Kabasinskas, Kristina Sutiene

The paper introduces a new multicriteria crypto-portfolio optimization problem based on preference rules, expected return, and measures. Comparing to classical mean-risk model with Conditional Value-at-risk, stochastic dominance ratio is added to the portfolio optimization problem. We first construct a three-criteria portfolio optimization model and identify the in-sample efficient portfolios. Then we investigate the out-of-sample optimality of those portfolios for at least some parameters of combinations of out-of-sample criteria. Finally, using XGBoost we predict out-of-sample optimality.

■ ME-15

Monday, 14:15-15:45 - Room: HG - Hörsaal 34 (Building: HG)

Applications of Game Theory I

Stream: Algorithmic Game Theory
Invited session
Chair: *Basak Altan*

1 - On ordinarily equivalent distributions from shareholders of a divisible asset
Josep Freixas, José María Alonso-Meijide, Silvia Lorenzo-Freire, Alicia Mascareñas-Pazos

The distribution of a divisible asset among several agents is an open problem in Operations and Research. Several solutions have been proposed, among which the Shapley-Shubik, Banzhaf-Penrose, and Felsenthal power indices stand out. This paper proposes to establish the ordinal equivalence of these indices; that is, to discover in which situations the allocations proposed by the three indices respect the same order. We also determine the limiting cases in which ordinal equivalence is not achieved, but is not contradictory.

2 - Evaluating Circular Economy Policies in Wood Construction Supply Chains: A Variational Inequality Approach
Mariapaz Widow Navarro, Lena Silbermayr, Vera Hemmelmayr, Tina Wakolbinger, Pamela C. Nolz, Alexandra Anderluh

We develop a variational inequality model based on insights of a case study of a wood construction multi-tier supply chain network. Our analysis explores the economic and environmental outcomes of various circular strategies, including reuse, remanufacturing, recycling, and energy recovery, under different environmental regulations. We identify trade-offs and changes in the system's equilibrium regarding material flows and prices, demonstrating how regulatory instruments influence decision-making among supply chain members in the Circular Economy transition.

3 - Optimization and Machine Learning Based Cost Allocation Mechanisms for the Capacitated Economic Lot-Sizing Game with Backorders
Basak Altan, Okan Ozener, Ali Ekici

We study a collaborative procurement setting in which firms facing varying demands over a finite planning horizon jointly order from a common supplier. While collaboration improves supplier capacity utilization, the resulting benefits must be allocated to ensure stable cooperation. We develop a game-theoretic cost allocation framework and propose scalable machine learning-based methods using gradient boosting and neural networks. Computation results show that the proposed approach outperforms existing methods in solution quality and computational time.

■ ME-16

Monday, 14:15-15:45 - Room: HG - Hörsaal 42 (Building: HG)

Mobility and Accessibility in Urban Infrastructure

Stream: Location Analysis for Urban and Digital Infrastructure
Invited session
Chair: *Yudai Honma*

1 - Evaluating Community Age-Friendliness with an Accessibility-Provision-Quality Framework: Evidence from Shenzhen
Chenhao Li, Xinyi Ma, Kai Zhang

We propose an APQ (Accessibility-Provision-Quality) framework for evaluating community age-friendliness. Accessibility is measured using equivalent walking distance, which incorporates slope, surface, and barrier-free continuity, while provision and quality reflect service capacity and performance. Applied to three Shenzhen communities, the framework reveals multidimensional service gaps and cross-community heterogeneity that proximity-based measures miss, and provides a practical tool for service diagnosis, comparison, and planning.

2 - A time-expanded network approach for traffic signal control optimization
Mihiro Sasaki, Shuma Furuya, Koichiro Iwaoka, Shungo Koichi

This study proposes an optimization model for traffic signal control using time-expanded networks. We enhance the "intersection-expanded network" to precisely represent signal phases by decomposing nodes and using internal arcs. Right-of-way is modeled by dynamically adjusting arc capacities. By integrating this with a time-expanded framework, the problem is formulated as a multi-commodity flow problem to determine optimal phase sequences and durations. Numerical experiments on an actual road network demonstrate the model's effectiveness in reducing delays.

3 - Modeling optimal location of charging stations for electric vehicles in urban areas
Jorge Amaya, Nicolas Herrera

In this talk we introduce models for locating electric vehicle charging stations in Santiago, Chile, using an optimization approach. The models exhibit varying degrees of complexity in terms of assumptions, constraints, and objective functions: location models, coverage models, and hybrid models. A time variable is introduced to simulate more realistic scenarios and evaluate the capacity of the charging stations within specific timeframes. We also consider, as metrics, the distance from users to their respective charging stations, as well as investment and site availability constraints.

4 - Nationwide Planning of Dynamic Wireless Charging Infrastructure for Electric Vehicles
Yudai Honma, Hiroyuki Hasada, Junya Maruyama, Kazuma Kawai

Dynamic wireless power transfer (DWPT) enables electric vehicles to receive energy while driving and may help overcome range limitations in long-distance travel. This study investigates nationwide planning of DWPT infrastructure on expressway networks using a flow-capturing location framework with continuous installation-length variables. Using origin-destination demand data for the Japanese expressway network, we analyze how infrastructure length influences demand coverage and deployment patterns. Results provide insights for large-scale electrification of long-distance road transport.

■ ME-18

Monday, 14:15-15:45 - Room: JUR - U 21 (Building: JUR)

Or in rising economies

Stream: OR in Rising Economies
Invited session
Chair: *Slim Belhaiza*

1 - Production-Linked Incentives vs. Import Taxes: Strengthen Domestic Manufacturing in Rising Economies
Suryakant Kumar, Tanmoy Kundu, Mark Goh, Jiuh-Biing Sheu

This study presents a game-theoretic model to examine Production-Linked Incentive (PLI) schemes in manufacturing supply chains in rising economies. We analyze government-manufacturer interactions across four policy regimes: joint intervention (incentive and tax), incentive-only, tax-only, and no intervention. Results indicate policy effectiveness depends on degree of product substitutability. When substitution is low, import taxes protect emerging industries better than incentives. High substitution requires joint incentives and taxes. Our framework offers guidance for policymakers.

2 - Strategic Energy Planning for a Just Transition: Large-Scale Optimization in South Africa's Power System
Tiancheng Zhang

South Africa faces a dual crisis: an aging coal fleet and urgent decarbonization needs. This presentation highlights an international collaboration between Cardinal Operations and Meridian Economics. By efficiently solving large-scale LP/MILP models previously computationally prohibitive, we enable high-fidelity scenarios for a "Just Transition." This OR application provides vital social value by optimizing clean energy investment and ensuring economic stability for affected communities, fostering a resilient, sustainable future for South Africa.

3 - Optimal Control Approach to Open-Pit Mine Planning
Honglei Xu

We will discuss an optimal control formulation for open-pit mine planning problems. This model includes not only the calculation of economic benefits in the objective function but also incorporates operational constraints. Next, we integrate buffer stockpiles to address long-term planning tasks and extend the planning horizon accordingly. Finally, we explore various numerical strategies and computational techniques from optimal control theory, such as control parametrization and automatic differentiation.

4 - Dynamic Route Optimization for On-Demand Laundry Collection Services
Slim Belhaiza

This talk presents the implementation of an adaptive Dynamic Vehicle Routing Problem with Multiple Soft Time Windows (VRPMSTW) framework for app-based laundry services, where pickup requests arrive continuously during route execution. A data-driven dynamic hybrid adaptive large neighborhood search (DD-DHALNS) combines demand and travel-time prediction with real-time route re-optimization. The approach integrates new requests into active routes while respecting capacity and service constraints, improving fleet utilization, efficiency, and customer responsiveness

■ ME-19

Monday, 14:15-15:45 - Room: HG - Hörsaal 05 (Building: HG)

Maintenance Optimization and Management

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Xiaoyue Wang*

1 - Maintenance optimization for production systems with polytype engineers under limited maintenance capability: a reinforcement learning approach
Xiaoyue Wang

This paper investigates the maintenance optimization for a production system with multiple machines connected in parallel. A limited number of maintenance engineers are considered and they are classified into different professional levels. The Markov decision process and Markov process are used to depict the operation and maintenance process of the system. The optimal maintenance engineer allocation and maintenance level are decided at each inspection epoch, by using a reinforcement learning method aiming to maximize total expected reward. Numerical examples are presented to verify the model.

2 - Estimating Maintenance Cost of Offshore Electrical Substations
Solène Delannoy-Pavy, Manuel Ruiz, Cyrille Vessaire, Axel Parmentier, Vincent Leclere

France aims to deploy 45GW of offshore wind by 2050. Offshore substations linking farms to the grid are owned and maintained by the grid operator, which must pay penalties when shutdowns curtail production, especially if weather delays repairs. Estimating costs under good maintenance strategies is therefore crucial. We model the problem as a Markov Decision Process (MDP) capturing component degradation and weather constraints. To handle the large state space, we exploit a decomposable MDP structure, and solve a linear program over an approximation of the polytope of reachable probabilities.

3 - Prognostic-Prescriptive Framework Based on Two-Phase Wiener Processes and Dynamic Programming for Maintenance Optimization
Ricardo Askenasy, Alejandro Mac Cawley, Rodrigo A. Carrasco, Margarita Castro, Anthony D. Cho, Gonzalo Ruz, Lucas Salcedo, Tomas Stuck

Predictive maintenance relies on accurate Remaining Useful Life (RUL) estimation to support condition-based maintenance decisions. However, industrial equipment often lacks sufficient run-to-failure data. This work proposes a hybrid prognostic framework that models degradation as a two-phase Wiener process and uses sensor-based indicators to estimate RUL under uncertainty. MonteCarlo simulation propagates stochastic degradation, generating failure probability distributions that feed a dynamic programming model to prescribe maintenance actions while accounting for risk in wine bottling lines.

4 - Fluctuations of profit related to predictive maintenance
Florian Sobieczky

Predictive maintenance (PdM) improves profitability, but short-term profit fluctuations remain critical for financial stability. We model production cycles by a stochastic renewal process and show that variability in cumulative profit determines the initial capital required to avoid ruin. An explicit relation links this capital to profit rate and variability. PdM reduces both downtime and profit fluctuations, thereby lowering required initial wealth. This provides a practical basis to assess maintenance strategies not only by expected profit, but also by financial risk.

■ ME-20

Monday, 14:15-15:45 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Multi-modal delivery considering Public Transportation

Stream: Vehicle Routing and related problems
Invited session
Chair: *Diego Delle Donne*

1 - Solving the Generalized Nested Steiner Routing Problem using Branch-and-cut
Alexander Lindhardt, Elena Fernandez, Jessica Rodríguez-Pereira

This presentation introduces the Generalized Nested Steiner Travelling Salesman Problem. Given an incomplete graph and required vertices partitioned into clusters, the objective is to find a primary tour visiting each cluster at least once and nested tours within the clusters such that the primary and nested tours together visit all required vertices at minimum cost. The problem relates to multi-modal routing problems on road networks such as garbage collection. A branch-and-cut approach is presented in which connectivity and parity constraints are separated. Preliminary results are promising.

2 - A branch-and-price method for last-mile delivery with capacitated robot stations
Laurent Alfandari, Diego Delle Donne, Yerlan Kuzbakov

We study a delivery system combining a truck route and Autonomous Delivery Robots (ADRs) launched from capacitated robot stations. The objective is to minimize the total tardiness of deliveries to end customers. We design an efficient branch-and-price approach where each column is a path to a single customer, following the truck route, inducing a non-linear pricing problem due to the tardiness function. The approach is shown to outperform solving the compact formulation of the problem. We also conduct a sensitivity analysis on robot fleet sizes and due delivery dates.

3 - The Service-Oriented School Bus Routing Problem: A Column Generation Heuristic
Farnaz Farzadnia, Jens Lysgaard

The Service-Oriented School Bus Routing Problem focuses on the convenience of the students while also considering the limitations of service providers like the number of school buses, the bus capacity, and the distance travelled by each school bus. The objective of the proposed model is to minimize the total walking distance of all students from their homes to their assigned pickup points. This paper provides a mathematical model and proposes a column generation heuristic to solve the problem. Computational experiments are reported.

4 - Stochastic capacity planning for multimodal urban passenger-freight networks
Cécile Dupouy, François Clautiaux, Walid Klibi, Olivier Labarthe

Urban parcel deliveries can benefit from spare capacity in public transport and autonomous shuttle services. We study the tactical capacity deployment problem of a logistics orchestrator using a shared passenger-freight multimodal network. Demand and transport service availability are uncertain and represented by scenarios. We model the problem as a two-stage stochastic program: first-stage decisions set weekly capacity, and second-stage routes demand. The model is solved using a combinatorial Benders decomposition and tested on a case study based on the public transport network of Bordeaux.

■ ME-21

Monday, 14:15-15:45 - Room: JUR - U 22 (Building: JUR)

Grand Challenges at the Artificial Intelligence / Operations Research Interface

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Laura Albert*

1 - AI and its impact on work: task, role and workflow redesign
Ramayya Krishnan, Rema Padman

We develop a theory of organizational responses to AI deployment. The response requires addressing three interlinked problems: (1) task transition—firms decompose tasks into automatable and judgment components subject to handoff costs, creating new task types; (2) workflow rewiring—precedence constraints update to accommodate decomposed tasks; (3) role rebundling—firms unbundle pre-existing generalist roles and rebundle tasks into specialized roles through optimal partitioning of tasks. We illustrate our ideas using healthcare examples.

2 - Human-AI Interaction in Congested Service Systems: When It Improves Performance, and When It Doesn't
Benjamin Legros, Francis de Véricourt

AI is increasingly used to support service agents, yet its operational impact is unclear. We model a congested queue where agents make cognitively demanding, time-pressured decisions; AI provides costless predictions. Comparing solo vs AI-assisted decisions, we find: AI always improves accuracy but may worsen congestion; capturing the gains can require more capacity and may reduce profit when benefits are modest. When accuracy is paramount, AI lowers staffing needs and increases profit. Effects depend on congestion, the value of accuracy, and agents' prior beliefs.

3 - Operations Research and Machine Learning: Two Fields With Different Dynamics
Tho Le, Laura Albert, Thibaut Vidal

Operations research (OR) has evolved over the past fifty years, but its growth has been overshadowed by the rapid rise of machine learning (ML). Despite its powerful decision-making capabilities, OR is often perceived as a niche discipline, with accessibility challenges limiting its broader adoption. This paper explores how the field can reach a wider audience by drawing lessons from ML's global success. We propose a set of recommendations to modernize outreach, increase public awareness, and refine research and technology strategies.

4 - OR with a White Hat: Evidencing Privacy Vulnerabilities in ML Models
Thibaut Vidal, Julien Ferry, Ricardo Fukasawa, Sébastien Gambs, Alice Gorgé

This talk examines how operations research can help analyse and mitigate privacy risks in machine learning. We present a white-box reconstruction attack that formulates the recovery of a random forest training data from a provided model as a maximum-likelihood combinatorial problem solved with constraint programming. Our approach can reconstruct entire datasets surprisingly well, even from forests with only a few trees. We will also show that differentially private random forests may still leak meaningful information, unless noise is so strong that predictive performance largely collapses.

5 - Making Operations Research More Accessible: Insights from the Rise of Machine Learning
Laura Albert

Operations research (OR) has evolved over the past 50 years into a versatile field, yet its growth has been overshadowed by the widespread adoption of machine learning (ML). Despite its powerful decision-making capabilities, OR is often perceived as a niche discipline, with accessibility challenges. This talk explores how OR can reach a wider audience by drawing lessons from ML's global success. We propose a strategic action plan consisting of 10 targeted initiatives to modernize outreach, increase public awareness, and refine research and technology strategies.

■ ME-23

Monday, 14:15-15:45 - Room: HG - Hörsaal 02 (Building: HG)

New solution methods for stochastic optimization

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Francesca Maggioni*

1 - Solving a probabilistic constrained optimization problem by using a data driven surrogate probability model
Edith Kovács

We consider a probabilistic constrained optimization problem in which the random variables are in the right sides of the stochastic inequalities defining the joint chance constrained. We suppose having a given sample set from the underlying joint probability distribution. Starting from this dataset we propose a surrogate joint probability model which uses only low dimensional marginals. Since the method utilizes scenario generation from the surrogate model, it is crucial to have probability bounds for the initial problem. To address this, we introduce new graph based probability bounds.

2 - Objective-Guided Scenario Search with Deep Generative Models for Two-Stage Stochastic Optimization
Atefeh Hemmati Golsefidi, David Pisinger

We introduce Deep Generative Scenario Search (DGSS), a general instance-wise framework for two-stage stochastic optimization. Rather than relying on large scenario sets, DGSS learns a very small set of synthetic scenarios that preserves decision-relevant information. The framework performs a local search over the scenario space, iteratively refining compact scenario sets to improve first-stage decisions. Across three NP-hard problems and against 25 baseline methods, DGSS attains near-optimal, and often optimal, solutions using remarkably few scenarios.

3 - Sequential Decision Support over Near-Optimal Integer Programming Solutions
Lorenzo Bonasera, David Pisinger

Recent work on postoptimality has characterized spaces of near-optimal integer-programming solutions. We study how such spaces can guide sequential decisions under uncertainty. From a pool of near-optimal solutions, we build a Hamming graph whose edges represent one-bit revisions. A rolling-horizon process fixes variables by weighted sampling and permits reoptimization only through adjacent moves. A finite-horizon dynamic program then selects the initial policy and prescribes, after each realization, the continuation move that best preserves expected future flexibility.

4 - Certified stopping rules for iterative stochastic programming algorithms
Ruben van Beesten, Nick Koning, Hongyu Zhang

We propose statistical certificates for stopping rules for iterative stochastic programming algorithms, such as SDDP. We use recent innovations in sequential hypothesis testing to statistically certify the claim that at the time of stopping, the algorithm has found an epsilon-optimal solution. We do so by accumulating evidence for convergence over multiple iterations. This allows us to certify existing stopping rules, which are often heuristic and lack a certificate. Moreover, we propose a new stopping rule, that stops as soon as a desired certificate is reached.

■ ME-24

Monday, 14:15-15:45 - Room: HG - Hörsaal 03 (Building: HG)

Human Aspects in Operations Management

Stream: Human Aspects in Operations Management
Invited session
Chair: *Olga Battaia*
Chair: *Songsong Liu*

1 - Human Decision Making with Digital Twin Support in Inventory Planning
Pascal Wolff

We examine how digital twin-based decision support affects human inventory management decisions. In a controlled dual-sourcing experiment, participants first used historical data only and then an interactive dashboard simulating future inventory, costs, and service levels. Results show that access to the digital twin reduced total costs by 21% and stabilized ordering behavior. However, the additional predictive information increased perceived cognitive workload, highlighting trade-offs between performance gains and human factors in digital twin-supported planning.

2 - Decision Support System via Chatbots
Davi Almeida, Luana Candaten, Júlia Almeida, Miguel Ângelo Lellis Moreira, Marcos Santos

A barrier to adopting mathematical methods in daily decisions is the lack of accessible tools and the cognitive cost of conventional systems. This research develops a Decision Support System integrated with Telegram and orchestrated by n8n to solve multi-criteria problems using Analytic Hierarchy Process (AHP) and Gaussian AHP. An event-driven asynchronous state machine manages data and persistence. Tests with smartphone selection and a high-dimensional military aircraft case show mathematical consistency and applicability, preserving the integrity of the original models.

3 - A Multi-Objective Rolling-Horizon MIP for Disaster Volunteer Assignment Under Acute-Phase Demand Dynamics
Berk Ozel, Bulent Sezen, Yavuz Selim Balcioğlu

We propose a five-objective mixed-integer program for disaster volunteer task assignment under acute-phase demand dynamics. Ideal-nadir normalization maps response time, skill matching, workload balance, reliability, and makespan to a common scale so weights reflect genuine decision-maker preferences. A rolling-horizon algorithm solves epoch-level subproblems with fatigue tracking and diminishing arrivals. Volunteer eligibility is governed by skill compatibility, cumulative fatigue thresholds, and maximum shift duration, ensuring operationally feasible assignments.

4 - EASIER: A Blockchain-Based Artificial Intelligence Support System for Small and Medium Enterprises
Chieh Lee

SMEs often struggle with inconsistent component names in bills of materials (BOMs), causing duplicated records and manual correction costs. This study proposes EASIER, an engineering-aware, blockchain-supported NLP system for automated BOM standardization. Using Action Design Research, we combine rule-based annotation, a lightweight DistilBERT model, deterministic name reconstruction, and human-in-the-loop refinement. The system achieves 99.77% accuracy, improves data consistency, and offers a scalable, resource-efficient solution for SME digital transformation.

■ ME-25

Monday, 14:15-15:45 - Room: HG - Hörsaal 16 (Building: HG)

OR and Health Informatics for Sustainable Societal Outcomes

Stream: OR for Development
Invited session
Chair: *Helper Zhou*
Chair: *Gordon Dash*
Chair: *Gerhard-Wilhelm Weber*

1 - Last-mile health facility electrification: an analytics toolkit and case study
Rebecca Alcock, *Justin Boutilier*, *Gabriela Hug*

Persisting energy poverty in healthcare facilities endangers patients and providers. For clinics not yet connected to a traditional grid, distributed clean energy solutions are the timeliest and most climate-resilient option. However, without relevant renewable energy design tools, these facilities must wait for grid connection or turn to carbon-based alternatives. Motivated by this need, we developed an analytics toolkit to optimally design a solar, storage, and e-vehicle network for never-before-electrified health facilities and consider a case study of an Indigenous community in Colombia.

2 - Integrating Multimodal Dark Data with Dendritic Optimization for Predictive Healthcare Digital Twins and Public Health Outcomes
Mabutho Sibanda

The rapid digital transformation of healthcare has produced vast volumes of data, with nearly 80% remaining "dark" and underutilised. This study proposes a framework for integrating multimodal dark data into Healthcare Digital Twins (HDTs) using dendritic computing. The approach enhances non-linear processing, feature extraction, and computational efficiency. By enabling real-time optimisation and simulation, HDTs support clinical decision-making and resource allocation. The framework further scales to population-level analytics, advancing precision medicine and public health systems.

3 - Latent Neural Systems of Stress Responsivity: Implications for Health and Social Environments
Gordon Dash, *Miriam Dash*, *Nina Kajiji*, *S Tiffany Donaldson*

Addressing stress is central to the SDG goal of good health and well-being. Our study models latent stress dynamics in rats bred for trait anxiety and reared socially or in isolation using multivariate machine learning approaches. Results show that stress responsivity is organized into domain-specific neural systems, driven primarily by sex, with limited contributions from trait and environment. These findings inform a future multi-objective goal-programming framework for public housing that incorporates vulnerability and environmental stressors to support a health-sensitive allocation policy.

■ ME-26

Monday, 14:15-15:45 - Room: HG - Elise-Richter-Saal (Building: HG)

Rail Freight Transportation

Stream: Freight Network Design and related problems
Invited session
Chair: *Uwe Höppner*

1 - Railway Capacity Estimation of Freight Junction: A Constraint Programming Approach
Alessia Grosso, *Luca Di Gaspero*, *Giovanni Longo*

This work proposes a methodology to estimate the maximum railway capacity of freight junctions serving industrial areas with multiple demand nodes (terminals). The problem is formulated as a Constraint Programming scheduling problem with optional trains, maximizing the number of scheduled ones while accounting for operational constraints. The model enforces a minimum number of trains per terminal to ensure competitiveness and supports what-if analyses. Passenger traffic is incorporated as fixed constraints. Validation is performed on the railway network of the Port of Trieste, Italy.

2 - Scenario generation for strategic classification yard planning
Daniel Haalboom, *Nikola Bešinović*

In Single Wagonload rail freight transportation, classification yards serve as central nodes in the network. Their strategic management is impacted by network design considerations, compounded by the complex infrastructure of the classification yard itself. In this contribution, we propose a scenario generation approach for the strategic planning of classification yards. In the approach, we model customer demand and timetable constraints. We compare instances of real-life-size for several scenarios using an existing solution method, quantifying the yard's ability to meet customer requirements.

3 - 4PL-Based Intermodal Service Network Design Considering Heterogeneous Logistics Characteristics
Taeyoung Shin, *Gwang Kim*, *Yoonjea Jeong*

This study addresses Intermodal Service Network Design from a Fourth-Party Logistics perspective, where a single non-asset-based integrator orchestrates multiple Third-Party Logistics partners with heterogeneous logistics haracteristics such as diverse hub configurations and transport modes. A Mixed-Integer Programming model minimizes costs including fixed, variable, mode-switching, inventory holding, and tardiness penalties. A Memetic Algorithm integrating a Genetic Algorithm and elite local search is proposed to handle large-scale instances, obtaining near-optimal solutions efficiently.

4 - Measuring the attractiveness of public sidings on German railfreight network
Uwe Höppner, *Henning Preis*, *Nikola Bešinović*

To evaluate public sidings as enablers of modal shift, we present a mathematical model for assessing the geographic-economical attractiveness. The German traditional „4-level-SWL-system" is designed as a network flow model. It takes shipments (requests) and potential sidings (locations) and aims to minimize transport costs. A posteriori, sidings are sorted based on use frequency and attractiveness patterns are identified. The model is demonstrated on a real-life German railfreight network and the results will inform policy recommendations for advancing Germany's rail system.

■ ME-27

Monday, 14:15-15:45 - Room: JUR - Hörsaal 13 (Building: JUR)

Machine Learning & Optimization Models for Humanitarian Logistics

Stream: Humanitarian Logistics
Invited session
Chair: *Raha Akhavan-Tabatabaei*

1 - Risk-Averse Fleet Modernization for Humanitarian Logistics: A Stochastic Programming Model
Ali Hassanzadeh, Vahid Akbari, Hossein Zarei

We develop a multi-period stochastic programming model for humanitarian fleet modernization under demand uncertainty. The model integrates vehicle purchases, rentals, and charging infrastructure decisions across sequential periods with daily operational assignments. Two variants address hard demand constraints and risk management, enabling progressive fleet transition for a resource-constrained non-for-profit humanitarian organization.

2 - Learning to prepare: data-driven robust optimization for humanitarian relief pre-positioning
Kate Ashley

We develop a data-driven robust optimization framework for pre-positioning humanitarian relief supplies ahead of disasters. Using quantile regression forests trained on historical disaster impact and geophysical covariates, we construct empirically grounded demand uncertainty sets, replacing ad hoc assumptions in standard robust models. A two-stage robust pre-positioning model with tractable MIP reformulation is developed and applied to Atlantic hurricane preparedness in the Caribbean. Out-of-sample evaluation demonstrates improved demand coverage and cost efficiency relative to benchmarks.

3 - The Network Fortification Problem for Evacuation Operations
William Titus, Brian Lunday, Matthew Robbins, Kenneth Hopkinson

We determine optimal pre-disaster network fortification strategies under transportation network disruption during natural disaster evacuations. A trilevel fortify-attack-route formulation is developed. We combine the attack-route phases into a subproblem. The main problem determines the optimal fortification using critical attack cuts, Benders cuts, and cuts derived from suboptimal solutions. The approach is tested on synthetic and real-world networks. Testing shows that using suboptimal solution cuts improves performance by leveraging commercial solvers that generate suboptimal solutions.

4 - Earthquake Response in Mega Cities: A Mathematical Model for the Selection of Relief Shelters in the Valley of Mexico
José Gerardo Huerta De Rubín, Jaime Mora Vargas

The thesis develops a mathematical model to select relief shelters after earthquakes in megacities using humanitarian logistics. It minimizes distances to affected areas and shelter adaptation costs. The model is validated on scenarios from controlled cases to large-scale applications using real and simulated data from the Valley of Mexico. Results are visualized with QGIS, supporting practical evaluation and informed post-disaster decision-making.

5 - A Machine Learning Framework for Detecting Disaster Distress Signals from Social Media
Raha Akhavan-Tabatabaei, Parinaz Kiavash, Altug Tanaltay, Nilüfer Sayın

This study examines how Platform X can support disaster response during the February 6, 2023 Türkiye earthquakes by identifying and mapping calls for help related to collapsed buildings. Using a framework that combines topic modeling, keyword filtering, machine learning, and geolocation, the study extracts spatial patterns of urgent distress messages from social media. The findings show strong alignment with official damage data, highlighting the potential of social media to improve situational awareness and support faster, more targeted emergency response.

■ ME-28

Monday, 14:15-15:45 - Room: JUR - Hörsaal 17 (Building: JUR)

Energy and resource efficient maritime operations

Stream: Maritime Logistics
Invited session
Chair: *Line Reinhardt*

1 - Benders decomposition for managing operations and energy in multi-energy port microgrid
Cagatay Iris

This study delivers a Benders decomposition framework for optimising energy management and operations planning in a container port microgrid. The energy management component decides on hourly energy purchase, generation and flow between energy assets, whereas operations management deals with scheduling of the equipment that deliver logistics tasks and determines the energy demand. The Benders decomposition (BD) framework has the master problem of equipment scheduling and a series of subproblems with energy flow optimisation. BD outperforms MIP solvers significantly for all instance sizes.

2 - Low-Carbon Ferry Scheduling and Capacity Optimization with Land Transport Substitution
Youkai Wu, Mario Guajardo, Bo Dong, Kenneth L. Rødseth, Kjetil Fagerholt

We studies the scheduling and capacity allocation problem for ferry and land-based public transport services in the context of low-carbon transition of public transport system. Given that ferry decarbonization remains costly and technologically slow compared with land-based transport, we formulate the problem as a mixed-integer linear program, minimizing system-wide operational cost and carbon emission, that simultaneously determines ferry schedules, service capacity. We conduct the case study using real operational data from the Norwegian coastal public transport system.

3 - Multi-period Optimization of Green Technology Adoption for Heterogeneous Fleets under Carbon Quota Policies
Jingjing Yu

This study investigates multi-period planning for decarbonization in liner shipping. A joint optimization model is developed to determine technology adoption and carbon allowance purchasing decisions for a heterogeneous fleet over time. The model captures retrofit constraints, annual budgets, and emissions compliance requirements under the EU Emissions Trading System. To solve the optimization model, a hybrid metaheuristic combining deep reinforcement learning and adaptive large neighborhood search is proposed to efficiently identify cost-effective decarbonization strategies.

4 - Fuel-Efficient Collection of Drifting Ghost Nets: An Online Orienteering Approach with Moving Targets
Paulina Heine, Kevin Tierney, Daniel Wetzel

Abandoned fishing gear drifting with ocean currents (ghost nets) poses a severe threat to marine ecosystems. In this project, maritime ghost net collection is modelled as an Orienteering Problem with Moving Targets, in which a fleet of vessels must intercept drifting nets within a time horizon. The objective is to minimize the fuel cost per kilogram of collected net where ocean currents are accounted for in the fuel. An offline approach is compared to an online solution incorporating dynamic weather routing, extending the classical problem to support energy-efficient ocean cleanup.

■ ME-29

Monday, 14:15-15:45 - Room: HG - Hörsaal 30 (Building: HG)

Graph Theory and Combinatorial Optimization I

Stream: Combinatorial Optimization
Invited session
Chair: *Yukun Cheng*

1 - Supermodular Maximization under Cardinality and Connectivity Constraints
Xujin Chen, Xudong Hu, Changjun Wang, Qingjie Ye

This talk examines maximizing a nonnegative monotone supermodular function over subsets with fixed or bounded size. When the function decomposes into simpler components, we present a polynomial-time approximation algorithm requiring no advance knowledge of this structure. Adding a connectivity constraint when the specific decomposition is known creates a generalization of the densest connected k-subgraph problem. Our polynomial-time algorithm improves previous approximation guarantees, notably achieving better approximation ratios than earlier methods for the densest connected k-subgraph case.

2 - Makespan Minimization with Group Job Removals
Guochuan Zhang

In this talk we present a new rescheduling model which allows to remove some jobs from a given schedule so that the makespan is minimized. Jobs are classified as groups. Each group is associated with a removal threshold that upper bounds the number of jobs removed from the group. We prove that the problem is solvable in polynomial time if there are a constant number of job groups, while it becomes NP-hard if the number of groups is part of input. We further provide an FPTAS for a fixed number of machines and a 2-approximation algorithm for the general case.

3 - New Concepts of Interval Optimization with Applications in Automobile Line Feeding
Feng Chen

In this talk, we present a new framework for interval programming (IVP) and develop several foundational concepts, including interval sequences, monotonicity, and continuity. We introduce invexity as an alternative to convexity in IVP and derive a sufficient condition ensuring that a sequence-agreeable IVP is invex. We also propose a transitive regularity condition to handle general additivity and spanning operations. These results are then applied to the development of exact and heuristic algorithms for a scheduling optimization problem in automobile line-feeding logistics.

4 - Mechanism Design for Efficient Task Allocation
Minming Li

Task allocation involves a group of agents contributing to various tasks and has been well-studied in resource allocation and related fields. In many scenarios, tasks are distributed across different areas. A key challenge is the tendency of agents to choose easier tasks or more prosperous areas for their own benefit. To address this problem, we study task allocation using a game-theoretic approach. We model the problem as task allocation games with different tasks and a group of rational, identical agents who strategically select tasks to minimize their workloads.

■ ME-30

Monday, 14:15-15:45 - Room: HG - Seminar-Raum 06 (Building: HG)

Uncertainty in Finance

Stream: Robust and Resilient Optimization in Finance and Businesses
Invited session
Chair: *Illia Kovalenko*

1 - Tractable Conditions for Stochastic Arbitrage in Index Options: Theory and Evidence
Thierry Post, Illia Kovalenko

This study derives tractable linear conditions for detecting stochastic arbitrage in equity index options, incorporating bid-ask spreads and portfolio constraints. Because return distributions vary with volatility, tests must be conditional. Applying the method to one-month S&P 500 options reveals out-of-sample arbitrage in high-volatility regimes, mainly call front spreads, driven by volatility-dependent risk premia and negative skewness. In low to moderate volatility, no significant arbitrage appears, consistent with higher pricing efficiency.

2 - Sparse vine copula-based portfolio optimization: A composite trade-off
Illia Kovalenko, Thomas Conlon, John Cotter

This paper studies sparse vine copula models for portfolios of varying sizes. Sparse vines, dominated by independence pair-copulas, improve performance in large portfolios by reducing turnover. Copula-based portfolios outperform equal weights before transaction costs and offer lower tail risk, appealing to risk-averse investors, especially in volatile markets with dependence asymmetry. After transaction costs, gains fade, but limiting turnover by lengthening horizons or allowing rebalancing error helps restore outperformance.

3 - Optimal Catastrophe Risk Pooling
Minh Chau Nguyen, Tony Wirjanto, Fan Yang

Catastrophe risk is a great threat to the insurance sector as natural disasters generally lead to large damages that traditional insurers may not be able to efficiently cover. Risk pooling is an effective way to diversify such risks. In this talk, I present how we can Pareto-optimally allocate the diversification benefits among members of a catastrophe risk pool. We propose evaluating the diversification benefits at the limit and using it to approximate the practical optimal pool. Numerical studies are undertaken to illustrate the implications and implementation of this framework.

4 - Convex Optimization Algorithms for Fair Classification with POE Parity
Joonhyuk Suh, Stan Uryasev

We study fair binary classification under Probability-of-Exceedance (POE) parity, which requires equal tail probabilities across sensitive groups. Although POE parity is nonconvex, we show it can be achieved exactly through convex optimization using standard convex losses with convex constraints based on bPOE, CVaR, and expectations. Tests on four benchmark datasets show near-zero POE gap, lower mean-squared error than existing methods, simple formulations, and much faster solution times.

■ ME-31

Monday, 14:15-15:45 - Room: JUR - Hörsaal 12 (Building: JUR)

Electric bus operations

Stream: Optimizing Transit
Invited session
Chair: *Guy Desaulniers*

1 - Integration of Photovoltaic Energy Storage System with In-Motion Charging System Planning Considering Charging Scheduling and E-Bus Scheduling
Abu Nasar, N. Nezamuddin

This study proposes a hybrid catenary-based in-motion charging (IMC) system for electric buses, complemented by onboard batteries for non-catenary sections. It jointly optimizes charging scheduling, bus scheduling, and IMC infrastructure, integrating photovoltaic energy storage (PV-ESS) to reduce peak grid use. A MILP model tracks each bus's state of charge across trips and segments, embeds time-of-use tariffs and prioritizes PV-ESS during peaks under uncertain solar irradiance. Results show that PV-ESS installation can significantly help in reducing grid dependency and electricity charges.

2 - Adaptive Real-Time Optimization for Electric Bus Depot Operations with State-of-Charge Tracking Signals
Guy Desaulniers, Soheyl Khalilpourazari, Jorge E. Mendoza

This paper studies the real-time electric bus (EB) parking, charging, and dispatching problem, aiming to optimize the EB operations in an indoor depot with FIFO parallel lanes. When an EB arrives, its state-of-charge (SoC) is observed and an integer program is solved to assign this EB to a lane, a charging schedule, and an upcoming trip service, taking into account forthcoming EBs. A tracking signal approach adjusts dynamically the SoC predictions. We report results on instances with up to 4 lanes and 10 parking spots per lane, showing the effectiveness of the tracking signal approach.

■ ME-32

Monday, 14:15-15:45 - Room: JUR - Hörsaal 14 (Building: JUR)

Last-mile delivery innovations

Stream: City Logistics
Invited session
Chair: *Oguz Sohret*

1 - Serving E-Commerce and E-Grocery Deliveries Together with Learning-Based Vehicle Dispatching
Oguz Sohret, Barış Yıldız, Gurhan Kok

We study a collaborative pooled last-mile delivery model in which an e-grocery retailer leverages its excess capacity to simultaneously deliver e-grocery orders and e-commerce packages. A novel learning-based algorithmic framework is developed to address the complex sequential decision-making problem (SDM), by combining machine learning with optimization. The numerical experiments, conducted with real-world data from a major grocery chain and a leading package delivery service in Europe, reveal that the proposed model can provide substantial economic and societal benefits.

2 - Adaptive Resilience Planning for Production and Logistics Networks
Yousef Maknoon

Supply chain resilience is increasingly strained by disruptions that outpace conventional planning models. This work develops an optimization-based framework that jointly identifies structural vulnerabilities and prioritizes resilience investments across production and logistics networks. Rather than relying on predefined scenarios, the approach endogenously exposes network weaknesses and adapts reinforcement decisions. Case studies in steel and pharmaceutical supply chains show that targeted production flexibility can improve delivery performance without proportional cost increases.

3 - Incentive-Based Strategies for Sustainable City Logistics: A Multi-Agency Bilevel Game-Theoretic Framework
Mingye Luan, Bilge Atasoy

City logistics contributes substantially to urban congestion and environmental pollution. Policymakers are increasingly exploring policy mechanisms to promote sustainable modes such as inland waterways and scheduled line services. Our study develops a multi agency game theoretic framework to analyze such policies, involving transportation authorities, logistics service providers (LSPs), and customers. The authority determines policy strategies to support sustainable services. LSPs respond by optimizing mode and pricing, while customers choose services based on a utility maximizing logit model.

4 - More Spaces or More Time? Optimal Location and Time-Based Capacity Design for On-Street Coach Parking Provision
Amirreza Pashapour, Maria Battarra, Meng Meng

We study the Coach On-Street Parking Provision Problem, determining the location and time limits of curbside coach parking under time-varying demand and service-level requirements. The objective minimizes coach travel distance, tourist walking distance, and the resulting disruptions to passenger vehicles. We develop centralized and decentralized mathematical models, with the latter incorporating coach drivers' preferences via the Multinomial logit model. We propose linearization techniques and assess the resiliency and the value of central coach parking provision through sensitivity analysis.

■ ME-33

Monday, 14:15-15:45 - Room: JUR - Hörsaal 15 (Building: JUR)

Space logistics

Stream: OR in Space
Invited session
Chair: *Theo Guyard*
Chair: *Thibaut Vidal*

1 - Recent Progress in Space Logistics Modeling and Optimization
Koki Ho

As space missions become increasingly complex, various new challenging problems emerge in the mission design process for applications such as human exploration campaigns, in-space satellite servicing/assembly/manufacturing, and mega-scale satellite constellations. In response to those challenges, advanced modeling and optimization techniques inspired by complex terrestrial logistics research have been developed. This talk will review and discuss the recent progress in logistics-inspired modeling and optimization for space mission design over the past decade.

2 - MINLP Solution Approaches for Space Logistics
Masafumi Isaji, Koki Ho

Integrated space logistics formulations feature strong coupling between discrete decisions and nonlinear system design, often yielding nonconvex mixed-integer nonlinear programs (MINLPs). To reduce the computational burden of such MINLPs, we develop heuristic and exact global optimization methods exploiting mathematical structure prevalent in space applications. These methods incorporate decomposition, piecewise-linear relaxation, and domain reduction to enhance tractability. The resulting computational improvements are demonstrated on representative case studies in integrated space logistics.

3 - Orbital debris remediation at scale via enhanced RQ-law and combinatorial metaheuristic
Theo Guyard, Mingde Yin, Thibaut Vidal, Graham Mackintosh, Thomas Templin

We propose a framework for orbital debris removal using a fleet of collecting spacecraft. Our approach extends the RQ-law by allowing drifting on intermediate orbits to reduce fuel consumption, and adapts the Hybrid Genetic Search method to coordinate the entire fleet in a dynamic orbital environment. For each spacecraft, the method outputs a debris sequence to visit, together with meeting times and transfer strategies to minimize fuel consumption. It can handle large-scale instances while accounting for operational and physical constraints.

■ ME-34

Monday, 14:15-15:45 - Room: JUR - Hörsaal 16 (Building: JUR)

Algorithmic Management: Opportunities, Regulation, and Decision Systems for Worker Well-Being

Stream: Warehousing
Invited session
Chair: *Arpan Rijal*

1 - Boosting Productivity without Losing Humans: Evaluating Algorithmic Management in Laboratory Settings
Linda Maria Wings, Thomas De Lombaert, Minqi Zhang, Eric Grosse, Armando Walter Colombo

Algorithmic management (AM) defines employees' scope of action and is often optimized for economic objectives disregarding worker heterogeneity, creating tension between productivity and well-being of workers. In a laboratory order picking study, participatory, dedicated, and random AM-based assignment systems are compared using objective and subjective workload measures as well as productivity. Results show that human-centered approaches have a positive impact on physical, cognitive, and psychosocial factors for workers while maintaining productivity.

2 - Compliance Burden or Operational Guidance? Lawful Worker Monitoring in Data-Driven Operations
Michele Molè

Smooth and efficient operations often rely on large volumes of data, including personal data from workers in warehouses or delivery operations. EU law, particularly the GDPR and the AI Act, limits how such data can be used to protect fundamental rights at work, including privacy, health, and safety. This presentation examines legal constraints on worker monitoring and shows how what may appear as compliance burdens for operations management can instead provide useful operational guidance for designing monitoring systems fostering well-being and efficiency.

3 - Compliance by Design: Pipelines for Algorithmic Management and Worker Well-Being under the EU AI Act and GDPR
Arpan Rijal

The complexity and pervasiveness of algorithmic management systems raise questions under the EU AI Act and GDPR, especially when sensitive data are used. This study presents a decision-making pipeline following the principle of compliance by design. Using a longitudinal dataset, we demonstrate how operations research techniques can be leveraged to ensure data minimization, privacy preservation, and the maintenance of accuracy under uncertainty to mitigate bias. The pipeline addresses regulatory requirements while responsibly handling sensitive data and improving worker well-being.

4 - Open Forum Dialogue: Aligning Empirical Insights, Legal Frameworks, and Algorithms.
Arpan Rijal

Digital tools are reshaping how work in logistics is organized, affecting organizational performance, worker well-being, and regulations. This panel looks ahead to how these challenges can be addressed, considering legal frameworks such as the General Data Protection Regulation and the EU AI Act. Sparked by the insights of speakers, the forum will engage audience members and experts in an open dialogue on future directions, practical solutions, and key challenges.

■ ME-35

Monday, 14:15-15:45 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Sustainable Supply Chains I

Stream: Operations Research and Sustainability
Invited session
Chair: *Lena Silbermayr*

1 - The impact of carbon tariff and subsidy policies on cross-border supply chain
Ping He

Carbon tariff intensifies the conflict between the carbon emissions generator (manufacturer) and the tariff bearer (retailer) in a cross-border supply chain. We explore the impacts of carbon tariff and carbon reduction subsidy on the firms' decisions and profits. We find that carbon tariff always reduces total emissions, but not necessarily reduce the unit carbon emissions of product; while carbon subsidy impacts conversely. The retailer and the manufacturer may benefit from carbon tariff under certain conditions. Two-part tariff agreement can coordinate the supply chain.

2 - Coordination of sustainable supply chains under environmental regulations
Werner Jammernegg, Lena Silbermayr, Peter Kischka

We examine a supplier-buyer supply chain where the supplier faces significant production emissions and must consider environmental regulations (emission limit, emission costs). We find that a wholesale price contract can coordinate the supply chain for a range of emission limits. If the buyer exhibits altruistic behavior, this contract enables the distribution of profits. A general finding for the wholesale price contract and for risk-sharing contracts is that coordination is more likely as emission costs increase, with a rule of thumb that costs must be at least half of the profit margin.

3 - Equity and Efficiency in a Brazilian Food Bank Supply Chain
Daniela Cantane, Rhyan Rampazo, Rogerio Antônio Oliveira

Food waste and food insecurity are interconnected global challenges, with edible food discarded annually as food insecurity rises. Food banks play a strategic role in redistributing surplus food. This study proposes an extended goal-programming model for food allocation planning in food banks, providing a structured decision-support framework. The model was validated with real operational data from a

Brazilian food bank and evaluated in terms of fairness. Results show improved allocation effectiveness and strong potential. The approach supports managerial decisions under resource constraints.

4 - From waste to value: Sustainable sourcing labeling in dual-channel supply chains with eco-conscious consumers
Lena Silbermayr, *Danja Sonntag*

In response to growing environmental concerns and shifting consumer preference, companies increasingly adopt sustainable sourcing labels to signal their environmental commitment. We investigate how these labels can be used by manufacturers to differentiate product offerings in dual-channel supply chains under stochastic demand by identifying profit-maximizing production quantities and labeling strategies. Leveraging sustainable sourcing labels to communicate material sourcing efforts can enhance profitability while promoting circular practices by transforming waste into valuable input.

■ ME-37

Monday, 14:15-15:45 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Optimization algorithms and applications 2

Stream: Nonlinear Optimization
Invited session
Chair: *Ya-xiang Yuan*

1 - Location optimization of RIS aided broadcast channel
Cong Sun

Reconfigurable intelligent surface (RIS) is a popular technology for 6G. The joint optimization model of RIS location and parameter is considered. It is formulated as a mixed integer programming problem. The Courant penalty function technique is applied for problem simplification. The RIS parameters are updated in closed form, and its location variables are solved through the trust region method. Numerical tests show solid improvement of the quality of service.

2 - A Two-Stage Optimization Method for Tensor Rank Decomposition
Hongchao Zhang

The tensor rank decomposition, also known as CP decomposition, has a long-standing history in multilinear algebra. However, computing a CP decomposition becomes challenging when the tensor's rank lies between its largest and second largest dimensions, especially when a significant dimensional gap exists. In this talk, we introduce a novel generating polynomial based two-stage algorithm for finding the order-3 nonsymmetric tensor decomposition even when the decomposition is not unique. Numerical comparisons with current state-of-the-art methods will be also presented.

3 - Learning Fused Row-Sparse Structures via Newton Method for Linear Matrix Equations
Ziyan Luo

We focus on the problem of learning fused row-sparse structures in linear matrix equations, which is formulated as the minimization of a least squares loss regularized by the total number of nonzero rows in the matrix formed by consecutive row differences. To numerically resolve the problem efficiently, an appropriate reformulation is adopted via its first-order optimality under some mild conditions. This further facilitates us to design a subspace Newton algorithm with quadratic convergence rate. Numerical results confirm the high efficiency of our proposed approach.

■ ME-38

Monday, 14:15-15:45 - Room: JUR - Seminar-Raum 44 (Building: JUR)

OR in Public Sector, Society, and Sustainability

Stream: The Practice of OR: Stories of Solutions, Setbacks, and Successes
Invited session
Chair: *Tamás Terlaky*

1 - Inmate Population Management Optimization: The OPTAMO experience
Tamás Terlaky, *Mohammad Shahabsafa*, *Anshul Sharma*

Inmate population management in large correctional systems is a complex and challenging task. It spans multiple tightly-coupled decision problems, including: 1) Inmate assignment to prison units, and in a more detailed model, assigning inmates to cells & beds; 2) Inmate transportation between correctional facilities; 3) Rehabilitation program scheduling. All problems include dozens of specific constraints. This presentation guides the audience through the academic research - implementation - commercialization trajectory.

2 - Lessons from an Agricultural Sustainability Project in Huapra, Peru
LluisM Pla-Aragones, *Pol Llagostera Blasco*

This talk presents the experience and lessons learned from the project "Development of a Computational Mathematical Model for the Evaluation of the Sustainability of the Agricultural System of the Community of Huapra (Peru)." The project aimed to design a mathematical and computational framework to analyze the sustainability of local agricultural practices and to support decision-making regarding resource use, crop planning, and long-term resilience of the community's farming system.

3 - Selected OR Consulting Projects in the USA and Israel
Zilla Sinuany-Stern

Several major Operations Research (OR) consulting projects are presented, three conducted in the United States and three in Israel. The primary methods applied include: multi-objective optimization and multi-salesman route planning, forecasting student enrollment, information systems development, resource allocation models, Data Envelopment Analysis (DEA) for efficiency evaluation, and DEA-based ranking. The presentation highlights how each project originated, strategies for "selling" OR within organizations, and the importance of physically visiting the operational site.

4 - Toolkit in my OR Journey
Cathal MacSwiney Brugha

I will discuss my OR journey as a mathematician in management, confronting flawed and incomplete thinking structures and systems and protecting good research projects. I have always worked in management, used mathematics, explored systems and methodologies with numerical structure, such as the 4 Temperaments, 4 Ps in Marketing, 5 Types of Wealth, 6 Types of Working Genius, McKinsey's 7Ss, 7 Types of Rest, 7 Habits of Highly Effective People, 8 Types of Intelligence, 8 Ps of Business, 9 Enneagram Personality Profiles, 16 Personality Types, based on a generic structure that asks 8 questions.

■ ME-45

Monday, 14:15-15:45 - Room: HG - Seminar-Raum 01 (Building: HG)

Pricing, Platforms, and Customer Response

Stream: Prescriptive Analytics in Operations Manage-

ment
Invited session
Chair: *Ömer Schmiel*

1 - Tariff optimization of last-mile vehicle routes in the shared economy
Marcel Goic, Dimitri Loaiza, Denis Saure

Last-mile logistic platforms have transformed how firms distribute products to their customers. In this setting, digital platforms match firms requiring delivery services with independent drivers for transportation. A key characteristic of these platforms is the absence of contractual relationships with drivers, allowing them to reject assigned routes. This makes the design of economic incentives essential to ensure sufficient operational capacity. We propose a tariff model to maximize revenues with dynamic considerations and provide an empirical evaluation of the impact of a tariff change.

2 - Personalized Pricing: A Literature Review and Future Research Directions
Sohrab Faramarzi-Oghani, Parisa Dolati Neghabadi, Hoang Duong Nguyen

Personalized pricing, the practice of tailoring prices to individual consumers using data and algorithms, has attracted growing attention in economics, marketing, and operations management. This paper reviews the literature on personalized pricing, focusing on its theoretical foundations, technological drivers, and implications for firms and consumers. By integrating insights across disciplines, the review highlights key debates and identifies gaps in current knowledge. The paper concludes by outlining promising directions for future research.

3 - Economics of Ad Blocking: Impact of Ad-Whitelisting, Customer Rewards, and Competition
Ayesha Arora, Tarun Jain

Online publishers sell spaces on their web pages to display advertisements (ads). These ads generate revenue for websites but may cause customers discomfort. In this paper, we analyze customers' decisions to opt between two models that allow them to block ads: (i) Customer incentivization model, where customers use an ad-blocking browser that blocks ads on the website, but also rewards customers if they choose to see some ads, and (ii) Whitelisting content provider model, where customers use a browser with an installed ad-blocker that whitelists some ads over the website.

4 - When Customers Come Back: The Role of Retrial Time Distribution
Ömer Schmiel, Benjamin Legros, Raik Stolletz

Call centers face challenging capacity planning decisions due to the stochastic variability and time-dependencies. Although many approaches rely on queueing theoretical formulas, the phenomenon of retrials where some customers leave the queue and call back later, is often ignored. This work analyzes the impact of retrial time distribution. We present the basic idea of a novel approach to approximate various performance measures for queues with generally distributed retrial times, as well as findings on how the retrial time distribution impacts performance measures and staffing decisions.

■ ME-46

Monday, 14:15-15:45 - Room: HG - Seminar-Raum 02 (Building: HG)

Shop Scheduling

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Karim Tamssaouet*

1 - Joint Production Scheduling and Transportation Planning for Product Deliveries in Distributed Hybrid Flow Shops with Heterogeneous Fleets
Sara Hatami, Antonin Ponsich, Meritxell Montanya Díaz, Eliana Maria Gonzalez-Neira, Ali Ghodratnama, Reza Tavakkoli-Moghaddam

An integrated production and distribution problem is considered in a distributed heterogeneous hybrid flow shop. Jobs are processed through multiple stages with unrelated parallel machines and subsequently delivered to customers by a heterogeneous fleet operating from multiple factories. Vehicles belong to a single factory and perform multi-trip routes under capacity constraints, allowing split deliveries. A mathematical model and a heuristic solution approach are developed to minimize total earliness and tardiness. Computational experiments assess the effectiveness of the proposed methods.

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Antonin Ponsich, Sara Hatami, Meritxell Montanya Díaz, Eliana Maria Gonzalez-Neira, Ali Ghodratnama, Reza Tavakkoli-Moghaddam

An integrated production and distribution problem is considered in a distributed heterogeneous hybrid flow shop. Jobs are processed through multiple stages with unrelated parallel machines and subsequently delivered to customers by a heterogeneous fleet operating from multiple factories. Vehicles belong to a single factory and perform multi-trip routes under capacity constraints, allowing split deliveries. A mathematical model and a heuristic solution approach are developed to minimize total earliness and tardiness. Computational experiments assess the effectiveness of the proposed methods.

3 - Reactive Scheduling of the fully dynamic Job Shop Problem using Neural Monte Carlo Tree Search
Fynn Martin Gilbert, Kevin Tierney

Reactive job shop scheduling is difficult when processing times vary, machines fail, and new jobs arrive during execution. We study the fully dynamic job shop scheduling problem as an event-driven Markov decision process and propose Neural Monte Carlo Tree Search for anticipatory scheduling under uncertainty. Experiments on standardized benchmarks indicate that the approach remains effective across multiple disruption types and instance sizes.

4 - A simple and efficient iterated greedy algorithm for a large class of shop scheduling problems
Karim Tamssaouet

Despite vast research on shop scheduling, generic yet efficient methods remain scarce. We address this with a simple Iterated Greedy (IG) algorithm for problems representable as directed acyclic graphs with non-negative weights and regular objectives. The IG relies on a novel, highly efficient operation insertion procedure across any set of sequences. We demonstrate the approach's genericity and performance by successfully solving diverse shop scheduling variants from the literature, ranging from open to job shop environments under various objective functions.

■ ME-47

Monday, 14:15-15:45 - Room: HG - Seminar-Raum 03 (Building: HG)

Vehicle Routing Problem under Uncertainty

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Paolo Beatrici*

1 - Synchronised truck-drone tandem for humanitarian aid delivery: A stochastic location-routing problem
Melih Celik, Hannan Tureci Isik

This study addresses post-disaster aid delivery via synchronised truck-drone operations, where drones ride on trucks and rendezvous at flexible locations. Pre-disaster depot placement accounts for post-disaster road-network uncertainty. As travel times violate the triangle inequality, trucks may revisit nodes, adding to routing complexity. A two-stage stochastic program determines depot locations and scenario-dependent routes to minimise expected arrival times. A heuristic combining Iterated Local Search and GRASP is benchmarked against CPLEX and applied to an earthquake case study.

2 - A-priori route planning for service delivery with customer choice
Ymro Hoogendoorn, Niels Wouda, Lucas Veelenturf, Niels Agatz

We study an attended home delivery service with customer choice. A set of customers needs to be serviced by a vehicle following a delivery route. The customer's service day is unknown during route planning, and chosen by the customer afterwards. As such, the goal is to design a-priori routes such that the expected routing costs are minimized. We develop an exact branch-price-and-cut and an integer L-shaped method, and a heuristic hybrid genetic search algorithm to solve this problem. The exact algorithms can solve moderately sized instances, and the heuristic scales well to larger instances.

3 - A Benders decomposition approach for a green bi-objective stochastic fleet size and composition vehicle routing problem
Paolo Beatrici, Francesca Maggioni, Mike Hewitt, Sebastian Birolini, Paolo Malighetti

This study presents a two-stage bi-objective stochastic mixed-integer programming model for fleet sizing, fleet composition, and routing decisions while accounting for vehicles emissions. The bi-objective problem is handled through the ϵ-constraint method to generate efficient trade-off solutions. To address computational complexity, a tailored L-shaped algorithm is embedded within this framework. Computational experiments show that the approach produces high-quality solutions in limited time and evaluate the quality of the deterministic solutions in the stochastic multi-objective setting.

4 - Attempts to solve large-scale multi-stage stochastic MIPs: a green shipping case study
Alberto Tamburini

We study the Strategic Tramp Fleet Renewal and Retrofit Problem with emission reduction, in which a fleet can be periodically updated by acquiring, selling, scrapping, or retrofitting vessels to progressively run on low- or zero-emission fuels. For each period, the fuel cost is uncertain, leading to a multi-stage stochastic formulation. Due to the computational intractability of optimally solving the stochastic formulation in a reasonable time, we developed heuristic solution methods. The results describe the heuristics' efficiency in terms of required computational time and solution quality.

■ ME-48

Monday, 14:15-15:45 - Room: HG - Seminar-Raum 04 (Building: HG)

Data-Driven Optimization in Real-World Logistics and Production Planning

Stream: Data-driven Operations Research
Invited session
Chair: *Anne Meyer*
Chair: *Bastian Amberg*

1 - Dynamic Truck Routing in Industrial Distribution: A Literature Review
Malte Meistrell

Industrial B2B logistics for metals and polymers faces dynamic challenges: uncertain travel times, traffic, late customer orders, and operational disruptions. Dynamic vehicle routing (DVRP) can improve responsiveness, cost efficiency, and service reliability, yet practical adoption is rare. This scoping review, following PRISMA-ScR and incorporating PRISMA-trAIce for transparent usage of AI tools, surveys DVRP research in road-based B2B truck distribution. Most studies are theoretical, highlighting gaps for adaptive, data-driven, operationally grounded routing solutions.

2 - Adaptive Districting under an Uncertain Balance-Compactness Trade-off
Niklas Jost, Adolfo Escobedo, Abeer Abdelhadi, Sriram Ramesh

Service districting routes real-time requests to facilities, balancing short response distances with workload equity under tight decision time. We model this setting (e.g., emergency-call policing) with an uncertain trade-off between compactness and workload balance. Our two-stage framework selects a small set of edges for multi-assignment, then resolves them to single-facility assignments once the trade-off is revealed. We derive structural/complexity results quantifying the cost of limited flexibility and propose an algorithm tracing the Pareto front.

3 - Leveraging Large Language Models to Generate and Evolve Heuristics for Large-Neighbourhood Search: An Inventory Routing Problem Case Study
Bastian Amberg, Thomas Bömer, Anne Meyer

We apply large language models to automatically generate and evolve large neighbourhood search (LNS) operators that are tightly integrated into an LNS framework for the inventory routing problem (IRP). The operators are trained on a recent benchmark set of real world like IRP instances; at each iteration the framework selects a subset of decision variables to modify, steering the search toward high quality solutions. Computational experiments compare the AI driven evolutionary approach with state of the art techniques. We demonstrate its potential for adaptive optimization.

4 - Adaptive Genetic Optimization for Production Layouts
Dirk Rechkemmer, Martin Benfer, Gisela Lanza

The optimization of production layouts is characterized by conflicting objectives such as floor space, walking distances, and reconfiguration costs, and often results in local minima. This study extends a genetic algorithm based on NSGA II to include layout-specific swap and shift operators as well as adaptive mutation strategies within the iterative optimization cycle. Through targeted diversification of the populations and generation-dependent mutation strengths, the search process can overcome local minima and more efficiently identify solutions within the layout search space.

■ ME-49

Monday, 14:15-15:45 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management in Transportation and Mobility 2

Stream: Data-Driven Demand Management
Invited session
Chair: *Simon Schmidbaur*

1 - Assignment Policies for the Integration of Micromobility Systems in Public Transport
Lisa Urban, Alexander Baur, Matthias Soppert, Claudius Steinhardt

Integrating micromobility into public transport systems improves flexibility and first- and last-mile connectivity for customers, yet operators face new challenges in demand and supply management. Optimal routing through the multimodal transport network requires coordinated decision-making to assign flexible micromobility vehicles to customers while ensuring feasible connections to scheduled PT services. To address this, we propose anticipative assignment policies based on dynamically solved mixed-integer programs to serve stochastic customer requests, evaluated in a simulation framework.

2 - A Reinforcement Learning Approach for the On-Demand Dynamic Dial-a-Ride Problem with Heterogeneous Fleet and Customer Preferences
Merve Ibis, Pirmin Fontaine, Marlin Wolf Ulmer

On-demand transportation with heterogeneous fleets requires real-time decisions while serving passengers with different assistance needs. Requests arrive dynamically and must be accepted or rejected immediately and, if accepted, assigned to compatible vehicles. We model the problem as a Markov Decision Process and propose a hybrid approach combining a Deep Q-Network with an optimization solver that checks routing feasibility at each decision epoch. Experiments show the method learns effective acceptance policies while respecting time windows, vehicle capacity, and compatibility constraints.

3 - Block Now or Relocate Later? Availability Control of Short-Term Rentals in Vehicle Sharing Systems Considering Long-Term Rental Reservations
Simon Schmidbaur, Matthias Soppert, Claudius Steinhardt

Besides spontaneous short-term rentals, vehicle sharing providers started to offer long-term rentals with a specified departure location and time which customers can reserve in advance. Now, the provider has to ensure vehicle availability for each reservation, for which a vehicle can either be blocked, which may cause lost revenue, or relocated, which infers relocation cost. We formulate a sequential decision process to address the problem of vehicle availability control for short-term rentals under given long-term rental reservations and develop a dynamic anticipative solution approach.

■ ME-50

Monday, 14:15-15:45 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Sector-Coupled Multi-Energy Systems II

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Senay Solak*

1 - Daily Optimization of Multiple Participation in Energy Communities: Cost Efficiency and Fairness
Ionela Knospe, Michael Boegl, Martin Mayr, Jakob Papouschek, Guntram Preßmair

Energy communities are a key driver for advancing the clean energy transition at local and regional levels. Participation in multiple energy communities can further increase the utilization of locally generated energy. We develop a day-ahead optimization model to determine optimal participation shares that minimize total costs and assess the resulting benefits for energy communities based on real case studies. We further analyze the Pareto trade-off between cost efficiency and the fairness of economic benefits across participants.

2 - Electric Demand Response via Vertical Farming optimal scheduling
Francesco Ceccanti, Aldo Bischi, Andrea Baccioli

Vertical farming is a fully electric Controlled Environment Agriculture system that reduces land and water use. Lighting and HVAC (heating, ventilation, cooling, dehumidification) can be modulated and shifted, enabling electric demand response. Electricity-demand and plant-growth maps were modelled across indoor setpoints and lighting levels. Nonlinear performance curves were piecewise-linearized to formulate a Mixed Integer Linear Program (MILP) that optimizes lighting schedules using photosynthesis efficiency and electricity prices, quantifying flexible-load potential and revenue streams.

3 - Optimal electricity procurement and storage investment for risk-averse hydrogen producers: a stochastic optimization approach using modeling to generate alternatives
David Wohlleben, Felix Schäfer

Green hydrogen mandates create a high-dimensional stochastic optimization problem. We advance a stochastic programming framework for weather-robust electricity procurement under EU regulation (RED II) and weather uncertainty. We incorporate risk aversion via CVaR and apply Modeling to Generate Alternatives (MGA) to explore near-optimal spaces within a 5% cost-slack. This identifies electricity procurement robust to market imperfections. Results show deterministic portfolios are suboptimal over multi-year horizons. Cost-slack significantly expands PPA options, enabling more flexible investment.

4 - Supply-Demand Balancing: Equitable Incentives for Demand Response Programs in Power Grids
Senay Solak, Solmaz Abbaspour, Wei Wei

Demand response programs aim to shift electricity consumption from peak periods to off-peak periods to better match supply with demand, typically through pricing or monetary incentives. We investigate incentivization policies in demand response programs by considering characteristics of various demographic groups. We model the trade-offs between equity and efficiency in such policies, and propose mechanisms that achieve efficiency while ensuring equity among different customer profiles.

■ ME-51

Monday, 14:15-15:45 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Recent Advances in Fair and Interpretable Learning I

Stream: Mathematical Optimization for Transparent and Fair Decision Making
Invited session
Chair: *Sandra Benítez-Peña*
Chair: *Pepa Ramírez-Cobo*

1 - Fairness-constrained Bayesian spatial modeling in urban analytics
Pepa Ramírez-Cobo, Jose Carlos Jiménez-Revuelta, Alan Gelfand

In this work we propose a fairness-aware hierarchical Bayesian spatial model for urban analytics. Using a Leroux CAR prior, we capture spatial dependence in census-tract data while introducing posterior regularization to shrink group-level predictive disparities between sensitive and non-sensitive populations. By varying the regularization strength, we characterize the fairness-accuracy trade-off and provide a framework for equitable spatial prediction in urban decision-making. The method is illustrated using a case study city, revealing disparities in accessibility to healthcare facilities.

2 - Functional relevance based on the continuous Shapley value
Cristian Pachón García, Pedro Delicado

Artificial intelligence (AI) is increasingly present in our society, creating a need to understand the behavior of its mechanisms, including predictive machine-learning models using tabular, text, or image data. This work studies interpretability for predictive models with functional data. In scalar-on-function regression, we propose a method based on Shapley values for continuous games, enabling fair attribution across an infinite set of features. Experiments with simulated and real data illustrate the approach, and the open-source Python package ShapleyFDA is presented.

3 - Robust and Fair Sparse Classification with Twin Support Vector Machines
Sandra Benítez-Peña, Silvia Novo

We address the trade-off between fairness and sparsity in classification. We propose a robust framework based on Twin Support Vector Machines with integrated feature selection. Various model configurations and calibration methods are explored to obtain probabilistic predictions, which are aggregated through a weighted ensemble. We analyze how fairness constraints affect predictive performance and the stability of selected features.

■ ME-52

Monday, 14:15-15:45 - Room: KOL - PC Raum 1 (Building: KOL)

Decomposition approaches and structure-aware energy system optimization

Stream: Energy Markets & Systems
Invited session
Chair: *Stefan Strömer*

1 - Asynchronous Dynamic Level-Set Stabilized Benders' Decomposition for Large Scale Energy Planning Problems
Anthony Papavasiliou

In this work, we propose an asynchronous Benders' decomposition algorithm with dynamic level-set stabilization for large-scale stochastic energy planning problems. The method relaxes the synchronization condition imposed by standard synchronous stabilized Benders' decomposition schemes, allowing subproblems to be solved asynchronously and in parallel with the two master problems. By exploiting partial subproblem information without waiting for a fully synchronized iteration, the proposed approach reduces idle time and improves high-performance computing resource utilization.

2 - Accelerating energy system optimization on GPUs
Benoît Legat

As energy system models grow in scale and complexity, exploiting domain-specific structure is critical for computational efficiency. This presentation highlights recent open-source advancements within the JuMP ecosystem that enable native GPU acceleration for large-scale energy system optimization. We will introduce GenOpt, a framework that allows practitioners to explicitly represent algebraic constraints as block structures that GPUs can directly exploit. We explore two approaches that leverages these blocks to accelerate automatic differentiation (AD): ExaModels, which evaluates constraints

3 - Risk-aware decision for emerging hydrogen markets using ADMM
Stefan Strömer, Kenneth Bruninx, Stefan Pfenninger

Clean hydrogen is central to decarbonizing industry, peak power, and seasonal storage, yet deployment remains limited. Traditional optimization models miss key market and regulatory constraints. This work applies an MCP-based hydrogen market and infrastructure model with an ADMM-inspired algorithm to study transition pathways across sectors, including price elasticity, regulation, risk, and supply choices. It examines how policy and market conditions shape investment, contracting, and uptake in Austria's H2REAL hydrogen valley.

4 - Industrializing Large-Scale Gas Distribution Optimization
Guillaume Marques

Optimizing the operation of a national gas distribution network (207,000 km of pipelines, 11 million delivery points) yields a nonconvex MINLP that no off-the-shelf solver can handle. This talk reports on an industrialized solution approach that separates the configuration variables from the physical simulation.

I will discuss the engineering choices behind the production pipeline, draw connections to the open-source Julia/JuMP ecosystem, and give some practical directions for making general-purpose decomposition tools more adoptable in industrial settings.

■ ME-53

Monday, 14:15-15:45 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Multiobjective Graph and Network Optimization

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Michael Stiglmayr*
Chair: *David Könen*

1 - On the Multiobjective Temporal Shortest Path Problem
Edina Marica, Clemens Thielen, Alina Wittmann

In this talk, we study a generalization of the classical shortest path problem to temporal graphs and multiple objectives. We first consider instances with isotonic objective functions, which preserve the ordering of path values when extended by the same arc, and then extend our analysis to cases with general objective functions. We discuss how the multiobjective temporal shortest path problem can be addressed using label correcting algorithms and highlight the challenges arising from the temporal nature of the graphs and the generality of the objectives.

2 - Supported Nondominated Points as a Representation for Multi-Objective Network Optimization Problems
David Könen, Michael Stiglmayr, Kathrin Klamroth, Lara Löhken

Finding nonsupported points Y_N in multi-objective combinatorial optimization is costly. This talk evaluates the quality of using supported Y_S and extreme supported Y_ES points as representations instead. Y_ES provides high-quality representations for binary problems but fails as network arc capacities increase. Conversly, Y_S consistently maintains high representation quality with a near-optimal hypervolume indicator. Furhermore, small subsets directly choosen from Y_S or Y_ES give decision-makers high-quality representations, bypassing the computationally expensive generation of Y_N.

3 - The Bi-Objective Minimum st-Cut Problem With Binary Capacities
Oliver Bachtler, Jan Boeckmann, Stephan Helfrich, Stefan Ruzika, Clemens Thielen

The minimum st-cut problem is known not to have a multi-objective fully polynomial-time approximation scheme (MFPTAS) unless P=NP. This holds both for the case of at least three objectives with binary capacities and for two objectives with general capacities. We strengthen these results by showing that this remains true for two objectives and capacities in (1,0),(0,1) or in (0,1),(1,1). We show that, on graphs of bounded tree-width, the problem with polynomially bounded capacities can be solved exactly in polynomial time for any constant number of objectives.

4 - Computing Safe Routes to School
Michael Stiglmayr, Rabea Freese, Kathrin Klamroth, Julia Sudhoff, Chiara Weuste

The inclusion of safety aspects in route planning raises new demands on optimization, as safety is often measured in categories. Thus, we obtain an ordinal shortest path problem. It is known that ordinal optimization problems can be represented by a vector optimization problem, which can be (linearly) transformed into a standard multi-objective optimization problem. Based on a safety assessment in up to 16 categories we use the k-shortest path algorithm and an adapted filtering to compute practically relevant, non-dominated paths to school.

■ ME-57

Monday, 14:15-15:45 - Room: HG - Seminar-Raum 07 (Building: HG)

OR Education 2

Stream: OR Education
Invited session
Chair: *Arne Heinold*
Chair: *Anna Collins*

1 - Friday Night at the ER: Gamifying OR/MS Education
Houra Mahmoudzadeh, Peter Vanberkel, Gizem Koca

In this talk, we discuss how we used the Friday Night at the ER' game to teach OR/MS concepts and compare its use across engineering courses, professional master's programs, and healthcare leadership workshops. We describe how we connect the gameplay experience to optimization, simulation, queuing, analytics, and AI, and highlight differences in how different audiences engaged with the game. We also share lessons learned, common pitfalls, strategies for successful implementation, and insights on adapting the activity for varied learning goals.

2 - Using AI to Evaluate Student Discussion in Operations Management
Ken Murphy

This presentation describes the use of AI to evaluate small group discussion in an Executive MBA Operations Management course. After providing context on the class, we outline the process of developing and delivering a lean management case study in synchronous, but instructor-less, mode via the Breakout Learning platform. We share instructor experience, student feedback, and insights with respect to the benefits of this tool, both in this setting and for case-based discussion in general.

3 - Enhancing Mathematical Modeling in Optimization Education: A Socratic AI Tutoring Approach
Pablo González-Brevis, Cristian Palma, Loredana Riquelme

Mathematical modeling is a core competency in Operations Research education, yet students often struggle to translate real-world situations into formal models. This work presents the design and implementation of a problem-based learning strategy supported by a Socratic AI tutor that guides students through structured questions rather than direct solutions. The intervention is implemented in undergraduate optimization courses and examines the tutor's usability and its potential contribution to improving students' mathematical modeling skills.

4 - Brewing Better Decisions: Gamification as a Gateway to Optimization with Gurobean
Anna Collins, Larry Snyder, Lindsay Montanari

Gurobean is an interactive educational game designed to introduce core operations research concepts through a simulated coffee shop. Players make operational decisions involving inventory, pricing, and service capacity under stochastic demand. Progressive rounds expose learners to feasibility, nonlinear trade-offs, queueing effects, and simulation-based optimization. Developed by Gurobi Optimization and Larry Snyder, Gurobean demonstrates how gamification can support experiential learning in OR education.

■ ME-58

Monday, 14:15-15:45 - Room: HG - Seminar-Raum 08 (Building: HG)

Production and Inventory Management

Stream: Integrated Planning in Manufacturing
Invited session
Chair: *Margaretha Gansterer*
Chair: *Mario Allmann*

1 - Inventory Management for Plant-Protein Products with Shared Raw Material and Substitution
Daniel Postică, Martin Grunow

Current plant-protein production discards 20-40% of the protein content in the form of a high-moisture solution. With novel processing technology, this waste stream can be processed to obtain either powdered or liquid products. Powders are more expensive to produce but have lower storage costs and a longer shelf life. Both products exhibit uncertain demands. Powders can fulfill demand for liquid products if a discount is provided. We model the problem as an MDP and determine a replenishment policy.

2 - Bridging Forecasting and Control: A Hybrid Mechanism for Replenishment Parameterization under Demand Opacity
Mario Allmann, Margaretha Gansterer, Holger Roschk

We develop a hybrid replenishment mechanism that translates operational proxy signals into executable control parameters when explicit consumption data are unavailable. Using 309,519 closed purchase orders from a global electronics manufacturer, reorder points and safety stocks are derived from order frequencies and lead-time variability within a classical ROP framework. Focusing on 200 high-runner items, we compare the mechanism with standard heuristics across service levels. The contribution is a transparent, ERP-ready mechanism linking proxy-based inference to replenishment control.

3 - Cost-Aware Learning for a Data Driven Newsvendor Problem with Features
Elvan Durdu, Fikri Karaesmen, Mustafa Baydoğan

The Newsvendor problem requires optimal decisions under demand uncertainty. Traditional ML models often minimize statistical errors, which may lead to suboptimal results when costs are asymmetric. In this study, we shift to a decision-focused learning framework by

proposing a cost-aware Random Forest. Unlike standard trees, our approach utilizes a custom splitting criterion that minimizes weighted operational costs directly. Experiments show our model yields competitive performance, exhibiting particular strength in scenarios with high cost asymmetry.

4 - Optimal production and inventory rationing of an assembly system with heterogeneous demands
Jianxin Fang

We examine the production and inventory control problem in an assembly system facing heterogeneous demands. In specific, we assume demands consist of a single lost-sales and multiple backorder classes, arriving according to Poisson processes. In this system, decision maker must determine, at each state, whether to produce components, whether to fulfill an order. To characterize the structure of the optimal policy, we show that the value function preserves the L-natural convexity. We also compare the optimal policy with heuristics through extensive numerical experiments.

■ ME-59

Monday, 14:15-15:45 - Room: KOL - Seminar-Raum 9 (Building: KOL)

Group decision MCDM

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Luqi Wang*

1 - Trust-Based Calibration for Dual-Layer Optimization in Renewable Energy Decision-Making
Luqi Wang, *Yuanxiang Dong*, *Jingyu Lv*, *Hangyang Li*, *Shuning Pan*

To address conflicts between investor preferences and algorithmic recommendations in renewable energy planning, this paper proposes a two-layer optimization framework for mutual trust calibration. The upper layer aligns AI confidence with investor judgments, while the lower layer employs interactive regression to resolve cognitive conflicts. Wind-solar portfolio planning demonstrates that this mechanism accelerates consensus formation, mitigates algorithm aversion and automation bias, and provides decision support for integrating human values with models in sustainable energy transitions.

2 - Group decision support for fluvial flood adaptation using MCDA: a Montreal case study
Melanie McGrory, *Francis Marleau Donais*, *Jean-Luc Martel*, *Magalie Gravel*, *Simon Gervais*

Developing flood adaptation strategies for riverfront neighborhoods requires decision processes integrating multiple criteria, institutions, and stakeholder perspectives. This study proposes a group decision-support framework using the MCDA method MACBETH to structure and evaluate adaptation strategies. Scenarios including floodwalls, renaturalization with property relocation, hybrid solutions, building adaptation, and status quo are assessed across 21 criteria. The framework was applied in Montreal through participatory workshops with over 40 professionals and a citizen consultation.

3 - A Two-Tiered Human-Machine Consensus Mechanism for Sustainable Healthcare: A Case Study of Emergency Group Decision-Making in Traditional Chinese Medicine
Luqi Wang, *Yuanxiang Dong*, *Jingyu Lv*, *Hangyang Li*, *Shuning Pan*

Addressing human-machine trust in emergency group decision-making, we propose a two-tiered dynamic mutual trust and preference alignment framework: the upper tier quantifies cognitive discrepancies via a preference consistency metric; the lower tier uses interactive ordered regression with experts' overall rankings to reverse-engineer and resolve criterion weight discrepancies. A TCM emergency case shows this mechanism integrates data-driven and multi-school expert prior knowledge, offering a new paradigm for sustainable medical consensus.

4 - Multi-Criteria Decision-Making in Networked Environments
Yu-wang Chen, *Tao Wen*, *Ting Wu*

This research develops a framework for analyzing decision-making and behavior in networked environments. It examines how individual decision makers implicitly form their initial beliefs within a multi-criteria decision-making paradigm, interact with others, and exchange information, leading to dynamic belief updating, which ultimately shapes group opinion dynamics and influences decision-making outcomes across the network. The framework also has the potential to be extended to heterogeneous networks that include both human and AI agents for collaborative decision-making.

■ ME-61

Monday, 14:15-15:45 - Room: KOL - Seminar-Raum 18 (Building: KOL)

Scouting in Football: Bridging Theory and Practice

Stream: OR in Sports
Invited session
Chair: *Denis Saure*
Chair: *Mario Guajardo*

1 - A Large Football Model for Scouting in Football
Denis Saure, *Sebastian Rios*, *Alejandro Baeza*

We develop a data-driven framework to evaluate football player transfers using event-level match data. Sequences of on-ball actions are modelled with transformer-based architectures trained to learn the temporal and contextual structure of play. The trained models are used to simulate full match trajectories under counterfactual transfer scenarios, enabling the estimation of player-specific impacts on team-level outcomes such as goal difference, win probability, and possession dynamics. The approach provides a scalable tool for transfer valuation and decision support in professional football.

2 - Multi-Season Football Squad Planning Using Predictive Modeling and Mixed-Integer Programming
Pablo Galaz

This study addresses a central management problem in professional football clubs: how to build competitive and financially sustainable squads over multiple seasons. It proposes an integrated framework that combines predictive modeling with mixed-integer programming. The approach forecasts future player performance and economic value, then supports recruitment, retention, and release decisions under budget, positional, age, and regulatory constraints. The framework is data-agnostic and can be implemented with event, scouting, market, or synthetic data.

3 - Match scheduling and travel distances in the FIFA World Cup and the UEFA Euro
Mario Guajardo

In many sport tournaments, teams are divided into groups that determine the matches of a first stage. This first stage often consists of a single round robin tournament within each group. This paper defines a match scheduling problem for this type of tournament, and formulates it as a multi-league scheduling model with multiple shared venues and other practical features. The model is applied to assess the schedules of the FIFA World Cup and the UEFA Euro, with particular focus on the minimization of distances.

4 - Spatio-Temporal Machine Learning Models for Player Evaluation and Opponent Analysis: A Case Study at Racing Santander
Manuel Pablo Duran, Guillermo Durán, Andrés Farall

This work presents the application of Machine Learning and Data Science methods to support decision making in professional football at Racing Santander. Using large-scale event and tracking data, we model player performance, scouting potential, and opponent behavior. By incorporating spatial information, off-ball movement and team structure, the models capture tactical dynamics and quantify the impact of players' off-ball actions, such as runs, positional rotations and defensive attraction, enabling more robust player evaluation, opponent analysis, and recruitment strategies.

■ ME-65

Monday, 14:15-15:45 - Room: HG - Hörsaal 27 (Building: HG)

Machine Learning in Finance: Interpretability, Risk, and Model Selection

Stream: Analytics
Invited session
Chair: *Yujia Chen*

1 - Semantic Serialization for Rapid Response: A Few-Shot GenAI Framework for Risk Detection in Decentralised Finance
Xingjie Wei

ICOs are a key form of decentralised crowdfunding, yet weak regulation has led to major losses from risky projects. Detecting such risks poses challenges: scarce labelled data, missing values, high-cardinality features, and heterogeneous data. We propose a novel LLM-based approach for ICO misconduct detection in few-shot settings, converting heterogeneous data into natural-language profiles and fine-tuning foundation models for classification. This handles data heterogeneity, preserves information despite missing values, and leverages pre-trained knowledge to offset limited examples.

2 - The Challenger: When Do New Data Sources Justify Switching Machine Learning Models?
Sébastien Saurin

We study the problem of deciding whether and when an organization should replace a trained incumbent model with a challenger using newly available features. We develop a unified economic and statistical framework linking learning-curve dynamics, data-acquisition and retraining costs, and discounting of future gains. We characterize the optimal switching time in stylized settings and show how horizon length, learning curve curvature, and costs shape the decision. We then propose practical algorithms with finite-sample guarantees and demonstrate their performance in a credit-scoring application.

3 - Interpretable Deep Survival Analysis via Group-Ensemble Networks
Yujia Chen

Deep survival models offer strong predictive power but limited interpretability. We propose a Group-Ensemble Survival Network that partitions covariates into meaningful groups, extracts within-group nonlinearities via dedicated sub-networks, and combines group representations through a sparse interaction layer preserving cross-group dependencies. The model outputs a discrete-time survival distribution and enables time-varying group-level interpretation via learned interaction weights and time-specific gradients. Experiments on credit risk data show competitive accuracy.

■ ME-66

Monday, 14:15-15:45 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Execution of Combinatorial Optimization Algorithms on Quantum Devices

Stream: Quantum Optimization
Invited session
Chair: *Daniel Egger*

1 - Parity Twine Optimizer-function
Josua Unger

Hybrid quantum algorithms are a promising route to enable quantum utility for optimization problems on the latest IBM QPUs but two qubit gate count and depth remain limiting factors. Parity Twine compilation tackles this problem and implements non-local interactions by making use of the underlying hardware connectivity. We present the Parity Twine Optimizer-function, based on this compilation, which allows users to submit optimization problems and handles the hybrid quantum algorithm, execution management at IBM QPUs and post processing. We perform benchmarks for two classically hard problems.

2 - Quantum Optimization for Benchmarking Quantum Processors Capabilities
Alejandro Montanez

Quantum computers have surpassed classical simulation limits, yet noise still restricts their utility. Benchmarking at scale remains challenging since exact simulation is no longer feasible. We present a benchmarking approach based on LR-QAOA, enabling a scalable evaluation of quantum hardware. By analyzing performance as circuit depth increases, our method captures hardware limitations and the interplay between noise and optimization. We extend this protocol to study quantum error correction (QEC) primitives, focusing on mid-circuit measurements and QEC codes structure.

3 - The Quest for Quantum Advantage in Combinatorial Optimization
Narendra Hegade

Understanding quantum advantage in combinatorial optimization requires moving beyond isolated algorithmic comparisons to full workflow benchmarking under realistic runtime conditions. This talk presents a practical assessment of a hybrid quantum-classical approach on current hardware, showing that meaningful system-level competitiveness is already emerging on selected problems, while also clarifying the regimes where advanced classical methods remain strongest.

4 - Executing quantum approximate optimization on superconducting qubits
Daniel Egger

Quantum computers can tackle combinatorial optimization problems by mapping them to ground state problems of Ising Hamiltonians. The candidate solutions are obtained by sampling from a quantum state. In this talk I will review the different steps to execute combinatorial optimization on superconducting quantum hardware which includes mapping optimization problems to a quantum formulation, preparing the quantum circuits for hardware execution, setting any variational parameters, and optionally post-processing the quantum samples.

Monday, 16:15-17:45

■ MF-01

Monday, 16:15-17:45 - Room: HG - Audimax

ROADEF/EURO Challenge

Stream: Special Sessions
Award Competition session
Chair: *David Savourey*

1 - ROADEF/EURO Challenge 2026
David Savourey

The French Operational Research and Decision Support Society (ROADEF) organizes jointly with EURO the ROADEF/EURO challenge 2026. This year the subject is dedicated to "Network Flow optimization" in collaboration with Orange Group, one of the world's leading telecommunications company. The goal of this challenge is to design an optimization algorithm that, given a network and a traffic matrix, computes a routing scheme that maintains acceptable network load, even in scenarios of network equipment unavailability. During this presentation, we will describe competition rules, the optimization problem with its industrial context and constraints. We will also answer questions from the audience. An overall amount of 35.000 EUR will be distributed to the best contributions during the competition. Registration is possible until September, 12th 2026.

■ MF-03

Monday, 16:15-17:45 - Room: HG - Hörsaal 33 (Building: HG)

OR in Forestry I

Stream: OR in Forestry
Invited session
Chair: *Taraneh Sowlati*

1 - MIP-based approaches in wildfire suppression
Filipe Alvelos

We present mixed-integer programming models to address wildfire suppression problems. The models rely on network representations of fire spread and the movement and attacks of firefighting resources. We describe how these networks and their interactions can be used to model different aspects of fire suppression (safety issues, direct and indirect attacks, and different operational objectives). We also provide an overview of how fire behaviour models are used and discuss implementation issues.

2 - Optimization of Aerial Wildfire Suppression under Uncertain Fire Spread
Erdi Dasdemir, Bismark Singh

We study aerial wildfire initial attack as a two-stage stochastic routing and scheduling problem under uncertain fire spread. Aerial vehicles are assigned and routed to emerging ignitions whose growth and propagation depend on stochastic environmental conditions and intervention timing. The objective is to maximize preserved value through timely suppression. We develop an exact stochastic optimization model and a hybrid genetic algorithm with simulation-based fitness, plan-aware pruning, and greedy seeding. Results show the GA closely matches optimal solutions while running much faster.

3 - Impact of governmental policies on the optimum design of the forest-based biomass to bioproducts supply chain
Taraneh Sowlati

The focus of this research is on using harvesting residues for bioproducts production and optimizing its supply chain. Previous studies have optimized biomass supply chains to reduce the delivered cost of feedstock, address uncertainties in supply availability and quality, and evaluate the effectiveness of government policies. However, most previous optimization studies considering governmental policies focused only on a single policy, particularly carbon pricing policies, and did not address uncertainty in those policies. This research addresses these gaps.

■ MF-04

Monday, 16:15-17:45 - Room: HG - BIG-Hörsaal (Building: HG)

Machine learning and decision support in healthcare

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Igor Tona Peres*

1 - Data-Driven Planning in Danish Emergency Departments
Cornelius Hasselris, Jens Brunner

Danish emergency departments operate under an appointment-based system where less acute patients call a regional hotline and are scheduled into time slots. We propose a two-phase framework for data-driven slot allocation. First, a gradient boosting model predicts patient length-of-stay from pre-triage information available at booking. Second, a decision support algorithm uses these predictions to dynamically assign patients to appointment slots. We develop and evaluate the framework using 71,000 patient contacts from a Danish hospital, and present some preliminary computational results.

2 - Surgical Case Planning with Two Types of Uncertainty
David Ajit Kirpekar-Sauer, Pieter Smet, Jens Brunner

We address the elective surgery scheduling problem with uncertain surgery durations and anesthesiologist availability. Simulating ML-based prediction of the uncertain parameters, we analyze the impact of the prediction error on the rescheduling costs. We perform daily rescheduling with three different rescheduling policies restoring feasibility through patient cancellations, postponements, or resource changes. For instances based on real-world data from Danish hospitals, we consider the interplay of the uncertainties.

3 - Forecasting patient pathways and hospital occupancy via Markov chains and artificial intelligence
Edilson Arruda, Bruno Salezze Vieira, Carlos Lamas-Fernandez, Christine Currie, Alexandra Hogan, Mark Wright

We propose personalised semi-Markov models to describe trajectories of inpatient hospital spells. For each spell, a customised semi-Markov model is obtained via machine learning as a function of the patient's attributes, such as demographics, diagnosis, etc. Predicted patient spells for existing and incoming patients are then aggregated to forecast hospital occupancy levels for the next two weeks. The model was validated with data from 2 years of operation of two NHS Trusts in the South of the UK, consistently predicting 14-day occupancy with an error rate between 5 and 10% for each Trust.

4 - SLOS: An R Package for Machine Learning-Based ICU Length-of-Stay Prediction and Benchmarking
Igor Tona Peres, Joana da Matta Furtado Ferreira

Efficient ICU management requires risk-adjusted metrics for resource use. We present a data-driven framework to predict ICU length of stay and assess efficiency using the Standardized Length of Stay Ratio, implemented in the R package SLOS. The model uses admission data from the first 24 hours and a stacking machine-learning approach.

Training included 99,492 ICU admissions from 109 ICUs in 38 Brazilian hospitals (2019), with external validation in 93 ICUs from 55 hospitals. Subgroup validation was performed in severe community-acquired pneumonia, supporting risk-adjusted ICU benchmarking.

■ MF-05

Monday, 16:15-17:45 - Room: JUR - Hörsaal 18 (Building: JUR)

Shared Autonomous Vehicles 1

Stream: Shared Mobility
Invited session
Chair: *Jakob Puchinger*
Chair: *Yue Su*

1 - Uncertainty-Aware Ride-Sharing Control
Negin Alisoltani

This paper presents an uncertainty-aware framework for ride-sharing operations that links probabilistic OD demand forecasting with scenario-based model predictive control. Using Chicago taxi data, the proposed method generates calibrated 15-minute demand distributions and converts them into scenarios for dispatching, ride-pooling, and vehicle rebalancing. Compared with point-forecast MPC and FIFO heuristics, the proposed approach improves service rate and passenger-kilometres while reducing waiting time, total VKT, and empty mileage under real-time operational constraints.

2 - Machine Learning-Based Search Space Pruning for the Electric Autonomous Dial-A-Ride Problem
Maria Bresich, Günther Raidl, Caspian Coleman, Pascal Welke, Steffen Limmer

We present a machine learning approach to improve the scalability of a state-of-the-art metaheuristic for the electric autonomous dial-a-ride problem. We explore graph sparsening techniques using support vector machines, gradient boosted trees, and a k-nearest neighbor heuristic to prune the search space by predicting and removing arcs unlikely to appear in good solutions. On very large-scale instances with up to 5200 requests, a performance boost of a large neighborhood search of up to 2.5% is achieved. We also uncover challenges, a fundamental limitation, and benefits of this approach.

3 - A Unified Optimization Model for Cross-Regional Dispatching of Shared Autonomous Electric Vehicles
Yiheng Zhou, Qianli Ma, Zhihao Zhu, Baiyu Ma

The operation of shared autonomous electric vehicle systems is challenging in real urban environments because dispatching decisions must simultaneously account for spatially imbalanced demand, battery limitations, and carpooling feasibility, which together increase the complexity of the problem. The aim of this paper is to present an integrated optimization framework for cross regional dispatching. The proposed model is applied to a real world case study, and the results show that it improves passenger service and fleet utilization while maintaining practical operational efficiency.

4 - A Hybrid Machine Learning and Optimization Framework for the Dynamic Electric Dial-a-Ride Problem
Léa Ricard, Yue Su

We study a dynamic electric dial-a-ride problem (E-ADARP) where autonomous electric vehicles serve ride requests revealed in real time. The system is modeled on an event-activity graph capturing routing, scheduling, capacity, and charging constraints. Decisions are updated at discrete epochs as new requests arrive. We propose a hybrid framework combining machine learning with combinatorial optimization: a predictive model estimates request values while a price-collecting E-ADARP determines routing and assignment decisions. The approach enables anticipatory decision-making and scalable optimiza

■ MF-06

Monday, 16:15-17:45 - Room: HG - Hörsaal 07 (Building: HG)

Transportation and Logistics Operations in Retail

Stream: Retail Operations
Invited session
Chair: *Florian Cramer*

1 - Solving a multi-trip, split-delivery Vehicle Routing Problem with non-simultaneity of service and vehicle compatibility: an Italian case study.
Giusy Macrina, Luigi Di Puglia Pugliese, Francesca Guerriero

In this work, we address a real-world vehicle routing problem arising in the distribution operations of an Italian retail company. Each customer order consists of multiple product categories, each requiring a specific delivery time window. Customers may need multiple visits, but service operations cannot occur simultaneously. We model the problem as a multi-trip VRP with a heterogeneous fleet, split deliveries and vehicle compatibility. We propose an integrated routing and scheduling approach tested on real instances that solves daily planning problems in a few minutes.

2 - Periodic delivery planning for grocery retail stores with time constraints
Heinrich Kuhn, Jean-Bertrand Gauthier, Stefan Voigt, Andreas Holzapfel

Persistent driver shortage in European grocery distribution requires structural changes to delivery planning and fleet utilization. This study investigates the integrated determination of weekly delivery patterns for grocery retail stores and the associated daily route planning from a single distribution center operating a heterogeneous fleet of multi-compartment vehicles. The problem is characterized by multiple temperature classes (ambient, chilled, frozen), store- and segment-specific time windows, admissible delivery patterns, vehicle restrictions, and legal limits on driving hours.

3 - Extending freshness - optimizing micro-hub and EV logistics beyond urban boundaries: a case study in food retail
Alexandra Anderluh

Delivering fresh food from central warehouses reduces freshness, increases in-store workload, and raises environmental impacts. This study examines whether an urban pilot of twice-daily deliveries of very fresh products can be scaled to suburban and rural areas. Using a hub-and-spoke concept with micro-hubs and electric vehicles, we apply hub-location optimization, EV-constrained routing, and multi-criteria impact assessment to identify feasible hubs, fleet sizes, and system effects for a sustainable regional logistics model.

4 - Optimizing Freight Distribution in a Retailer's Network Through Sponsored Search Advertising
Faten Afandi, Chefi Triki

This study integrates transportation optimization with sponsored search advertising to improve freight distribution in retail networks. A multi-objective model minimizes distance and truck underutilization while maximizing advertising-driven sales. An adaptive NSGA-III algorithm generates Pareto-efficient solutions under demand uncertainty. Results from real data show improved vehicle utilization, computational efficiency, and coordinated logistics-marketing decisions, demonstrating the value of advanced OR methods in retail operations.

■ MF-07

Monday, 16:15-17:45 - Room: HG - Hörsaal 21 (Building: HG)

Robustness in Market Design

Stream: Auctions and Market Design
Invited session
Chair: *Bernhard Kasberger*
Chair: *Simon Finster*

1 - Moment equilibrium
Bernhard Kasberger

We introduce moment equilibrium for games in which players observe only coarse statistics of opponents' actions. Players best respond to moment-based belief sets, and equilibrium requires these moments to match play. We prove existence in finite normal-form games with incomplete information, characterize when the concept nests or reproduces Bayes–Nash behavior, and study how refinement and learning affect stability.

2 - A "Non-Guessing" Theory for How to Process Information
Karl Schlag

We introduce a new theory for how to use information when making choices under uncertainty. The postulated objective is to outperform a given mixed action in the unknown underlying state. A Bayesian typically does not have this property as they act as if the underlying state has been drawn from their prior and do not care that they might do badly in the true state. It is as if a Bayesian guesses the true underlying state. We show how this relates to informativeness, hypothesis testing and provide new insights on how to make choices based on data.

3 - Ambiguous Bid Evaluation
Kyle Woodward, Justin Burkett

Procurement auctions often require bids across multiple dimensions, such as price and quality, which evaluated via a composite score that reduces these dimensions to a scalar. In practice, scoring functions are rarely fully specified. We study competitive procurement auctions in which bidders face ambiguity about the scoring rule ultimately applied. Intuitively, ambiguity might benefit the procurer by inducing anxious bidders to strengthen their bids. We show, however, that the procurer never gains from ambiguity — and is strictly better off committing to a well-specified scoring rule.

4 - Dependence Uncertainty
Gerrit Bauch

We consider robust decision-making when marginal distributions are known, but dependency is uncertain. We first provide an additive decomposition of a probability measure into the independent product of its marginals and its underlying dependence structure and identify extreme points as exactly the local maxima of divergences. Second, we axiomatically characterize preferences over dependence, providing comparative statics and making phenomena such as correlation neglect testable. Examples of applications include portfolio choice, insurance, and climate change. Joint work with Lorenz Hartmann.

■ MF-08

Monday, 16:15-17:45 - Room: HG - Hörsaal 41 (Building: HG)

Location under Uncertainty

Stream: Location Analysis
Invited session
Chair: *Okan Dukkanci*

1 - The deployment of charging stations in urban areas under stochastic demand
Aleksandra Colovic, Mario Marinelli, Michele Ottomanelli

Electric vehicles have been receiving increasing attention in the global market, but new strategies for optimal charging infrastructure deployment are still needed. To this aim, a two-stage stochastic programming model is proposed to determine locations of charging stations by minimizing investments and maximizing potential revenues under stochastic demand. The results show its potential to support strategic charging deployment and to prevent excessive concentration of charging stations in certain areas by mitigating their inefficient utilization, and higher operational costs for providers.

2 - The Impact of Process Flexibility on Reliable Modular Production Networks
Lea Raubuch, Stefan Lier, Tristan Becker

The modular production paradigm offers new flexibility to address the volatility and uncertainty production networks face today. This flexibility enables short-term adjustments of facility processes and capacities. To ensure reliability, module breakdowns should be considered during location planning. We propose a two-stage stochastic program which extends the capacitated reliable facility location problem to multiple heterogeneous modules per facility where each product requires processing on a subset of modules. Further, modules can be relocated between facilities in response to breakdowns.

3 - Overflow-aware recycling bin location with random utilities
Gonzalo Mendez-Vogel, Sebastián Dávila, Pedro Jara, Jorge Zamorano

Recycling bins often overflow in dense areas, triggering "micro-landfills" when residents leave glass beside full bins. We propose an overflow-aware, lexicographic model that integrates a multinomial logit user choice rule and the option not to recycle: first, maximize expected glass recycled (inside bins), then minimize expected overflow. A real case study in Chile shows how the model redistributes recycling bins around demand hotspots and highlights overflow risk at specific locations, showing how explicit overflow modeling can change location patterns.

4 - A truck-drone delivery problem with location and routing decisions under uncertainty
Okan Dukkanci

This talk will present a new truck-drone delivery problem with location and routing decisions under uncertainty. Trucks with drones on board are routed between parking lots, from which drones make deliveries to stores. The problem decides parking lot locations, truck routes, and store assignments. The problem aims to minimize the total transportation cost and to satisfy payload capacity, drone range and time windows. The problem is modeled as a two-stage stochastic program and solved by a scenario decomposition algorithm. The talk will present results over two different real-life data sets.

■ MF-09

Monday, 16:15-17:45 - Room: HG - Hörsaal 50 (Building: HG)

Optimization and Machine Learning: Methodological Advances

Stream: Data Science meets Optimization
Invited session
Chair: *Antonio Forno*
Chair: *Michael Römer*

1 - Feature-Wise Adaptive Missing Data Imputation via Simulated Annealing for Machine Learning Tasks
Saied Farham-Nia

Incomplete data remains a major challenge in data-driven analytics. Most missing value imputation methods apply a single strategy across all features, ignoring feature heterogeneity and model interactions. We propose an automated and systematic framework that uses metaheuristic to assign optimal imputation methods to each individual features for a given predictive task. Experiments on six benchmark datasets for regression and classification show consistent and statistically significant improvements over strong baselines, demonstrating robustness, scalability, and task generalizability.

2 - A Machine Learning-Assisted Genetic Algorithm for Solving the Vehicle Routing Problem with Stochastic Demand
Ming-Jong Yao, Fong Wang

The Vehicle Routing Problem with Stochastic Demand (VRPSD) is often solved using genetic algorithms (GAs) combined with Monte Carlo simulations (MCS), known as GA+MCS. However, this method can be time-consuming. We propose a three-phase framework, GA+MCS+ML, integrating machine learning (ML) to replace MCS within the GA. Our experiments show that for instances with 20 and 60 customers, GA+MCS+ML performs worse than GA+MCS in runtime or solution quality. However, for 100-customer instances, both methods achieve similar solution quality, while GA+MCS+ML improves solution time by over 13.14%.

3 - A Two-Level Mixture-of-Experts Model for Regime-Adaptive Financial Forecasting and Trading Strategy
Aivaras Bielskis

Study proposes a two-level Mixture-of-Experts (MoE) model for financial time series forecasting, designed to address non-stationarity and regime shifts. At the internal level, LSTM, GRU, and attention-based experts are dynamically weighted via a gating network. At the external level, regime similarity weighting combines models specialized for different market periods. Macroeconomic events (CPI, FOMC, labor reports) are incorporated as regime signals. The framework integrates technical features and supports both accurate forecasting and the development of trading strategies.

4 - AI-Driven Design Optimization: Integrating LLMs with Simulated Annealing
Antonio Forno, Paulo Nascimento, Carlos Henggeler Antunes, Samuel Moniz

This work demonstrates how a Large Language Model can generate valid, optimized CAD geometries from task specifications, addressing constraint handling - one of AI's hardest manufacturing challenges. A hybrid two-phase framework is proposed: first, the LLM generates and stabilizes a parametric design; second, geometric exploration is delegated to a Simulated Annealing optimizer that searches the design space under explicit engineering constraints, while the LLM supervises by adapting search parameters and objective priorities to steer convergence toward optimized solutions.

■ MF-10

Monday, 16:15-17:45 - Room: HG - Hörsaal 31 (Building: HG)

Graph Theory and Combinatorial Optimization II

Stream: Combinatorial Optimization
Invited session
Chair: *Yukun Cheng*
Chair: *Shengjie Chen*

1 - The Application of Graph Theory Methods in Coding
Zicheng Ye, Guiying Yan

The Gilbert-Varshamov (GV) bound is a celebrated lower bound on the maximum number of codewords for a given code length and minimum distance. We formulate this problem in terms of the independence number of the Gilbert graph and introduce improvements to the GV bound based on graph-theoretic methods. Furthermore, we introduce an approach based on coset graphs together with the Alon-Boppana theorem to derive an upper bound on the maximum number of codewords. In addition, we discuss the connections between the Erdős-Ko-Rado theorem and the maximum code and anticode problem.

2 - Two extremal problems in uniform hypergraphs
Tong Li

In this talk, I will report some recent progress on two extremal problems in uniform hypergraphs. In the first part, we consider the rainbow Turán problem raised by Keevash, Mubayi, Sudakov and Verstraëte in 2007 and study the rainbow Turán number for hypergraph matchings and paths. In the second part, we consider the anti-Ramsey problem raised by Erdős, Simonovits and Sós in 1975 and determine the anti-Ramsey number for some classical hypergraphs such as paths and cycles. These results are based on joint work with Hao Huang, Yucong Tang, Guanghui Wang, Guiying Yan and Wenling Zhou.

3 - Valid Inequalities for the Beta-Edge Disruptor Problem
Shengjie Chen

The beta-edge disruptor problem seeks a minimum-weight set of edges whose removal ensures a specified connectivity degradation in a graph. This NP-hard problem is crucial for network vulnerability assessment. In this talk, we develop an efficient algorithm for solving its integer programming model exactly. Using the mixing technique, we derive a family of mixing inequalities. We also introduce the concept of cover for this problem, propose cover inequalities, and strengthen them via sequential lifting. Computational results demonstrate the effectiveness of our approach.

■ MF-11

Monday, 16:15-17:45 - Room: HG - Hörsaal 32 (Building: HG)

Vehicle Routing I

Stream: Combinatorial Optimization
Invited session
Chair: *Luis Gouveia*

1 - An Integrated MILP Framework for Time-Dependent Vehicle Routing with Emissions and Theft Risk
Daniel Morillo-Torres

This paper presents an integrated Vehicle Routing Problem that jointly considers time-dependent travel times, pollutant emissions, and theft risk. A mixed-integer linear programming formulation is proposed to capture realistic operational, environmental, and security-related factors while preserving solvability. A hierarchical multi-objective approach is employed to prioritize conflicting objectives. Results show that integrated modeling significantly influences routing decisions, emphasizing the importance of jointly addressing efficiency, sustainability, and risk in real logistics planning.

2 - Exact and Heuristic Solutions for a Military Airlift Planning Problem
Robert Dell, Arvind Rathore

We present a novel vehicle routing problem for military airlift planning. Problem characteristics include a heterogeneous fleet of aircraft operating from multiple airfields, multiple cargo types, multiple pickup and delivery airfields, and time windows for deliveries over a multiple day time horizon. We present both exact and heuristic computation experience for realistic airlift planning problems.

3 - New valid inequalities and projection results for the Hamiltonian p-Median problem
Francisco Canas, Luis Gouveia

Given an edge-weighted undirected graph G = (V,E) and an integer p, we consider the problem of determining the minimum total cost set of at least p node-disjoint cycles spanning all nodes of the graph. We study extended formulations with tight LP relaxations, along with the projections of their sets of feasible solutions onto lower dimensional subspaces. Projection results relating these formulations with other formulations defined using the natural variables are presented, and new effective valid inequalities are obtained.

4 - Cyclic Exchange Heuristics for the Hamiltonian P-Median Problem
Gonçalo Cunha, Luis Gouveia, Francisco Canas

Given a positive integer p and a weighted undirected graph G=(V,E), we study a problem in which the objective is to find a minimum weight set of p elementary cycles partitioning the vertices of G known as the Hamiltonian P-Median Problem (HpMP). We study the effectiveness of cyclic exchange heuristics as a neighborhood exploration for the HpMP. We also compare it to classical neighborhood-based heuristics to assess the contribution of cyclic exchanges.

■ MF-12

Monday, 16:15-17:45 - Room: JUR - Hörsaal 11 (Building: JUR)

City Design for Health Promotion

Stream: Health Care Logistics
Invited session
Chair: *Shungo Koichi*

1 - Locating Heat-Mitigating Infrastructure on Urban Road Networks for Pedestrian Safety
Zeli Zhang, Ken-ichi Tanaka, Shungo Koichi

Extreme summer heat is a major public health concern, increasing the risk of heat-related illnesses and limiting access to essential daily services. Ensuring safe walking environments in summer is crucial for sustainable urban life. While providing shade via arcades or street trees is an effective measure, determining the optimal placement of these facilities remains challenging. This study proposes a network design model to optimize the location of line-like heat-mitigating facilities on road networks under a budget constraint. Numerical examples and applications of the model are presented.

2 - Evaluating Opportunities for Physical Activity under Summer Weather Conditions
Ken-ichi Tanaka

In recent years, physical activity has been widely recognized as an important factor in health promotion, and ensuring opportunities for such activity in daily life has been recommended. However, exercising on hot and humid days poses health risks. Motivated by this issue, this study develops a simple model to evaluate whether sufficient opportunities for physical activity can be maintained during summer based on daily meteorological conditions. The proposed model is applied to several Japanese cities to assess the availability of exercise opportunities.

3 - Inter-Municipal Cooperation in Multimodal Transit Network Design
Tsutomu Suzuki, Masao Takeuchi, Daisuke Hasegawa

This study examines the effects of inter-municipal cooperation on multimodal transit network design. Efficient regional transportation systems are important for ensuring accessibility to essential services, including healthcare. A multimodal network design problem is solved to minimize system costs, defined as the sum of users' travel costs and operators' operating costs. The study area consists of two adjacent municipalities, and travel demand is generated using a doubly constrained exponential gravity model. Numerical results indicate that cooperative planning can reduce system costs.

4 - Environmental and Fairness Considerations in Location Routing Problems
Lisa Nechwatal, Ann Campbell, Jan Fabian Ehmke

Growing amounts of e-commerce cause urban spaces to be confronted with increasing externalities of last-mile delivery. To ease the impact on close residents, we implement a Location Routing Problem with constraints for emission thresholds regarding noise, nitrogen dioxide (NO), and small particulate matter (PM.). While optimizing costs, the chosen locations ensure that the environmental impacts stay below the set thresholds at all resident locations. Finally, we determine effects that environmental constraints have on such location decisions in relation to different objectives.

■ MF-13

Monday, 16:15-17:45 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Cuts & Heuristics

Stream: Software for Operations Research
Invited session
Chair: *Sven Wiese*

1 - Finally Wide Split Cuts in a MIP solver?
Sven Wiese

More than a decade has passed since the introduction of so-called wide split cuts, i.e., split cuts whose underlying disjunctions are widened to potentially yield stronger cuts. The computational experiments reported at the time were limited to instances where the validity of these disjunctions followed from problem-specific knowledge. Here, we investigate the use of wide split cuts within the general-purpose MIP solver in the commercial software package MOSEK.

2 - Efficient implementation of SDP-based cuts within an RLT-based solver
Brais González Rodríguez, Marta Cean-Romero, Julio González-Díaz

This talk presents a methodology for efficiently integrating linear SDP-based cuts into a Reformulation-Linearization Technique (RLT)-based solver. We discuss strategies used to keep the sparsity of the linear relaxations and benefit from the potential of these cuts. Finally, we provide numerical results that show significant improvements in performance with respect to past approaches for integrating SDP-cuts and RLT.

3 - A GPU Tabu Search Driven Heuristic Framework for MIP
Gennesaret Tjusila, Gioni Mexi, Timo Berthold, Sebastian Pokutta

We present a GPU-accelerated tabu search heuristic for mixed-integer programming. Our approach uses best shift moves, where the piecewise linear structure of the penalty score enables efficient GPU evaluation of the majority of variables at every iteration. We exploit parallelism at two levels: intra-algorithm through GPU primitives, and inter-algorithm by running multiple search instances in parallel. Our tabu search operates within a broader GPU-CPU heuristic framework coordinated through a shared solution pool.

4 - From Infeasibility to Feasibility - Improvement Heuristics to Find First Feasibles for MIPs
Mario Ruthmair, Tobias Achterberg

RINS and its large neighborhood search (LNS) variants are the most important heuristics in Gurobi to find good solutions quickly. But they can only be employed after an initial feasible solution has been found. This initial feasible solution is usually found by other heuristics, e.g., by rounding of LP solutions, fix-and-dive, or Feasibility Pump. In this talk, we consider infeasible integral vectors as input to the improvement heuristics and search in the neighborhood for vectors with small violation to act as a new starting point for the next LNS improvement heuristic invocation.

■ MF-14

Monday, 16:15-17:45 - Room: HG - Hörsaal 01 (Building: HG)

GLOW Circles of Connection

Stream: Global Leadership in OR for Women
Panel session
Chair: *M. Grazia Speranza*

1 - GLOW Circles of Connection
Janny Leung, M. Grazia Speranza, Elise del Rosario

Join IFORS Past Presidents Elise del Rosario, Grazia Speranza and Janny Leung for GLOW Circles of Connection, a mentor-led networking session designed to bring together women in Operations Research across countries, sectors, and career stages. This interactive gathering will feature themed discussion circles facilitated by experienced women leaders and GLOW members. Participants will rotate across small groups to exchange experiences, seek advice, share challenges, and explore opportunities for visibility, collaboration, and action. The session will focus on topics such as career growth, visibility and sponsorship, leadership, inclusive teams, OR for social good, and the role of OR in addressing gender equality and bias. This is not a formal lecture or panel. It is a space for conversation, mentoring, peer learning, and meaningful connection. Participants will leave with new contacts, practical insights, and ideas that GLOW can carry forward beyond Vienna. Come ready to connect, reflect, and help shape the future of women in OR.

■ MF-15

Monday, 16:15-17:45 - Room: HG - Hörsaal 34 (Building: HG)

Applications of Game Theory II

Stream: Algorithmic Game Theory
Invited session
Chair: *Songsong Liu*

1 - Efficacy of Customer Loyalty and Reward Programs
Saeed Zolfaghari, Amirhossein Bazargan

This study uses game-theoretic models to evaluate loyalty programs profitability and design in competitive markets. By incorporating customer valuations of both reward and time, it finds that loyalty programs are only dominant when rewards are prioritized over time. The study also examines redemption restrictions through nine sub-games. While high restrictions are often optimal, a prisoner's dilemma arises when customers value time or neither factor highly, requiring less restrictive policies at equilibrium. These findings contribute via comprehensive, stochastic analytical models.

2 - Acyclic Mechanism for Line-haul Truck Platooning
Zhendong Li

Truck platooning can reduce emissions, but requires stable cost-sharing among self-interested operators. We study cost-sharing mechanism for a non-profit platform, considering platoon cardinality and length limits. We design a truthful Acyclic Mechanism using a lexicographical greedy algorithm to maximize platoon size. We prove a 2-budget-balance guarantee for general cases and better ratios for specific settings. Numerical results show the mechanism outperforms these bounds. Finally, we evaluate its economic efficiency and impact on social welfare under diverse conditions.

3 - Efficient liability assignment under shock propagation
Jens Gudmundsson, Jens Leth Hougaard

We study how to assign liabilities in networks where shocks propagate and generate losses along a directed path. A liability rule maps realized losses to agent payments, and we seek to implement efficient paths in the induced sequential-move game. We axiomatically characterize rules that set liabilities proportional to total realized losses with agent weights depending on the underlying graph structure. We propose to set such weights based on path frequencies. These weights coincide with the Shapley value of an associated "path-counting" cooperative game and can be computed in polynomial time.

4 - Submodular Welfare Maximization with Budget Constraints in the Random-Order Model
Max Klimm, Martin Knaack

We study online item allocation with agent budgets and a monotone submodular objective. Items arrive in random order; upon arrival, an item's agent-specific costs are revealed, and it must be assigned irrevocably without exceeding budgets. We give a polynomial-time competitive algorithm for any number of agents with a competitive ratio of 1/14.85, improving prior work for the single-agent case. For unit costs and budgets (online submodular matching), we improve the best polynomial-time ratio from 1/9.66 to 1/6.86.

■ MF-16

Monday, 16:15-17:45 - Room: HG - Hörsaal 42 (Building: HG)

Mathematical Optimization for Urban Systems

Stream: Location Analysis for Urban and Digital Infrastructure
Invited session
Chair: *Shinji Imahori*

1 - Designing walkable cities: Optimizing the layout of the 15-minute city
Christian Leimbach, Nils Boysen, Dirk Briskorn

To advance the development of livable, resilient, and sustainable urban environments, the 15-minute city concept envisions urban layouts in which residents can access all essential resources within a 15-minute walking distance from their homes. We formulate the design of such cities as a layout optimization problem in which a ground plot is discretized into spatial units assigned as residential or resource locations. We analyze how ground-plot geometry, walking range, and the number of essential resources affect the share of residential units with access to all resources.

2 - Customer insertion feasibility in a multi-depot vehicle routing problem
Shinji Imahori, Hajime Yamamoto, Jinha Hibino

We study a multi-depot vehicle routing problem motivated by home appliance delivery and installation operations, in which each customer requires both product delivery and a subsequent installation task at the customer's location. Given a feasible solution for the current set of customers, we consider the feasibility of inserting a newly arrived customer into the existing routes. To enable rapid responses when a new customer arrives, we precompute necessary information. The proposed methods are evaluated through computational experiments on real-world instances.

3 - The large-scale maximal covering location problem for battery swapping station planning - a case study in San Francesco
Ling Jin, *Sanne Wøhlk*, *George Xydis*

This paper presents an optimization of battery swapping station infrastructure for electric taxis using the maximal coverage location problem (MCLP). The study focuses on determining the placement of battery-swapping stations based on nodes generated by taxi order pick-up and drop-off points, treating these as battery-swapping demand points in San Francisco. We tested two MCLP scenarios, considering different dataset scales, geological distances, and station coverage distances. The findings highlight the potential of efficiently designed battery-swapping infrastructure to support the adoption.

4 - Detecting Structural Outlier Paths in Mobility Networks via Linear Inverse Shortest Path Optimization
Hiroyuki Hasada, *Daisuke Hasegawa*, *Xuesong Zhou*, *Yudai Honma*

This study proposes a framework for detecting structural outliers in mobility networks by estimating hidden link costs from observed path data. The method formulates the inverse shortest paths problem as a linear programming model to infer network cost structures and identify paths that deviate from cost-consistent routing behavior. Experiments on synthetic and real networks show stable detection performance and the ability to detect spatially close but structurally inconsistent paths. The approach also supports real-time applications and provides a basis for AI-based outlier detection.

■ MF-18

Monday, 16:15-17:45 - Room: JUR - U 21 (Building: JUR)

OR at Africa I

Stream: OR in Rising Economies
Invited session
Chair: *Aya Mellouli*
Chair: *Nizar El Hachemi*
Chair: *Tarik Aouam*

1 - Stochastic Multiproduct Inventory Routing under Stock-out Substitution
Abderrahmane Abbou, *Tarik Aouam*

The inventory-routing problem (IRP) involves the coordination of inventory control and transportation planning. Our research concerns an IRP wherein the vendor supplies multiple retail locations, each facing uncertain demand for multiple substitutable products. We formulate the IRP as an infinite horizon Markov decision process. Due to the "curse of dimensionality", we apply the principles of approximate dynamic programming to develop computationally efficient inventory-routing policies with provable performance bounds. Our methodology is validated using an extensive simulation study.

2 - Restless Bandit Modeling for stochastic inventory routing problem
Chaimae Laissaoui, *Abderrahmane Abbou*, *Tarik Aouam*

Motivated by vendor-managed inventory systems, we study a stochastic inventory routing problem under direct deliveries, which dynamically determines which customers to visit and how much inventory to deliver on each visit subject to transportation fleet capacity and limited stock availability at the vendor. The problem is formulated as a multi-action restless bandit model. By investigating the structure of the optimal policy for the single-bandit subproblem, we develop a computationally efficient inventory routing policy and numerically demonstrate its near-optimal performance.

3 - A Two-Stage Location-Allocation Model for Tactical Distribution Network Design under Uncertainty
Nadia Jaoui, *Tarik Aouam*, *Nizar El Hachemi*, *Walid Klibi*

This paper addresses a multi-period, multi-product distribution network design problem under demand and production uncertainty. We propose a two-stage stochastic model where location and capacity decisions are made before uncertainty is revealed, while allocation, production, inventory, backordering, and backup sourcing decisions are adjusted afterward. A Benders decomposition approach with enhancement strategies is developed. Numerical results inspired by a real case study demonstrate the value of explicitly considering uncertainty and provide managerial insights for distribution planning.

4 - A Scenario-Based Framework for the Operational Planning of Phosphate Beneficiation and Blending
Aya Mellouli, *Tarik Aouam*, *Ilyas Himmich*

Phosphate rock must undergo several processing steps before becoming marketable, with beneficiation at washing plants playing a key role in improving quality, mainly assessed through phosphorus content.This work addresses a real case study in the phosphate industry. We first propose a path-based framework to model beneficiation operations, generate feasible processing schemes and blending options, and simulate their chemical and physical output patterns. Building on this framework, we then develop a scenario-based MILP for the operational planning of beneficiation and blending operations.

■ MF-19

Monday, 16:15-17:45 - Room: HG - Hörsaal 05 (Building: HG)

Optimization and Games

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Baolong Liu*

1 - Supply Chain Network Structure and Scope 3 Emissions: An Empirical Study
Qidi Wu, *Yanlu Zhao*

This paper investigates how supply chain network structure affects firms' upstream Scope 3 carbon emissions from an operations research perspective. Using firm-level panel data linking supplier-customer networks with carbon disclosure data, we quantify horizontal, vertical, and spatial supply chain complexity. Fixed-effects models show that greater horizontal complexity reduces upstream emissions intensity, while spatial dispersion significantly increases it. The results highlight structural trade-offs in supply chain design and inform OR-based strategies for managing Scope 3 emissions.

2 - From Frustration to Engagement: Ancillary Services in Queues
Baolong Liu, *Opher Baron*, *Yang Li*, *Rowan Wang*

Waiting hurts customers and system performance. Instead of only reducing congestion, we study adding ancillary services that create value

during the wait. Using a game-theoretic queueing model with two customer types, we show that although ancillary services attract more demand and raise congestion, they trigger self-selection: delay-sensitive customers exit, while experience-oriented customers join. This improves throughput, profit, and welfare, especially under tight capacity, and can outperform priority queues.

3 - Service rate optimization in single-server queues with time-varying arrivals and capacity constraints
Roshan Mahes, Femke Boelens, Richard Boucherie, Anne Zander

We study capacity allocation in a single-server queue with time-varying arrivals and known demand forecasts. Service rates are chosen per period under period and cycle capacity constraints, in static and dynamic settings. We minimize the average queue length over a cycle and end-of-cycle backlog, showing that each objective alone leads to extreme allocations. A multi-objective model balances both. We provide exact analysis and a scalable stochastic programming approximation, supported by numerical experiments.

4 - Mathematical Analysis of an MAP/PH/1 Queueing System with Negative Arrivals and Unreliable Repairers
Dinesh Sharma

In many practical service and production systems, repairs and corrective actions are initiated immediately when performance degradation is detected, rather than waiting for the system to become completely idle. Motivated by this operational reality, a repair policy in which the server undergoes repair at each degraded state instead of only during idle periods. Such a mechanism is particularly relevant in environments where service quality deterioration directly impacts revenue, customer satisfaction, or safety, making delayed repairs economically undesirable.

■ MF-20

Monday, 16:15-17:45 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Routing and Last-Mile Logistics

Stream: Vehicle Routing and related problems
Invited session
Chair: *Markus Leitner*

1 - Pricing, bundling, and compensation decisions in dynamic crowdsourced delivery problems
Alim Buğra Çınar, Claudia Archetti, Wout Dullaert, Markus Leitner, Stefan Waldherr

Crowdsourced delivery leverages the unused transport capacity of vehicles already on the road to perform parcel deliveries. We consider a setting where delivery tasks and occasional drivers arrive dynamically and stochastically, and the operator can offer bundles of tasks. Acceptance probabilities depend on both the driver and the offer, and bundles and compensation are determined jointly. We formulate the problem as a Markov Decision Process and solve it by using Approximate Dynamic Programming. Preliminary results indicate clear advantages over benchmark policies.

2 - A matheuristic and a hybrid algorithm for the asymmetric period travelling salesman problem
Sofia Henriques, Ana Paias

We propose a matheuristic for the Period Travelling Salesman Problem that is based on a period-aggregated formulation. In addition, we develop an Iterated Local Search algorithm and introduce a hybrid heuristic that combines elements from both approaches. We assess the performance of the three heuristics using both benchmark instances from the literature and a newly generated set of asymmetric instances, with up to 443 nodes and 5 periods. All proposed methods produced high-quality solutions. For large-scale instances, the matheuristic was able to find the global optimum in many cases.

3 - An exact algorithm for vehicle routing problems with temporal dependency constraints
Markus Leitner, Loek van Montfort, Rosario Paradiso

Vehicle routing problems with temporal dependencies are characterized by several types of synchronization constraints between customer visits and arise in applications such as home healthcare or technician routing. We present a fragment-based formulation and an exact solution method capable of handling all wide range of temporal dependencies. The novel formulation is solved using a price-cut-and-enumerate algorithm. Computational results demonstrate that the proposed approach outperforms a benchmark method based on time-window branching, while handling a wider range of temporal dependencies.

■ MF-21

Monday, 16:15-17:45 - Room: JUR - U 22 (Building: JUR)

Two Heads Are Better than One: Combining Operations Research and Constraint Programming.

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Michael Trick*

1 - Combining CP and IP for Dantzig-Wolfe Decomposition: An Application to Multi-Project Scheduling
J. Christopher Beck, Maximilian Kolter, Martin Grunow, Rainer Kolisch

We propose a decomposition approach that combines techniques from constraint programming (CP), integer programming (IP), and metaheuristics to compute primal and dual bounds for the multi-project scheduling with global and local resources. The Dantzig-Wolfe decomposition is solved by an approach that consists of three steps: presolve, primal heuristic, and lower-bound computation, with each step exploiting the block-angular structure and including CP. We achieve the best-known optimality gaps for 29 of the 30 benchmark instances due to tight dual bounds.

2 - Modelling Choices and Results for the IHTC 2024 Problem
Helmut Simonis

In this talk we present modelling alternatives for the International Hospital Timetabling Competition (IHTC) 2024, about integrated resource management for inpatient admission and care in hospitals. We are comparing Constraint Programming, Integer Programming and Local Search techniques, each of which can express some, but not necessarily all constraints of the problem well. We also show how different decomposition methods affect the overall solution quality over a benchmark set of widely varying size and complexity.

3 - Beyond the Traveling Tournament Problem
Michael Trick

The Traveling Tournament Problem is a very well studied problem in sports scheduling that has proved a challenge for a wide range of techniques. There are a number of generalizations that provide an ideal opportunity to combine optimization methods with constraint programming. Here we introduce some of these generalizations and show how the combination of methods improves on individual methods.

■ MF-22

Monday, 16:15-17:45 - Room: KOL - Seminar-Raum 5 (Building: KOL)

Forecasting in Energy Systems

Stream: Forecasting in Energy
Invited session
Chair: *Peru Muniain*

1 - A Hybrid Fuzzy-Markov Model for Demand Forecasting Under High Uncertainty in Supply Chains
Francisco Trejo, Alberto Ochoa-Zezzatti

Demand forecasting under high uncertainty is formulated through a Hybrid Fuzzy-Markov Forecasting Model integrating fuzzy sets with Markov chains. The method defines a demand fluctuation index, performs fuzzification to construct fuzzy states, estimates a fuzzy state transition matrix, and derives forecasts via Markov-driven inference. Validation on real logistics data demonstrates improved predictive accuracy, robustness, and interpretability in noisy and low-data environments.

2 - A constrained nonlinear least-squares algorithm for electricity demand forecasting
Pierre Borie, Fabian Bastin, Alain Marcotte, Stéphane Dellacherie

We present an algorithm for calibrating parameters of a short-term electricity demand forecasting model in Québec. Calibration uses nonlinear least-squares optimization subject to mixed constraints. Nonlinear constraints are handled via an augmented Lagrangian reformulation while linear feasibility is maintained by a gradient-projection method combining a Cauchy step with subspace minimization. We exploit the least-squares structure through a structured Hessian approximation. Our method is implemented in Julia and we present numerical experiments to illustrate its performance.

3 - From Celsius to megawatt hours: Week-ahead forecasting of electricity demand using publicly available weather predictions
Dawid Linek, Rafal Weron

Accurate electricity demand forecasting relies on weather, yet integrating forecasts across diverse climates is complex. We tested strategies for feeding weather data into up to week-ahead electricity demand forecasting models across five European markets (Greece, Spain, Finland, Germany, Poland). By evaluating regional extremes like Nordic winters and Mediterranean heatwaves, we found that combining diverse weather variables from multiple locations significantly outperforms classical single-point methods.

4 - Risk-Aware Participation of Energy-Intensive Industries in Sequential Electricity Markets Under Price Uncertainty: The Case of Iron and Steel Plants
Danial Ramin, Gabriele Marchesi, Alessandro Brusaferri, Andrea Ballarino

This contribution examines the economic benefits of iron and steel plants participating in sequential electricity markets under price uncertainty by integrating probabilistic neural-network-based price scenario generation with two-stage stochastic programming for risk-aware participation and energy-aware scheduling. It shows that reliable price forecasting is a key enabler of effective market participation by energy-intensive industries and quantifies the impact of explicitly accounting for price uncertainty compared with a deterministic participation strategy based on point forecasts.

■ MF-23

Monday, 16:15-17:45 - Room: HG - Hörsaal 02 (Building: HG)

Applications of stochastic programming

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Milos Kopa*
Chair: *Martin Branda*

1 - Distributionally Robust Fixed Interval Scheduling with Heterogeneous Machines with Random Delays
Monika Matoušková, Martin Branda

We study fixed interval scheduling problems (FIS) with random delays on heterogeneous machines. Jobs are assigned to machine types based on class compatibility, and processing delays follow machine-dependent distributions. We focus on a distributionally robust formulation in which a given amount of the delay distribution is stressed. Under structural assumptions on the multivariate delay distribution, we propose a deterministic reformulation and compare two solution approaches on generated instances.

2 - Is there anything authentic on Telegram? A quantitative approach
Martin Smid, Frantisek Zapletal

We study coordinated inauthentic behavior on Telegram using statistical indicators of content creation, sharing, coordination, and support. The key contribution is framing detection as a multi-criteria decision-making problem: channels are evaluated across hierarchically structured criteria derived from statistical tests. A modified weighted sum method aggregates evidence while reducing redundancy within groups. The approach enables transparent classification of channels by inauthenticity risk and provides a systematic tool for analyzing manipulation on social networks.

3 - Multi-stage multi-horizon optimization of a virtual power plant under stochastic non-dominance constraints
Jana Junova, Miguel Carrión, Milos Kopa

A virtual power plant integrates renewable and conventional power plants, batteries, and fixed and flexible demand into a single entity. We seek its optimal investment strategy minimizing total costs over 30 years. Uncertainty in future investment costs and operational scenarios is captured by a multi-stage, multi-horizon model. Because minimizing costs alone can yield solutions that perform well on average but are very expensive in some scenarios, we regulate risk using second-order stochastic dominance constraints or, to achieve a controlled relaxation, non-dominance constraints.

4 - Preventive maintenance in fixed interval scheduling problems - two-stage stochastic programming approach with endogenous uncertainty
Martin Branda

Fixed-interval scheduling assigns jobs with predetermined processing intervals to machines. We study a variant with random delays in completion times and minimize the expected number of overlaps, penalizing the need for additional machines when delays occur. Preventive maintenance is incorporated to improve reliability and reduce delays. The resulting two-stage stochastic problem with endogenous uncertainty is reformulated via robust graph coloring and solved using a Benders decomposition approach, evaluated on simulated instances.

■ MF-24

Monday, 16:15-17:45 - Room: HG - Hörsaal 03 (Building: HG)

Human-Centric Modeling for Workforce Scheduling and Operations Planning

Stream: Human Aspects in Operations Management
Invited session
Chair: *Taha Arbaoui*
Chair: *M.-Lounes Bentaha*
Chair: *Masood Fathi*

1 - Optimization model for shiftwork scheduling problem integrating workforce health conditions based on circadian rhythm disruptions.
Karen Nino, Daniel Sanchez Pineda, Dagoberto Castillo

Shiftwork scheduling is a key operations research problem affecting both performance and worker health. Most models optimize efficiency but ignore physiological factors such as circadian rhythm disruption. This study proposes a multi-objective mixed-integer optimization model that incorporates health conditions linked to circadian misalignment while reaching operational requirements and balancing workload. Results show that considering worker well-being in scheduling can improve productivity and reduce fatigue by aligning shifts with natural recovery patterns.

2 - Shift scheduling problem of career advisors in recruit agency services
Shunji Umetani, Ryusuke Kimura, Shu Sakimoto

Some recruit agency services employ professionals called career advisors (CA) supporting job seekers through interactive communication, primarily through online interviews. CAs work in shifts because the online interviews are usually held outside of job seekers' working hours. The managers are accordingly asked to plan CA shifts and interview schedules simultaneuously every month. We present a case study of MIP and CP approaches for the CA shift scheduling problems taking account of interview schedules with job seekers, and some numerical results using general-purpose solvers.

3 - Scheduling personalized study plans considering the stress factor
Yasmin Rios Solis, Luis Salazar

Learning path generation involves the computation of learning trajectories to personalize academic instruction to prevent school problems. The Educational Planning Problem schedules activities that satisfy expected grades while minimizing the plan's makespan. In this work, we propose two scheduling models with two new activity duration functions incorporating student stress and sequence dependence to mimic learning effects and increase personalization. We also developed a metaheuristic algorithm to solve real-size instances.

4 - Skill-Based and Behavioral Task Allocation in Software Projects
Roberto Campolina, André Batista

This research extends the Software Project Scheduling Problem by optimizing developer task allocation across multiple sprints. We introduce a novel approach where task duration is dynamic, varying according to technical skills and behavioral traits. The objective is to simultaneously minimize project cost and duration. We propose a mathematical model capturing these dependencies and a metaheuristic approach for large-scale instances. Preliminary modeling shows behavioral factors significantly impact team productivity. The study aims to provide a decision-support tool for project managers.

■ MF-25

Monday, 16:15-17:45 - Room: HG - Hörsaal 16 (Building: HG)

Advancing Circular Economy and Urban Sustainability in Developing Countries

Stream: OR for Development
Invited session
Chair: *Sadiye Eylul Sadanoglu*
Chair: *Nina Kajiji*

1 - Community Behaviour and Urban Circular Economy Transitions: A Sustainability Framework for Local Practice
Sadiye Eylul Sadanoglu, Jin Chan

Community-based circular economy (CE) initiatives are widely promoted in urban sustainability strategies, yet a persistent gap remains between ambition and implementation. This study examines how citizen behaviour and institutional governance shape engagement in local repair and carbon reduction initiatives. Drawing on behavioural theory and primary evidence from focus groups with residents, small businesses, and community organisations, the research develops a novel behavioural engagement framework that explains uneven participation across urban contexts and offers insights for CE practices.

2 - From Efficiency to Impact: A Longitudinal Theory of Change Analysis of Urban Sustainability Transitions in London Boroughs
Sadiye Eylul Sadanoglu, Li Zhou

This paper investigates long-term urban sustainability transitions using a longitudinal, theory-informed approach. Drawing on borough-level data from London over more than a decade, it moves beyond short-term efficiency assessments to examine sustainability pathways over time. By integrating Malmquist-Luenberger performance analysis with a Theory of Change framework, the study reveals how policy interventions, governance capacity, and institutional learning shape environmental, economic, and social outcomes, and explains why some boroughs achieve sustained improvements while others do not.

3 - ML-Based Risk Assessment in Agricultural Commodities Trading & Mitigation Approaches
Sundaravalli Narayanaswami

We present a machine learning-based framework for price risk assessment in agricultural commodity trading. Focusing on four major Indian crops (rice, pigeon pea (tur), mustard, and cotton), we develop Random Forest regression models driven by state-level weather inputs and use Monte Carlo simulation to quantify price uncertainty. We evaluated multiple modeling approaches relating weather to prices and selected a direct weather→price model due to its richer data availability and alignment with market behavior (traders rapidly price in weather anomalies). Results and insights are presented.

■ MF-26

Monday, 16:15-17:45 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis I

Stream: Data Envelopment Analysis
Invited session
Chair: *Panagiotis Mitropoulos*
Chair: *Xun Zhou*

1 - Evaluating the Efficiency of the America-Europe-Asia Trade Network: A Two-Stage SNA-DEA Approach
Barbara Będowska-Sójka, Anna Łozowicka

This study investigates how efficiently countries across the globe transform their economic potential—measured by GDP per capita, trade openness, and FDI inflows per capita—into central positions within international trade networks. By applying a two-stage methodological framework, we first utilise Social Network Analysis (SNA) to extract network centrality outcomes for separate export and import networks. Subsequently, Data Envelopment Analysis (DEA) evaluates the relative efficiency of countries in converting their economic inputs into these strategic network positions.

2 - Frugal DEA: A Backward Elimination Framework for Input & Output Selection in Data Envelopment Analysis
Konstantinos Petridis, Ali Emrouznejad

Data Envelopment Analysis suffers from dimensionality bias when inputs and outputs are numerous relative to DMUs. We propose Frugal DEA, a backward elimination framework that iteratively removes variables by maximizing Kendall's τ preservation between full and reduced models. Benchmarked against Correlation, PCA, LASSO, and XGBoost across six configurations (n 800,...,5000), our algorithm achieves Pareto-superior RMSE and rank correlation in 100% of cases, with up to 40% RMSE improvement under aggressive reduction, enabling more interpretable and robust efficiency measurement.

3 - Paradoxes of the public sector productivity measurement
Xun Zhou, Timo Kuosmanen

The standard total factor productivity (TFP) measurement in the public sector is flawed because poor output data and common output conventions lead to paradoxical declines, even with real productivity gains (technical progress, improved allocative or scale efficiency, lower input prices). Distorted output prices further confuse TFP with pricing shifts. UK and Finnish data confirm these distortions. We propose public sector TFP measurement to move away from cost-based aggregation towards non-market valuation methods grounded in economic theory.

4 - Integrating Cooperative Network DEA and Convergence Analysis for Service Efficiency Assessment
Panagiotis Mitropoulos, Alexandros Mitropoulos, Kostas Tsolkas, Dimitris Papadopoulos

We propose a framework for assessing the evolution of efficiency in the service sector by explicitly accounting for interdependencies among its subsectors at a regional level. A two-stage network Data Envelopment Analysis (DEA) model, grounded in cooperative game theory, is employed to capture these linkages and provide a comprehensive representation of the production process. Convergence analysis is then applied to examine whether regional efficiencies follow a common long-run path or diverge into heterogeneous patterns.

■ MF-27

Monday, 16:15-17:45 - Room: JUR - Hörsaal 13 (Building: JUR)

Preparedness and Early Action in Humanitarian Operations

Stream: Humanitarian Logistics
Invited session
Chair: *Rein Lommerse*
Chair: *Thomas Breugem*

1 - Optimizing Triggers for Anticipatory Action: Mitigating the Impact of Flooding on Agriculture in South Sudan
Janne de Rooij, Joris Wagenaar, Yasemin Merzifonluoglu, Burcu Balcik

Anticipatory Action (AA) is a humanitarian approach, aiming to act ahead of predicted hazards to reduce impacts before they unfold. Operational AA protocols rely on static, threshold-based triggers - combining forecasts with return periods. While transparent and easy to operationalize, these triggers may not result in the optimal timing of taking actions. Using stochastic optimization and reinforcement learning, this research explores whether adaptive decision rules can improve operational performance over static triggers while remaining interpretable for humanitarian use.

2 - Resource Allocation for Disaster Preparedness and Response in Fuel Distribution Systems
Polle Dankers, Shraddha Rana, Luk Van Wassenhove

Fuel is critical in disaster aftermath, supporting emergency logistics, search & rescue, evacuation, and backup generators. Combined with hoarding, this causes demand to surge, while road damage and terminal closures disrupt fuel supply to gas stations. Resulting shortages are rarely caused by insufficient regional supply. The bottleneck lies in distribution. We apply a two-stage simulation-based optimization model to identify preparedness and response interventions that most effectively improve disaster fuel distribution, using Florida's hurricane-prone fuel system as a case study.

3 - Evacuation Under Infrastructure Uncertainty: Integrating Optimization and Simulation for Disaster Response
Darya Hrydziushka, Arild Hoff, Lars Magnus Hvattum, Gregorio Tirado

This work presents a simulation-optimization framework for post-disaster evacuation under uncertain infrastructure conditions and demand. A model creates evacuation plan from unsafe locations to hospitals and shelters while prioritizing critical patients. The model minimizes evacuation time, waiting time, and operational cost. To capture disaster dynamics, the optimization is embedded in a discrete-event simulation that generates stochastic evacuee arrivals, resource updates, and probabilistic road failures, enabling rolling-horizon re-optimization and adaptive evacuation planning.

4 - From Forecasts to Action: Optimizing Trigger Design for Anticipatory Action
Rein Lommerse, Thomas Breugem, Burcu Balcik

Anticipatory action (AA)—interventions triggered by forecasts—is becoming a central focus in humanitarian operations. Designing such triggers requires navigating critical trade-offs: frequent triggering reduces missed events but increases false alarms, while conservative triggers work vice versa. We present a stochastic optimization framework to determine the optimal trigger design, balancing competing risks. Applying our framework to flood data in Uganda, we demonstrate how forecast accuracy, timing uncertainty, and cost structures drive trigger design and expected benefits of AA.

■ MF-28

Monday, 16:15-17:45 - Room: JUR - Hörsaal 17 (Building: JUR)

Decarbonizing shipping networks

Stream: Maritime Logistics
Invited session
Chair: *Frederik Schulte*
Chair: *Ping He*

1 - Robust Optimization of Dual-fuel Liner Services
Ping He, Lingxiao Wu, Jian Gang Jin, Shaorui Zhou, Frederik Schulte

To cut emissions, shipping companies use dual-fuel vessels to balance regulatory compliance and costs via fuel-switching and speed optimization. Given volatile fuel prices, this study develops a distributionally robust chance-constrained model based on the Wasserstein metric to minimize costs under uncertainty. By dividing voyages into sub-legs, the model optimizes fuel proportions, speeds, and bunkering for specific zones. Validated by COSCO Shipping data, the model efficiently solves real-world instances, significantly outperforming traditional sample average approximation methods.

2 - Distributionally Robust Optimization for Joint Bunkering and Speed Decisions under Fuel Supply Uncertainty
Frederik Schulte, Xinyu Tang, Ping He

The work studies a joint bunkering, fuel choice and sailing speed decision problem under uncertain port fuel supply. A deterministic mixed-integer optimization model is first formulated to minimize total cost subject to operational constraints. To capture uncertainty, a distributionally robust chance-constrained (DRCC) model based on Wasserstein ambiguity sets is proposed. The model is compared with a chance-constrained programming (CCP) approach solved via sample average approximation (SAA). Results show improved robustness with competitive cost performance.

3 - Terminal Data Sharing for Smoother Port Operations: Coordinated Optimization of Inland Shuttle Routing and Berth Allocation
Di Zhang, Jiangang Jin, Hai Wang

Port inefficiency arises not only from quay scarcity but also from information asymmetry. Inland shuttle vessels, typically assigned lower priority than seagoing vessels and lacking real-time berth visibility, often follow a "first come, first wait" pattern, leading to higher fuel use, congestion, and unnecessary emissions in port waters. To address this issue, we jointly optimize shuttle routing and berth allocation through real-time berth data sharing, promoting greener, low-carbon, energy-saving, and emission-reduction port operations.

4 - Optimizing Manpower-Dependent Berth Allocation Problem in Automotive Terminals
Ziqiao Mei

This paper studies a manpower-dependent berth allocation problem in automotive terminals. We formulate a mixed-integer linear programming model for joint berth allocation and manpower assignment under manpower limits, car-flow congestion, vessel-specific capacity, and tidal time windows. A Hybrid Adaptive Large Neighborhood Search is proposed. Results show that better coordination of terminal resources reduces vessel turnaround time and enables greener, low-carbon, and more energy-efficient terminal operations, helping reduce emissions and support decarbonization goals.

■ MF-29

Monday, 16:15-17:45 - Room: HG - Hörsaal 30 (Building: HG)

Solving previously unsolved instances of some combinatorial optimization problems

Stream: Combinatorial Optimization
Invited session
Chair: *Juan José Salazar González*

1 - Breaking new unsolved instances of combinatorial graph problems
Tim Kunt, Thorsten Koch

We present approaches to different combinatorial optimization problems on symmetric graphs, including the n-Queens problem in higher dimensions and the snake-in-the-box problem using integer programming. These problems share the symmetries of the hypercube and that their instances can only be solved for comparably small model sizes today. We address symmetries and graph structure with competing integer programming formulations, sets of additional valid inequalities and canonical augmentation, achieving faster solving times and breaking new instances.

2 - A Branch-and-Cut-and-Price Method for Bilevel Network Design Problems
Anna Laura Pala, Henri Lefebvre, Martin Schmidt

We study a bilevel network design problem in which the leader makes binary decisions while the follower solves a multicommodity flow problem. A branch-and-cut-and-price method is proposed based on a strong-duality reformulation combined with a Dantzig-Wolfe decomposition. Extreme points of the follower are generated through column generation, while violated dual feasibility constraints are identified by solving a separation problem. Computational results compare the proposed approach with the classic KKT-reformulation, showing its effectiveness on benchmark instances from the literature.

3 - Subproblem Solving in Benders Decomposition for Affine Potential-Based Flow Problems with Topology Switching and Robustness Scenarios
Oliver Gaul, Tim Donkiewicz

Potential-based flow problems are network flow problems where the flow between adjacent nodes depends on their potentials, applicable, e.g, in gas or power networks. We consider affine potential functions, topology decisions and robustness scenarios, solved by Benders decomposition. Our subproblems are flow problems, for which we propose a fast method to obtain feasiblity and optimality cuts by solving systems of linear equations. Factorization updates exploit similarity between subproblems. Results show significant improvements in total solving time.

4 - Finding an Euclidean TSP solution with optimal internal area.
Juan José Salazar González, Hipólito Hernández-Pérez

This paper describes approaches to finding the maximum-area and minimum-area polygons within a given set of points in the Euclidean plane. Both problems are NP-hard and of interest in Computational Geometry. They have been extensively studied, though only recent literature provides mathematical formulations that consistently find optimal solutions to some instances with up to 25 points. We introduce a new model that solves all the benchmark instances with up to 50 points. This work is based on the article published "European Journal of Operational Research" 329 (2026) 767-777.

■ MF-30

Monday, 16:15-17:45 - Room: HG - Seminar-Raum 06 (Building: HG)

Operations Innovations

Stream: Robust and Resilient Optimization in Finance and Businesses
Invited session
Chair: *Arvind Sainathan*

1 - Integrating Evolutionary Forecast Into Dynamic Dual-Channel Inventory Rationing
Xuhan Tian

We consider a dynamic inventory rationing problem for a dual-channel retailer with evolving demand forecasts. We develop an MDP model that integrates the additive Martingale Model of Forecast Evolution (MMFE), based on which we study the impact of the forecast information structure and investigate the effective framework for its integration. An approximation algorithm is proposed leveraging temporal aggregation of forecast information, followed by extensive quantitative studies to derive actionable managerial insights.

2 - Increasing mHealth usage through strategic payer incentives for providers and patients
Arvind Sainathan, Sal Agnihothri, Balaraman Rajan

Innovations in digital and mobile health (mHealth) services are transforming chronic care delivery by improving health outcomes and efficiency. However, despite the proven benefits of mHealth, usage remains hindered by a critical challenge: patient engagement after adoption. This lack of patient engagement leads to health complications that are expensive, especially for payers. Timely provider interventions are essential to mitigate these costs. Our study explores how payers can leverage targeted incentives to enhance patient usage of mHealth technology.

3 - Influencer's Effort Allocation in Live Streaming E-Commerce
Jie Zhang

In collaborations between brands and live streaming influencers, influencers' efforts (time and energy) are limited, and they must allocate their efforts reasonably across multiple brands. We construct a game-theoretic model between two competing brands and one influencer to study the optimal effort allocation and analyze the impact of commission rates and product substitutability on the equilibrium. We find the optimal effort level of the influencer is not necessarily increasing in the brand's commission rate, sometimes may even be decreasing.

4 - Learning Behavior in Inventory Decisions with Unknown Demand Information: From a Data-Driven Perspective
Yingshuai Zhao, Shuaikun Hou, Xiaobo Zhao

We explore humans' learning patterns in inventory decisions under unknown demand distributions. A 2x2 lab experiment tested the impact of censored versus uncensored historical demand across varying profit margins. We show that standard gradient descent algorithm cannot capture the learning dynamics. Instead, a framework incorporating exponential smoothing and state-dependent step sizes accurately fits the data, implying that individuals place great weight on recent demand and the adjustment magnitudes depend on inventory status. Furthermore, uncensored demand facilitates faster learning.

■ MF-31

Monday, 16:15-17:45 - Room: JUR - Hörsaal 12 (Building: JUR)

Bus and crew scheduling

Stream: Optimizing Transit
Invited session
Chair: *Guido Schryen*

1 - Integrated Electric Bus and Crew Scheduling
Thomas van der Plas, Han Hoogeveen, Marcel van Kooten Niekerk, Philip de Bruin

This study proposes a new method to integrate the vehicle and crew scheduling steps for electric bus planning, incorporating both non-linear charging behavior and battery degradation costs. This method consists of applying a Lagrangean relaxation to the constraints linking the worked time in vehicle and crew schedules, allowing for decomposition into vehicle and crew subproblems. These subproblems are then solved using a combination of local search and column generation. A real life case study is performed in which cost savings of 0.3 - 1% are achieved when compared to sequential methods.

2 - Electric Bus Scheduling in Urban Transit: A Scalable Deep Reinforcement Learning Approach
Yun-Chia Yen, Chung-Cheng Lu, Chih-Kang Lin

This study addresses the electric bus scheduling problem by developing a mixed-integer linear programming (MILP) model and a deep reinforcement learning (DRL) framework. The MILP is formulated on a multi-layer time-space network incorporating charging, deadheading, parking, and servicing constraints. To overcome scalability limits, a Deep Q-Network is proposed to learn operational decisions. Using real data from Taiwanese transit agencies, results show that DRL generates high-quality schedules within seconds and reduces operating costs by 2.1% 14.3%.

3 - A state-expanded network formulation for Multiple-Depot Integrated Vehicle and Crew Scheduling
Jonas Brenker, Michael Römer, Guido Schryen

In public transport systems, planning vehicle schedules and crew duties is a major operational challenge. The integrated vehicle and crew scheduling problem (VCSP) seeks minimum-cost vehicle and crew schedules that are feasible for a given timetable. Since the multiple-depot VCSP is NP-hard, research relies largely on heuristics and exact methods typically scale only to small instances. We propose a novel exact reformulation using state-expanded networks to reduce run time on large instances and evaluate it on well-known benchmark instances against state-of-the-art solution methods.

■ MF-32

Monday, 16:15-17:45 - Room: JUR - Hörsaal 14 (Building: JUR)

Sustainable and Emerging Urban Delivery Systems

Stream: City Logistics
Invited session
Chair: *Maged Dessouky*

1 - Sustainable Urban Last-Mile Delivery: A Systematic and Memetic Review
Amira Belhadj Ammar, Mohamed Cheikh, Taicir Moalla Loukil

The growth in urban freight challenges the United Nations Sustainable Development Goals 11, 12 and 13 because it leads to greater congestion, emissions and consumption of resources. This article integrates a memetic and literature review of last-mile delivery optimization of sustainable urban transport. It compares routing and location models and their variants to greener approaches, putting into focus multi-objective models, which consider environmental, economic and social objectives to support low-carbon, resilient urban logistics solutions.

2 - Using Battery Electric Heavy-Duty Trucks for Drayage Operations to Reduce Emissions
Maged Dessouky

Urban freight shipments are overwhelmingly made by trucks which generate significant GHG emissions. We examine the potential of battery electric heavy-duty trucks (BEHDTs) for drayage operations. The

freight movement problem using BEHDTs is decomposed by solving a minimum cost flow for demand satisfaction. The second solves a bin-packing problem based on a flow solution, which also considers the BEHDTs' charging plans with range constraints. Numerical experiments are conducted with real-world data that provide a quantitative comparison of truck travel costs, fleet size, and GHG emissions.

3 - Resilient Decision Support for Strategic Municipal Solid Waste Management
Katarzyna Gdowska, Roger Książek

Municipal solid waste systems, as part of critical urban infrastructure, must remain efficient and reliable amid the transition to net-zero emissions, socio-economic disruptions, and evolving waste-collection policies. We address strategic decision-making in municipal solid waste management under uncertainty through a decision-support framework based on MILP models. The framework integrates sectorization, fleet sizing, and schedule load balancing to support robust and resilient planning. It helps municipalities design reliable, efficient, and sustainable waste collection systems.

4 - Designing Scalable Multi-Tier Networks for Physical Internet Enabled Hyperconnected Urban Logistics
Praveen Muthukrishnan, Walid Klibi, Benoit Montreuil

The Physical Internet paradigm conceptualizes urban freight as a hyperconnected multi-tier system of open, interoperable hubs. Detailed design of such systems require screening to manage large candidate sets, demand heterogeneity, and cross-tier dependencies. This paper develops an iterative, multi-objective, set-cover based framework retaining potential hub candidates across three tiers with coverage, modular capacity, KPI performance, and top-down/bottom-up refinement. A case study shows how design settings shape accessibility, redundancy, cost, capacity deployment, and solve time.

■ MF-33

Monday, 16:15-17:45 - Room: JUR - Hörsaal 15 (Building: JUR)

Space logistics II

Stream: OR in Space
Invited session
Chair: *Mariusz Kaleta*

1 - Learning to Construct Solutions for Multi-Load Earth Observation Satellite Scheduling
Xiaolu Liu, Jie Chun, Weiyi Yang, Jun Wen

This paper addresses the multi-load Earth observation satellite scheduling problem, where a single satellite carries heterogeneous payloads (optical, SAR, hyperspectral) each with distinct operational constraints, and each task requires specific payload types. We formulate it as a Markov decision process incorporating payload selection and task sequencing decisions. A deep reinforcement learning framework based on proximal policy optimization is proposed to learn optimal scheduling policies. Experiments demonstrate superior task completion and resource utilization over competitors.

2 - An Exact Decision Diagram Approach for Solving the Asteroid Routing Problem
Michael Römer, Isaac Rudich, Quentin Cappart, Manuel López-Ibáñez, Louis-Martin Rousseau

The Asteroid Routing Problem (ARP) involves two levels of optimization: an outer search for asteroid sequences and a computationally costly inner problem for trajectories between moving bodies. We present a framework using the Peel-and-Bound technique for Decision Diagrams to find exact solutions. Leveraging problem-specific knowledge, we minimize expensive inner evaluations. Results demonstrate scalability and robust performance on ARP benchmarks, yielding exact solutions (contingent on inner-optimizer quality), effectively navigating the complexity of space-time dependent mission planning.

3 - Multi-Rover Mission Planning with Time-Energy Conversion and Risk Measures
Mariusz Kaleta

We consider a planetary mission in which a fleet of rovers conducts research at Points of Interest (PoIs). Each task yields scientific gain, but time and energy constraints limit the PoIs visited. Each rover uses a battery and solar panels for recharging. We aim to maximize total gain within a fixed time window. This problem extends the Team Orienteering Problem by allowing time-to-energy conversion via scheduled charging. We formulate a model that incorporates parameter uncertainty and risk measures, enabling decision-makers to balance scientific goals with risk levels interactively.

■ MF-34

Monday, 16:15-17:45 - Room: JUR - Hörsaal 16 (Building: JUR)

Integrated decision making in warehousing

Stream: Warehousing
Invited session
Chair: *Hana Rudová*

1 - A Clustering Approach to Solve the Warehouse Slotting Problem
Abhijit Gosavi, Teng Yang

In the era of Industry 4.0, a warehouse management system (WMS) of a manufacturing system faces the challenge of selecting suitable slots to assign to each product while demand data change, because of fluctuating markets. The exact approach suggested in the literature for this problem is computationally burdensome. For this problem, a new methodology, which is rooted in k-means clustering and helps improve material-handling costs, is developed in this research. Numerical results are presented on a WMS using the clustering algorithm to show its superiority over a widely used heuristic.

2 - Resource Sharing in Logistics Parks
Pascal Wolff

Logistics parks are critical nodes in supply chains. Yet independent planning within these parks often results in inefficient use of resources. This study proposes a mixed-integer programming model that enables resource sharing across warehouses and functional zones (e.g., receiving, storage, picking, shipping) within logistics parks. It minimizes total operational costs while considering workforce heterogeneity, minimum working times, and transfer times. A computational study shows that resource sharing reduces costs by about 13% on average, exceeding 20% in highly heterogeneous parks.

3 - Simulation environment for complex warehouse planning
Hana Rudová, Róbert Zvara, Václav Sobotka

We present a simulation environment for large-scale multi-floor warehouses that integrates processes for storage location assignment, order batching, floor selection, product position selection, pickbox batching into picking carts, and picker routing. The modular platform allows for the inclusion and combination of various algorithms. We demonstrate and evaluate base and advanced implementations of particular processes using real-world data from the Notino company, featuring an order stream of up to 160,000 orders per day with an average of 3.4 products per order.

■ MF-35

Monday, 16:15-17:45 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Sustainability through Service Optimization

Stream: Operations Research and Sustainability
Invited session
Chair: *Arman Derakhti*

1 - Economic and Environmental Performance of Peer-to-Peer Crowdshipping under Different Spatial Structures
Emma Innocente, Jean-Sébastien Tancrez

Crowdshipping, where private individuals deliver parcels with small detours from planned trips, has emerged as a potentially cost-efficient and sustainable delivery option for e-commerce. It creates a dynamic crowdshipper-parcel assignment problem under uncertainty, which we solve using approximate dynamic programming with value function approximation. We study how the economic and environmental performance of peer-to-peer car-based crowdshipping is shaped by the spatial structure of crowdshippers and parcels (city sizes, spatial organization, distance sensitivity) and operational conditions.

2 - Dynamic Sustainability Benchmarking in Water Utilities: A Composite Index Approach
Maria Molinos-senante, Alexandros Maziotis

Ensuring the sustainability of water utilities is essential for long-term water services. This study proposes a framework for dynamic sustainability benchmarking through the Sustainability Change Index (SCHI), decomposed into internal (SII) and external (SEI) change components. Applied to 28 Chilean WUs over 2013-2023, the results reveal heterogeneous sustainability trajectories and distinguish between improvements driven by internal performance and external benchmarking shifts. The framework supports regulatory evaluation and targeted policy design and is transferable to other contexts.

3 - A Heuristic approach for EV charging in the lens of Energy management
Sridhar Puppala, Rahul Patil

Renewable-aware EV charge scheduling includes energy scheduling, grid reliance, battery lifespan, and demand management. Decisions focus on aligning charging with renewables, minimizing battery wear, and coordinating collective EV charging, including V2G energy transfer. The study develops a heuristic approach for large instances, where the study includes the usage of Flexible EV charging wherein charge schedules are shifted to align with the renewable availability, and results show that about 23% reduction in curtailment, 8% in grid supply, and 98% decrease in solving time over all instances.

4 - Carbon Tax Design for Electrifying Last-Mile Delivery: An Optimization Approach
Arman Derakhti

Urban freight transport is a major source of greenhouse gas emissions, particularly in last-mile delivery. This study develops an optimization model to analyze how carbon tax policies influence fleet composition and operating costs in urban logistics systems. Using a case inspired by Santiago, Chile, the model evaluates electric and conventional vehicle adoption under different tax levels. Results identify carbon price thresholds that trigger fleet electrification and quantify associated emissions reductions, providing insights for both policymakers and logistics operators.

■ MF-37

Monday, 16:15-17:45 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Optimization algorithms and applications 3

Stream: Nonlinear Optimization
Invited session
Chair: *Cong Sun*

1 - Understanding Generalization in Decentralized Learning: A Time-Uniform and Topology-Aware Analysis
Qing Ling

The existing generalization analyses of decentralized learning with convex losses often yield time-divergent and/or topology-independent bounds. These contradict with the empirical observation that the generalization performance typically stabilizes over training time and depends on network topology. To bridge this gap, we investigate the influence of training time and network topology on generalization of decentralized learning. We establish the non-divergent and topology-aware generalization guarantee for decentralized learning with convex losses, using tools borrowed from optimization.

2 - Purity Law for Neural Routing Problem Solvers with Enhanced Generalizability
Congying Han

In this presentation, we uncover Purity Law, a fundamental structural principle for optimal solutions of routing problems, defining that edge prevalence grows exponentially with the sparsity of surrounding vertices. Statistically validated across diverse instances, Purity Law reveals a consistent bias toward local sparsity in global optima. Building on this insight, we propose Purity Policy Optimization (PUPO), a novel training paradigm that explicitly aligns characteristics of neural solutions with Purity Law during the solution construction process to enhance generalization.

3 - Differential Privacy in Distributed Learning: Beyond Uniformly Bounded Stochastic Gradients
Jiaojiao Zhang

We study differentially private distributed algorithms for solving nonconvex ERM problems. Existing methods often assume that stochastic gradients are uniformly bounded, which is unrealistic in practice. We propose PriSMA (Private Stochastic Recursive Momentum with Gradient Clipping), a new algorithm that carefully integrates gradient clipping with recursive momentum to balance privacy protection and learning performance. Our approach removes the need for uniformly bounded gradients. We show that PriSMA achieves an improved learning error rate compared to the current state of the art.

■ MF-45

Monday, 16:15-17:45 - Room: HG - Seminar-Raum 01 (Building: HG)

Intelligent Manufacturing and Resilient Supply Chains

Stream: Prescriptive Analytics in Operations Management
Invited session
Chair: *Hubert Missbauer*

1 - Dynamic resource allocation with the use of Reinforcement Learning in Industry 5.0
Yang Deng

Dynamic resource allocation typically refers to the transformation of production materials, data information, and human resources between the supply and demand sides in Industry 5.0. With the increase in the variety of resources and the growing uncertainty in supply and demand, these problems pose additional challenges similar to those of optimization problems in complex, multi-layered, and dynamic operational scenarios. We propose a model-free, hierarchical reinforcement learning decision system to optimize adaptive decisions in high-dimensional and uncertain steel manufacturing environments.

2 - An LLM-Driven Iterative Heuristic Generation Framework for the Flexible Job-Shop Scheduling Problem
Tzu-Yen Hong

This study proposes an LLM-driven iterative framework that generates and refines executable heuristics for Flexible Job-Shop Scheduling Problem (FJSP) through execution feedback, feasibility checks, and performance evaluation. A Tree-of-Thoughts mechanism and iterative feedback further support adaptation to changed objectives. Experiments and ablation studies show that the framework produces feasible and competitive heuristics, and the proposed iterative refinement is critical to heuristic effectiveness. The results demonstrate automated heuristic design for complex scheduling problems.

3 - Price-based coordination of order releases and shop-floor scheduling
Hubert Missbauer, Reha Uzsoy, Gregor Blossey

Any production planning model must anticipate cycle times and work-center utilization, both of which are determined by order release decisions. Hence anticipating the effects of a specified order release schedule on these values which result from shop-floor scheduling is a crucial modeling task. We formulate an integrated optimization model encompassing both order release and detailed scheduling, and propose a price-based coordination approach using a variant of augmented Lagrangian relaxation that ensures separability of these subproblems. Computational experiments yield promising results.

■ MF-46

Monday, 16:15-17:45 - Room: HG - Seminar-Raum 02 (Building: HG)

Scheduling in Order Picking, Production and Maintenance, and Drone Delivery

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Sven Mallach*

1 - A dynamic programming framework for order picking in warehousing
Jan-Erik Justkowiak, Mikhail Y. Kovalyov, Erwin Pesch

We consider a set of closely related synchronization problems to optimize order picking in parts-to-picker warehousing. Synchronization in this regard concerns coordinating an inbound stream of storage bins (supplying items) with an outbound stream of customer orders (requesting items). For several synchronization problems, we analyze their computational complexity and develop a dynamic programming algorithm. We then evaluate the performance of this algorithm through computational experiments and in comparison with mixed-integer linear programming approaches from literature.

2 - Branch and price for nonlinear production-maintenance scheduling in complex machinery
Ksenia Bestuzheva

This talk will present a mixed-integer nonlinear programming approach to joint scheduling of maintenance and production for groups of complex machines with multiple interacting components. We introduce an abstract model where the production and the machine condition are given by convex functions, allowing the model to be employed in various application areas where systems of a suitable structure occur. We propose a branch-and-price algorithm to solve this problem and enhance in by acceleration techniques. Experiments comparing this approach to solving the compact formulation will be presented.

3 - Scheduling heterogeneous drones for last-mile delivery
Juan F. Correcher, Juan Vicente Serrano-Galvañ

This study addresses a drone last-mile delivery scheduling problem involving single-stop deliveries, heterogeneous drones and knapsack-based item assignment to minimize makespan. We propose a Mixed Integer Linear Programming (MILP) model and a Greedy Randomized Adaptive Search Procedure (GRASP) to provide solutions for large instances. Numerical results on extensive benchmark instances show that our methods yield high-quality solutions within short computation times, proving their viability for large-scale drone logistics.

4 - A TSP-based Exact Approach for the Job Sequencing and Tool Switching Problem in Wiring Harness Manufacturing
Jihun Lim, Jongheon Lee

The cutting and crimping process in wiring harness manufacturing involves a complex scheduling problem with tool switching. This problem can be formulated as a variant of the Job Sequencing and Tool Switching Problem with Sequence-Dependent Setup Time (SSPSD). Since existing SSPSD solution approaches do not explicitly capture the tool configuration structure arising in wiring harness processing, we propose a TSP-based mathematical model and an exact solution approach using tool-configuration-based node contraction and connectivity constraints with a branch-and-cut implementation.

■ MF-47

Monday, 16:15-17:45 - Room: HG - Seminar-Raum 03 (Building: HG)

Networks and supply chains

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Nezir Aydin*

1 - Modeling and Optimization of dynamic container drayage operations with foldable and combinable containers
Zengni Zhang

Recently, growing port trade volumes have worsened congestion and costs, posing significant challenges to container drayage operations. Thus, innovative containers with advanced functionalities have been increasingly applied. We introduce foldable and combinable containers into dynamic container drayage operations under uncertainties, model the problem as a Markov decision process and solve it by a hybrid algorithm framework combining column generation and variable neighborhood search respectively for periodic and real-time scheduling. The method's superiority is validated by experiments.

2 - Robust e-waste recycling network design with social-influenced uncertain customer behavior
Jiaze Tang, Zhi-hai Zhang

Although consumer behavior is vital to the successful implementation of e-waste reverse supply chain, scant attention has been paid to the underlying social and economic drivers in network design. This study employs an evolutionary game model to capture the social and monetary influence on recycling behaviorand incorporate distributionally robust optimization to enhance the robustness of the network design. We investigates the solution methodology for a two-stage RSC network design model with decision-dependent ambiguity set, and analyze the impact of recycling behavior on network design.

3 - Low-Carbon and Resilient Medical Supply Network Design under Demand Uncertainty
Nezir Aydin, Melike Cari, Ertugrul Ayyildiz

Medical supply chains face demand volatility, disruptions, and sustainability pressures. This study proposes a two-stage stochastic mixed-integer model to design a resilient, low-carbon distribution network for a metropolitan area, illustrated with a Doha case. The model optimizes facility location, capacity, inventory, and flows under disruption scenarios, incorporating service reliability and carbon constraints. A decomposition approach enables scalable solutions, providing decision support for robust, sustainable health logistics planning.

■ MF-48

Monday, 16:15-17:45 - Room: HG - Seminar-Raum 04 (Building: HG)

Data-Driven Transportation, Mobility, and Logistics

Stream: Data-driven Operations Research
Invited session
Chair: *Katharina Glock*

1 - Managing equitable contagious disease testing: A mathematical model for resource optimization
Peiman Ghasemi

The COVID-19 pandemic created major challenges in diagnostic testing due to limited resources and disrupted supply chains. This study proposes a bi-objective, multi-period optimization model for mobile testing and resource allocation, prioritizing equitable patient access. A team orienteering approach considers capacity, geography, and risk-based patient groups. Using MOVNS and NSGA-II, results show prioritization significantly reduces untreated high-risk patients, while demand and quarantine policies strongly influence waiting times and service efficiency.

2 - Incorporating Hybrid Greedy Insertion and Tabu Search Algorithms into a Demand Responsive Transportation Service Dispatching System
Rong Yan Hu, Cheng-Chieg Chen

This study initially analyzes historical DRTS dispatching data, to explore the features and linkages of demand frequency, distributions of time and space, and demand prediction mechanisms. A hybrid Greedy Insertion method is used to construct initial solutions, followed by Tabu Search to optimize the routing problem. Findings shows that the proposed strategies and algorithms could significantly reduce total travel distance and shorten passenger delay by 53% to 63%, respectively, while also offering practical guidance for rural DRTS operations.

3 - Data-Driven Redesign of Intralogistics Processes in a Transshipment Hub
Katharina Glock, Anne Meyer

Internal operations in transshipment hubs of groupage service networks are critical to truck waiting times and, hence, to the network's on-time delivery rates. For a real-world transshipment hub, we discuss alternative concepts for intralogistics operations: We evaluate zone-based assignment of jobs to fork lifts, fast-track, single-stage and multi-stage transports, truck gate and time window assignments in a simulative study and show the potential of redesigning hub processes. Moreover, the study assesses the feasibility of re-designing processes within a data-driven, real-world system.

■ MF-49

Monday, 16:15-17:45 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management under Novel Theoretical Aspects

Stream: Data-Driven Demand Management
Invited session
Chair: *Philipp Hausenblas*

1 - Bid Price Control in Network Revenue Management under Degeneracy
Philipp Hausenblas, Sebastian Spindler, Andreas Brieden, Claudius Steinhardt

Primal degeneracy in deterministic linear programs leads to multiple optimal dual solutions and ill-defined bid prices in network revenue management. This ambiguity causes incorrect acceptance decisions and revenue losses under classic bid price control. We analyze the impact of degeneracy in network revenue management and propose two novel control approaches that restore optimal acceptance behavior and extend naturally to dynamic and choice-based settings. A computational study demonstrates consistent revenue improvements over traditional bid price controls.

2 - Resolving Degeneracy, a Solution to Non-Unique Bid Prices
Thiemo Wasielewski, Henrik Nordhaus, Jochen Gönsch

In DLP- and RLP-based capacity control for revenue management, degeneracy leads to non-unique dual variables and consequently to non-unique bid prices for resources. When bid prices, obtained directly from the solver output, are used to approximate opportunity costs, they are not necessarily economically meaningful and may result in suboptimal control decisions. We propose a new DLP-based modeling approach that ensures an economically correct approximation of opportunity costs in the context of RLP-based controls for flexible products.

3 - Endogenous Attention and Context Effects in Discrete Choice
Moha Ghaderi

I introduce a behavioral discrete choice model in which a decision-maker endogenously allocates attention across subsets of attributes to reduce ex post choice uncertainty. By endogenizing attention, the decision problem is reformulated from "which alternative to choose" to "which informational cues to process," with the observed choice emerging as the outcome of this attentional allocation. The model nests RUM, relaxes IIA and regularity, captures key context effects (attraction, compromise, similarity) in a testable way, and yields better in-sample and out-of-sample predictions.

4 - Demand Information Sharing in Online Retail Marketplaces
Fernando Bernstein, Ignacio García-Jurado, Juan Carlos Gonçalves-Dosantos, Ana Meca

This paper studies how market characteristics create incentives for retailers to acquire and share demand information in a multi-agent online marketplace. We model these interactions as a two-stage biform game: in the first stage, retailers selling through the marketplace independently decide whether to acquire demand signals from an external source; in the second, they may cooperatively share the acquired information and distribute the resulting gains through an allocation rule. We study both settings without competition as well as with inventory or price competition.

■ MF-50

Monday, 16:15-17:45 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Bilevel & Equilibrium Models in Energy

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Hubert Abgottspon*

1 - Prosumer energy trading embedded in a dynamic operating envelopes framework
Benjamin Dosse, Jérôme De Boeck, Bernard Fortz

High penetrations of distributed energy resources increasingly stress distribution networks and require new approaches to allocate limited network capacity. Dynamic operating envelopes provide time-varying limits on power injections and withdrawals, but their allocation is typically centralised. We present a market mechanism in which the system operator is the leader, and the follower are energy prosumers. We formulate it as a bilevel equilibrium problem enabling the exchange of DOE rights among network participants and investigates how initial allocations affect outcomes of the market.

2 - Stability-aware Capacity Planning for Sector-Coupled Energy Community
Yuin Moon, Seokwoo Kim, Dong Gu Choi

Sector-coupled energy communities integrate power and hydrogen systems to mitigate renewable variability. As stakeholders from different markets share infrastructure, profit allocation can influence community stability. Yet, prior studies on energy community design focus on capacity planning that maximizes total welfare, while profit allocation is considered separately. This study proposes a unified bi-level framework that jointly considers capacity planning and profit allocation. The upper level determines player participation and settlement, while the lower level optimizes system operations.

3 - A Decomposition-based Approach for Integrated Layout and Cable Routing Optimization in Offshore Wind Farm
JeongHoon Park, Seulgi Joung

This study proposes a logic-based Benders decomposition framework for the integrated offshore wind farm layout and cable routing problem. Although the integrated formulation guarantees global optimality, it becomes computationally intractable for large-scale instances. The proposed approach decomposes the problem into a master problem and exact subproblems, preserving optimality through valid optimality cuts and converging to the same global optimum as the integrated model. Computational experiments demonstrate the effectiveness and performance of the proposed approach.

4 - Hedging Battery Energy Storage Systems under Market Incompleteness: A Practical Optimization Approach
Hubert Abgottspon

Battery Energy Storage Systems (BESS) derive value from short-term price dispersion, leading to highly non-linear revenues. In incomplete electricity markets, no standard instruments exist to hedge this exposure, requiring proxy hedging via base and peak forwards. We present a practical framework highlighting the structural mismatch between asset payoffs and hedge instruments. A stochastic optimization model minimizes portfolio PnL variance and quantifies residual risk under realistic price scenarios.

■ MF-51

Monday, 16:15-17:45 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Recent Advances in Fair and Interpretable Learning II

Stream: Mathematical Optimization for Transparent and Fair Decision Making
Invited session
Chair: *Sandra Benítez-Peña*
Chair: *Arturo Pérez-Peralta*

1 - Functional Cox regression: a penalized approach
Pilar González-Barquero, Jeff Goldsmith, Álvaro Méndez-Civieta, Rosa Elvira Lillo Rodríguez

Functional covariates, which capture processes evolving over time such as physical activity or heart rate, are increasingly used in survival analysis. However, identifying which regions of these predictors influence time-to-event outcomes remains challenging. We consider a penalized functional Cox regression approach designed to improve interpretability by isolating relevant time intervals. Penalizations are applied both to the coefficient function and to its derivatives, encouraging smooth effects while shrinking non-informative regions exactly to zero.

2 - Fair Graph Heat Methods: Exploring geometric ideas for fair classification
Arturo Pérez-Peralta, Sandra Benítez-Peña, Rosa Elvira Lillo Rodríguez

ML algorithms are ubiquitous in key decision-making contexts, which has spawned a great demand for fairness in these procedures. However, the theoretical properties of such models in relation with fairness are still poorly understood. In our work we propose a geometrically inspired framework leveraging graph convolutions in order to build fair classifiers. Some desirable properties of these models include the ability of handling group and individual fairness in a unified manner, the use of spectral tools to generate actionable diagnostics, and flexibility of placement in the ML pipeline.

3 - Accuracy versus Fairness in Recommender Systems
Rosa Elvira Lillo Rodríguez, Sandra Benítez-Peña, Jorge Moral

Recommender systems play a key role in shaping user experiences by predicting preferences and personalizing content. However, optimizing accuracy often reinforces different types of bias. In this work, we shift the focus from classical biases related to sensitive attributes to popularity bias, where popular items dominate recommendations while niche content remains underexposed. Using the MovieLens 100k dataset, we evaluate collaborative filtering and latent factor models, analyzing the trade-off between predictive performance and fairness.

■ MF-52

Monday, 16:15-17:45 - Room: KOL - PC Raum 1 (Building: KOL)

Recent Advances in Power Systems and Energy Market Models

Stream: Energy Markets & Systems
Invited session
Chair: *Steffen Rebennack*
Chair: *Anil Kaya*

1 - Scheduling Electricity Production Units to Mitigate Severe Weather Impact
Antonio Conejo, Yongzheng Dai, Feng Qiu

Extreme weather events can trigger power transmission line outages, leading to load shedding. We propose a framework that schedules generation while accounting for post-event transmission topologies. Generation units are scheduled first, followed by power dispatch decisions that minimize load shedding under the worst-case event. Convexified AC power flow constraints are used to ensure accuracy. The resulting tri-level mixed-integer nonlinear problem is solved using an outer-approximation algorithm within a column-and-constraint generation framework.

2 - Incomplete Risk Markets, Contract Design, and Long-duration Energy Storage Investment in Electricity Markets
Adam Suski, Elina Spyrou, Jacob Mays, Richard Green

Emerging technologies such as long-duration energy storage (LDES) are characterized by volatile revenue streams and limited opportunities for risk hedging, creating fundamental challenges for investors. We use stochastic equilibrium modelling with risk-averse agents under an incomplete market setting to examine how risk preferences and alternative contractual mechanisms shape investment, reliability, and welfare. Special attention is given to the role of LDES-dedicated contracts. Our work highlights how these frameworks can support decision-making in the design of policies and mechanisms.

3 - Novel Approaches for Combining Benders Decomposition and Stochastic Dual Dynamic Programming: An Application to Power Expansion Planning
Anil Kaya, Alexander Shapiro, Steffen Rebennack

We propose novel algorithmic approaches using Benders decomposition and Stochastic Dual Dynamic Programming to address multi-stage stochastic mixed-integer programming problems with a specific structure. Combining these two methods leverages the two-stage and multi-stage structures of the problem; however, the optimality cut for the master problem might not be guaranteed to be tight or valid. In this regard, we implement four strategies within two different frameworks. The proposed approaches are then applied to an expansion planning problem (ARTESIS project) to evaluate their performance.

4 - Co-Optimizing Storage and Transmission in a Nodal German Power System: A Stabilized Benders Decomposition Approach
Lene Marie Grübler, Martin Klein, Felix Muesgens

Germany's energy transition requires the expansion of renewable generation capacities. The intermittent and spatially concentrated availability of these resources increases the need for expansion of storage systems and transmission grids, which can act as complements or substitutes. We analyze how co-optimizing operation and expansion of storage and transmission technologies can leverage cost savings, using a nodal, hourly model of the German energy system for 2040. A stabilized Benders decomposition enables tractable solution of this large-scale capacity expansion problem.

■ MF-53

Monday, 16:15-17:45 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Multi-Objective Optimization for Health Systems

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Guillermo Cabrera-Guerrero*
Chair: *Ana Belen Ruiz*

1 - The MAUT-KBP model for evaluating IMRT treatment plans in cancer: Integration of multi-criteria theory and knowledge-based planning
Sandra GonzÁlez Gallardo, Liany Tobón-Castro, Guillermo Cabrera-Guerrero, Mauricio Moyano, Ana Belen Ruiz

Intensity-Modulated Radiation Therapy (IMRT) requires robust plan quality evaluation, yet standard binary protocols fail to capture trade-offs among conflicting clinical objectives. This work integrates Knowledge-Based Planning (KBP) and Multicriteria Decision Making using Multi-Attribute Utility Theory (MAUT) to assess IMRT plans. Based on 91 prostate cancer plans, utility functions and a Global Utility Score were defined to rank plans. Results show that MAUT enables robust discrimination and reveals clinically relevant differences, supporting improved clinical decision-making.

2 - Knowledge-Guided Pareto Surface Navigation for Intensity-Modulated Radiotherapy Treatment Planning
Mauricio Moyano, Guillermo Cabrera-Guerrero, Liany Lizeth Tobón Castro, Nicolle Ojeda Ortega

Radiotherapy treatment planning involves balancing multiple objectives, such as achieving tumour coverage while minimising radiation to surrounding tissues. Most methods rely on objective functions based on voxel dose. However, these criteria do not necessarily reflect the clinical indicators used in practice. We propose a knowledge-based framework for exploring treatment plans that combines Pareto Surface Navigation (PSN) with an MCDM model based on a database of previously accepted plans. PSN generates treatment plans, while the model evaluates them to identify clinically relevant plans.

3 - A Robust Multi-Objective Location-Allocation Model for Diagnostic Medical Equipment
Yerlis Valdelamar González, Washington Oliveira, Flávia Barbosa, Priscila Rampazzo

The location and allocation of medical equipment play a key role in enabling early disease detection, particularly for cancer. We propose a multi-objective optimization model that determines the optimal placement of diagnostic equipment by maximizing demand coverage, minimizing patient travel time and installation costs, and reducing inequalities in access to healthcare services. Demand uncertainty is addressed using a robust optimization approach. The model is applied to cases from the Brazilian public health system and can be adapted to other healthcare settings.

4 - Non-convex Multi-Objective Optimization for Functional Airway Preservation in Radiation Therapy Planning Using a Max Flow Model
Tam Linke, Karl-Heinz Küfer, Katrin Teichert

Radiation therapy planning aims for the minimization of dose-induced damage to healthy structures while ensuring tumor control. For large organs such as the lung, current dose metrics can cause hotspots within. An additional objective is needed to steer these peaks away from functionally important areas. We present a multi-objective framework that integrates such information of the bronchial tree, where a max-flow-based characterization of airway functionality induces a non-convex objective that departs from the original linear model. We examine its structural behavior and properties.

■ MF-57

Monday, 16:15-17:45 - Room: HG - Seminar-Raum 07 (Building: HG)

Behavioural aspects of strategic planning

Stream: Behavioural Operational Research
Invited session
Chair: *Martin Kunc*

1 - The impact of AI-based strategic planning on the behaviour of planners
Martin Kunc

This article explores how AI-driven strategic planning tools influence the cognitive and behavioural patterns of human planners. By integrating GenAI, ML and predictive analytics into decision-making processes, AI alters traditional planning roles, shifting focus from intuition-based and analytics-based judgments to AI-enhanced. The study examines changes in trust, autonomy, and collaboration, highlighting implications for organizational adaptability and planner skill development.

2 - Pass-through differentiation as a competing strategy under market uncertainty
Phat Luong

This paper explores how producer risk aversion affects cost pass-through, modeled using a CARA utility function. This study was motivated by the changes in the stainless steel industry; American and European firms fully pass through costs, while Asian producers do not. Our models suggest that maximum pass-through differentiation occurs when a risk-neutral supplier (China) competes with a risk-averse supplier (US). When both are risk-averse (US and EU), pass-through rates settlebetween 40% and 60%. Our models also suggest tariffs do not effectively enhance domestic competitiveness.

3 - The Strategic Value of Nostalgia: How Emotional Connections Drive Heritage Brand Consumption
Yingxue Ren

In today's fiercely competitive consumer market, nostalgia serves as a pivotal emotional driver of purchasing decisions. Conventional economic models prioritize rational factors like cost-benefit analysis and neglect such profound emotional impacts. This study innovatively examines how nostalgia shapes consumers' purchase intention toward time-honored dairy brands, focusing on the mediating role of multidimensional perceived value. Using questionnaire surveys across diverse demographics and structural equation modeling (SEM) for path analysis.

4 - Why Doesn't Information Always Impact Decisions? Goal Ambiguity, Worldviews, and Information Interactions in Strategic Decisions
Giovanni Cunico

Why, in sustainability policy and complex strategic decisions, does information exert weaker-than-expected influence while worldviews more consistently shape choices? We argue goal ambiguity—multiple conflicting goals without prioritization—explains this pattern. In a dynamic decision experiment using system dynamics, goal ambiguity fundamentally reshapes behavior: under clear goals neither worldviews nor additional information affect decisions; under ambiguous goals both do, with worldview effects dominating. This helps explain the limited impact of additional information on strategies.

■ MF-58

Monday, 16:15-17:45 - Room: HG - Seminar-Raum 08 (Building: HG)

Assembly Systems and Flow Shops

Stream: Integrated Planning in Manufacturing
Invited session
Chair: *Julia Rieck*

1 - A local search heuristic for the strategic assembly line feeding problem
Hannah Verplancke, Emmanouil Thanos, Gohar Porbar, El-Houssaine Aghezzaf, Veronique Limère

The Strategic Assembly Line Feeding Problem (SALFP) addresses long-term decisions on facility design and transportation fleet sizing in manufacturing systems. Strategic planning optimization requires incorporating shorter-term tactical decisions such as part feeding policies and route selection. The resulting integrated problem is computationally challenging for exact solvers. Therefore, we propose a local search heuristic that efficiently solves large-scale instances and supports strategic decision-making in assembly line intralogistics settings.

2 - Planning Cobot Integration in Existing Multi-Stage Manufacturing Flow Lines: A DES-Based Sensitivity Analysis
Anita Onay, Alejandro Secades, Manuel Felder

For existing multi-stage flow lines, collaborative robots (cobots) can raise automation potential. However, successful cobot integration constitutes a multi-level decision-making problem. This study (i) applies a discrete-event simulation model based on real manufacturing data and (ii) conducts a sensitivity analysis with the following experimental factors: cobots' processing time variability, mean time to failure/repair, and flow line utilization level. The study shows that DES-based sensitivity analysis yields reliable threshold values for a robust cobot integration strategy.

3 - Flexible Job Shop Scheduling with Alternative Sequences and Parallel Operations under Capacitated Buffer Constraints
Lars Müller, Julia Rieck

Machine scheduling often assumes unlimited buffers, but this can cause congestion in space-constrained systems such as automobile assembly. We study a flexible job shop variant with finite buffers, where a job blocks a workstation until a suitable buffer becomes available. Jobs can be run according to alternative assembly sequences, and their operations can be partly parallelized. Workstations perform sequence-dependent setup processes, and transferring jobs between workstations or buffers incurs transport times. We present a metaheuristic aiming to minimize the makespan.

4 - Bottleneck and qualification-oriented workforce planning using predictive task times in industrial housebuilding industry
Tobias Weberhofer, Maria Anna Gartner, Wolfgang Grenzfurnter, Manfred Gronalt

In industrial housebuilding industry, producing high-customised, individual and complex products such as wall panels on manual mixed-model assembly lines can result in bottlenecks and high variations in process times. To improve WIP and mitigate these issues, process times for each wall panel are predicted and used to allocate the appropriate workforce according to their skill level. Scaling this process across multiple lines enables dynamic scheduling, balances the workload among workers and improves throughput and overall line performance.

■ MF-59

Monday, 16:15-17:45 - Room: KOL - Seminar-Raum 9 (Building: KOL)

Weights in MCDM

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Jafar Rezaei*

1 - Exact Decision Support under Joint Weight-Embedding Uncertainty in Ordinal Multi-Criteria Evaluation
Dimitris G. Sotiropoulos

We consider additive multi-criteria evaluation when only a ranking of criterion importance is available and performances are expressed on a shared ordinal scale. Both the weight vector and the numerical meaning of grade labels are then unknown. We prove that robust pairwise preference admits an exact finite test via cumulative dominance conditions over extreme embeddings, and we derive a closed-form minimax regret index with explicit certificates. The framework yields an auditable screening and selection tool that requires no ad hoc weight elicitation.

2 - Data-Driven Attribute Preference Analysis for Consumer Decision Making with Online Reviews
Peijia Ren

We provide consumer with online decision-making support that assists them in making informed choices by incorporating preference learning and decision-making based on online reviews. Firstly, we outline the process of preprocessing reviews presented from online platforms. Secondly, we develop an online optimization model aimed at minimizing the regret associated with the deviation from linear additivity of attributes. An online learning algorithm is proposed to learn the attribute weight vectors for candidate products. Lastly, we present the learned vectors to the user for decision support.

3 - Indifference structures in mcda: a tool for weight sensitivity analysis
Christian Carling

Ranking of alternatives in MCDA can be very sensitive to weight assignment. Holding scores constant, the pairwise indifference solutions form a hyperplane arrangement in weight space. The faces of this arrangement correspond to all possible rankings, including ties. Many properties of this arrangement can be studied by purely combinatorial means. Uncertainty in weight assignment can be modelled by a Dirichlet distribution, giving a probability distribution over all feasible rankings. Score uncertainty can then be included to analyse the overall stability properties of rankings.

4 - Coalition-Indexed Weight Assessment: An Adaptive Weight Elicitation Method for Multi-Criteria Decision Analysis
Jafar Rezaei

We introduce the Coalition-Indexed Weight Assessment (CIWA), an adaptive weight-elicitation method for multi-criteria decision-making based on outranking reasoning. Decision-makers provide pairwise comparisons between stylized alternatives, generating linear constraints on criterion weights that define a feasible weight region. Two adaptive algorithms, a maximin query-and-propagate procedure and an LP-based variant, exploit prior responses and logical relations to reduce elicitation effort. The approach preserves non-compensatory structure, and a numerical case illustrates its application.

■ MF-61

Monday, 16:15-17:45 - Room: KOL - Seminar-Raum 18 (Building: KOL)

Performance Optimization

Stream: OR in Sports
Invited session
Chair: *Mario Guajardo*

1 - Limits to growth in performances in running, skating, and swimming
Marcel Turkensteen, Marnix Peek, Gerard Sierksma

In track-and-field sports disciplines, tiny differences between performances of top athletes appear to be-come more frequent, often within the margin of error of time measurement devices, while large differences become increasingly rare. Gould's hypothesis states that this arises from a convergence of performances to a ceiling of the humanly possible due to more intense competition. For three sports disciplines, with world records of around 100 seconds, we analyze the extreme tail of performances and determine whether the hypothesized convergence to the limit occurs.

2 - Examination of lineup to maximize expected runs in softball —Using the data from WBSC Women's Softball World Cup 2024 Finals—
Nobuyoshi Hirotsu

Using data from the WBSC Women's Softball World Cup 2024 Finals, this study examined base-advancement tendencies and batting orders that maximize expected runs. We found that, after a single with a runner on second base, the runner scored and stopped at third at almost the same rate, which we define as a "50/50 advancement model." Under this model, the lineup with a high-OBP leadoff hitter and the highest-Scoring-Index batter in the cleanup spot yielded the highest expected runs per game (5.5), exceeding 4.9 for Japan's most frequently used lineup.

3 - A Fuzzy Multi-Criteria Decision-Making Model for Player Position Assignment in Floorball and Ice Hockey
Helena Brozova, Vojtěch Šimůnek, Jan Saro

The paper presents a fuzzy multi-criteria decision model to help floorball or ice hockey coaches assign players to positions - defender, forward, and goalkeeper. Inputs include relative results of four cognitive tests and two game situation tests, fuzzified with three-level linguistic variables. Each athlete is evaluated using a weighted sum, with weights set by the coach according to position-specific skills. The model provides suitability scores for each position, supporting decisions on team composition and training.

4 - Performance Optimization of Winch Launches in Gliding
Johannes Weiland, Armin Fügenschuh

Gliding enables sustained flight without an onboard engine and is highly sensitive to launch performance. During a winch launch, a single control input determines rope force and speed, while the pilot controls the angle of attack. We model this as a time-dependent optimal control problem with nonlinear flight dynamics, differential-algebraic equations, and binary decisions for lift-off and release. After discretization, a sequence of nonlinear programs is solved. We analyze performance trade-offs between maximal altitude and maximal total energy for different ropes and glider types.

■ MF-65

Monday, 16:15-17:45 - Room: HG - Hörsaal 27 (Building: HG)

Statistics and Mathematics in the age of Data Science - OR - Analytics I

Stream: Analytics
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Sadia Samar Ali*
Chair: *Aviv Gibali*

1 - CDS Area Measures for Cumulative Credit Stress: Decomposition, Factor Structure, and Index Hedging
Xinyuan Li, Shaomin Wu

Existing CDS (credit default swap) work extracts common factors from daily spreads or returns and designs index hedges around one-day comovements, on which there are two issues for cumulative stress: Daily quotes are noisy from liquidity and microstructure frictions, and one-day targets are misaligned with weekly-to-monthly horizons.Motivated by these frictions and the horizon mismatch,this paper derives a common-idiosyncratic decomposition for the area panel with an explicit minimum-variance index hedge ratio that is approximately scale-stable as the accumulation length increases.

2 - AI-Powered Time Series Forecasting: A Validation and Generalization Perspective
Xin James He

This study provides (1) a structured review of transformer-based and foundation forecasting models, (2) a critical evaluation of current validation methodologies, and (3) a proposed framework for robust evaluation under non-i.i.d. time series conditions. Through multi-domain empirical benchmarking across macroeconomic, financial, and energy datasets, we assess forecasting stability, regime robustness, and generalization performance relative to classical statistical models and recurrent neural networks.

3 - Mechanisms and Prediction of Repeated Collaboration under Interorganizational Dependencies
Ruimin Liu

Repeated collaboration is a common yet insufficiently explained phenomenon in interorganizational networks. This study examines how knowledge, relational, and structural dependencies shape repeated collaboration behavior and influence the persistence of cooperative ties. By integrating dependency analysis with network features, it explores the mechanisms underlying repeated collaboration and predicts future ties among organizations. The study provides a basis for partner identification, relationship governance, and data-driven collaboration decision support in complex cooperative settings.

■ MF-66

Monday, 16:15-17:45 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Quantum Computing and Operations Research

Stream: Quantum Optimization
Invited session
Chair: *David Bernal Neira*

1 - Quantum-enhanced Markov chain Monte Carlo for combinatorial optimization
Kate Marshall

In this work, we offer a different way to approach combinatorial optimization with near-term quantum computing. We combine ideas of quantum-enhanced Markov chain Monte Carlo (QeMCMC) for sampling, together with warm-starting and parallel tempering, in the context of combinatorial optimization. We demonstrate empirically that our algorithm recovers the global optima for instances of the Maximum Independent Set problem (MIS) up to 117 decision variables using IBM quantum hardware. We also show early evidence of a scaling advantage of our algorithm compared to similar classical methods.

2 - Quantum Optimization Benchmarking Library
Thorsten Koch

Recent progress has brought benchmarking of (heuristic) quantum algorithms at scale within reach. Particularly in combinatorial optimization, it is key to empirically analyze and track progress towards quantum advantage. This work introduces a systematic, fair, and comparable benchmarking framework for quantum optimization methods by presenting ten model-independent problem classes that are challenging for classical methods. Track records of specific instances and solutions are given in an accompanying open-source repository.

3 - A quantum enhanced Frank-Wolfe Algorithm for Peer-2-Peer Energy Trading
Corey OMeara

We study the problem of decomposing a graph into a weighted sum of a small number of matchings, a task that arises in peer-to-peer energy exchange. Computing such decompositions is challenging for classical algorithms, even for small instances. To address this problem, we propose E-FCFW, a hybrid quantum-classical algorithm based on the Fully-Corrective Frank-Wolfe (FCFW) algorithm. In this talk, we present several variants of E-FCFW and report competitive performance of the resulting hybrid algorithms using up to 150 qubits on IBM Quantum computers.

4 - Is this quantum computer useful? Let's solve optimization with it! Evaluating the performance of quantum processing units at large width and depth
David Bernal Neira, Alejandro Montanez

Quantum computers have moved beyond the limits of classical simulation, but noise still blocks practical use. We present LR-QAOA, a scalable benchmark for quantum processors based on combinatorial optimization. Unlike gate-fidelity metrics or shallow-circuit tests, it captures algorithmic performance as circuit depth increases. We benchmarked 29 processors from six vendors on problems with up to 156 qubits and 10,000 layers. The results establish LR-QAOA as a unified, cross-platform benchmark for tracking progress in quantum hardware at scale.

■ MF-67

Monday, 16:15-17:45 - Room: KOL - PC Raum 3 (Building: KOL)

Selected Aspects of International Finance and OR 1

Stream: Selected Aspects of International Finance and OR
Invited session
Chair: *Sajid Siraj*

1 - A Neutrosophic Decision-Making Framework for Portfolio Stock Selection
Ozan Apaydın, Zerrin AladaĞ

Portfolio stock selection is a challenging process that may result in potentially risky outcomes. This is largely because the process depends on forecasts about the future that are inherently uncertain, while the information guiding the decision is affected by epistemic uncertainty. This study aims to provide a framework for the process of building a stock portfolio by combining mathematical models and a neutrosophic decision-making method. Uncertainties are incorporated alongside the information influencing decision-making. This allows for a more accountable portfolio selection in retrospect.

2 - Interactions between the Carbon Credit Market and International Equity Markets: Some Evidence by Causality Tests, VECM Models and Dynamic Volatility Spillovers

Andre Assis de Salles, *Renato Barros Lima*

Economic development, especially that which uses fossil fuels, has led to an increasing concentration of greenhouse gases in the atmosphere and contributes to climate change. The carbon credit markets mitigate this. Once the capital market finances the production, the relationship between these markets should be observed. This study aims to investigate the relationships between these markets. The methodology includes causality and cointegration hypothesis tests, as well as the estimation of VECM and GARCH models. The results provide statistically significant estimates of volatility contagion.

3 - A Generalized Allocation Framework for Big Boss Games

İsmail Özcan, *Gerhard-Wilhelm Weber*

This study introduces the k-proportional τ-value as a generalized allocation rule for big boss games by modifying the minimal right vector with a proportionality parameter, k. The model preserves core allocations while allowing flexible payoff distribution. An AI- and OR-focused case based on Amazon's personalized recommendation system illustrates its use in analyzing hierarchical collaboration, incentive alignment, and fair reward sharing in complex, data-driven organizational settings. This approach offers a practical tool for evaluating cooperation and equity in modern firms.

Tuesday, 8:15-9:00

■ TA-01

Tuesday, 8:15-9:00 - Room: HG - Audimax

Induction Ceremony of the IFORS Hall of Fame

Stream: Special Sessions
Award Competition session
Chair: *Janny Leung*
Chair: *Paolo Toth*
Chair: *Thomas Magnanti*

1 - IFORS Hall of Fame
Janny Leung

The IFORS Hall of Fame, created in 2003, celebrates the significant contributions made by the OR pioneers to methodology, to applications, to teaching, to the advancement of IFORS, to OR for development, and to the international dissemination of OR knowledge and understanding. Three new members, Prof. Dr. Hans Juergen Zimmermann, Prof. Andres Weintraub, and Prof. Judith Liebman, will be inducted into the Hall of Fame at the ceremony.

Tuesday, 9:00-10:00

■ TB-01

Tuesday, 9:00-10:00 - Room: HG - Audimax

Plenary Harald Ponweiser

Stream: Plenaries
Plenary session
Chair: *Jan Fabian Ehmke*

1 - Automated Resource Planning at ÖBB
Harald Ponweiser, Maximilian Kunovjanek-Bachler

Railway resource planning is a challenging task, as it must meet high stability and safety standards, fulfill efficiency requirements and operate reliably in a dynamic environment. A multitude of interdependencies between planning stages and objects further drives complexity. The use of optimization and simulation approaches has the potential to significantly support these planning tasks. As part of the ARP (Automated Resource Planning) program at ÖBB - the Austrian Federal Railways - the automation of planning processes is a key operational objective. Optimization algorithms have already been successfully applied to enable the automated planning of railway resources such as locomotives and locomotive drivers, which have been implemented as effective decision-support tools. In addition, various simulation approaches help to address the stochastic nature underlying these planning problems.

Tuesday, 10:30-12:00

■ TC-01

Tuesday, 10:30-12:00 - Room: HG - Audimax

Tutorial David Bernal-Neira

Stream: Tutorials
Tutorial session
Chair: *Andres Medaglia*

1 - Quantum computing for operations research: current state and perspectives
David Bernal Neira

Quantum computing is processing information through phenomena that can be described through quantum mechanics. Compared to non-quantum, classical, computing, this computational paradigm promises to accelerate specific tasks. The study of algorithms running in quantum computers has spurred a series of novel research in various areas, including computational chemistry, quantum system simulation, and combinatorial optimization. Some of these topics are particularly interesting to the Operations Research community, as they include core tasks in our profession. This tutorial is aimed to provide a bird's-eye overview of the state of usage of quantum computing in operations research. The work of the Quantum Computing committee at INFORMS for over a year, gathering experiences and perspectives of academics, practitioners, and stakeholders, provides a solid base to present various approaches on how one can leverage current and future quantum devices for OR tasks, particularly optimizations.

The tutorial will have a hands-on experience with quantum computing hardware for combinatorial optimization. In particular, we are going to cover the formulation of problems using quadratic unconstrained binary optimization (QUBO) models, which, given their equivalence to the transverse field Ising model, are the standard framework to encode optimization as the energy minimization of a quantum energy function, or Hamiltonian.

We will then cover different quantum algorithms designed to address QUBO problems, including quantum annealing, the quantum approximation optimization algorithm (QAOA), and variational quantum eigensolvers (VQE). We will explore the different topics while executing codes in quantum simulators, quantum annealers, gate-based quantum computers, and other novel hardware for this framework. All the codes are developed as open-source alternatives and run on cloud services, allowing anyone with an internet browser to experience using quantum computers.

■ TC-02

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 10 (Building: JUR)

EURO Doctoral Dissertation Award (EDDA)

Stream: Special Sessions
Award Competition session
Chair: *Sarah Fores*
Chair: *Violeta Cvetkoska*
Chair: *Gerhard-Wilhelm Weber*

1 - Machine Learning for Sequential Decisions in Logistics
Fabian Akkerman

This thesis explores how machine learning (ML) enhances sequential decision-making in logistics under uncertainty, complementing operations research methods. Through real-world collaborations, it tackles challenges in supply logistics (inventory control, dual sourcing), distribution logistics (vehicle routing, last-mile delivery), and revenue management (out-of-home delivery, time slot pricing). It distinguishes data analytics (prediction) from decision analytics (policy learning), proposing a framework for integrating ML into logistics operations.

2 - Optimising Fair Work Allocation: Applications in Railway Crew Planning
Bart van Rossum

In many real-life settings, the size and complexity of work allocation problems necessitate the use of operations research (OR) techniques. Traditionally, OR models have prioritised efficiency objectives, such as cost minimisation. However, there is a growing interest in methods that ensure fair work allocations. This thesis applies OR techniques to design models and methods that achieve fairness in work assignments. The first part of this thesis focuses on railway crew planning, addressing practical problems that arise in the proposed crew planning process of Netherlands Railways. The first study considers tactical crew scheduling, introducing a Benders decomposition approach for robust template selection. The second study examines fair operational crew scheduling under the assumption that template-based rosters have already been constructed. It proposes a tailored column generation heuristic to construct individual crew schedules that are fair over time. The third study presents an efficient exact pricing algorithm to accelerate column generation algorithms for basic railway crew scheduling problems. The second part of this thesis takes a more theoretical perspective, developing general optimisation methods for fairness-oriented work allocation. The first study centers on fairness over time in settings where work must be assigned online to homogeneous workers. It provides theoretical and experimental justifications for using an intuitive work allocation policy. The second study investigates branch-and-price methods for minimising the range and other order-based objective functions, introducing a generic branching rule that enables the use of classical, efficient branch-and-price methods for this type of problem.

3 - Data-Driven Modeling and Analytics for Information Propagation and Decision-Making in Social Networks
Tao Wen

Social platforms have become a central part of today's digital ecosystem, significantly affecting information diffusion, belief updating, and the emergence of collective decisions. These developments raise an important challenge for operational research and decision science: how can decision-makers act responsibly and effectively in large-scale, uncertain, heterogeneous, and dynamic networked systems? This dissertation addresses this challenge by developing theoretical, data-driven, and explainable models to support decision analysis and reasoning in large-scale social networks under uncertainty. In particular, generalized Bayesian inference is operationalized as a unifying modelling language for networked environments, representing partial knowledge and uncertainty, integrating heterogeneous and conflicting evidence, and supporting interpretable reasoning. Specifically, the dissertation investigates several interconnected studies, including information flow and communication behaviour in organizational networks through large-scale data analytics, influential-user identification through heterogeneous and conflicting evidence integration, propagation source localisation from sparse early-stage observations, and belief evolution and the emergence of collective decisions among socially embedded decision-makers. These studies connect individual-level behaviour with system-level network outcomes, supporting timely decision-making under uncertainty and limited information in social networks. Evaluations on real-world and synthetic networks demonstrate the applicability, robustness, and practical relevance of the proposed models. Overall, the dissertation extends explainable decision analytics to networked social systems in which uncertainty, interaction, and structural complexity are fundamental features of the problem.

4 - Linear Bilevel Optimization and Applications in the Grid Integration of Energy Storage
Bárbara Rodrigues

Despite only having been introduced in the 1930s, bilevel optimization has rapidly gained researchers' interest as a useful hierarchical modelling framework for numerous applications. In particular, bilevel optimization has been playing an important role for studying the effective integration of energy storage systems into the energy grid, a pivotal step for addressing challenges in decarbonizing the energy sector as we

shift to renewable-powered networks. Within this context, this thesis explores key theoretical aspects of bilevel optimization and practical applications in grid-integration of energy storage, and it is composed of three main research contributions. First, we investigated unboundedness in bilevel and multilevel optimization, an often overlooked issue as most research assumes boundedness. In this first contribution, we show that deciding whether an optimistic linear bilevel problem is unbounded is strongly NP-complete, and that the hardness part of this result is valid for the pessimistic formulation. In general, we show that deciding unboundedness of an optimistic k-level problem is Σp k1-hard for linear problems and Σp k-hard for mixed-integer problems. We also propose two algorithmic approaches for detecting unboundedness and compare their performance through computational experiments. In the second part of this thesis, we focus on an application of bilevel optimization in the energy industry. We propose an innovative business model to harness the potential of aggregating the behind-the-meter residential storage that arises with the emergence of prosumers. In this business model, a grid-scale aggregator compensates prosumers for on-demand use of their storage systems, while allowing them to sell the electricity they generate at wholesale market price. Our computational results for a realistic Texas case study show that the model has strong economic potential, with participants and the aggregator both achieving profitability. Lastly, we focus on another energy application arising from the energy transition and, we study the viability of hydrogen storage as a supplemental source of baseload support in a fully-renewable energy grid. Using a two-stage stochastic optimization model, we analyse investment decisions in renewable plants and hydrogen storage, while accounting for the operational costs of running the hydrogen storage systems under uncertain renewable generation. Our results indicate that green hydrogen is particularly valuable in high-wind environments and that long-term liquid hydrogen storage is more profitable than intraday hydrogen gas storage. The optimization model presented provides a framework to further investigate the potential of green hydrogen under many different energy grids.

■ TC-04

Tuesday, 10:30-12:00 - Room: HG - BIG-Hörsaal (Building: HG)

Emergency services

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Marion Rauner*

1 - A Cross-Border Ambulance Location-Allocation Framework for Emergency Medical Services
Hossein Torkinezhadirani, Amin Asadi, Derya Demirtas

Emergency Medical Services (EMS) face rising pressure as emergency calls increase while resources such as staff and ambulances remain limited. In border regions, ambulances from neighboring countries may reach incidents faster; however, cross-border collaboration remains rare and largely manual. We propose a cross-border ambulance location-allocation model that considers heterogeneous fleets, urgency-based response requirements, and country-specific constraints. The model is solved using logic-based Benders decomposition (LBBD). Preliminary results show improved coverage and resource usage.

2 - Optimizing Coverage under Capacity Limits: Balancing Ambulance Busyness by Integrating Bound Constraints
Isabel Wiemer, Jutta Geldermann

Ambulance utilization varies both within and between ambulance stations. We extend the maximum expected covering location problem by allowing each ambulance to have an individual busy fraction while balancing workload across vehicles. The model introduces lower and upper bounds on ambulance busyness and includes level-based interdependencies among ambulances. A real-world case study for the city of Duisburg, Germany, evaluates the approach. Preliminary results indicate reduced workload variation and a more realistic representation of ambulance utilization without compromising patient care.

3 - Beyond Three Tiers: Subtype-Aware Stochastic Optimization and Resource Misallocation Measurement for Earthquake Emergency Medical Response
Thanh Nguyen

Three-tier triage classification misallocates 22.1% of all doctor-time in earthquake response—131 doctor-hours per event. We present three model-agnostic contributions: eight-subtype casualty classification with Markov survival dynamics; Monte Carlo scenario generation calibrated to Istanbul seismic data; and the Resource Misallocation Index—a pre-event diagnostic converting classification coarseness into wasted doctor-hours. At 50 scenarios (696,550 variables), solve time is 69 seconds. Under 3 to 5 times capacity stress, 6-10 additional lives are saved versus the 3-tier baseline.

4 - A Bayesian Analysis of Personality Types and Stress Coping Strategies of Austrian Red Cross Paramedics
Marion Rauner, Ayşegül Engin

Stress management is vital for emergency medical services personnel. Burnout is common among paramedics, highlighting the need for effective stress coping. Using an online questionnaire with the Big Five Inventory for personality traits/types and scenario-based stress coping items, we surveyed Austrian Red Cross staff and analyzed responses with Bayesian regression models. Results show a shift toward resilient personalities, with higher roles boosting active coping and women less often classified as active copers, highlighting structural disparities.

■ TC-05

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 18 (Building: JUR)

Shared Resources in Last Mile Delivery

Stream: Shared Mobility
Invited session
Chair: *Simona Mancini*

1 - Profitable Pre-assigned Pickup and Delivery Problem with Product Compatibility
Maryam Darvish, Simona Mancini

In many rural areas, individuals travel to deliver their own products while significant vehicle capacity remains unused. We study a collaborative logistics platform that allows these travelers to perform additional pickup and delivery tasks along their pre-assigned routes. Decisions balance profitability and detour costs while respecting product compatibility, as some goods cannot be transported together due to safety, hygiene, or regulatory constraints. We propose a mathematical formulation and a multi-neighborhood matheuristic, and derive insights from computational experiments.

2 - Sharing Delivery Robots in Last Mile Vehicle Routing
Simona Mancini, Margaretha Gansterer

We study a novel VRP for last mile delivery where a global fleet of delivery robots is shared across vehicles. Vehicles can load a variable number of robots, inducing a flexible trade-off between robot availability and loading capacity. Customers are served either by vehicles or by robots launched from vehicle stops within a compatibility radius. We propose a MIP formulation and a two-phase hybrid method combining a Robot-Aware GRASP and a MIP to coordinate routes, robot assignments, and launching points. Computational results highlight the benefits of robots as a shared resource.

3 - Real-Time Parcel Locker Assignment with Stochastic Decision-Dependent Pickup Times
Alessio Sclafani, Simona Mancini, Margaretha Gansterer

Parcel lockers are an effective solution for last-mile delivery. We address the real-time problem of accepting or rejecting storage requests and assign accepted parcels to compatible lockers. A key novelty is that pickup times depend on recipients' travel distance, yielding a decision-dependent stochastic problem. We propose a scenario-aware framework training supervised learning models on optimal solutions to handle pick up time uncertainty. Results show our approach outperforms benchmarks and achieves solutions within 15-18% of a perfect-information bound.

4 - A dynamic overbooking model for parcel locker systems
Gijs Bakker, Jose Lopez Alvarez, Iris F.A. Vis, Nicky Van Foreest

We study a revenue management problem for parcel lockers under stochastic demand and pickup times. In collaboration with European logistics providers, we observe that capacity overbooking is applied in practice but remains unexplored in the literature. To address this gap, we develop an overbooking model tailored to parcel lockers and formulate it as a semi-Markov decision process. We prove properties of an optimal policy and propose a scalable solution method with near-optimal performance. Results show that overbooking can raise utilization by up to 30% while reducing operational variability.

■ TC-06

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 07 (Building: HG)

SCM and Consumer Behavior in Retail Stores

Stream: Retail Operations
Invited session
Chair: *Fredrik Eng Larsson*

1 - Revisiting the Eye-Level Effect
Necati Ertekin, Maxime Cohen, Mehmet Gumus

The principle that "eye-level is buy level" underpins planogram optimization and retailer-manufacturer agreements. When a product is moved to eye-level, the remaining products on the same shelving unit can be reorganized in several different ways (i.e., planogram reorganization). This study examines how different planogram reorganizations affect the magnitude of the eye-level effect. Using data from a subset of a field experiment, we compare eye-level placement under two distinct planogram reorganizations.

2 - The Freshness Dilemma: How Customer Picking Drives Food Waste in Grocery Stores
Fabian Schäfer, Tobias Winkler, Kai Hoberg, Alexander Hübner

This study investigates the impact of customer withdrawal behavior in grocery stores on retail food waste. Combining expiration-date and transaction data from 211 stores and 1,877 chilled products, we develop a novel and replicable approach to quantify food waste caused by customer picking. Our empirical findings show that, on average, 45% of the food waste in our setting is caused by customers picking fresher products. We further apply an exploratory approach to identify product and store-related drivers of customer-picking waste.

3 - Evaluating the Price of Resilience in Retail Supply Chains with Dynamic Robust DEA
Matthias Klumpp, Aliasghar Arabmaldar, Katharina Berendes, Maik Hammerschmidt

Recent disruptions have exposed major retail supply chain vulnerabilities and highlighted the need to balance resilience with efficiency. This study proposes a dynamic robust DEA framework to measure the price of resilience over time. The approach distinguishes routine operational uncertainty from disruption-specific shocks and evaluates how resilience initiatives affect performance outcomes in terms of efficiency. It offers a clearer basis for assessing resilience-efficiency trade-offs and supports informed resilience management decisions on a more detailed level within retail supply chains.

■ TC-07

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 21 (Building: HG)

Procurement Auctions

Stream: Auctions and Market Design
Invited session
Chair: *Nicolas Fugger*

1 - Gaming the test - when should test thresholds be unpredictable?
Helene Mass

We study pass/fail tests when agents can manipulate their perceived ability at a cost. A principal wants only sufficiently able agents to pass but faces uncertainty about gaming costs. We show that randomizing the passing threshold can outperform a deterministic cutoff and becomes optimal whenever there is a positive probability that some agents cannot game at all. Randomization allows high-ability agents with high gaming costs to pass without encouraging excessive gaming by low-ability agents. The resulting rules are robust to limited knowledge of abilities and gaming costs.

2 - Bid heterogeneity and the winner's curse in multi-unit auctions
Marion Ott, Karl-Martin Ehrhart, Jan Kreiss

We examine how the number of goods, or the level of competition, affects the winner's curse in common value auctions. In our experiment, the bidders' profits increase with the number of goods with both discriminatory and uniform pricing. The observed pattern does not align with equilibrium predictions but is replicated by a model of heterogeneous, dispersed bids. With discriminatory pricing, dispersion always strengthens the winner's curse. With uniform pricing, dispersion may protect against the winner's curse if the number of goods is sufficiently large, as is observed in the experiment.

3 - Procurement score auctions in the presence of profitability bidding constraint
Panos Lorentziadis

In a procurement auction the score can be quasilinear in price or the price-over-quality ratio. The administration of bidding firms often requires a minimum margin. We explore bidding in quasilinear or price-over-quality score auctions under the presence of an exogenously imposed profitability constraint. The equilibrium bidding strategies in a first-score and in a second-score auction are derived and compared. The impact of the profitability constraint on the score is investigated. It is demonstrated that the profitability constraint increases the eventual score for a procurement project.

4 - Optimal Procurement Auctions in Dynamic Stochastic Environments
Yukun Cheng

Procurement auctions are vital for cost efficiency, yet designing optimal mechanisms for scenarios involving dynamic interactions and stochastic demand remains a complex challenge. This study addresses this gap by investigating auction design for a buyer procuring divisible goods from self-interested suppliers arriving randomly over a finite horizon.

■ TC-08

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 41 (Building: HG)

Multi-Objective Facility Location

Stream: Location Analysis
Invited session
Chair: *Serena Fugaro*

1 - Multi-objective optimization for global supply chain redesign with production relocation
Teresa Melo, *Angelo Aliano Filho*, *Isabel Correia*

We propose a tri-objective MILP model for global supply chain redesign with production relocation (reshoring). The model captures partial capacity transfers to new regional sites over multiple periods with endogenous relocation timing and temporary capacity during transition, along with multi-modal transport decisions. Objectives minimize cost and CO2 emissions while maximizing relocated capacity to support regional development. Numerical experiments on global-scale instances provide insights into trade-offs between economic efficiency, environmental impact and supply chain resilience.

2 - Resilient supply chain network design: A bi-objective two-stage stochastic model with flexible strategies
Isabel Correia, *Angelo Aliano Filho*, *Teresa Melo*

We propose a bi-objective two-stage stochastic program for resilient and agile three-echelon supply chain design. It integrates backup sourcing, facility fortification, bounded delivery delays and minimum service levels under demand, cost and disruption uncertainty. First-stage decisions include facility deployment and supplier choice; second-stage decisions cover flows and backup supplier activation. Minimizing expected cost and unmet demand, a tailored MIP-based heuristic within an epsilon-constraint framework solves large instances and reveals cost-resilience-responsiveness trade-offs.

3 - Optimizing Resilient Facility Locations under Natural Disaster Disruptions
Nathan Whitehead, *Brian Lunday*, *William Caballero*

To develop resource prepositioning strategies for disaster response, we present a multi-objective, bilevel location model; the leader maximizes pre- and post-disaster coverage and minimizes total assets, and nature responds via worst-case disruptions from one of four disaster classes. Reformulation techniques identify provably equivalent, single-level MILPs for three classes; for the fourth class, they provide a heuristic with a verifiable optimality condition. Empirical testing demonstrates the methodology and evaluates the scalability of its practical computational tractability.

4 - Trends, challenges, and a research agenda in Multi-Objective Facility Location
Serena Fugaro, *Antonino Sgalambro*

Facility Location Problems play a key role in strategic decision-making across public and private sectors. Problems arising in these contexts often involve multiple, potentially conflicting objectives, motivating research on Multi-Objective Facility Location Problems. We present a Systematic Literature Review of 288 papers published between 2011 and 2025. Our analysis covers modelling approaches, solution algorithms, and managerial application contexts. From this analysis we identify emerging trends and propose a research agenda outlining key priorities for both researchers and practitioners.

■ TC-09

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 50 (Building: HG)

Optimization and Machine Learning for Optimization under Uncertainty

Stream: Data Science meets Optimization
Invited session
Chair: *Michael Römer*

1 - The Imitation Game: Imitation learning for Dynamic Decisions under Uncertainty
Prakash Gawas, *Antoine Legrain*, *Louis-Martin Rousseau*

Imitation learning (IL) has become a promising approach for solving large-scale combinatorial optimisation problems by learning decision policies from expert demonstrations. However, the notion of a "good" expert remains unclear. This work introduces a taxonomy of experts based on uncertainty modelling, optimality, and interaction with the learner. We propose a generalised DAgger framework supporting multiple and interactive experts. Experiments on a stochastic assignment problem show that stochastic and interactive experts yield superior policies.

2 - Quantile-Based Sequential Learning and Optimization
Nele Bertling, *Kevin Tierney*, *Michael Römer*

We propose a Quantile-Based Sequential Learning and Optimization(QSLO) approach for predict-then-optimize problems, where uncertain parameters can appear not only in the objective but also the constraints, which can render solutions infeasible. QSLO predicts a conditional quantile, using the quantile level to control the feasibility-decision quality trade-off. Compared to ODECE, a state-of-the-art decision-focused learning(DFL) method, QSLO achieves Pareto-optimal or dominant trade-offs on three benchmarks while training up to 99% faster, challenging the need for DFL in constrained settings.

■ TC-10

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 31 (Building: HG)

Innovations in Discrete and Quantum-Inspired Optimization I

Stream: Combinatorial Optimization
Invited session
Chair: *Fred Glover*
Chair: *Gary Kochenberger*

1 - Parameter-Efficient QAOA for Optimization Problems Interpolating Between Classical Ising Models and Quantum Hamiltonians
Reuben Tate

Many combinatorial optimization problems admit Ising formulations, such as Max-Cut. We study problems that interpolate between classical Ising objectives and quantum Hamiltonians by introducing non-diagonal terms. We present Snapshot-QAOA, a variant of the Quantum Approximate Optimization Algorithm that exploits this structure by

viewing the target Hamiltonian as a "snapshot" of a partial annealing schedule. This yields a structured QAOA parameterization controlled by a single parameter, providing a low-dimensional alternative to standard QAOA training.

2 - Hybrid simulated annealing and tabu search algorithm for pipeline-aware register allocation problem in protocol-independent switch architecture chips
Jintong Ren, Zequn Wei, Yang Wang

Protocol-Independent Switch Architecture chips enable flexible customization for network protocols, improving switch design. This paper addresses register allocation in two stages: pipeline allocation of basic blocks and register optimization based on inter-block dependencies. We propose a hybrid algorithm using simulated annealing for pipeline allocation and tabu search for register optimization. Experiments on real-world benchmarks show better performance than list scheduling, with an analysis of key algorithm components. The goal is to minimize register usage while meeting all constraints.

3 - Beyond QUBO: Direct Optimization of Higher-Order Binary Models
Gary Kochenberger, Fred Glover, Rick Hennig

Many combinatorial optimization problems are naturally formulated as higher-order unconstrained binary models with cubic and higher-degree interactions. These are often reduced to QUBO to use existing solvers and quantum hardware, but such reductions add auxiliary variables and penalties that increase size and distort the energy landscape. We present a solver that operates directly on PUBO models, avoiding reductions, preserving model fidelity, and achieving superior performance, especially for higher-degree interactions.

■ TC-11

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 32 (Building: HG)

Applications of combinatorial optimisation in industry and services 2

Stream: Combinatorial Optimization
Invited session
Chair: *Adriana Cherri*
Chair: *José Fernando Oliveira*

1 - Random-Key Optimizer for the Time-Dependent Traveling Salesman Problem
Antonio Chaves, Mauricio Resende, Carise Schmidt

Mixed-Integer Programs (MIPs) are NP-hard optimization problems for decision-making contexts. Exact solvers address small and medium-sized instances, but their effectiveness declines as problem size increases. We explore the Random-Key Optimizer (RKO), a heuristic framework with adaptable decoders for large-scale MIPs. Specifically, a decoder for the Time-Dependent Traveling Salesman Problem is introduced, reducing the search space and improving convergence. Our results indicate that RKO achieves solution quality and computation time comparable to or better than those of a commercial solver.

2 - Coordinating Robots and Public Transit for Urban Meal Delivery Services
Yunzhi Zhang, Yu Zhou, Yun Wang, Qingwan Xue

We study robot-transit meal delivery where ADRs handle first/last mile and ride scheduled transit. A unified space-time network jointly optimizes order assignment and routing with capacity, battery, and time-window constraints to maximize profit. We prove Q=1 is polynomial (reduces to maximum-weight matching) while Q>1 is NP-hard. We develop a certified branch-and-price method with exact pricing on the space-time network and validate scalability on a real transit network.

3 - A Comparison of Methodologies for the Data Download Scheduling Problem for Multiple Satellites and Multiple Ground Stations
Maria José Pinto, Hiawata Pola, Carlos Sampaio, Felipe Medeiros, Ana Cláudia Iwazaki, Tahisa Neitzel Kuck

This work addresses the image data download scheduling from multiple satellites to multiple ground stations over a planning horizon. Different methodologies were proposed to solve the problem considering data transmission protocols, priorities and due times. Furthermore, the download to a ground station can be performed by different satellites, or the same satellite can download to different ground stations if a setup time is respected when the respective visibility time-windows overlap or are close. The methodologies were applied to some instances for comparison and the results are presented.

4 - A MILP Model for Integrated Planning of Sugarcane Biorefineries with Biogas and Biomethane
Marcos Furlan, Adriana Cherri, Rafael Paiva, Reinaldo Morabito

This study addresses integrated planning in sugarcane biorefineries that produce sugar, ethanol, electricity, biogas, and biomethane. A mixed-integer linear programming (MILP) model was developed considering the integration of biogas production using continuous digesters fueled by vinasse and filter cake. Results show an increase of 16.8% in profit, despite a marginal increase in gross revenue. The analysis indicates improvements obtained with the use of by-products as low-cost feedstock. These findings underscore the economic feasibility of including biogas in the production portfolio.

■ TC-12

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 11 (Building: JUR)

Routing Problems in Health Care

Stream: Health Care Logistics
Invited session
Chair: *Martin Flegl*
Chair: *Anisha Maharani*

1 - Optimizing Mobile Clinic Routing for Rural Patients with Co-morbidities
Yafei Shi, Shandong Mou

We address rural healthcare inequity by examining a mobile clinic routing problem. Patients with co-morbidities require multiple diagnostic tests, necessitating coordinated heterogeneous fleet routing. We develop a mathematical model incorporating distance-decaying demand and synchronized multi-vehicle time windows. An enhanced heuristic is proposed. Computational experiments demonstrate that the proposed heuristic reduces substantial computation time versus exact solvers while preserving solution quality. This work helps maximize screening coverage while minimizing operational costs.

2 - Balancing Efficiency and Equity: A Bi-objective Periodic Vehicle Routing Problem for Mobile Healthcare Service
Jiawei Shi, Zili Zhang

Mobile health unit(MHU) is vital to bridge healthcare gaps. Unlike home healthcare or emergency services focusing on cost or demand satisfaction, long-term MHU operation faces challenges in balancing staff workload to avoid burnout. We model this as a bi-objective Periodic Vehicle Routing Problem with Multi-Skill optimizing efficiency and equity. We propose a strengthened formulation solved by a tailored epsilon constraint branch&cut algorithm. Using integrality, our method efficiently builds a comprehensive Pareto front. Results show equity can be greatly enhanced with negligible cost rise.

3 - Optimizing Mobile Breast Cancer Screening in Mexico City Metropolitan Area Through a Vehicle Routing Problem with Time Windows
Martin Flegl, Jaime Palma-Mendoza, Rafael D. Tordecilla, Rocio Ortiz-lopez

Breast cancer is the most common cancer among Mexican women, yet late detection and limited access to screening remain major challenges. This study designs a Breast Cancer Ambulatory Screening and Prevention (BCASP) model applying a Capacitated Vehicle Routing Problem with Time Windows to optimize mobile medical units in the Mexico City metropolitan area. Using anonymized patient data from FUCAM, the model develops cost efficient routes, evaluates operational and economic outcomes, and shows how logistics optimization can enhance early detection and deliver scalable healthcare interventions.

4 - An integrated nurse routing and rerostering problem for hospital-at-home
Anisha Maharani, Véronique François, Yasemin Arda

Hospital-at-home (HaH) enables patients with acute illnesses to receive care at home, improving their well-being and reducing healthcare costs. We study a weekly HaH operational planning problem, where patient admission, nurse routing, and rerostering decisions are made simultaneously. We develop two metaheuristic algorithms based on a large-neighborhood search framework to first maximize the number of patients treated at home, and then minimize routing cost. We provide managerial insights, including the effects of time window length and rerostering limit.

■ TC-13

Tuesday, 10:30-12:00 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Modelling packages

Stream: Software for Operations Research
Invited session
Chair: *André Schnabel*

1 - Open-source modelling APIs for FICO Xpress
Francesco Cavaliere

Model development is perhaps the most intellectually challenging part of practical mathematical optimization. Having once developed an algebraic model of a business problem, OR practitioners are faced with deciding how to implement the model inside some larger IT system. This talk discusses a non-comprehensive list of open-source third party modelling APIs for Xpress giving a comparative feature overview, including Pyomo, PuLP, Google OR-Tools, Linopy, CVXPY, MiniZinc, PyOptInterface, Jump, AMPL, as well as Xpress' Python API on top of which some of these APIs are built and Xpress Mosel.

2 - AMPL presolve configuration
Marcos Dominguez Velad, Gleb Belov, Robert Fourer, Filipe Brandão

Mathematical programming solvers have rapidly evolved in recent years. In particular, the spectrum of discrete and nonlinear expressions they natively accept has grown. We discuss how AMPL and its ASL and MP solver interfaces tackle this, automating reformulation of high-level expressions for a given solver. Flexible and maintainable ways of modeling are illustrated, as well as presolve options and tools fostering experimentation.

3 - GAMSPy: Python Ease, GAMS Speed
André Schnabel

GAMS bridges the gap between algebraic modeling notation and the complex data structures required by solvers. However, its native syntax can be unfamiliar, especially to Python developers. GAMSPy was created to bridge this divide and overcome the limitations of existing Python OR packages. It offers a Python frontend for abstract mathematical model formulation while leveraging the efficient GAMS execution backend. This talk introduces GAMSPy, compares it to native GAMS, demonstrates unique features such as automatic ML model reformulations, and showcases recent feature additions.

■ TC-14

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 01 (Building: HG)

GLOW - Global Leadership in OR for Women

Stream: Global Leadership in OR for Women
Panel session
Chair: *M. Grazia Speranza*

1 - GLOW Panel
Rosa G. González-Ramírez, M. Grazia Speranza

This panel brings together distinguished leaders from academia and regional Operations Research (OR) communities to explore pathways to leadership and professional advancement in the field. Through diverse international perspectives, panelists will discuss structural and cultural barriers affecting women's leadership trajectories, the influence of regional contexts on gender equity, and effective practices for developing inclusive leadership pipelines. The discussion will also provide practical guidance for early-career women in OR seeking to build leadership skills, navigate professional challenges, and expand their impact within the profession. By fostering dialogue across regions, the panel aims to identify shared challenges and actionable strategies for strengthening diverse leadership in the global OR community.

■ TC-15

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 34 (Building: HG)

Applications of Game Theory III

Stream: Algorithmic Game Theory
Invited session
Chair: *Lin Li*

1 - Memory-Based Foothold Planning and Optimization for Quadruped Robots in Discontinuous Terrains
Donglin Chen, Dehong Cong, Xiangman Song

Quadruped robots show strong adaptability in complex environments. This study investigates foothold searching for quadruped robots traversing discontinuous terrains, focusing on stairs. Instead of relying on real-time sensing for the rear legs, a memory-based mechanism infers candidate foothold regions from terrains previously traversed by the front legs. A customized data structure stores terrain information. A terrain scoring mechanism and an optimization-based foothold selection strategy are developed. MATLAB simulations show the method can identify safe footholds on stair terrains.

2 - Coordination Mechanism and Strategy Optimization of Green Hydrogen Supply Chain: Based on the Analysis of Noncooperative-cooperative Biform Game
Xin Xin, Chen Wang, Shufen Dai

Green hydrogen is crucial for the low-carbon transition of energy systems. This study examines a three-tier supply chain composed of power generation, hydrogen production, and steel manufacturing firms. By introducing a cost-sharing mechanism and the Myerson value, a noncooperative-cooperative biform game is developed to explore its coordination mechanisms, and the results are compared with optimal decisions and overall performance under the non-cooperative scenario. The study provides a theoretical basis for the coordinated development of the green hydrogen supply chain.

3 - Impact of exact waiting-time disclosure and price optimizations in an M/M/1 queueing game
Ayane Nakamura

We study strategic customer behavior in an M/M/1 queue with full waiting-time disclosure. We derive the explicit formulas for throughput, revenue, and social welfare under an admission fee. We then characterize revenue-maximizing and socially optimal fees and establish a waiting-time version of Naor's inequality. Finally, we compare the full information model with existing observable and unobservable queues under fixed and optimal pricing.

4 - Supply Chain Role-Based Tripartite Game and Carbon Emissions: Evidence from the Automotive Industry with AI-Mediated Information Asymmetry
Lin Li, Meng Li

This study examines carbon emission strategies across supply chain roles in the automotive industry via a tripartite Stackelberg game among firms, regulators, and investors. Firms are classified into structural roles using Stochastic Block Models. AI adoption is modeled as an information asymmetry variable altering strategic payoffs. Results show role position significantly moderates emission responses to external pressure, with broker-role firms leveraging AI-driven information advantages in decarbonization.

■ TC-16

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 42 (Building: HG)

Machine learning and routing

Stream: Vehicle Routing and related problems
Invited session
Chair: *Okan Ozener*

1 - Explainable Machine Learning for Guiding Metaheuristic Search in the Capacitated Vehicle Routing Problem
Dionisis Theodosis Papaloukas, Manolis Kritikos, Gregory Koronakos

We study the Capacitated Vehicle Routing Problem (CVRP) and propose a learning-guided metaheuristic integrating supervised machine learning with a multi-neighborhood tabu search. Structural features describing routing instances and intermediate solutions are used to train a gradient boosting classifier that distinguishes high-quality from poor solutions. The learned model guides neighborhood selection during the search. Experiments on standard CVRP benchmarks show improved solution quality and reduced optimality gaps compared to the baseline heuristic.

2 - Beyond the Doorstep: A Machine-Learning Framework for Behavioral Ride-Sharing Optimization
Omer Faruk Kurt, Milad Elyasi, Okan Ozener

This study optimizes ride-sharing via customer assignment, vehicle routing, and dynamic pricing. Using homogeneous, capacity-limited vehicles, the model allows customers to walk to alternative nodes for a discount. The objective maximizes profit by balancing costs with customized price offers. Crucially, customer attitudes are integrated to model behavioral responses to walking and pricing. The approach determines optimal routes and assignments while incentivizing pickup flexibility. Results show that incorporating behavioral data and flexible meeting points significantly boosts profit.

3 - Approximating Travel-Time Convolutions in Stochastic Networks using Bézier Distributions and Deep Learning
Andrés Rueda, Andres Medaglia, Daniel Francisco Villarraga Florez

Convolution in stochastic transportation networks is computationally expensive and relies on restrictive parametric assumptions. We leverage Bézier distributions to flexibly model the sum of heterogeneous travel times. We develop a deep neural network that approximates convolution by predicting the Bézier control points of the output distribution. Validated on Sioux Falls and Chicago networks against analytical and numerical results, our method yields high statistical accuracy (Kullback-Leibler divergence) and substantial computational speedups against a Monte Carlo simulation approach.

4 - Optimizing Salesperson Routing with Integrated Travel and Accommodation Decisions
Okan Ozener, Yagmur Selenay Selcuk, Basak Altan

We study a multi-city technician routing and scheduling problem with time windows (TRSPTW) that includes heterogeneous travel modes, accommodation choices, preferences, and budget constraints. We propose an integrated cost-minimization framework formulated as a MILP, solved with column generation for large instances, and complemented by a machine-learning model that quickly predicts feasibility and objective values. Computational results show the benefits of combining optimization and learning-based prediction.

■ TC-18

Tuesday, 10:30-12:00 - Room: JUR - U 21 (Building: JUR)

OR at Africa II

Stream: OR in Rising Economies
Invited session
Chair: *Navonil Mustafee*

1 - The Integrated Phosphate Supply Chain under Financial and Environmental Constraints
Maxime Agius, Nabil Absi, Tarik Aouam, Oussama Kajjoune

We study an optimization model for an integrated phosphate supply chain involving a mining Strategic Business Unit (SBU) and a manufacturing SBU within the same parent company. Mining can supply phosphate through alternative modes with different costs, qualities, and environmental impacts. Manufacturing faces quality requirements and financial constraints, including payment delays and working capital limits. We analyze the effects of environmental and financial constraints on coordination and system performance.

2 - Integrated Production Planning, Berth Allocation, and Quay Crane Assignment/Scheduling Problem
Ibtissam Guissou, Tarik Aouam, Leandro Coelho, Nizar El Hachemi

We study the integrated Production Planning, Berth Allocation, and Quay Crane Assignment/Scheduling Problem in a fertilizer supply chain. The problem coordinates production, inventory, transfer, and shipping decisions under complex operational constraints. A two-stage approach is proposed. First, we determine production plans, berth allocation, and vessel schedules by proposing two alternative MILP formulations. Second, a heuristic generates detailed quay crane schedules. Computational experiments compare both MILP formulations and assess the overall approach on benchmark instances.

3 - Mixed-Fleet Vehicle Routing for Bio-Waste Collection in Emerging Cities : A Column Generation Approach
Manar Tayouga, Mohamed Ouzineb, Adil Tahir, Tarik Aouam, Soumaya Yacout

Urban bio-waste collection in many African cities still relies largely on diesel fleets despite growing organic waste streams. During waste collection, vehicle load increases along the route, making fuel and electric energy consumption depend on the cumulative payload carried. We study a mixed-fleet routing problem under a three-day freshness constraint using Moroccan urban data, with Montreal as reference. A column-generation formulation with resource-constrained pricing identifies the battery and route-duration limits that govern electric vehicle feasibility.

■ TC-19

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 05 (Building: HG)

Chance Constrained Optimization and Its Applications

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Kai Pan*

1 - Distributionally Robust Chance-Constrained Linear Matrix Inequalities
Kai Pan, Jianqiang Cheng, Fengjie Liang

This talk presents approximation and reformulation techniques for optimization problems with distributionally robust chance-constrained linear matrix inequalities (DRCCLMIs) with moment information. First, we develop a tractable inner approximation for DRCCLMIs in a general setting by leveraging decision rules and convex approximation techniques. We then study an important class of block-structured DRCCLMIs and show the problem admits an exact semidefinite reformulation. Finally, we demonstrate the effectiveness and practical relevance of the proposed methods through numerical experiments.

2 - Route Optimization under Rider Acceptance Uncertainty
Youngki Lee, Seulgi Joung

When food delivery platforms plan bundled pickup-and-delivery routes, riders may reject assigned orders, causing re-dispatching and service disruption. While conventional routing assigns each order to a single rider without considering rider uncertainty, this study proposes a robust optimization model with chance constraints that assigns orders to multiple riders to hedge against acceptance uncertainty. Worst-case scenarios are modeled via a budget uncertainty set, with a branch-and-cut algorithm enhancing computational efficiency. Benchmark experiments evaluate the performance of the model.

3 - Linear quasi-shrinkage estimator for high-dimensional optimization with linear constraints
Naqi Huang, Nestor Parolya, Theresia van Essen

In large-scale data-driven optimization, the constraint matrix is often noisy and only limited data is available. We study optimization problems with linear constraints where the number of constraints and variables are large and comparable. We propose a linear shrinkage estimator that minimizes the Frobenius distance to the true constraint matrix. The shrinkage coefficients are consistently estimated using only a few observations. Experiments result in objective values close to the true optimum and low constraint violations, outperforming nominal and robust approaches across various scenarios.

4 - Chance Constrained Program with Quadratic Randomness: A Unified Approach Based on Gaussian Mixture Distribution
Xiaochuan Pang

This paper investigates the chance constrained program where the randomness takes a quadratic form of random variables following multivariate Gaussian mixture distribution (GMD). We prove that the asymptotic distribution of this quadratic randomness is a univariate GMD and identify the key factors influencing the associated asymptotic approximation error. These results enable the reformulation of such chance-constrained programs into more tractable forms, facilitating the search for globally optimal solutions. The convexity properties of the resulting models are also analyzed.

■ TC-20

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Stochastic vehicle routing problems

Stream: Vehicle Routing and related problems
Invited session
Chair: *Mahdi Bashiri*

1 - The Split Delivery Vehicle Routing Problem with Stochastic Demands
Caio Tomazella, Pedro Munari, Reinaldo Morabito, Remy Spliet

We address the Split Delivery Vehicle Routing Problem where customer demands are uncertain, and only unveiled upon arrival. First, we discuss some structural properties of the problem and how recourse actions are modeled. The allocation of split demands is particularly challenging, as it affects the recourse actions of multiple routes. We then develop a pseudo-compact MIP formulation to obtain the delivery configuration for split customers that minimizes the expected costs of recourse, and propose a branch-and-cut approach to handle instances more effectively.

2 - Stochastic Hard Clustered Vehicle Routing Problem with Time Window for Medical Waste Collection
Yaren Çelik, Kumru Didem Atalay, Tusan Derya, Berna Dengiz

Sustainable waste management requires efficient logistics planning. This study addresses the transportation of medical waste generated by healthcare facilities to a collection center using a Hard-Clustered Vehicle Routing Problem with a time window framework. A chance-constrained programming is developed to capture uncertainty in waste generation and operations. Travel time variability is modeled using Normal, Weibull, and Exponential distributions. Computational results highlight how distributional assumptions affect routing plans and operational costs, demonstrating the effectiveness of the

3 - Stochastic routing optimization for organic waste collection
Barbara Tomarchio, Sacha Varone, Léa Ricard, Michel Bierlaire

We present a variant of the stochastic inventory routing problem for waste collection. In this problem, the type of unloading facility selected for a route depends on the quality of the waste collected. We propose a formulation of this novel routing problem that incorporates expected cost terms arising from the uncertainty in the waste quality and quantity. To solve this problem, an adaptive large neighborhood search algorithm that integrates these stochastic aspects is developed. Through simulations, we observe that this approach significantly outperforms alternative deterministic policies.

4 - Drone-Assisted Home Healthcare Planning Under Uncertainty
Arghavan Sharafi, Mahdi Bashiri, Thomas Statheros, Dhananjay Thiruvady, Daniel Lai

Home healthcare systems often require caregivers to travel to obtain medical supplies identified during patient visits, increasing non-care activities. We propose a drone-assisted home healthcare system where drones deliver supplies from the healthcare centre to nearby drone stations for caregiver pickup. A two-stage stochastic mixed-integer programming model jointly optimises caregiver routing, drone station location, and drone dispatching under uncertain demand, while capturing caregiver-drone synchronisation. Results show that drone integration can reduce caregiver non-care time.

■ TC-21

Tuesday, 10:30-12:00 - Room: JUR - U 22 (Building: JUR)

Leverage LLM for Operations Research: Formulation and Solution

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Hai Wang*

1 - Large-Scale Optimization Model Auto-Formulation: Harnessing LLM Flexibility via Structured Workflow
Jianming Mao, Kuo Liang, Yuhang Lu, Shuyi Sun, Chunwei Yang, Congcong Zeng, Xiao Jin, Hanzhang Qin, Ruihao Zhu, Chung Piaw Teo

Large-scale optimization is central to modern business decisions but costly to formulate. We propose LEAN-LLM-OPT, a lightweight agentic framework for LLM-assisted automatic optimization modeling. Given a problem description and data, LLM agents construct and execute a step-by-step modeling workflow to generate the final formulation. By structuring modeling into sub-tasks and offloading data handling to tools, the framework reduces planning burden while retaining flexibility. Experiments and a Singapore Airlines case demonstrate strong performance and practical value.

2 - Towards Fine-Grained Supervision for Operations Research Language Models
Jianghao Lin, Chenyu Zhou

OR language models can translate text into solver-ready formulations, but outcome-only rewards suffer credit assignment: correct optima may reinforce flawed steps, while stepwise discriminative PRMs are myopic and miss inter-step dependencies. We present fine-grained supervision with generative process reward modeling and a self-evolving loop. A policy model co-evolves with a Generative PRM that critiques whole trajectories, paired with solver verification; the dual signal trains the policy via weighted preference optimization and yields a reusable verifier for inference-time scaling.

3 - Grammar-Aware Literate Generative Mathematical Programming with Compiler-in-the-Loop
Roberto Rossi, Steven Prestwich

This work investigates Generative Mathematical Programming through the lens of Algebraic Modelling Languages (AMLs) and compiler-guided model synthesis. By leveraging PyOPL, an OPL-like AML compiler that provides detailed syntax diagnostics, we introduce SyntAGM, an end-to-end system that translates natural language problem descriptions into PyOPL models via a generate–compile–assess–revise loop. In a comparative study against established prompting baselines SyntAGM achieves competitive accuracy with superior token, cost, and latency profiles. Code: https://gwr3n.github.io/rhetor/

4 - From Correctness to Efficiency: Improving LLMs' Ability on Scalable Optimization Algorithm Design
Minwei Kong

Industrial decision-making relies on large-scale optimization, and large language models offer a promising yet underexplored paradigm for automating such processes. We introduce a self-improving LLM experience library that facilitates solver-ready formulation through structured knowledge reuse, improving generalization across OR tasks. Beyond formulation correctness, we further construct a benchmark to evaluate LLMs for efficiency-aware algorithm design, addressing the limited attention to efficiency in existing research.

■ TC-22

Tuesday, 10:30-12:00 - Room: KOL - Seminar-Raum 5 (Building: KOL)

Electricity Price Forecasting with Fundamental and Data-driven Models

Stream: Forecasting in Energy
Invited session
Chair: *Simon Hirsch*

1 - Bridging an energy system model with an ensemble deep-learning approach for electricity price forecasting
Souhir Ben Amor

We combine a techno-economic energy system model with an econometric model to maximise the accuracy of electricity price forecasts in the German electricity market. The results demonstrate that the ensemble deep neural network model performs best, and that incorporating the energy system model's output improves its forecasting accuracy by 6%. We demonstrate the economic value of improved price estimators by maximising revenue from an electric storage resource through exemplary storage optimisation, in which incorporating a techno-economic energy system model increases revenue by up to 10%.

2 - An Interpretable Functional Framework for Electricity Auction Curve Forecasting
Wenzhen Huang, Florian Ziel

This study addresses the challenge of forecasting day-ahead electricity auction curves in markets with high renewable penetration. We propose an interpretable functional framework for the entire price spectrum, unifying a fixed basis for negative prices with a fuel-dependent dynamic B-spline model for positive prices. This dynamic model adapts its structure based on fuel costs to naturally capture merit order dynamics and potential inversions. Our approach provides a holistic, interpretable tool for forecasting curves and quantifying the drivers of bidding behavior.

3 - Sigomid Functions to Forecast Electricity Prices Using Bid Data
Aitor Ciarreta

We propose a price forecasting approach based on publicly available auction data to model the supply and demand curves of the Iberian Day-Ahead electricity market for 2022-2025. Fractional polynomial, linear, and logistic functions are fitted to historical sale and purchase bidding data to estimate equilibrium prices. Time series models are then specified for both historical and estimated prices. Using a rolling window, we produce one-day-ahead forecasts for 2024 and evaluate performance with in-sample and out-of-sample criteria.

■ TC-23

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 02 (Building: HG)

Data-Driven Decision Making in Uncertain Dynamical Environments

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Tobias Sutter*
Chair: *Axel Friedrich Wolter*

1 - Robust Markov Decision Processes on Continuous State Spaces
Mengmeng Li

We study infinite-horizon robust Markov decision processes (MDPs) on continuous state spaces with structured rectangular ambiguity set. The proposed ambiguity set falls within the convex hull of unknown generating kernels. The obtained sample complexities for both robust policy evaluation and optimization appear to be new for robust MDPs with continuous state spaces. Of independent interest, the proposed method is also directly applicable to zero-sum Markov games, which appears to improve the state-of-the-art sample complexity for continuous state spaces.

2 - A Two-Timescale Primal-Dual Framework for Reinforcement Learning via Online Dual Variable Guidance
Axel Friedrich Wolter, Tobias Sutter

Using regularized LP formulations and stochastic approximation, we propose PGDA-RL, a primal-dual projected gradient descent-ascent algorithm for MDPs. It combines experience replay with a two-timescale scheme, runs asynchronously on a single correlated trajectory, and updates the policy online via a dual variable for the occupancy measure. We prove almost-sure convergence to the optimal regularized value and policy under weaker assumptions, without a simulator or fixed behavior policy. Under stronger ergodicity, we establish last-iterate mean-square convergence at rate k to the power -2/3.

3 - On the Sample-complexity of Online and Data-driven Decision Making
Michael Muehlebach

My talk will study the sample complexity of online reinforcement learning in the general non-episodic setting of nonlinear dynamical systems with continuous state and action spaces. Our analysis accommodates a large class of dynamical systems ranging from a finite set of nonlinear candidate models to models with bounded and Lipschitz continuous dynamics, to systems that are parametrized by a compact and real-valued set of parameters. The proposed algorithms are likely to be useful in practice, due to their simplicity, their ability to incorporate prior knowledge, and their benign transients.

4 - Adversarial Satisficing
Shu Yang

Adversarial robust optimization is known in machine learning (ML) for improving reliability under adversarial noise. However, its performance depends strongly on the choice of the perturbation radius, which is hard to tune in practice. Motivated by robust satisficing, we propose an adversarial satisficing (AS) framework that allows the one to specify a target performance level and then make robust decisions under uncertainty while aiming to meet this target. Since AS differs from standard ML formulations, we develop an efficient first-order method and show strong empirical performance.

■ TC-24

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 03 (Building: HG)

Combinatorial optimization for human-centered assembly line planning

Stream: Human Aspects in Operations Management
Invited session
Chair: *Olga Battaia*
Chair: *S. Ehsan Hashemi Petroodi*
Chair: *Alexandre Dolgui*

1 - Mixed-Model Human-Robot Collaborative Assembly Line Balancing with Mobile Workers and Travel Time Consideration
Pedram Beldar, Amos H. C. Ng, Ehsan Mahmoodi

Human-robot collaborative assembly lines combine human flexibility with robotic precision. Most studies assume workers are fixed to stations, which limits realism. This paper studies a mixed-model human-robot collaborative assembly line balancing and scheduling problem where a limited number of human operators can move between stations while robots remain fixed. A mixed-integer linear programming model determines task assignments, resource allocation, and scheduling while considering travel time between stations and minimizing cycle time.

2 - Exact methods for asynchronous repair planning in mixed-model assembly lines
Sebastian Granda Altamirano, S. Ehsan Hashemi Petroodi, Olga Battaia, Alexandre Dolgui

Traditional defect management in mixed-model assembly lines imposes a trade-off between production continuity and defect propagation. Asynchronous repair mitigates this conflict by diverting defective units to parallel stations and reinserting them without line stoppages. We propose four MILP models to jointly distribute repair stations and coordinate rework activities. To solve large instances, we develop a Logic-Based Benders Decomposition method. Experiments demonstrate our approach maximizes throughput, outperforming traditional strategies as defect rates and repair durations increase.

3 - Sustainable Mixed-Model Assembly Line Balancing with an Analytical Lower Bound and Adaptive Large Neighborhood Search
Esam Alhomaidi

The growing focus on sustainable manufacturing has led to integrating environmental and social factors into traditional assembly line balancing problems (ALBPs). This study proposes a Sustainable Mixed-Model ALBP integrating task precedence, machine selection, worker assignment, carbon limits, and green incentives. A cost-minimization model is solved using a tailored Adaptive Large Neighborhood Search with customized operators and simulated annealing. Results show gaps below 5%, validated on a 166-task aircraft case.

4 - Bi-Objective Collaborative Assembly Line Balancing with Human-Cobot Interaction Modes: Exact and Metaheuristic Approaches
Hind Bahir, M-Amine Abdous, Flavien Lucas, Eric Duviella, Richard Bearee

We address a bi-objective collaborative assembly line balancing problem where workstations operate under multiple human-cobot interaction modes: independent, sequential, supportive, and simultaneous. A mixed-integer linear program that minimizes energy and operational costs is solved using epsilon-constraint to produce exact Pareto fronts on benchmark instances adapted to our collaborative settings. A multi-phase GRASP metaheuristic is also proposed for larger problems. The resulting Pareto fronts enable managers to navigate cost-energy trade-offs when designing human-cobot production lines.

■ TC-25

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 16 (Building: HG)

Community OR

Stream: OR for Development
Invited session
Chair: *Olabode Adewoye*

1 - Gender Influences and Corporate Governance Elements Priority in Fintechs in Nigeria
Bolajoko Dixon-Ogbechi, Adeyinka Adeyemi, Oluwayemi Jeje, Naomi Ogbechi, Ismaila Adeleke

Research has shown that Gender diversity is increasingly being recognized to be beneficial in organizations. However, the underrepresentation of women in leadership positions in developing countries appears to hinder performance of fintechs and limit their abilities to fully contribute positively to the society. This study applied the Analytic Hierarchy Process Model to investigate whether gender influences the priority of key corporate governance framework elements, CGFEs, in fintechs in Nigeria - to enable fintechs develop appropriate strategies in line with sustainable development goals.

2 - Improving Security in the Community: An OR Approach.
Olabode Adewoye

Every nation tries to control and probably eradicate crime. The Government has done a lot to improve security. Some of the measures include: Creating the Rapid Response Squad (RRS); Police Trust Fund (PTF); Neighborhood Watch (NW); Community Guards, etc. All these efforts brought little improvement to the security situation. These necessitated the use of the Operations Research Approach (OR) to solve the problem. We developed a heuristic model and tested it in a small community. The model is then enlarged and supported by AI tools as a proposed model for solving the insecurity problem.

3 - Analysis of Determinants Affecting Generation Z Customers Online Retailing Repurchase and Switching Behaviour Using AHP Approach: Evidence from Nigeria
Adebola Glorious Adekoya, Olamilekan Oyenuga, Taiyelolu Fabson

This study aims to explore the application of the AHP model to investigate post-purchase factors that determines Generation Z online retailing consumers repurchase and switching behaviour from Global South country, Nigeria. Adopting the quantitative approach, descriptive and exploratory AHP based questionnaire, it attempts to analyse, prioritise and rank factors that are critical for Gen Z online retailing consumers repurchase and switching behaviour using AHP for improving service delivery of online retailing service providers in Nigeria.

4 - An Alternative Method of Solving the Assignment Problem
Ukamaka Cynthia Orumie

The assignment problem is a classical optimization challenge encountered in diverse fields. While the Hungarian method remains the most widely adopted solution technique, this research introduces an alternative approach that achieves the same optimal results with improved efficiency when applied to various cases. Comparative analysis demonstrates that, although both methods yield identical outcomes, the alternative method requires fewer computational steps, thereby saving time and enhancing practical applicability in real-world scenarios.

■ TC-26

Tuesday, 10:30-12:00 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis II

Stream: Data Envelopment Analysis
Invited session
Chair: *Mohsen Afsharian*
Chair: *Shiang-Tai Liu*

1 - Empirically validating milton friedman's view of social responsibility of firms on public sector banks in india
Vipul Gupta

The present study is an empirical investigation which validated Milton Friedman's views on social responsibility of firms in the context of Public Sector Banks (PSBs) in India. The study analyzed Corporate Social Responsibility (CSR) using composite index with the sample of 25 PSBs in India from 1994 to 2017. Both parametric and non-parametric methodology was employed. The analysis confirmed a negative impact of social responsibility on Profit Efficiency of PSBs in India. This implies that socially responsible banks had a competitive disadvantage and results an extra burden on their profits.

2 - Frontier refinement for reducing extreme input-output substitution in regulatory benchmarking
Sara Kamali, Mohsen Afsharian, Heinz Ahn

Frontier benchmarking is central to incentive regulation and is widely used by regulators to set efficiency targets and shape firms' cost-reduction incentives. However, it can generate excessive flexibility in input-output trade-offs and create incentives to appear efficient via extreme profiles. In the context of the Brazilian water and sewage sector, we propose an alternative method that identifies and removes weak or isolated facets and evaluates firms against the remaining well-supported efficient facets, yielding a simpler, more stable, and less manipulation-prone frontier.

3 - A slacks-based measure model for fuzzy cross-efficiency under variable returns to scale
Shiang-Tai Liu

Cross-efficiency effectively ranks decision-making units (DMUs), but variable returns to scale (VRS) can yield negative, unrealistic efficiency scores. This paper treats observations as fuzzy numbers and develops a fuzzy cross-efficiency method based on the slacks-based measure (SBM) model under the VRS situation. This approach eliminates negative values and resolves weak efficiency issues. By employing bi-level mathematical programming, the study provides a robust computational framework for evaluating fuzzy cross-efficiency under VRS technology.

4 - Predicting Demand for New Products Using Polytope Volume and Benchmarking
Mohsen Afsharian, Peter Bogetoft

Predicting demand for new product entries reduces launch failures, optimizes inventory, and supports supply chain planning. We propose two approaches: a volume-based method and a benchmarking-based method. The volume-based approach builds ranges of attribute weights for which a new alternative is preferred and uses their size to quantify demand shifts. The benchmarking approach improves practical applicability by using Data Envelopment Analysis and super-efficiency models to measure how far products exceed the efficiency frontier. Examples show practical use and consistent predictions.

■ TC-27

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 13 (Building: JUR)

Equity, Access, and Resilience in Humanitarian Operations

Stream: Humanitarian Logistics
Invited session
Chair: *Reut Noham*

1 - Navigating the Trade-Off Between Effectiveness and Equity: An Empirical Analysis
Ohad Eisenhandler, Joachim Meyer, Michal Tzur

Resource allocation problems often involve a trade-off between maximizing system performance (effectiveness) and ensuring fairness (equity). This study empirically examines how decision-makers navigate this trade-off using simulated realistic scenarios. Participants evaluated predefined allocations derived based on the Z function, the Gini index, max-min, and alpha-fairness. Results show a strong preference for equity-oriented allocations, while schemes that focused too strongly on effectiveness were less favored. The findings also suggest the existence of distinct preference profiles.

2 - A Lexicographic Approach to Equitable Access for Subpopulations Using Kolm-Pollak Linear Objective in Post Disaster Humanitarian Logistics
Felipe Aros-Vera, Wilhemina Bofla, Azadeh Sadeghi

We present a Mixed-Integer Optimization model that maximizes population coverage and equity in access for heterogenous demand. Objectives are modeled in lexicographic order: (1) maximize coverage, (2) maximize equitable access using the Kolm-Pollak (KPL) linear proxy under group-specific radii, and (3) minimize social costs. We enforce service radii for subpopulations and use the linear Kolm-Pollak Equally Distributed Equivalent to penalize distance inequality. The model is applied to a case study of the City of Flint, Michigan

3 - Evaluating resilience of active mobility networks in case of disruptions
Pamela C. Nolz, Gerhard Hiermann

We study the impact of natural disasters on the transport infrastructure, using real-world data from an Austrian commune. We design Pareto-optimal paths for citizens aiming to reach their destination by active modes of transport (walking, biking), respecting four objectives: travel time, safety, comfort, environment. Experimental results evaluate the alternative mobility options if no infrastructural measures can be taken in the short run. We present a recommendation for authorities on the most urgent infrastructure projects following damage by a disaster, given a limited budget.

4 - Equity-Aware Network Design for Humanitarian Aid under Uncertainty
Reut Noham, Hadar Engel

We study an Equity-Driven Stochastic Facility Location model for humanitarian logistics, addressing the tension between effectiveness, efficiency, and equity under demand uncertainty. Unlike classical commercial models that optimize expected cost, we introduce an inter-scenario social welfare objective that balances service accessibility and fairness across affected populations. We analyze capacitated and uncapacitated settings, quantify trade-offs, and develop tractable solution methods. The framework supports equitable aid center placement under disaster-driven uncertainty.

■ TC-28

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 17 (Building: JUR)

Data analytics for Green Shipping Management

Stream: Maritime Logistics
Invited session
Chair: *Ran Yan*

1 - Energy-Aware Federated Learning for Ship Fuel Consumption Prediction via Q-Learning
Ran Yan, Xing Pan

Deep learning (DL) is widely used for ship fuel consumption (SFC) prediction. However, existing DL-based SFC studies focus on accuracy, overlooking data privacy and energy costs in maritime deployments. To address this, we propose an energy-aware federated learning framework for SFC prediction. A Q-learning strategy adaptively selects ships, and a blockchain-based incentive mechanism records model performance and allocates rewards. Experiments on real-world data show the proposed framework improved prediction accuracy, privacy and energy efficiency, supporting maritime decarbonization.

2 - Electric Tugboat Scheduling in Seaports
Tingting Chen

This paper studies the electric tugboat scheduling problem to simultaneously optimize the working and charging schedules of electric tugboats. The complexity arises from (1) time consistency constraints that require multiple electric tugboats to work simultaneously, (2) service sequence constraints that establish precedence relationships between different tugging services, and (3) nonlinear charging profiles. The problem is formulated as a mixed-integer programming model. A tailored branch-and-price algorithm is developed to solve the problem efficiently.

3 - Optimizing Multi-Fuel Operations for Green Container Shipping: Optimization Models, Analysis, and Solution Approach
Xuecheng Tian

This study investigates the optimization of multi-fuel operations for container shipping in the context of evolving environmental regulations. Faced with increasing pressure to reduce emissions, particularly of sulfur oxides and carbon dioxide, the maritime industry must navigate a complex regulatory landscape in terms of the energy usage. Key policies include Sulfur Emission Control Areas, the European Union's (EU) Maritime Emissions Trading System, and the FuelEU Maritime Regulation. We propose a novel mathematical programming model to minimize total operational costs, including fuel and car

■ TC-29

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 30 (Building: HG)

Quadratic Programming

Stream: Combinatorial Optimization
Invited session
Chair: *Paolo Toth*
Chair: *Silvano Martello*

1 - Linearizable Instances of the Quadratic Minimum Spanning Tree Problem
Lucas Waddell

An QMSTP instance is called linearizable if it can be rewritten as a linear minimum spanning tree problem in such a way that the objective function value preserved at all feasible solutions. A known sufficient condition for linearizability is that the (symmetric) matrix of cost coefficients is a weak sum matrix. This condition is also necessary for QMSTP instances defined on complete and complete bipartite graphs, but not necessary for other underlying graph structures. We prove that the sufficient linearizability condition is also necessary if and only if the underlying graph is 3-connected.

2 - Branch-and-Cut Algorithms for Fixed Cardinality Binary Quadratic Programs
Thi Thanh Tu Le, *Thorsten Koch*

The Fixed Cardinality Binary Quadratic Program (FCBQP) is an NP-hard problem and is challenging to solve to optimality. Facet-defining inequalities for this problem were originally introduced by Manfred Padberg and later extended by Alain Faye. In this work, we investigate the impact of incorporating these inequalities within a branch-and-cut framework via Gurobi callbacks. Numerical results encourage the use of these cuts for solving FCBQP instances that Gurobi struggles with.

3 - Formulations and Matheuristic Algorithms for the Quadratic Multiple Knapsack Problem with Setup
Paolo Toth, *Laura Galli*, *Silvano Martello*, *Carlos Rey*

The "Quadratic Multiple Knapsack Problem with Setup" (QMKPS) generalizes three well-known strongly NP-hard combinatorial optimization problems: the "Quadratic Knapsack Problem", the "Multiple Knapsack Problem" and the "Knapsack Problem with Setup". In this talk, several linear formulations are presented, and dominances among them are investigated. Effective matheuristic algorithms, based on the optimal solution of Integer Linear Programming models, are also proposed. Computational results are reported which show the good performance of the proposed models and algorithms.

4 - A Preprocessing Technique for Quadratic Unconstrained Binary Optimization
Serigne Gueye, *Philippe Michelon*

We present some preprocessing techniques, based on necessary optimality conditions, for solving the Quadratic Unconstrained Binary Optimization (QUBO) problem. Our techniques generalized the notion of persistencies by allowing us to fix a product of any number of p (integer) literals. The set of all generalized persistencies generated can be equivalently viewed as a p-SATisfiability (p-SAT) problem for which the QUBO optimal solution is a solution. We then introduce methodologies and associated algorithms capable of generating and exploiting this p-SAT problem to find further inferences.

■ TC-30

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum 06 (Building: HG)

Portfolio optimization 1

Stream: Robust and Resilient Optimization in Finance and Businesses
Invited session
Chair: *David Saunders*

1 - Smart classify and optimize for portfolio construction - a differentiable quadratic programming approach
Roy Kwon

We propose an end-to-end framework for portfolio construction that integrates screening (via support vector machines) and allocation (via mean-variance optimization) into a single differentiable optimization pipeline. Both the SVM and the MVO are represented as quadratic programming (QP) layers, connected through a differentiable gating mechanism that enables gradient-based training. Empirical results on sector-diversified U.S. equities demonstrate that the integrated model delivers improved risk-return trade-offs over a typical two-stage baseline, especially over volatile regimes.

2 - Omega-based Stochastic Dominance for Portfolio Selection
Bo-Lin Wu, *Wen-Yi Lee*

Traditional Second-order Stochastic Dominance (SSD) requires strict dominance across all returns. While aligning with risk aversion, this strict condition often makes models overly conservative, limiting excess returns. We propose an Omega-based framework using a threshold to distinguish upside potential from downside risk. This enables investors to pursue upside potential while controlling downside risk. Computationally, we employ a Cutting Plane Algorithm to reduce the computation complexity.

3 - A GARCH-Based Framework for Optimizing Sustainable Investment Portfolios
Rudi Zagst

We present a tractable framework for optimal sustainable investment. Using a multivariate affine GARCH model, we jointly capture the dynamics of asset returns and sustainability profiles and introduce a sustainability-adjusted CRRA utility function that reflects investor preferences over both financial performance and sustainability. Within this framework, we derive closed-form solutions for the optimal sustainable strategy. Numerical results show that the optimal sustainable strategy consistently tilts portfolios toward greener assets while maintaining stable performance.

4 - Relatively Robust Multiproduct Pricing
Ru Zhang, *Thomas Weber*

We develop a relatively robust pricing framework for multiproduct monopolies under demand-parameter ambiguity using 2-norm and Frobenius-norm uncertainty sets. The optimal robust price vector solves a quasi-concave program that maximizes worst-case profit relative to the ex-post optimum, equivalently minimizing maximum relative regret. We derive a unique first-order characterization, propose a scalable projected Danskin-L-BFGS algorithm, calibrate ambiguity sets from multivariate regressions, and provide strong guarantees and downside protection in synthetic and live retail data.

■ TC-31

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 12 (Building: JUR)

Network design and line planning for public transport 2

Stream: Optimizing Transit
Invited session
Chair: *Pieter Vansteenwegen*
Chair: *Maarten Wens*

1 - Optimization based models for Metro Rail operations
Narayan Rangaraj, *Madhu Belur*, *Ashutosh Mahajan*

Work with Metro Rail operations in India has led to applications of OR models for decisions of line planning (deciding what services to run), timetabling (deciding detailed timings), vehicle planning (inducting vehicles into service and deploying them efficiently) and crew planning (designing crew duties, respecting safety and operational constraints). Some methods are well known, with appropriate extensions. Other decisions are analyzed with a mix of existing and new methods to meet computational needs, user control over decisions and effective integration with planning needs.

2 - Combined Route Selection and Redesign of the Surrounding Bus Network for a new BRT line in Greater Copenhagen
Rowan Hoogervorst, Evelien van der Hurk

We look at the route selection of a new BRT line in Greater Copenhagen and the redesign of the surrounding bus network. Traditionally, these problems have often been solved sequentially, where the rapid transit route is selected on demand in the studied corridor. However, this doesn't take into account the full (in)flow of passengers and the possibility for other buses to benefit from the new corridor. We propose a column generation framework, extensively using cuts, to solve this integrated problem. We present both computational results for the algorithm and insights from the case.

3 - Fast passenger assignment for transit network design
Pieter Vansteenwegen, Maarten Wens, Jeroen Verstraete

The simplest form of passenger assignment assumes all passengers take their shortest path. This assignment is complicated by transfers, so it is worthwhile to develop assignment techniques exploiting the specific context of public transport. These techniques can reveal structure in a network, and reduce the calculation times of the algorithms. We present a graph that decomposes a network in several layers. These layers consolidate routes that appear in many OD-pairs, e.g. common routes after the first transfer. The method works for routing problems, even when timetables are considered.

■ TC-32

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 14 (Building: JUR)

Collaboration and consolidation in urban logistics

Stream: City Logistics
Invited session
Chair: *Yvonne Kummer*

1 - Delivering Efficiency: Joint Optimization of Parcel Locker Location and Configuration considering Vehicle Routing and Flexible Delivery Alternatives
Lissa Melis

Parcel lockers offer a promising solution to urban last-mile delivery challenges, yet decisions on locker location, size, and routing are rarely integrated. We introduce the parcel locker location-configuration-routing problem with flexible deliveries, where parcels may be delivered to homes or nearby lockers. We propose a population-based incremental learning algorithm combined with an LNS heuristic. Results from realistic instances show that flexible locker delivery and multiple locker sizes significantly reduce carrier costs, while incentives can help balance customer inconvenience.

2 - Urban Construction Consolidation Centers: A Two-echelon, multi-commodity, multi-period network flow problem
Yvonne Kummer, Manfred Gronalt, Patrick Hirsch

Construction logistics centers (CLC) offer temporary storage and consolidation for materials, waste, and reusable items. We develop a mixed-integer network flow model with inventory management and backlog penalties, evaluating CLC effects on transport trips and CO2e emissions. Key challenges are material heterogeneity and time-dependent demand during construction. Parameter variations reflect different construction site types and sizes, and levels of construction activity. Results show that CLC benefit small sites in dense urban areas and when flows from multiple sites are consolidated.

3 - Optimizing Urban Consolidation Center Locations with Service Equity and Profit Considerations
Seyyedreza Esmaeilzadeh

Urban freight distribution requires balancing profitability, service equity, and sustainability. This study proposes a mixed-integer linear programming model to jointly determine the optimal locations of Urban Consolidation Centers and allocate freight flows in dense urban areas. The model maximizes net profit while limiting unmet demand and ensuring a minimum service level for each customer. Computational experiments on a dataset with 69 candidate facilities and 156 customers show that the model achieves high service coverage and strong profitability.

4 - Drone-Enabled Transshipment in Kiosk-Based Delivery Networks
Wenqian Liu, Xiangtong Qi

We study a dynamic pickup and delivery problem featuring drone-enabled transshipment in kiosk-based networks. While trucks operate along fixed routes, drones perform inter-truck package transfers to enhance delivery flexibility. We propose an exact network flow approach within a rolling horizon framework to optimize real-time drone schedules and maximize on-time fulfillment. Computational results demonstrate the effectiveness of the solution method and quantify the advantages of drone transshipment over traditional truck-based delivery.

■ TC-33

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 15 (Building: JUR)

In-orbit facility location

Stream: OR in Space
Invited session
Chair: *Pieter Deleye*

1 - Guidelines for Modeling and Solving In-Orbit Facility Location Problems
Yuri Shimane

At the conception stage of in-space infrastructures for New Space applications, the placement and allocation of assets, i.e., a facility location problem (FLP), must be appropriately formulated and evaluated. The FLP in the in-orbit context requires considerations that are unique to its dynamic environment, pertaining to (i) the appropriate discretization of the decision space, (ii) the nonlinearity of associated cost metrics, and (iii) the potential time dependence of the position of assets and clients. This work provides guidelines for these three considerations across two examples.

2 - Spaceports Facility Location Planning Models
Max Li, Oliver Jia-Richards

The rapid growth of commercial space transportation is driving demand for expanded launch infrastructure. We present several works which develop a spaceport facility location planning framework to support a potential future spaceport network in the United States. The model integrates key factors including population density, launch trajectories, and the impacts of launch operations on surrounding air traffic. We will present both deterministic and chance constrained formulations of this spaceport facility location planning model.

3 - Locating a facility in space: An operations research review
Pieter Deleye, Christof Defryn

This study reviews locating decisions for space-based applications from an Operations Research perspective. A systematic review of 183 publications covers orbit selection, constellation design, and on-orbit services, showing how classical OR models—coverage, n-cover, facility location, and location routing—are adapted to space's dynamic, high-dimensional setting. We assess modelling assumptions, constraints, solution methods, and research gaps.

■ TC-34

Tuesday, 10:30-12:00 - Room: JUR - Hörsaal 16 (Building: JUR)

Storage Assignment

Stream: Warehousing
Invited session
Chair: *Felix Weidinger*
Chair: *Kris Braekers*

1 - Storage Assignment in Stacked Dense Storage Systems
Constantin Wildt, Felix Weidinger

In stacked dense storage systems, SKUs are stored in bins that are stacked vertically within a metal grid. Independently controlled robots travel on top of the grid to retrieve requested bins from the stacks. If a requested bin is not on top of a stack, blocking bins must first be removed and temporarily relocated by the robots. This presentation addresses the storage assignment problem in stacked dense storage systems. To this end, the problem is formulated as an integer programming model and solved using an adaptive programming framework with problem-specific destroy and repair methods.

2 - Cold.chain warehouse dynamic partitioning problem
Saurabh Chandra, John Francis Savio Rodrigues

The problem deals with partitioning a cold chain warehouse space into contiguous rectanglular grids for each product temperature category such that capacity requirements are met and energy loss is minimum. Each partition must share the warehouse boundary for easy access. A mixed integer nonlinear programming model is presented to solve the problem.

3 - Optimizing Temperature-Zone Storage Assignment for Fruits and Vegetables
Mostafa Bahadornia, Katrien Ramaekers, Kris Braekers, Trijntje Cornelissens, Ruben D'Haen

Food loss in fruit and vegetable (F&V) supply chains depends on storage conditions and retail inventory decisions, while maintaining low temperatures requires energy. We develop a mathematical model for storage location assignment in micro-fulfillment centers that allocates F&V across temperature zones to jointly minimize cooling energy and food loss at retailer and consumer levels within a life-cycle assessment framework. The model integrates demand, inventory, and remaining shelf life, and allows relocation of stock under capacity limits.

■ TC-35

Tuesday, 10:30-12:00 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Operations Research for a Sustainable Future

Stream: Operations Research and Sustainability
Invited session
Chair: *Lorena Pradenas*

1 - Group-and-Cut Approach for Dynamic Programming with Frechet-Distributed Quantizers
Anna Timonina-Farkas

Multi-stage stochastic optimization is a well-known quantitative tool applied in a wide variety of decision-making problems. In this work, we focus on generalized flood risk-management problems with Frechet distributions used to describe the uncertainty. We introduce an approximation scheme, which computes and groups together optimal quantizers of Frechet distributions. The groups are distinguished by a particular risk threshold and differentiate between higher- and lower-impact floods.

2 - Integrated Production and Investment Planning under Carbon Emission Regulations
Cagri Koc, İrem Sultan Hastürk, Eda Yücel, Bahar Yetis Kara

This study introduces an integrated multi-period planning problem under strict environmental regulations, such as CBAM, jointly optimizing equipment investment, product composition, and production decisions. The carbon tax is considered as a cost component directly affecting profitability, while customer-specific emission caps are incorporated as binding constraints on production decisions. We formulate a mathematical model and propose a Benders decomposition algorithm. Experiments highlight the strategic trade-offs between profitability and environmental performance.

3 - Multi-Period Optimization for the Ramp-Up of Regional Carbon Capture and Storage Supply Chains
Lisa Herlicka, Frank Meisel

Carbon capture and storage (CCS) requires coordinated capture, transport, and storage infrastructure. We develop a multi-period, multimodal MILP to analyze the ramp-up of CCS supply chains under increasing capture targets. The model integrates capture decisions, pipeline and vehicle transport, condition changes, intermediate storage, and permanent storage. To enable regional analysis for Germany, emission sources are spatially clustered and connected through a backbone pipeline structure that allows the evaluation of regional transport configurations during the ramp-up phase.

4 - A hybrid decomposition-based method to select and schedule projects in Antarctic stations under uncertain project durations.
Lorena Pradenas, Mauricio Vega-Hidalgo, Víctor Parada

We study the Stochastic Research Project Selection and Scheduling Problem (SRPSAP), motivated by Antarctic campaigns. Projects are selected before uncertainty is revealed, while feasible multi-site schedules must satisfy precedence, time windows, resource limits, and transfer constraints. We formulate a two-stage stochastic mixed-integer model to maximize expected profit and propose a decomposition-based hybrid solution method. Results on Antarctic test instances show the value of uncertainty modeling and hybrid decomposition-heuristic approaches.

■ TC-37

Tuesday, 10:30-12:00 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Stochastic algorithms

Stream: Nonlinear Optimization
Invited session
Chair: *Xingju Cai*
Chair: *Deren Han*

1 - The variance reduced Douglas-Rachford splitting method for large-scale optimization problem
Deren Han

This paper addresses large-scale composite optimization problems consisting of a finite-sum smooth loss function and a nonsmooth regularization term. By integrating the variance-reduction mechanism of Point-SAGA with the Douglas-Rachford (DR) splitting paradigm, we propose an efficient framework termed the Variance-Reduced Douglas-Rachford (VR-DR) method. We prove the global convergence and establish convergence rates for the generated iterative sequences by leveraging the KL framework.Numerical experiments demonstrate the superior efficiency of our methods.

2 - Fully First-Order Methods for Decentralized Bilevel Optimization
Xiaoyu Wang

This paper focuses on decentralized stochastic bilevel optimization (DSBO) where agents only communicate with their neighbors. We propose Decentralized Stochastic Gradient Descent and Ascent with Gradient Tracking (DSGDA-GT), a novel algorithm that only requires first-order oracles that are much cheaper than second-order oracles widely adopted in existing works. We further provide a finite-time convergence analysis showing that for agents collaboratively solving the DSBO problem, the sample complexity of finding an stationary point in our algorithm matches the currently best-known results.

3 - Online Learning over Probability Measure Spaces
Xiaohui Bei

Many online learning problems require decisions that are probability distributions rather than vectors. We study online gradient descent over probability measures by viewing these spaces through a geometric lens. We show that no regret guarantees follow from a simple contraction property tied to the geometry of the space. This condition holds for two important geometries: Wasserstein and spherical Hellinger. Our results unify existing analyses and show how the choice of geometry shapes the power and limits of online learning over probability distributions.

4 - Stochastic Distributed Regularized Splitting Method for Large-Scale Convex Optimization Problems
Xingju Cai

This paper investigates the problems large-scale distributed composite convex optimization. We integrate consensus optimization and operator splitting techniques to develop a novel stochastic splitting algorithm, termed (S-D-RSM. In practice, S-D-RSM performs parallel updates of proximal mappings and gradient information for only a randomly selected subset of agents at each iteration. In contrast to conventional stochastic methods, our theoretical analysis establishes that S-D-RSM achieves global convergence without requiring diminishing step sizes or strong convexity assumptions.

■ TC-38

Tuesday, 10:30-12:00 - Room: JUR - Seminar-Raum 44 (Building: JUR)

OR in Emergency Response, Healthcare, and Human Protection

Stream: The Practice of OR: Stories of Solutions, Setbacks, and Successes
Invited session
Chair: *Amy Cohn*
Chair: *Stefan Nickel*

1 - Integrated surgery scheduling: from theory to modelling to implementation
Edilson Arruda

In this talk, I will share details of a completed surgery scheduling project at a large orthopaedic hospital in Rio de Janeiro, Brazil. I will discuss different aspects of the study, from the project's conception to its eventual implementation, including interactions with hospital staff and external societal factors that played an important role in bringing the project forward.

I will discuss technical aspects and the challenges of properly conveying modelling insights, thereby ensuring buy-in from the hospital, which is essential for implementation.

2 - Improving Care in the Emergency Department: OR is necessary but not sufficient
Amy Cohn

Overcrowding and lengthy stays are ubiquitous in many emergency departments (EDs), leading to sub-optimal care. Operations research techniques can be invaluable tools to help improve the flow in an ED, but these alone are rarely effective. In this talk we will discuss our experiences in a major academic medical center ED and the issues "before and after the OR" – how to scope the problem appropriately, partner with domain experts to understand the nuances of the problem, and ensure that the solutions are effectively implemented and sustained.

3 - Co-designing Solutions to Human Trafficking with Lived Experts for Better, Smarter Operations Research Models
Kayse Maass

This talk will describe the ways we partner with people with lived experience (e.g., homeless youth, human trafficking survivors) to better understand the complexities and nuances of societal issues. Such approaches move away from extractive research on marginalized communities to co-creating research and solutions in partnership with people that are most affected by the issue. Additionally this also helps to understand and mitigate any unintended negative consequences that may come from implementing the policies, technologies, or operational changes suggested by the models.

4 - Modern EMS Logistics: Connecting Stakeholder Perspectives
Stefan Nickel, Sven Watzinger, Boris Amberg

Emergency Medical Services (EMS) combine logistics and medicine to provide prehospital treatment and transport for patients. A vital step in supporting logistic decisions in EMS, and healthcare in general, is validating whether quantitative objective criteria align with the goals of the system. We draw on experience from using real-world data in an applied project with the EMS in our federal state to discuss how OR can support quantifying quality and informing legislation in EMS, and how models can bridge the gaps between medical expertise, legal requirements, and logistic decisions.

5 - Operations Research for Pediatric Care: Solving Big Problems for Small Patients
Lauren Steimle

The Children's Healthcare of Atlanta Pediatric Technology Center (PTC) at Georgia Tech brings together clinicians from Children's and engineers from Georgia Tech to co-develop technological solutions that improve the health and care of children. This talk highlights how the PTC integrates human-centered design principles with operations research, artificial intelligence, and software engineering to address real challenges in pediatric care. I will discuss some examples of the PTC's work that highlight the promise of this interdisciplinary approach.

■ TC-43

Tuesday, 10:30-12:00 - Room: JUR - Seminar-Raum 63 (Building: JUR)

Metaheuristics 1

Stream: Metaheuristics
Invited session
Chair: *Thomas Stützle*

1 - Neighborhood operators for the multi-objective model inference optimization problem
Javier Yuste, *Alejandro Aunión*, *Eduardo G. Pardo*

We address the Multi-Objective Model Inference problem, which seeks to find the optimal model to represent a software system: the one with maximal accuracy and minimal size. These models are important in software engineering to support and enhance testing activities. In this work, we introduce several neighborhood operators designed to reduce model size without compromising accuracy, using pattern detection and removal of redundant information. Empirical evaluations demonstrate that exploring these neighborhoods effectively improves input models.

2 - Multi-Mode Resource-Constrained Project Scheduling Problem with Time-Dependent Resource Costs and Capacities: A Bi-Objective Approach
Javier Alcaraz, *Laura Anton-Sanchez*, *Sofía Rodríguez-Ballesteros*

This research studies a realistic variant of the Multi-mode Resource-Constrained Project Scheduling Problem (MRCPSP), where each activity can run in different modes under limited resources. We incorporate time-dependent resource costs and capacities, so availability and cost vary across periods. The model has two objectives: minimize makespan and total resource cost. Since exact methods scale poorly, we design a multi-objective genetic algorithm to approximate the Pareto front. Tests on benchmark instances confirm its effectiveness.

3 - Can less efficient turbines be used to improve wind farms?
Martin Gregusson, *Ahmad Hemmati*, *Rahul Nath*

Wake effects, where downstream turbines in a wind farm experience lower wind speeds, can account for a power loss of over 15%. This paper aims to investigate whether a non-uniform three-dimensional wind farm design can mitigate the this effect. We employ a metaheuristic approach to optimize turbine selection, placement, and height, aiming to minimize the Levelized Cost Of Energy of offshore wind farms. Modeling is conducted in Python using the PyWake library, with simulations performed under both uniform wind conditions and realistic wind data from NORA3, the Norwegian Hindcast Archive.

■ TC-45

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum 01 (Building: HG)

Robust and Data-Driven Decision Making under Uncertainty

Stream: Prescriptive Analytics in Operations Management
Invited session
Chair: *Nora Gönsch*

1 - Distributionally Robust Classification under Data-Dependent Uncertainty
Rashed Khanjani Shiraz

This paper studies classification under uncertain data with dependencies often ignored by standard classification methods. Unlike traditional distributionally robust classification, which typically assumes independent data and known marginals, we propose a Distributionally Robust Optimization model with a data-dependent ambiguity set. The set preserves nominal marginals and copula structure within Wasserstein-based ambiguity set. This captures dependence uncertainty, reduces misclassification risk, and yields a tractable and more reliable framework for classification under Data-Dependency.

2 - On pricing of pre-owned items
Nora Gönsch

Both financial constraints as well as their eco-consciousness make customers pull back spending and become more deliberative about what they buy. Thus, the recommerce market, i.e. buying and selling pre-owned goods, is poised for solid growths.

In this talk we consider a company that sells pre-owned items. To mitigate the sales risk, it does not buy them upfront but instead offers pre-owners a fixed revenue percentage. We derive the firm's optimal selling price, analyze when it is profitable and compare our findings with real-world examples.

3 - Joint Production-Pricing under Substitutable Production Formulations and Demand Uncertainty
Shan Xiao, *Vahid Roshanaei*, *Jianbin Li*

Previous research assumes unique production formulations. However, substitution relationships exist between raw materials, creating non-unique formulations. We explore production planning under non-unique formulations through linear programming for deterministic demand and two newsvendor models for stochastic cases with exogenous and endogenous pricing. We employ Sample Average Approximation with trust-region algorithm. Results show formulation flexibility serves as strategic buffer under uncertainty, and price-quantity co-optimization achieves significant profit gains.

4 - A Parametrized Complexity View on Robust Scheduling with Budgeted Uncertainty
Dvir Shabtay, *Noam Goldberg*

In this study, we investigate a robust single-machine scheduling problem under processing time uncertainty. The uncertainty is modeled using the budgeted approach, where each job has a nominal and deviation processing time, and the number of deviations is bounded. The objective is to minimize the maximum number of tardy jobs over all possible scenarios. Since the problem is NP-hard, we focus on analyzing its parametrized tractability with respect to the following three parameters: the robustness parameter, the number of distinct due dates and the number of jobs with nonzero deviations.

■ TC-46

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum 02 (Building: HG)

Applications 1

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Chiara Maragò*

1 - A Rolling Horizon-Based Matheuristic for Sustainable Decision-Making in the Fishing Industry: Vessel Routing, Scheduling, and Energy Usage

Chiara Maragò, Ali Ghavamifar, Francesca Guerriero, Rosita Guido, Allan Larsen, Dario Pacino

The fishing industry plays a vital role in the global food supply and economy. Several challenges concerning fish availability, overfishing, environmental impact, regulatory compliance and market volatility, make decision-making complex and dynamic. This study proposes a rolling horizon-based matheuristic to solve an optimization model that considers fish quality, with the aim of maximizing profitability and enhancing sustainability of an Icelandic fishing company. The results provide decision-makers with valuable insights into vessel routing, scheduling, and production processes.

2 - Test Chamber Scheduling at a Refrigerator Manufacturer
Furkan Ibis, Ali Ekici, Okan Ozener

This study addresses a test chamber scheduling problem from the refrigerator industry, where new products must complete multiple research and development tests before market launch. The problem involves selecting chamber conditions and scheduling tests under resource limits, precedence relations, and due dates. To solve it, we propose a two-stage iterative approach combining a mathematical model and a genetic algorithm. Computational results show that the approach reduces tardiness and improves the use of testing infrastructure.

3 - Tuning Proximal Policy Optimization to solve chemical process scheduling problems with heuristics and reinforcement learning
Philipp Willms, Marcus Brandenburg

The inherent complexity of chemical processes presents numerous challenges in production planning and scheduling. This study proposes a reinforcement learning approach using Proximal Policy Optimization. After preprocessing with an MRP heuristic, customer orders are represented as aggregated production chains. A PPO agent applies a forward scheduling heuristic to minimize makespan. Results of a numerical study on benchmark problem instances show that aggregation to production chains and waiting time-based slot determination reduce complexity and enable efficient solutions for large instances.

■ TC-47

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum 03 (Building: HG)

Electric vehicle charging in uncertain environments

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Nezir Aydin*

1 - Managing Energy Consumption Uncertainty in EV Routing and Overnight Charging Scheduling
Ariel Rojas, Ola Jabali, Fabien Lehuédé, Jorge E. Mendoza

We study an electric vehicle routing and overnight charging scheduling problem under energy consumption uncertainty. We propose a robust optimization model. For a given budget of uncertainty, the resulting solutions are comprised of operational plans, consisting of customer routes and charging schedules, that remain feasible under worst-case realizations of the energy consumption. We devise an exact branch-and-price-and-cut algorithm to solve the problem, which we enhance by introducing several algorithmic features. Our computational analyses provide algorithmic and managerial insights.

2 - A Simulation-Based Optimization Framework for Electric Bus Charging Schedules
Chun-Chih Chiu, Yu-Ting Kao, GuanTing Li

We present a simulation-based optimization framework for electric bus charging scheduling under realistic charging dynamics, charger congestion, and traffic uncertainty. A discrete-event simulator models post-trip arrival, queuing, charger assignment, and charging, while a metaheuristic search improves decisions across multiple criteria such as total waiting time, charging cost, and backup fleet needs. Experiments on large fleet instances show the approach quickly delivers high-quality and robust schedules, supporting both daily operations and capacity planning.

3 - Optimizing Medical Drone Delivery Under Uncertainty
Abolfazl Maleki, Amin Asadi, Miguel Lejeune, Breno Alves Beirigo, Erwin W. Hans, Derya Demirtas

Drone-based medical delivery holds promise in healthcare logistics but faces complexities for efficient and sustainable fleet management. Specifically, it is challenging to find the policy that balances responsiveness to demand, cost, and energy considerations, which becomes more complex under uncertain demand or service time. Our research proposes an optimization model to derive optimal policies on charging strategies, fleet sizing, and resource allocation. Preliminary results show improved service quality with practical insights for practitioners.

4 - Decision-Dependent Stochastic Multi-Objective Electric Vehicle Charging Station Location Analysis for Sustainable Cities
Nezir Aydin

The rapid growth of electric vehicles requires efficient planning for charging infrastructure in urban areas. This study develops a decision-dependent stochastic, multi-objective facility location model to determine the optimal number and locations of EV charging stations in sustainable cities. The model simultaneously minimizes costs, unmet demand, and CO emissions under uncertain demand conditions. Two-stage stochastic programming and a weighted-sum approach are used to address uncertainty and multiple objectives, providing practical insights for sustainable urban infrastructure planning.

■ TC-48

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum 04 (Building: HG)

Data-Driven Scheduling and Manufacturing Systems

Stream: Data-driven Operations Research
Invited session
Chair: *Ju-Yong Lee*

1 - A Decision Support Framework for Sensor Adoption in Manufacturing Under Uncertainty
Parham Fakhr

Around 24% of UK SMEs are considering installing sensors to improve operation efficiency, but many remain uncertain about their values. This study presents an empirical evaluation of sensor value under uncertainty, using 52 machining sound datasets as a case study. Operator reliability in anomaly detection is analysed using ANOVA and logistic regression, and sensor-based algorithms are benchmarked against human performance. The findings show that high anomaly rates favour sensor adoption, while high operator experience may be sufficient in some processes.

2 - DRL-based Temporary Capacity Expansion for Multi-line Fabs
Jun-hee Han, Tring Ming Dang, Ju-Yong Lee

Disruptions in multi-line semiconductor fabs cause bottlenecks. We propose a temporary capacity expansion policy via WIP balancing to redistribute workloads. To manage complex simultaneous transfers, we develop an integrated MILP model. A deep reinforcement learning (DRL) method is proposed to handle high-dimensional action spaces that challenge conventional RL. Experiments show our approach significantly improves throughput and machine utilization while reducing backlogs compared to existing planning algorithms.

3 - A ML-Driven Decision Support System for Assembly Line Balancing Problem Precedence Constraint Validation
Joseph Thompson, Nadia Lahrichi, Patrick Meyer, Simon Thevenin

The assembly line balancing problem (ALBP) seeks to optimally distribute tasks across stations in manufacturing assembly lines. A key barrier to ALBP adoption in industry is the difficulty of obtaining accurate precedence graphs, which specify the ordering of constraints between tasks. In this work, we propose a data-driven decision aid for the validation of individual precedence constraints. This tool uses machine learning to prioritize the precedence constraints by their likelihood to impact the underlying ALBP, helping planners focus on validating the most important constraints.

4 - Integrated Release Control and Dispatch in Airport Parcel Sorting Systems Using Learning and Optimization
Qiujian Wang

Airport parcel hubs face a dynamic release-control problem in which ULD-level arrivals are converted into parcel-level execution under finite gate buffers and shared sorting capacity. We develop a rolling-horizon quota-and-dispatch framework that separates service deadlines from priority weights. It generates interpretable gate-priority quotas, refines them with contextual-bandit feedback, dispatches ULDs to parallel sorting lines, and applies local MIP repair only when feasibility is threatened.

■ TC-49

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management through Pricing Optimization

Stream: Data-Driven Demand Management
Invited session
Chair: *Claudius Steinhardt*

1 - Pricing Optimisation for Subscription-Based Revenue Management: Duration Discount, Model Selection, and Flat-Rate Bias
Bowen Xue, Xiao-jun Zeng

We propose a general revenue optimisation framework for subscription businesses over a multi-period pricing horizon. Flat-rate and usage-based models are compared under dynamic subscriber evolution, yielding closed-form optimal prices. Incorporating duration and cross-model discounts, the framework supports optimal price menu design. Analytical results show longer horizons lower subscription fees but not usage charges. Flat-rate model dominates when fee sensitivity is low, especially under short pricing horizons or high costs, while flat-rate bias weakens the advantage of usage-based pricing.

2 - Optimal pricing in the presence of consumer strategic behavior
John Wilson

The sale of ancillary items is crucial to the profitability of many airlines. -especially for low cost carriers that offer extremely low ticket prices. Customers who act strategically by watching for low fares and booking early in the cycle can deprive airlines of much needed ancillary revenue. We consider the issue of jointly pricing the base item, such as an airline ticket, and bundles consisting of the base item and various subsets of ancillary items. Importantly, we specifically take into account the stochastic arrival and demand behavior of customers who seek different bundles.

3 - Dynamic Pricing for Vertically Differentiated Reusable Resources
Fuxiang Zhou

We study a revenue management problem for vertically differentiated reusable products with limited inventories. Customers sequentially request products for specific time intervals over a finite selling horizon, and prices are dynamically offered based on the current inventory to maximize expected future revenue. Customers' choices follow a vertical choice model with linear utility. Due to the extremely large state space,we propose four decomposition-based approximation methods to estimate value functions and derive practical pricing policies for reusable resource systems.

■ TC-50

Tuesday, 10:30-12:00 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Stochastic Optimization & Operational Strategies I

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Cyrille Vessaire*

1 - When Does Time Discretization Preserve Optimality in Energy Storage Control?
Klaus Rheinberger

Energy related optimal control problems are typically time-continuous, and time-discrete reformulations are often applied to make them computationally tractable. However, time discretization may introduce suboptimal solutions compared to the original problem. We restrict our analysis of this issue to the control of electrical, thermal and mechanical energy storage systems under piecewise constant constraints. Our main findings are that event-based time discretizations preserve energy cost optimality only for non-dissipative storages and always preserve peak power optimality.

2 - A Two-Stage Stochastic Approach for Wind Farm Repowering with Batteries and Green Hydrogen
Rafael Zarate-Miñano, Ana Fernández-Guillamón, Isabel Cristina Gil-García, Miguel Cañas-Carretón, Miguel Carrión

This work formulates wind-farm repowering as a two-stage stochastic MILP with endogenous technology selection. The model jointly determines turbine replacement and the sizing of batteries, electrolyzers, and hydrogen storage, subject to spacing and grid constraints. Uncertainty is represented through wind output and electricity and hydrogen prices. Computational tractability is achieved through time clustering and iterative technology screening. In a real-world case study, hydrogen improves expected profits, whereas batteries are not cost-effective under current cost assumptions.

3 - Optimal Decision Making in a Residential Microgrid under Market Price, Demand, and Renewable Uncertainties
Gulfem Er, Christine Currie, Gevorg Stepanyan

We analyze a residential grid-connected microgrid with wind turbines, photovoltaic panels, and batteries. To address uncertainties in renewables, price and demand, we use two-stage distributionally robust optimization. The first stage minimizes investment costs, while the second focuses on battery management and grid power exchange to minimize operational costs. Our case study of a hypothetical microgrid in the UK reveals that this method outperforms traditional stochastic approaches. Moreover, a hybrid wind-solar-battery setup offers significantly lower costs compared to solar-battery system.

4 - An Implementation of a Real-Time Zonal Congestion Controller for the Transmission Grid
Cyrille Vessaire

The growing integration of renewable energy increase the volatility of flows in the grid. In order to satisfy thermal limit constraints on power lines, RTE, the French TSO, implemented a closed loop controller on sub-transmission area power network which can change the topology, curtail renewable and batteries. We present the architecture of the controller, consisting of a closed loop - which optimizes the sub-transmission zone - and an automatic parameter update mechanism - which assesses the influence of the rest of the network on the zone.

■ TC-51

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Fairness in Decision Making

Stream: Mathematical Optimization for Transparent and Fair Decision Making
Invited session
Chair: *Farnaz Farzadnia*

1 - Predict Fairly or Decide Justly? Disentangling Fairness and Justice in Credit Grant Decisions
Enis Kayis, Elif Ersoy

This study distinguishes fairness in prediction from justice in prescription in a predict-then-prescribe framework for credit decisions. We compare four models: unconstrained, fairness-aware prediction, justice-aware prescription, and a combined approach. Using six real datasets, we show that fair predictions do not necessarily produce just decisions. Justice-aware prescriptions achieve disparity reductions at significantly lower economic cost, as they target low-cost decision changes rather than altering the full prediction distribution.

2 - On the Trade-off Between Global Fairness and Individual Representation in Cluster Analysis
Ansgar Boss Henrichsen, Dolores Romero Morales

Cluster analysis is widely used in ML and OR, to uncover latent data structures. As its role has grown and its applications found their way into high-stakes decision making, concerns about fairness and heterogeneous treatment of groups have intensified. To remedy this, a plethora of fairness notions have been proposed, yet, blindly enforcing these can be detrimental to its own and other fairness objectives. We propose a mathematical optimization model that highlights this trade-off between global fairness and intra cluster homogeneity to facilitate transparency and individual representation

3 - Fairness in Parallel Evaluation Systems
Jie Ren, Christiane Barz, Denis Saure, Ozge Sahin

Inspired by the Eurovision Song Contest semifinal practice, we investigate fairness in parallel evaluation systems where referees may exhibit participant-specific bias. The objective is to mitigate differential treatment induced by parallel sessions. Our fairness objective is a dispersion-based criterion measured by the worst-case within-session bias gap between participants. We reformulate the problem as a mixed-integer linear program, explore structured cases with exact solutions, develop heuristic algorithms for the general case, and illustrate the approach for the 2025 Contest.

4 - A matheuristic for large-scale fair facility location
Claudio Mantuano

We study the fair facility location problem of Filippi et al. (2021), which has applications in healthcare, public services, and other domains. The problem consists of placing a fixed number of facilities to serve customers who travel to their nearest facility at their own cost. The objective is to minimize a convex combination of efficiency, measured by the average travel distance, and fairness, measured by the average of a predefined fraction of the longest travel distances. We propose a new matheuristic and report results on large-scale instances.

■ TC-52

Tuesday, 10:30-12:00 - Room: KOL - PC Raum 1 (Building: KOL)

Optimization and Equilibrium Modeling in Energy: Part 1

Stream: Energy Markets & Systems
Invited session
Chair: *Steven Gabriel*
Chair: *Dominic Flocco*

1 - A Bilevel Approach for the Generation Capacity Investment Problem Considering Cost Recovery Mechanisms
Miguel Carrión, Giorgia Oggioni, Ruth Dominguez

Optimal generation capacity planning is increasingly complex due to growing penetration of variable renewable sources and profit cannibalization, which may hinder cost recovery for new units. To address this issue, this work proposes and evaluates different generation investment models, progressing from a standard approach to a bilevel formulation incorporating reliability options and renewable auctions to ensure the total cost recovery. Case studies show that investment decisions and generator profitability depend strongly on the cost recovery mechanisms used.

2 - Redefining Time Series Aggregation: Exact Methods for Tractable Energy System Planning
Sonja Wogrin

Achieving net-zero energy systems requires large-scale renewable integration, flexibility technologies, and sector coupling, which greatly increase the complexity of expansion planning models. Time series aggregation (TSA) is used to manage this, but common heuristic clustering often compromises model accuracy. The ERC-funded NetZero-Opt project introduces a paradigm shift: a simplex-based clustering method that reduces dimensionality while preserving exact optimality, redefining TSA as a performance-guaranteed model reduction technique, which we discuss in this talk.

3 - A Computational Study for Non-Convex, Bilevel, Spatial Price Equilibrium Problems
Helmi Hankimaa, Seksun Moryadee, Steven Gabriel, Fabricio Oliveira

We study a spatial price equilibrium model of imperfectly competitive oil-derivative markets. In developing economies, these markets are often dominated by a single firm, which we represent as a market leader facing a competitive fringe. However, unlike a classical quantity-based Stackelberg game, in this context, the leader also sets prices strategically at its distribution terminals. This bi-level problem induces a computationally challenging non-convex mixed-integer quadratic program for which we propose alternative formulations, tighter bounds, and valid inequalities.

4 - Efficient Warm-Start Strategies for Nash-based Linear Complementarity Problems via Bilinear Approximation
Steven Gabriel, Dominic Flocco

We present an effective warm-starting scheme for solving large linear complementarity problems (LCPs) arising from Nash equilibrium problems. The approach generates high-quality starting points that, when passed to the PATH solver, yield substantial reductions in computational time and variance. Our warm-start routine reformulates each agent's LP using strong duality, leading to a master problem with bilinear constraints that is equivalent to the original LCP.

■ TC-53

Tuesday, 10:30-12:00 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Exact Methods for Multiobjective (Mixed) Integer Linear Optimization

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Sophie Parragh*

1 - A Branch-and-Bound Method with Preprocessing for Computing Lorenz-Efficient Solutions in Bi-Objective Knapsack Problem
Mohamed Tebbal, Chaabane Djamal

This paper proposes a novel branch-and-bound algorithm to generate all Lorenz-efficient solutions for the Bi-Objective Knapsack Problem. Unlike traditional methods that evaluate fairness after constructing the Pareto front, the approach embeds fairness directly into the optimization process. An adaptable preprocessing phase reduces dimensionality, followed by two stages: first identifying supported extreme solutions, then applying a specialized branch-and-bound scheme to uncover unsupported fair solutions. Experiments show major reductions in runtime and search space on large instances.

2 - A systematic approach to generate test instances for multi-objective mixed-integer optimization
Leo Warnow, Gabriele Eichfelder, Tobias Gerlach

In this talk, we present a flexible generator for test instances in multi-objective mixed-integer optimization, built from continuous and purely integer problems with known efficient solutions and nondominated sets. Leveraging a separable problem structure, we show how to precisely control efficient set, nondominated set, and efficient integer assignments of the resulting test instances - often scalable in the number of variables and objectives. This lays the foundation for systematic benchmarking and evaluation of solver performance in multi-objective mixed-integer optimization.

3 - Comparison of epsilon-constraint algorithms for a bi-objective CVRP
Margarida Aires de Abreu, Daniel Santos, José Rui Figueira

This presentation addresses the Bi-objective Capacitated Vehicle Routing Problem. Routing problems are a class of optimization problems with significant real-world applications, often involving conflicting objectives, and are inherently challenging to solve. We conduct a computational study using benchmark instances to compare the exact epsilon-constraint methods proposed by Mavrotas (2013) and Mesquita-Cunha et al. (2023) with a novel approach that enhances these methods by incorporating warm starts derived from supported non-dominated points and constructive and improvement heuristics.

4 - A disjunctive approach for multi-objective mixed-integer linear programming
Sophie Parragh, Nicolas Forget

In multi-objective mixed-integer linear programming, the presence of continuous variables in more than one objective function may lead to Pareto frontiers which are composed of points, line segments, as well as of disconnected, partially or fully non-dominated facets. In this work, we propose a disjunctive cut-based criterion space search approach to enumerate the integer components of all those solutions whose images contribute to the Pareto frontier. Preliminary results on available benchmark instances with three objectives are promising.

■ TC-57

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum 07 (Building: HG)

Behavioral OR general papers 1

Stream: Behavioural Operational Research
Invited session
Chair: *Valentin Bertsch*
Chair: *Bayu Nuswantoro*

1 - Human or Digital Human? Deciding on whom to accept in critical conversations
Michael Leyer, Bayu Nuswantoro, Alexander Richter

Digital humans try to mimic humans as much as possible, with quite good results for their technical assessment and appearance. But we do not see many digital humans in reality. In the search for reasons, we conduct interviews with students on their decision to accept a digital human to inform them about AI regulations for studying. The results provide interesting insights into why digital humans are accepted or not considered in critical conversations.

2 - Patterns of Supplier-Buyer-Customer Triad in Manufacturing Supply Chain: A Case Study in Engineered Plastics Industry
Jeff Yan, Luke Teng, Jie Xiong

Recent supply chain research has moved from buyer-supplier dyads to triadic structures. This study analyzes supplier-buyer-customer triads in manufacturing, where relationship strength and flow continuity vary across actors. Based on structural hole theory and balance theory, we deductively derive 10 theoretical triad patterns and test them using pattern-matching case analysis in the engineered plastics industry. 5 patterns are observed, demonstrating the analytical value of deductive pattern typologies for understanding structural diversity and strategic behavior in complex supply networks.

3 - A Nonlinear Dynamic Savings Method for the Multi-Objective Capacitated Vehicle Routing Problem
Amin Roshanizarmehri, Anna Sciomachen, Massimo Paolucci

We present a multi-objective approach for the Capacitated Vehicle Routing Problem based on a nonlinear savings formula, dynamic savings adaptation, and a soft-filling route construction strategy. The method extends the Clarke-Wright framework to efficiently generate diverse routing solutions while maintaining low computational cost and good scalability on large road-network instances. Compared with the NSGA-II metaheuristic, the proposed approach produces solutions significantly faster and provides a competitive approximation of the Pareto frontier on tested instances.

4 - Value-focused modelling to generate alternatives (VF-MGA) for participatory energy planning based on multi-criteria decision analysis and energy system modelling
Valentin Bertsch, Emily Bergup, Sebastian Schär, Jonas Finke

Multi-criteria decision analysis and energy system models are often used separately in energy planning, ignoring their complementarity. We propose value-focused modelling to generate alternatives (VF-MGA) to integrate both. We demonstrate VF-MGA's capabilities for decarbonisation planning of a university campus's energy supply. An objective hierarchy is developed in stakeholder interviews. This hierarchy informs the systematic generation of energy system alternatives via MGA. Preferences are elicited to evaluate these alternative systems and identify patterns of consensus and disagreement.

■ TC-58

Tuesday, 10:30-12:00 - Room: HG - Seminar-Raum 08 (Building: HG)

Scheduling

Stream: Integrated Planning in Manufacturing
Invited session
Chair: *Yoel Shin*

1 - Block Scheduling with Area-Capacitated Workshops and Storage Buffers in Large-Scale Shipbuilding
Yoel Shin, Eun kook Cho, Byung-In Kim, Sang Hun Kim, Donghyeon Lee

Assigning blocks to workshops and storage yards under capacity constraints is a key planning problem in shipbuilding industry, yet it is often handled manually. We formulate the block scheduling problem as a fixed-interval scheduling and packing problem with storage buffers, where process times are predetermined by an upper-level plan. A stage-indexed MIP model and a two-phase matheuristic are proposed. Experiments with real shipyard data show improved space utilization and reduced transport costs.

2 - Double-Constrained Distributed Permutation Flow-Shop Scheduling Problem Based on an Improved Genetic Algorithm
Yanfeng Chu

For the double-constrained distributed permutation flow-shop scheduling problem with sequence-dependent setup time and flow shop eligibility restriction, a mixed-integer linear programming model is constructed with the optimization objective of minimizing the maximum completion time, and an improved genetic algorithm is proposed to solve the problem.

3 - Planning the Flight Tests of Newly Developed Aircraft
Guopeng Song, Hanqiao Tao, Christopher Hojny, Roel Leus

Flight tests play a critical role in the R&D process for new aircraft, as they help verify the capabilities and expose the design and manufacturing defects. We study the flight test planning problem to minimize the number of required test flights, thereby decreasing the cost and time required during the entire test process. We establish a MIP model, and present a Dantzig-Wolfe reformulation, augmented by novel valid inequalities and polyhedral results, leading to an efficient branch-price-and-cut algorithm. Comprehensive computational experiments demonstrate the efficiency of the algorithm.

■ TC-59

Tuesday, 10:30-12:00 - Room: KOL - Seminar-Raum 9 (Building: KOL)

MCDA: novel formulations

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Juuso Liesiö*

1 - Multicriteria portfolio selection in blockchain environments
Adam Mielniczuk, Grzegorz Miebs, Matteo Brunelli, Milosz Kadzinski, Jonas Gehrlein

We consider a portfolio selection problem in proof-of-stake blockchains, where nominators select validators based on criteria such as commission rate, cluster size, and self-stake. The problem is multicriteria at two levels: evaluating individual validators and composing diversified portfolios across multiple stashes. We propose a two-stage solution: the first uses pairwise comparisons to learn nominator preferences for validator evaluation; the second applies multicriteria optimization to find the best portfolio of portfolios balancing validator quality and fund diversification.

2 - Unlocking the Decision Power of Digital Product Passports: A MCDA Framework for Industrial Systems
Federica Tomelleri, Matteo Brunelli, Alice Mondello, Franco Donati, Marco Cinelli

The EU is advancing Digital Product Passports (DPPs) under the ESPR, but their decision-support potential is still underused. We map DPP data elements into MCDA-ready criteria and propose a modular, user-sensitive DSS that adapts to roles, access rights, and decision contexts. Using a DPP ontology, we illustrate the workflow in an industrial case by building an MCDA decision matrix to support material selection for laser welding. The framework supports transparent, data-driven choices for industry, regulators, and customers.

3 - An MCDA Approach for Sovereign Nature Bond Issuance: Coordinating Fragmented Decision-Makers in Ireland's River Restoration
Francisco Silva Pinto, John Garvey

Ireland faces the challenge of issuing a sovereign nature bond for river restoration, requiring coordination across fragmented stakeholders, as the Ministry of Finance, intermediaries, and local communities. MCDA provides a framework to align decision-makers around a set of criteria, as financial risk-return and EU policy compliance, enabling consensus on bond design and fund deployment pathways. To target the existing contextual ignorance, we allow for criteria measurements/predictions, elicited value functions and weighting coefficients, to be represented by probability distributions.

4 - Scenario-based decision analysis when scenarios are not mutually exclusive: axiomatic foundations and implications to decision support
Juuso Liesiö, Elmira Nurbayeva, Eeva Vilkkumaa

Although scenario-based decision analysis (SDA) has been successfully applied in real-world decision support, it is commonly criticized for assuming that the scenarios are mutually exclusive. This paper establishes an axiomatic foundation for SDA using subjective expected utility theory and shows how relaxing the assumption of mutually exclusive scenarios results in a set of feasible probability measures for the possible futures. It also develops optimization models to analyze how sensitive the decision recommendations are to violations of the mutually exclusivity assumptions.

■ TC-61

Tuesday, 10:30-12:00 - Room: KOL - Seminar-Raum 18 (Building: KOL)

Risk and Predictions

Stream: OR in Sports
Invited session
Chair: *Jakub Morkowski*

1 - Anomalies detection in figure skating refereeing
Anastasia Kolupaeva

The objectivity of judging in figure skating continues to be a subject of debate. This study introduces a methodological framework and a reproducible toolkit to detect anomalous judging behavior and potential collusion, shifting focus from individual biases to the interdependence of judges' decisions. Using ISU data, we combine correlation-based network analysis, graph algorithms, and unsupervised anomaly detection to identify atypical scoring patterns. Preliminary results indicate that approximately 7% of judges may be subject to systematic bias or be involved in subgroup coordination.

2 - Modeling the Transition from Junior to Professional Tennis: Predicting Success on the WTA Tour
Jakub Morkowski

This study examined whether early-career results (ITF junior) can help predict later success in women's professional tennis (WTA). The study used historical data on junior rankings and early professional results to analyze the career paths of players who later reached the top 100 in the WTA rankings. The dataset includes junior-ranking positions, the age at which the highest junior ranking was achieved, the number of tournaments played, and early results in professional tournaments. The study identified early indicators that are most strongly associated with breaking into the top 100.

3 - Risky Behavior in Professional Volleyball
Ekaterina Lodneva

This study examines decision-making in elite team sports through gendered risk-taking at the Paris 2024 Olympics. We find that men are generally more risk-taking. Aligning with prospect theory, both genders risk more during serves (loss frame) than attacks (gain frame). Interestingly, men increase risk when leading in sets, while women decrease it. Despite the stakes, both genders shift toward aggressive strategies during playoffs. Our findings reveal how gender and situational framing dynamically reshape strategic choices in professional volleyball.

■ TC-65

Tuesday, 10:30-12:00 - Room: HG - Hörsaal 27 (Building: HG)

Causal Machine Learning for Data-Driven Decision Support Systems

Stream: Analytics
Invited session
Chair: *Joaquín Roa*

1 - Towards Timely and Equitable Access: Assessing Geographic Inequities and the Right to Timely Elective Surgery in Chile's Public Health System Using Causal ML
Constanza Contreras, José Arenas, Patricio Wolff, Sebastian Rios

Long elective surgery waiting times in Chile raise concerns about equitable healthcare access. This study investigates socioeconomic disparities (gender, age, and geography) using Causal Random Forest models on more than 180,000 surgery records from 74 public hospitals. Findings reveal that while women and older patients face longer waits, these inequities are not system-wide discriminatory structures but localized, facility-specific issues. Uncovering this non-linear heterogeneity provides actionable evidence to guide targeted health policies.

2 - Forecasting Hydric Stress in Pear Trees via Temporal Fusion Transformers and Microtensiometer Data
Joaquín Roa, Jan Diels, Estefanía Serral

We evaluated different Temporal Fusion Transformer architectures as a modular and scalable approach for forecasting hydric stress in pear trees using continuous microtensiometer-based Stem Water Potential data, together with Soil Water Potential and weather covariates across three treatments. Results show promising predictive performance and highlight the potential of Transformer-based time-series models to anticipate tree water stress and support data-driven irrigation management, with the goal of reducing water use and optimizing orchard production.

3 - Mapping the Research Landscape of Quantum Optimization: Causal Discovery of Emerging Issues in Operations Research
Won Sang Lee

Quantum computing is gaining attention for solving complex optimization problems in OR. However, the relationships among emerging research topics in quantum optimization remain unclear. This study maps the research landscape of quantum optimization and identifies causal relationships among key topics. LDA is applied to quantum optimization studies to extract latent research topics. Then, causal discovery identifies directional relationships among them, such as QAOA, quantum annealing, and variational quantum algorithms. The findings contribute to the evolution of quantum optimization research.

4 - The Impact of Deceptive Reviews on E-commerce Platforms: Strategic Manipulation, Consumer Response, and Technological Intervention
Boru Li, Jie Wang, Yong-Hong Kuo

This study examines how rating manipulation and deceptive reviews affect consumer behavior in e-commerce, and evaluates online sellers' strategic choices regarding rating manipulation and investment in technology intervention. Empirical results show that the review environment influences purchase decisions of consumers through perceived authenticity and platform trust. Analytical findings further identify how product quality, cost, and other related factors jointly shape the conditions under which sellers choose different review-related strategies.

■ TC-66

Tuesday, 10:30-12:00 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Quantum Algorithms for Optimization

Stream: Quantum Optimization
Invited session
Chair: *Stefan Woerner*

1 - Solving a million variable linear optimization problem with quantum computer
Tamás Terlaky, Mohammadhossein Mohammadisiahroudi, Adrian Harkness, Pouya Sampourmahani

Quantum computing optimization offers novel challenges and opportunities for optimization. Several variants of Quantum Interior Point Methods (QIPMs) were developed recently. Ultimately, the Iterative Refinement Inexact QIPMs are proved to have clear quantum advantage. Regardless of the major theoretical brak-throughs, due to QC hardware limitations, solving LO and SDO problems on real quantum computers remained out of reach. In this paper we discuss how a million variable linear optimization problem was solved on quantum computer simulators, and on an IBM Quantum Computer.

2 - Optimization by Decoded Quantum Interferometry
Adam Zalcman

DQI is a quantum algorithm that reduces combinatorial optimization problems to decoding tasks. We apply it to two problems: 1) a regression task called Optimal Polynomial Intersection which DQI reduces to decoding Reed-Solomon codes, obtaining a superpolynomial speed-up over all classical algorithms known to us, and 2) unstructured sparse max-k-XORSAT which DQI reduces to decoding Low Density Parity Check codes, obtaining a practical speed-up over general-purpose heuristics, but not over a tailored heuristic. Our results represent a promising new approach to quantum optimization.

3 - Stronger Problem Formulations for the Quantum Approximate Optimization Algorithm
Conrad Haupt

The Quantum Approximate Optimization Algorithm (QAOA) offers a promising method for solving combinatorial optimization problems with quantum computers. However, current implementations are predominantly designed for near-term hardware. Here we strengthen QAOA problem formulations, e.g., for the Maximum Independent Set problem, identifying alternatives that outperform canonical near-term formulations in metrics such as the probability to obtain optimal solutions. Our results show that extending beyond near-term constraints yields substantial performance gains.

4 - Exponential Speed-ups for Structured Goemans-Williamson relaxations via Quantum Gibbs States and Pauli Sparsity
Daniel Stick Franca

We study QUBO, an NP-hard optimization problem, via the Goemans-Williamson SDP relaxation. For instances whose cost matrix has a sparse Pauli-string decomposition with suitable algebraic structure, matrix multiplicative weights give quantum and quantum-inspired algorithms that approximate the SDP in polylogarithmic time, exponentially faster than prior methods. We also provide efficient condition checks, rounding heuristics, and strong numerical results, including a 250-variable SDP solved on a desktop with a feasible QUBO solution within 0.15% of optimal.

■ TC-67

Tuesday, 10:30-12:00 - Room: KOL - PC Raum 3 (Building: KOL)

Business Management in Dynamic Emerging Markets

Stream: Selected Aspects of International Finance and OR
Invited session
Chair: *Helper Zhou*

1 - Edge-Optimized Computer Vision for Financial Inclusion: Dendritic Neural Networks in Infrastructure-Constrained Retail Environments
Helper Zhou, Alford Toruvanda, Gordon Dash, Nina Kajiji

Informal retail sustains billions in emerging markets, but digital POS systems often fail due to unstable connectivity, low literacy, and dynamic inventories. This paper introduces a camera-first, offline POS using smartphones for inventory tracking without barcodes or SKUs. Using vegetable recognition, we evaluate dendritic optimization via PerforatedAI to enhance lightweight vision models under edge constraints. MobileNetV3-Small achieved 97.44% accuracy (vs. 95.16%), a 47.1% error reduction without added complexity. Results show impact of dendritic optimization.

2 - When Growth Misleads: The CAGR Paradox in Linear Performance Models
Tomas Macak

This paper analyses a paradox in performance evaluation arising when the compound annual growth rate (CAGR) is applied to indicators with different baselines. We study a linear profit model (EBIT(t) = a + bt), and show analytically that the CAGR decreases with the intercept parameter a. Consequently, indicators with smaller baseline values may appear to grow faster despite lower absolute performance. We derive formal conditions under which CAGR rankings are consistent with absolute growth dominance and provide a practical investment example illustrating the potential decision bias.

3 - Evaluating the Robustness and Practical Utility of XAI-Driven Early Warning Systems in firm distress prediction
Trustlord Marecha, Helper Zhou

South African SMMEs face >70% failure rates in the first five years due to opaque risk signals. This study evaluates the real-world applicability and robustness of an XAI-driven Early Warning System (EWS) for firm distress prediction, moving beyond predictive accuracy to assess actionability, temporal resilience, and performance under data scarcity. Using 28,400 SMMEs (2016-2024), SHAP/LIME-augmented Gradient Boosting/LightGBM models provide actionable insights. The XAI-EWS emerges as a deployable tool for lenders and agencies.

Tuesday, 13:00-14:00

■ TD-01

Tuesday, 13:00-14:00 - Room: HG - Audimax

Keynote Georgios Paschos

Stream: Keynotes
Keynote session
Chair: *Stefanie Kritzinger*

1 - Amazon Fulfillment Optimization
Georgios Paschos

Delivering customer orders quickly and cost-effectively requires a well-planned and finely tuned supply chain system. When a customer visits a product page as well as when an order is placed, multiple systems coordinate to determine a reliable delivery date. This process encompasses verifying item availability, selecting the optimal warehouse to fulfill from, computing the item's path through Amazon's transportation network, and calculating the precise timing of when each fulfillment operation should take place. In particular, when optimizing delivery resources across multiple customer orders, the system identifies potential consolidation and delivery synchronization opportunities evaluating additional delivery options, potentially expediting delivery times while maintaining efficiency. This complex orchestration—managing millions of daily packages across a vast selection of items—relies on Amazon's sophisticated framework of forecasting, planning, and execution systems, powered by advanced optimization models and machine learning algorithms. In this presentation, I will provide a high-level overview of key components within Amazon's fulfillment optimization framework, with particular emphasis on package path computation within the middle mile network.

■ TD-02

Tuesday, 13:00-14:00 - Room: JUR - Hörsaal 10 (Building: JUR)

Keynote Asgeir Tomasgard

Stream: Keynotes
Keynote session
Chair: *Bernhard Lutz*

1 - Stochastic optimization for the energy transition
Asgeir Tomasgard

In this presentation, we focus on stochastic optimization models for the energy transition. Often, these models are multiscale and include both long-term and short-term periods. In the long run, the focus is often on how to invest in technologies within the energy system, for example, power generation capacities, carbon capture, and storage. Other long-term investments relate to the decarbonization of transport and industry. In the short-term periods, the focus is on storage management and balancing supply and demand. To address uncertainty in both the long and short term, we introduce the concept of multihorizon stochastic programming. This approach allows for uncertainty in both time scales. The structure of these models enables decomposition, and we present computational results for different decomposition methods while discussing how uncertainty affects transition strategies.

Tuesday, 14:15-15:45

■ TE-01

Tuesday, 14:15-15:45 - Room: HG - Audimax

Tutorial Veronica Piccialli

Stream: Tutorials
Tutorial session
Chair: *Kevin Tierney*

1 - Optimizing machine learning
Veronica Piccialli

The integration of mathematical optimization with machine learning represents a significant advancement in addressing complex learning tasks. While many machine learning models rely on optimization for training, the use of tailored optimization techniques has shown particular promise in handling non-convex formulations and improving the quality of the machine learning models produced. This interdisciplinary approach has led to substantial improvements in solving challenging machine learning problems and in achieving some desirable properties of machine learning models, such as transparency and interpretability. The topic of this talk highlights the synergy between optimization and machine learning, demonstrating how optimization techniques can improve model quality and robustness. Specifically, we explore three fundamental problems: the Minimum Sum of Squares clustering problem (MSSC), including its constrained or semi-supervised variant, Semi-Supervised Support Vector Machines (S3VM), and optimal decision trees. MSSC aims to partition a set of data points into a fixed number of clusters while minimizing the sum of Euclidean distances to cluster centroids. The integration of background knowledge transforms the MSSC into a semi-supervised task. Similarly, S3VM extends traditional SVMs by leveraging both labeled and unlabeled data to learn a more reliable decision boundary. Finally, univariate decision trees represent the most interpretable machine learning model, and hence the most desirable in high-stakes contexts such as medicine and finance. The complexity of these machine learning tasks translates into NP-hard optimization problems, necessitating advanced optimization techniques for efficient solutions. We explore how recent research bridging mathematical optimization and machine learning has advanced the state of the art for these tasks, demonstrating the mutual benefits of combining expertise from both domains.

■ TE-04

Tuesday, 14:15-15:45 - Room: HG - BIG-Hörsaal (Building: HG)

Home Health Care

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Salma Makboul*

1 - The Value of Integrated Decisions in Multi-Period Home Health Care Operations
Maria I. Restrepo

In most home health care (HHC) approaches, tactical and operational decisions are planned separately. This method can produce suboptimal outcomes because tactical choices, such as caregiver staffing, directly affect the feasibility and quality of daily operations. Ignoring these interdependencies leads to planning structures that adapt poorly to demand variability. We develop mathematical models and algorithms that coordinate the two decision levels. Numerical experiments show that integration improves overall system performance and robustness.

2 - Routing and Teleconsultation Scheduling in Home Health Care
Cristina Requejo, Raquel Bernardino, Cândida Mourão, Leonor S.Pinto

We study a routing problem variant that integrates scheduled online medical consultations into home health care operations. The problem is defined on a network where each patient (node) requires a set of operations that may follow precedence relations. A set of visiting technicians with heterogeneous profiles and a limited number of online consultation slots with remote specialized physicians are available. The objective is to determine technician routes and consultation schedules that minimize overall travel costs.

(project 2024.17418.PEX (https://doi.org/10.54499/2024.17418.PEX))

3 - Enhancing planning practices in a home health care setting considering client service and staff preferences.
Pauline Fonteijn, Richard Boucherie, Gréanne Leeftink

Staff shortages in home healthcare make appointment and staff scheduling a challenge. We developed a multi-objective VRPTW model that balances client service, staff preferences, and operational efficiency. The model is developed and refined with practitioners and evaluated in two Dutch home-care organizations, considering quality of care and employee well-being. This real-world validation shows how preference-aware optimization allows home care organizations to make improved and informed decisions in a pressured work environment.

4 - Robust Staffing and Capacity Allocation for Home Health Care Under Demand Uncertainty
Maïna Boivent, Salma Makboul, Feng Chu

The home health care sector faces rapid growth while confronting severe workforce shortages and highly uncertain demand. Effective planning requires coordinating staffing and dynamic capacity allocation decisions. We consider two decision-makers: one fixing all decisions before observing demand, one adapting allocation to realized demand. Uncertainty is modeled via a polyhedral uncertainty set, yielding a min-max-min problem solved through a decomposition algorithm. Numerical experiments evaluate operational and computational performance under various cost structures and uncertainty levels.

■ TE-05

Tuesday, 14:15-15:45 - Room: JUR - Hörsaal 18 (Building: JUR)

Collaborative transportation

Stream: Shared Mobility
Invited session
Chair: *Margaretha Gansterer*
Chair: *Christian Truden*

1 - Multi-Period Vehicle Routing Problem with Consistency and Arrival Time Spread for Population Screening Programs
Raffaele Dragone, Emilio Jose Alarcon Ortega, Margaretha Gansterer, Karl Doerner

Motivated by a real-world COVID-19 screening program in Vienna, we introduce the Multi-Period Vehicle Routing Problem with Consistency and Arrival Time Spread Constraints (MPVRPCAS). The problem jointly addresses temporal consistency in customer service and dispersion of vehicle arrivals at a central laboratory to prevent congestion. We present a mixed-integer formulation and a matheuristic combining Adaptive Large Neighborhood Search with a reduced exact submodel. Computational experiments on real-world instances confirm the scalability and effectiveness of the approach.

2 - Collaborative Vehicle Routing with Strategic Request Acceptance
Yannick Scherr, Margaretha Gansterer, Richard Hartl

We study carriers receiving pickup-and-delivery requests that must be answered immediately and fulfilled the next day. Before fulfillment, carriers can exchange requests in a combinatorial auction. We propose a two-step request acceptance policy considering strategic rejection and overbooking. The impact of profit sharing is assessed based on the Shapley Value and a new adjustable mechanism. Results show revenue gains and cost savings due to strategic acceptance. Experiments with carriers using different strategies reveal incentives to deviate based on the profit-sharing mechanism.

3 - The Risk of Unintended Information Leakage in Carrier Collaboration
Steffen Elting, Jan Fabian Ehmke, Margaretha Gansterer

Does the mechanism for combinatorial auction-based collaborative transportation unintentionally leak private carrier data to the auctioneer? We question the assumption that carriers have full control over the dissemination of their private data. Derivative-free optimization is employed to reverse-engineer locations of private delivery orders from auction bids. Our findings show the auctioneer can indeed infer spatial dispersion patterns, but that the precise identification of individual order locations remains challenging. Further study of privacy preservation in such auctions is needed.

4 - Auction-Based Parcel Exchanges for Horizontal Cooperation in Last-Mile Logistics
Christian Truden, Margaretha Gansterer

We study auction-based mechanisms for horizontal cooperation among parcel carriers operating in the same region. Using a game-theoretic framework, we identify key properties of parcel exchange mechanisms and show a trade-off between incentive compatibility and budget balance under non-free disposal. We argue that incentive compatibility is crucial for long-term participation and therefore focus on a VCG-based parcel auction. A computational study resembling real-world settings shows that second-price payments are typically moderate and outperform non-cooperative last-mile logistics.

■ TE-06

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 07 (Building: HG)

Assortment and Shelf Space Management

Stream: Retail Operations
Invited session
Chair: *Fabian Schäfer*

1 - Assortment in a retail store: A bi-level hierarchical knapsack approach
Vincenzo Gulotta, Simona Mancini, Margaretha Gansterer

This work addresses bilevel optimization applied to retail. In our problem, the retailer has to select a set of products to offer, among a larger set, and each customer decide the combination of products to buy maximizing her preferences. The goal of the retailer is to maximize her own profit. The problem is modeled as a single-leader multi-follower bilevel hierarchical knapsack problem and is solved by an ad-hoc tailored Combinatorial Benders Cuts procedure (CBC) enhanced with valid inequalities. Computational results and several managerial insights will be discussed at the conference.

2 - Assortment optimization under dynamic switching and replenishment costs
Alicia Marleen Hamann

We study dynamic assortment optimization for retail formats where assortment changes and replenishment incur revenue losses from service downtime, motivated by mobile retail formats such as store-hailing. Unlike existing models assuming frictionless adjustments, we explicitly capture time- and assortment-dependent switching costs in a MILP that jointly optimizes assortment selection, replenishment, and switch timing. Our two-stage decomposition approach with a candidate assortment generation heuristic achieves near-optimal solutions at reduced computational cost.

3 - Shelf space planning from an operations management perspective
Rob Broekmeulen

We study a shelf space planning problem at a grocery retailer with a focus on in-store logistics. By setting clear lower bounds on the allocation, we prevent backroom inventory and thereby reduce out-of-stocks due to late backroom replenishments. We extend the model by allowing unpacking case packs at the distribution center and exploiting the excess shelf space (difference between maximum inventory on-hand and allocated space) in the planogram for service differentiation. We show the potential improvements based on a case study at an European retailer.

4 - The operational value of flexible shelf space
Sandra Zajac, Eren Selman, Michael Sternbeck, Heinrich Kuhn

Retail management improves operational efficiency by temporarily utilizing unused shelf space from neighboring products to place new product deliveries from the DC directly onto the shelves. This operational strategy is known as the "shelf space sharing" approach. The paper analyzes this strategy in comparison to a strategy with dedicated shelf space allocations through a simulation study that uses real-world data from a large European grocery retailer. The flexible shelf space strategy systematically improves operational efficiency and product availability on the shelf.

■ TE-07

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 21 (Building: HG)

Applied Market Design

Stream: Auctions and Market Design
Invited session
Chair: *Daria Boratyn*

1 - Zonal vs. Nodal Pricing in the German Electricity Market
Laura Mathews, Martin Bichler

Rising congestion in the European electricity market has raised concerns about the current bidding zone design, prompting the European Commission's Bidding Zone Review (BZR). We focus on Germany, where redispatch costs have sharply increased due to structural bottlenecks. While prior studies focus on splits into two to five zones, we evaluate configurations from the national zone to fifty zones using the official BZR dataset and a mixed-integer market clearing model. Efficiency gains remain below 0.39%, while nodal pricing reaches 5.28%, highlighting the limited benefit of zonal refinements.

2 - Reverse combinatorial auctions in environmental modelling
Petr Fiala

Reverse combinatorial auctions (RCA) are an advanced public procurement mechanism in which a buyer invites bids from multiple suppliers who compete with one another by submitting bids on packages of items. This article proposes the use of RCAs as a suitable tool for modelling and addressing environmental issues. The CRAB software tool is used to solve, combinatorial auction problems. A sensitivity analysis was designed to provide a basis for further decisions. The results of laboratory experiments were presented, showing to what extent the negotiating parties are able to achieve optimal result

3 - Political Coalition Formation: A Multi-Objective Optimization Framework
Dariusz Stolicki, Daria Boratyn

We model coalition formation as a multi-objective optimization problem where parties with known positions in a policy space form a governing coalition. Each coalition member maximizes a weighted combination of policy proximity to the coalition's policy output, portfolio allocation benefits, and intra-coalition voting power. Seat allocations arise from Dirichlet-distributed vote shares, yielding stochastic majority constraints. We derive coalition feasibility probabilities in closed form and formulate the problem as a stochastic program linking inputs to equilibrium coalition structures.

4 - Allocation Proportionality of Multiwinner Voting Rules
Daria Boratyn, Dariusz Stolicki

We extend the allocation proportionality degree framework to ordinal multiwinner rules lacking an OWA representation, such as STV, ordinal Phragmén, and Condorcet-based committee rules. For each such rule, we construct the OWA scoring rule minimizing worst-case or expected output discrepancy over ordinal profiles, via tractable LP and convex programming formulations. The proportionality degree of the approximating OWA rule yields a bound on that of the original rule, with approximation error characterized as a function of voters, candidates, and committee size.

■ TE-08

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 41 (Building: HG)

Location and Transportation

Stream: Location Analysis
Invited session
Chair: *Diego Ponce*

1 - Green Charging Infrastructure for Road Freight Transport
Glaydston Ribeiro, Conrado Plaza, Francisco Glaubos Nunes Clímaco, Marcos Guerine, Luan Marvila, Eduardo Feitosa

The Charger Location Problem with Routing and Driver's Working Hours (CLPR-DWH) determines the locations, types and numbers of chargers together with vehicle routes while considering the limited range of long-haul electric heavy-duty trucks and drivers' working hours regulations. These constraints are represented through a communication-time-expanded network structure, producing very large-scale optimization models. To tackle the resulting computational complexity, this study proposes a greedy constructive heuristic and a GRASP-based metaheuristic to solve large real-world instances.

2 - Closing the Loop: Optimising Supply Chain Networks with Hybrid Retailers/Collection Centres
Mahdi Doostmohammadi, Mehdi Amiri-Aref

Closed-loop supply chains extend traditional open-loop systems by incorporating the collection of used products for recycling, remanufacturing, or refurbishment. This study develops a mathematical model

for a closed-loop supply chain with hybrid retailers/collection centres, integrating production planning, facility location, and transportation decisions. The problem is solved using relax-and-fix and fix-and-optimise heuristics with novel relaxation and fixing strategies. Computational experiments based on a realistic case study demonstrate the applicability and effectiveness of this approach.

3 - A Process-Modular Facility Location Model for the Design of Sustainable Aviation Fuel Supply Chains
Gaétan Richoux, Guillaume Martin, Mariam Lafkihi, Shenle Pan, Didier Gourc

Designing sustainable aviation fuel supply chains requires jointly selecting technologies, facilities and logistics under spatially heterogeneous supply and demand. We propose a process-modular facility location model integrating technology, location, and transportation mode choices. The formulation combines discrete and continuous locations in a MINLP. A solution approach combining linearization and tailored metaheuristic explores candidate sites and process configurations. Synthetic instances illustrate the model's ability to spatially match technologies to resources availability.

4 - The Charging Stations Location Problem in Networks
Diego Ponce, Laura Anton-Sanchez, Luisa I. Martínez-Merino, Justo Puerto

Within alternative fuel-vehicles routing problems, in contrast to fuel stations, we cannot assume ubiquity for electric vehicle charging stations. Kuby and Lim (2005) define the Flow Refueling Location Model (FRLM) as an extension of the FCLM where the distance range is considered. In this work, we introduce the Charging Stations Location Problem in Networks (CSLPN) where we admit solutions in the edges. Given an undirected graph and the populations of the nodes, the CSLPN locates a given number of chargers with the aim of maximizing the captured demand of pairs origin-destination.

■ TE-09

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 50 (Building: HG)

From Decisions to Explanations: Optimization in Explainable Artificial Intelligence I

Stream: Data Science meets Optimization
Invited session
Chair: *Johannes Hejny*

1 - MKL-LIME: Improving the Stability of Local Explanations with Multiple Kernel Learning
Ferhan Çelik, Sureyya Ozogur-Akyuz

LIME generates local explanations through kernel-weighted sampling around individual instances. While kernel function and bandwidth selection are central to LIME's perturbation weighting, their impact on explanation stability is not well understood. We propose MKL-LIME, a multi-kernel extension that combines multiple kernel functions within the LIME framework, and analyze how kernel composition and width affect explanation stability and fidelity, providing empirical insights into how kernel configurations influence local decision boundary approximation.

2 - Designing Robust and Interpretable Decision Rules via Integer Linear Programming
Özen Yilmaz, Sureyya Ozogur-Akyuz, Duygu Üçüncü

A key challenge in explainable artificial intelligence for tree-based ensemble models lies in selecting a compact and consistent set of rules without sacrificing predictive faithfulness. In this work, a rule selection framework is developed in which stability and sparsity are formulated directly as design objectives within a Binary Integer Programming. The results show that treating stability and sparsity as controllable design properties, rather than observed outcomes, leads to more consistent rule extraction under repeated resampling without a significant loss in predictive performance.

3 - Optimizing Client Participation in Federated Counterfactual Representation Learning
Sureyya Ozogur-Akyuz, Faramarz Mehrnami

This work examines how client participation impacts federated representation learning. Using synthetic data with true counterfactual targets, a model is trained with a sparse latent causal constraint. By comparing counterfactual latent error across different client counts, the study identifies an effective participation level that improves robustness and accuracy.

4 - Explaining explanation using Large Language Models: A User Study
Johannes Hejny, Michael Römer

This study presents an approach to improve the interpretability of mathematical optimization results. First, a formal post-hoc explanation method identifies the factors influencing the obtained solution. An LLM then translates these explanation outputs into clear natural language, acting as an interface that communicates explanation results to users. An experimental study evaluates the impact of LLM-mediated explanations on users' understanding and acceptance of optimization solutions.

■ TE-10

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 31 (Building: HG)

Innovations in Discrete and Quantum-Inspired Optimization II

Stream: Combinatorial Optimization
Invited session
Chair: *Fred Glover*
Chair: *Gary Kochenberger*

1 - Decomposition Strategies for a Multi-Product Brown Water Transportation, Inventory and Routing Problem
Javier Yuste, Sergio Cavero, Marco Better, Manuel Laguna

We address a multi-product inventory and routing problem involving river transportation by tugboats pulling barges, where exact models struggle to find quality solutions for long planning horizons. Two decomposition strategies are presented: vertical and horizontal. Vertical decomposition iteratively solves the problem using a rolling horizon, while horizontal decomposition separates decision layers and solves the routing layer heuristically. Experiments show that both strategies improve performance compared to the exact model, with horizontal decomposition excelling on the largest instances.

2 - Revisiting MILP Formulations of the Stable Set Problem: Compact Aggregation Models and Relaxation Analysis
Abraham Punnen, Navpreet Dhanda, Haichao Liu, Yang Wang

The Maximum Weight Stable Set Problem is a fundamental combinatorial optimization problem. We revisit zero one linear programming formulations and introduce compact mixed integer linear programming models based on structured neighborhood aggregation. The proposed STAR families require far fewer constraints than the classical edge formulation. We analyze the strength of their linear relaxations and show conditions under which compact models match the classical bound. Computational experiments on standard benchmarks demonstrate improved performance and faster discovery of high quality solutions.

3 - Electric Freight Vehicle Route Planning and Charge Scheduling with Time-dependent Electricity Price and Demand Charge
Haijie Huang, Yang Wang, Wei Yang, Zhipeng Lyu, Abraham Punnen

This paper addresses the electric freight vehicle route planning and charge scheduling problem with time-dependent electricity price, demand charge and complex operational features. We propose a three-phase matheuristic to solve this problem. Experiments demonstrate our algorithm matches CPLEX efficiently for small instances and outperforms a two-phase method for medium and large-scale instances. Finally, we analyze the impacts of several factors and propose management insights for the operation of EFV fleets.

■ TE-11

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 32 (Building: HG)

Applications of combinatorial optimisation in industry and services 2

Stream: Combinatorial Optimization
Invited session
Chair: *Adriana Cherri*
Chair: *José Fernando Oliveira*

1 - Procedures for the multi-stage stochastic two-dimensional cutting stock problem with usable leftovers
Adriana Cherri, Douglas Nogueira Nascimento, José Fernando Oliveira, Beatriz Brito Oliveira

The 2D cutting stock problem with usable leftovers involves cutting rectangular plates to produce items, minimizing waste and considering the possibility of generating usable leftovers. A scenario is producing items from usable leftovers of varying dimensions to meet unknown demands over a finite planning horizon. We treat this problem as a multi-stage case under uncertainty in item demand. We propose a mathematical formulation and heuristic procedures for this problem. Computational experiments were performed. Supported research: FAPESP (Proc. 2024/05964-2) and CNPq (Proc. 317460/2021-8).

2 - A Large Neighborhood Search Algorithm for the Variable-Sized Bin Packing Problem with Conflicts
Ali Ekici

We analyze the Variable-Sized Bin Packing Problem with Conflicts (VSBPPC). In VSBPPC, a set of items each with a certain size has to be packed into bins of various types with different capacities and costs, and some pairs of items cannot be packed into the same bin due to conflicts. The goal is to pack the items into the bins such that the total cost of the used bins is minimized. VSBPPC generalizes the Variable-Sized Bin Packing Problem (VSBPP) and Bin Packing Problem with Conflicts (BPPC). We propose a new lower bound and develop a large neighborhood search algorithm for the problem.

3 - A Lifter-Based Approach for Rectangular Cutting with Overcuts
José Fernando Oliveira, Walison Oliveira, Tiago Silveira, Elsa Silva, Marina Andretta, Rui Guerreiro, Fernando Sousa, Maria Antónia Carravilla

This work addresses the Two-Dimensional Single Knapsack Problem (2D-SKP) arising in the ornamental stone industry, incorporating practical constraints such as overcuts and the use of vacuum lifters. We propose a mixed-integer optimization model to allocate rectangular items on a plate while maximizing utilized area. The model penalizes lifter use and enforces geometric feasibility, non-overlapping conditions, and guillotine-cut overcut constraints. Experiments based on real-world instances show the approach is promising for industrial applications, achieving effective plate area.

■ TE-12

Tuesday, 14:15-15:45 - Room: JUR - Hörsaal 11 (Building: JUR)

Health Care Logistics and Resource Management

Stream: Health Care Logistics
Invited session
Chair: *Taesik Lee*

1 - Cost-Aware Measurement Scheduling for Sedated ICH Patients using Offline Reinforcement Learning
Yujeong Choi, Minyoung Shin, Chulho Kim, Seung-Ho Shin, Yoon Ho Choi, Gyumin Lee, Sujee Lee

Scheduling clinical measurements in the ICU requires balancing diagnostic value against measurement burden and cost. Using sedated patients with intracerebral hemorrhage (ICH) from MIMIC-IV, we formulate measurement scheduling as a sequential decision-making problem. We propose a two-stage offline reinforcement learning framework: a mortality prediction model estimates patient risk and information gain, and a cost-aware policy learns when and which measurements to schedule. Results show reduced unnecessary measurements while maintaining predictive performance.

2 - A Robust Design of Hierarchical Screening Systems Under Performance Drift
Inkyung Sung, Aleksejs Sazonovs, Izabela Nielsen

We examine hierarchical screening systems where individuals are sequentially filtered through multiple binary stages. In practice, operational variability and population heterogeneity often cause realized performance to drift from its validated baseline. We model these deviations as an uncertainty set and formulate a robust optimization model to select stage-specific sensitivity-false positive rates operating points. Under operational budget constraints, our model maximizes worst-case screening effectiveness across all realizations in the uncertainty set.

3 - Compliance-Aware Social Distancing Policy Design
Hyelim Shin, Taesik Lee

We develop a Stackelberg game framework for designing optimal social distancing policies that incorporates individuals' compliance, a factor often neglected in existing studies. Accounting for individuals' compliance in the policy design problem makes the resulting optimization problem difficult to solve. To address this challenge, we reformulate the problem as an optimal control problem by exploiting a unique property of the decision variables. Numerical experiments show how the optimal timing and intensity of social distancing vary with disease characteristics and behavioral factors.

4 - Countering the Shortage Crisis: An Optimization Approach to Public Health Physician Distribution
Taesik Lee, Joon Seok Im, RyangHa Kim, Ji-Su Lee

PHPs are a vital safety net in Korea's underserved regions, yet supply has plummeted 30% recently. This study develops a GIS-based optimization model using 500m×500m population grids and healthcare big data. Results show that optimized placement can increase covered grids from 5,121 to 8,285, improving accessibility 1.6-fold. In addition, we identified a 200-PHP critical threshold, below which vulnerability escalates sharply. This provides a scientific, evidence-based framework for physician deployment amidst impending PHP shortages.

■ TE-13

Tuesday, 14:15-15:45 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Python Ecosystem

Stream: Software for Operations Research
Invited session
Chair: *Jens Schulz*

1 - Beyond Jupyter: optimization modeling with MOSEK
Jens Schulz

Nowadays optimization model developers often rely on plain Python scripts or favor Jupyter notebooks. Scripts provide reliability and easy integration with software workflows, whereas notebooks enable interactive exploration but often suffer from hidden state and fragile execution order. We compare these approaches with marimo, a reactive notebook environment that combines interactivity with reproducible, script-based execution. The discussion is illustrated using an energy optimization model solved with MOSEK.

2 - Scentree: a Python package to generate scenario trees for multi-stage stochastic programming problems.
Cristian Pachón García, Albert Solà Vilalta, F.-Javier Heredia

We present scentree, a Python package to generate scenario trees for multi-stage stochastic programming problems. The package combines classical statistical methods and machine learning techniques to produce realistic scenarios. A key feature is its ability to explicitly model and preserve correlation and dependency structures between uncertain variables. The framework also organizes scenarios into structured trees suitable for multi-stage optimization and is designed to be flexible and extensible, enabling integration of different forecasting models in stochastic programming workflows.

3 - The Pythonic Way: Simplifying the Formulation of Industrial Optimisation Problems
Tereso del Rio

Most modelling languages are declarative: they specify the constraints that a solution must satisfy. For non-expert modellers, this level of abstraction can make optimisation models difficult to write, understand, and especially debug. In collaboration with an industrial partner, we developed a Pythonic optimisation modelling language that lets users express models procedurally, similarly to implementing a simulator. Further, this language can be translated into MiniZinc to gain access to multiple state-of-the-art solvers.

■ TE-14

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 01 (Building: HG)

Lot Sizing - Solution Methods

Stream: Lot Sizing, Lot Scheduling and Production Planning
Invited session
Chair: *Christian Almeder*

1 - Time complexity and optimality of an environmentally sustainable feasible policy for dynamic lot sizing model with remanufacturing and separate setup costs
Chee Khian Sim

We introduce the dynamic lot sizing model with remanufacturing and separate setup costs, and a feasible policy for the model that prioritizes remanufacturing over manufacturing. The policy can be found with polynomial time complexity and we also provide theoretical results comparing the cost under the policy with the optimal cost for the model. Numerical results are also provided showing that the feasible policy can be found quickly for different parameter settings and that the cost under the policy does not deviate too far from the optimal cost for reasonable choice of parameter values.

2 - Advanced MILP Approaches for Optimizing Single-Machine Batch Scheduling with Families and Setups
Annalisa Castelletti, Renata Mansini, Lorenzo Moreschini

Motivated by an industrial application, this study addresses scheduling on a single batch-processing machine with limited capacity, accounting for compatible families and sequence-dependent setup times. Non-identical jobs are assigned to batches and processed simultaneously to minimize makespan. Batch duration is set by the longest job, while setups depend on the dominant families of consecutive batches. We develop and compare alternative MILP formulations strengthened through problem-specific valid inequalities. Computational results show improved solution times, quality, and scalability.

3 - A Hybrid Evolutionary Algorithm for the Multi-Objective Capacitated Lot-Sizing Problem
Weiyan Jia, Yang Yang, Yun Dong

Existing studies on the capacitated lot-sizing problem often combine several costs into a single weighted objective. However, real production planning usually involves conflicting goals. Public benchmark instances for the multi-objective capacitated lot-sizing problem are still limited. We build a benchmark set by adapting standard instances and consider holding, setup, and overtime costs. We also propose a multi-objective evolutionary algorithm with problem-specific strategies and cluster-guided large neighborhood search, showing competitive and often better Pareto front approximations.

4 - A construction heuristic for a lot-sizing problem with job-shop scheduling constraints
Daryna Dziuba, Christian Almeder, Stéphane Dauzere-peres

A fast construction heuristic is proposed for a lot-sizing problem with job-shop scheduling constraints. Lot-sizing decisions are made on a discretized planning horizon, while scheduling decisions occur in continuous time. Lots must be completed in their associated periods but may start earlier, intertwining operations across periods. The two-step heuristic integrates both decision levels. Several approaches to evaluate the feasibility of increasing production quantities under capacity constraints are proposed and compared through computational experiments.

■ TE-15

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 34 (Building: HG)

Applications of Game Theory IV

Stream: Algorithmic Game Theory
Invited session
Chair: *Zongyi Li*

1 - Dynamic Information Design with Learning
Shiyuan Wang

We study a dynamic principal-agent model with two-sided information asymmetry: the agent's search effort is unobservable (moral hazard), while the principal privately knows the productivity of the search technology. The agent learns about the treasure's existence and the technology type from unsuccessful search outcomes. In continuous time, the principal designs a dynamic information disclosure policy to maximize profit. Using a Lagrangian approach with a dual variable, we derive a lower bound on the principal's value and characterize the optimal policy.

2 - Data sharing and embodied intelligence platform control structure model selection strategy
Hangyang Li, Yuanxiang Dong, Shuning Pan, Jingyu Lv, Luqi Wang

Embodied intelligence is increasingly important for sustainable real-world operations. This study develops a game-theoretic model of an AI-supplier-led embodied intelligence platform with a hardware supplier to examine control structure choice, pricing, and platform performance. We compare centralized, decentralized, and hybrid algorithmic control with and without data sharing. The results show that data sharing does not always improve performance. Centralized control is better in standardized scenarios, while hybrid control performs better when hardware adaptation is important.

3 - Decentralized Billing in Mobile App Platforms: Equilibrium Cutoffs with Spillover and Network Effects
Priel Levy, Tatyana Chernonog

In this paper we study a new business model designed by prominent distribution platforms in the mobile-app industry, following court rulings against the platforms' monopoly provision of the payment process. The model is based on new guidelines in which platforms allow app developers to offer additional payment options for users of apps distributed via the platform's store. Using a game-theoretical framework, it examines interactions between platforms and heterogenous developers, incorporating spillover and network effects. Findings reveal an "equilibrium cutoff" for market stability.

4 - Algorithmic Nudges for Users' Long-Term Welfare under Platform Competition
Zongyi Li, Ziqiong Zhang

Digital platforms often favor short-term engagement over users' long-term welfare. We study the survival of welfare-improving algorithmic nudges under platform competition. Using a data-calibrated computational framework for a dynamic game between competing platforms and heterogeneous users, we show that these strategies fail when fewer than 20% of users are willing to explore better-matched options, but become evolutionarily stable when that share exceeds 23.5%. Dynamic subsidies tied to long-tail value outperform punishment-based regulation in both social welfare and platform profit.

■ TE-16

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 42 (Building: HG)

Inventory, production and periodic routing problems

Stream: Vehicle Routing and related problems
Invited session
Chair: *Sanne Wøhlk*

1 - A Hybrid Genetic Search for the Inventory Routing Problem
Rafael Martinelli, Bruno Castro, Marcus Poggi

The Inventory Routing Problem combines routing, scheduling, and inventory decisions and remains challenging in practice. We propose a Hybrid Genetic Search that explores routing and scheduling while computing optimal inventory levels through an efficient network flow procedure. The method introduces a tailored crossover, improved solution construction, and a hybrid local search strategy. Experiments on standard benchmarks show that it outperforms 22 methods and finds many new best known solutions.

2 - Production-Routing Problem in Reverse Supply Chain with Multi-Level Product Structure
Muhammad Khakim Habibi, Simon Thevenin

To better manage Waste Electrical and Electronic Equipment (WEEE) flows in reverse supply chain, a new MILP model is introduced by incorporating dummy nodes in the bill of material where each represents a leaf item or a sub-assembly of the product. The objective is to minimize the total cost comprising setup, disassembly, inventory, backlog, and routing costs. The constraints comprise the disassembly and the routing specificities. Preliminary results have been obtained by using Column Generation to provide optimal faster compared to CPLEX.

3 - Periodic Vehicle Routing for Household Organic Waste Collection: An Operational Extension of the OWLNDP Framework in Chile
Maria Victoria Gutierrez Padilla, Germán Paredes-Belmar

Household organic waste collection usually follows periodic service patterns where neighborhoods are visited on specific days within a planning horizon. This work develops an optimization model based on a periodic vehicle routing formulation to support the design of municipal organic waste collection schedules in Chile. The model incorporates service frequencies, vehicle capacities, and multi-period routing decisions. The approach is formulated as a MIP and will be solved using exact and approximation methods. Preliminary results suggest that service frequency decisions affect efficiency.

4 - A Multi-period Vehicle Routing Problem with Driver Consistency and Arrival-Time Diversification
Jahir Llagas, Sanne Wøhlk, Foteini Stavropoulou

We study a multi-period vehicle routing problem combining driver consistency and arrival-time diversification, motivated by applications such as cash-in-transit operations. Driver consistency improves service familiarity and operational stability by assigning the same vehicle to each customer across periods, while arrival-time diversification enhances security by enforcing a minimum temporal separation between visits. We propose a MILP formulation and an exact Logic-Based Benders Decomposition, and develop a matheuristic exploiting restricted diversification checks.

■ TE-18

Tuesday, 14:15-15:45 - Room: JUR - U 21 (Building: JUR)

OR at Africa III

Stream: OR in Rising Economies
Invited session
Chair: *Amina Lamghari*

1 - A Decomposition Approach for Integrated Maritime and Inland Fertilizer Logistics
Omar Boussouf, Issmail El Hallaoui, Ilyas Himmich, Amina Lamghari, Tarik Aouam

We address maritime fertilizer transport from Morocco to East Africa with SMIRB-ITP, an extension of the Maritime Inventory Routing Problem integrating storage, bagging, and inland transport. Using a Benders-inspired decomposition combined with tactical (weekly) and operational (daily) discretization, our approach efficiently solves large-scale instances, providing managers with actionable plans to optimize fleet utilization, port operations, warehouse capacities, and overall annual logistics costs.

2 - Event-driven deep reinforcement learning for continuous-process scheduling
Mouad Sidki, *Amina Lamghari*, *Asma Rakiz*

We propose a continuous-time, event-driven deep reinforcement learning approach for scheduling an integrated continuous-process supply chain in the phosphate industry. The model incorporates a comprehensive representation of production, multimodal transportation, and storage management constraints. The policy is trained using Proximal Policy Optimization and uses a Transformer self-attention encoder to represent long-range dependencies, and hard constraints are enforced through action masking. The policy is evaluated on a real-world case study from Morocco's phosphate industry.

3 - An integrated comprehensive approach to continuous-flow process scheduling: A sparse mixed-integer linear programming formulation
Aurelio Oliveira, *Mouad Sidki*, *Amina Lamghari*, *Asma Rakiz*

We propose a mixed-integer linear programming model for integrated scheduling in a continuous-flow process network, jointly optimizing production, transportation, and storage over a planning horizon to minimize cost while meeting demand. The model accounts for changeovers, minimum run lengths, maintenance, contamination, and shared resource and utility constraints. Results on large-scale case studies from Morocco's phosphate industry show high-quality solutions within a one-hour time limit.

■ TE-19

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 05 (Building: HG)

Data-Driven Optimization and Its Applications

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Yuwei Wu*

1 - Data-driven robust multiproduct pricing with fairness concerns
Yuwei Wu

Data-driven techniques enable customized pricing across customers, times and locations, but face concerns over robustness to demand uncertainty and pricing fairness, hindering their real-world use. This talk presents a tailored data-driven pricing approach with automatic robustness and fairness guarantees, putting forward a Wasserstein ambiguity set-based distributionally robust optimization model with a novel price fairness constraint. Numerical tests will be presented to show the benefits of our approach in enhancing revenue, robustness, and fairness for pricing strategy under uncertainty.

2 - From Demand Prediction to Decision Optimization: Rethinking Retail Promotion Planning
Hossein Zolfagharinia, *Parisa Hajialirezaei*, *Saman Amin*

This study develops a data driven framework that integrates demand learning with optimization for retail promotion planning. Predictive models capture demand responses, including cross-product interactions and temporal effects, and are embedded within a multi-period optimization model for promotion selection and timing. The framework accounts for demand dependencies and decision-dependent effects, bridging estimation and decision making. Results show that targeted and selective promotion strategies improve performance and operational efficiency.

3 - A Contextual Data-Driven Approach to Dynamic Container Freight Pricing with Contract and Spot Markets under Regime Uncertainty
Minjeong Kim, *Stefan Minner*

Container carriers allocate limited slot capacity across contract and spot markets under hidden regime-switching patterns. We propose a dynamic pricing model for two types of Markov-modulated demands with different booking horizons. Contract prices are chosen within pre-negotiated ranges, while spot prices are posted for residual capacity. To handle partial observability and unknown price sensitivity, we develop a contextual data-driven approach using booking history and contextual signals. Experiments on synthetic and real data show profit-maximizing performance in high-dimensional settings.

4 - Acquisition Pricing with Price-Sensitive Supply
Itir Karaesmen, *Ozden Cakici*

A collector (buyer) chooses the acquisition price (the unit cost for procuring a good) when the supply is price sensitive. The amount of supply is known only after the acquisition price is set. The collector needs to determine what the optimal acquisition price should be when the supply is uncertain. With a newsvendor formulation, we study the effect of supply uncertainty on the optimal acquisition price. We show that the optimal acquisition price is monotonic in the noise when the noise changes according to a particular stochastic order that we call "acquisition price-sensitivity ratio".

■ TE-20

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Branch-and-price and column generation approaches for routing problems II

Stream: Vehicle Routing and related problems
Invited session
Chair: *Nour Elhouda Tellache*

1 - Branch and Price Algorithm for Pickup and Delivery with Split Loads
Misra Simsir, *Vildan Ozkir*, *U. Mahir Yıldırım*, *Doruk Sen*

This study presents an extension to the classic Pickup and Delivery Problem by incorporating split loads (PDPSL), allowing requests to be served by multiple vehicles. We propose an arc-based mixed-integer programming formulation and decomposed into a master problem and a pricing subproblem. A branch-and-price algorithm is developed to solve PDPSL. To improve computational efficiency, heuristic methods are integrated for faster pricing subproblem solutions. The algorithm is tested on benchmark datasets, offering a new decomposition approach. (Supported by TUBITAK Project No:123M504)

2 - A column-generation approach for an electricity technician routing and scheduling problem with a lexicographic objective
Elise Bangerter, *David Schindl*, *Meritxell Pacheco Paneque*, *Nour Elhouda Tellache*, *Rodolphe Griset*

This study addresses a technician routing and scheduling problem at Électricité de France (EDF), involving skill-constrained interventions with time windows and operational rules such as lunch breaks and workload limits. A lexicographic objective is employed to first maximize total covered intervention duration and then minimize operational costs without reducing coverage. We propose a set packing formulation and develop column generation-based heuristics, using tailored strategies to handle the lexicographic objective. Computational experiments were conducted on EDF instances.

3 - User-Oriented Cumulative Vehicle Routing: A Column Generation Approach with Enhanced Labeling
Ali Akbar Sadat Asl, Hugues Delmaire, Antoine Legrain, Francois Soumis

This work studies a user-oriented formulation of the cumulative vehicle routing problem where the objective is to minimize total passenger ride time. Optimizing this objective within a column generation framework is challenging because the reduced cost structure may violate the nondecreasing property required by conventional dominance rules in labeling algorithms for resource-constrained shortest path problems. To address this issue, we introduce additional resources that restore this property and enable efficient labeling strategies for solving the pricing problem on benchmark instances.

■ TE-21

Tuesday, 14:15-15:45 - Room: JUR - U 22 (Building: JUR)

Operationalizing OR: Methods, Deployment, and the Human Factor

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Jelle Adan*
Chair: *Ivo Adan*

1 - Methods: Smart batching in the food-processing industry
Ivo Adan

In this talk, we focus on fixed-weight batching in the fish-, meat- and poultry-processing industry. We propose flexible AI-based algorithms for various batching equipment that aim to minimize the giveaway, that is, the excess of the target weight of the batch. We demonstrate the effectiveness of these algorithms, including validation through deployment on a real batching machine, and show that the giveaway can be drastically reduced.

2 - Deployment: Making a machine intelligent
Jelle Adan

In this talk, we focus on deployment: integrating the AI-based batching algorithms into an existing fixed-weight batching machine. We show how to connect to the hardware and build a reliable control layer first, then add the intelligence on top. The result is an open, modular software foundation that is easy to extend with additional intelligent modules as needs evolve.

3 - AI-Powered Process Assistant for Plastic Injection Molding Operations
Eyyüb Batuhan Ünal, Alara Baysal, Ahmet Eralp Avunduk, Cevdet Utku Şafak, Erinc Albey

This paper presents an AI-assisted system designed for plastic injection molding operations, combining a domain-specific conversational agent with automated end-of-day reporting. Incoming queries are validated within a defined domain scope before retrieving relevant information from a technical knowledge base and historical cycle data recorded by an external production monitoring system. By grounding responses in both documentation and operational data, the system supports fault pattern identification across production cycles and generates structured daily reports automatically.

■ TE-22

Tuesday, 14:15-15:45 - Room: KOL - Seminar-Raum 5 (Building: KOL)

Evaluation of Electricity Price Forecasts

Stream: Forecasting in Energy
Invited session
Chair: *Rafal Weron*

1 - Statistical and economic evaluation of forecasts in electricity markets: beyond RMSE and MAE
Arkadiusz Lipiecki, Katarzyna Maciejowska, Bartosz Uniejewski

In the literature, forecasts are typically evaluated using squared or absolute errors. While appropriate for statistical assessment, these measures do not adequately reflect the economic value of forecasts. We explore the relationship between forecast accuracy and profits of BESS, which must determine optimal charging and discharging times in the day-ahead market. We show that measures capturing the alignment between predicted and actual daily price curves have a stronger relationship with profitability than standard error measures and are thus better suited for selecting profitable forecasts.

2 - BESS Optimization and the Value of Intraday Electricity Price Forecasts
David Schaurecker, Simon Hirsch, David Wozabal

We extend a recent grid-scale battery high-frequency-intraday-trading dynamic programming formulation of the rolling intrinsic by integrating price forecast information. We demonstrate that blindly relying on inaccurate forecasts leads to poorer financial outcomes, compared to the myopic RI. However, carefully constructed informed price forecasts, based on public information, can significantly enhance trading yields. Moreover, we argue that improved forecast accuracy, as measured by standard error metrics, does not automatically translate to higher trading profits.

3 - Multivariate Probabilistic Forecasting for Day-ahead Electricity Prices, Battery Trading and the Financial Evaluation of Forecast Performance
Simon Hirsch, Florian Ziel

Probabilistic electricity price forecasting is crucial for decision-making in energy markets and the operation of energy assets. Yet it remains unclear how improvements in statistical forecast quality translate into economic value. In this paper, we analyse the measurement of improved foreacsts for risk-averse and risk-neutral battery trading strategies, including the popular quantile-based trading strategies. We discuss pitfalls in application-based evaluation of price forecasting and conclude with implications for forecast evaluation practice and directions for future research.

4 - Stealing accuracy: Predicting day-ahead electricity prices with Temporal Hierarchy Forecasting (THieF)
Rafal Weron, Kaja Bilińska, Nikolaos Kourentzes, Arkadiusz Lipiecki

We introduce the concept of temporal hierarchy forecasting (THieF) in predicting day-ahead electricity prices and show that reconciling forecasts for hourly products and 2- to 24-hour blocks can significantly (up to 13%) improve accuracy at all levels. These results remain consistent throughout a challenging 4-year test period (2021-2024) in the German and Spanish power markets and across model architectures, including linear regression, shallow feedforward neural networks, gradient-boosted decision trees, and a state-of-the-art, pretrained transformer.

■ TE-23

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 02 (Building: HG)

Algorithmic Developments in Optimization under Uncertainty

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Man-Chung Yue*

1 - An error bound-based convergence analysis framework for a class of randomized algorithms
Li Jiang

Current error-bound analyses for stochastic descent algorithms often yield incomplete or overly conservative guarantees. We introduce a novel framework based on a unified error bound (UEB) condition, subsuming standard error bounds and Kurdyka-Łojasiewicz conditions from various contexts. Under global and local UEB, we establish non-asymptotic in-expectation and asymptotic almost-sure convergence rates. We demonstrate the framework's versatility through new convergence guarantees for randomized alternating-type algorithms across common fixed-point and optimization problems.

2 - Screening with Fairness Consideration: A Unified Framework
Zihao Xiang

The screening problem aims to design an expected profit-maximizing mechanism for selling a product to a single buyer assuming the knowledge of his valuation distribution. Due to the infinite-dimensional nature, integrating fairness consideration in the screening problem is highly non-trivial. In this work, we develop a unified framework for modelling, analyzing, and solving fair screening problems. A central theoretical result is the characterization of the extreme points of the fair mechanisms, which allows us to reduce the infinite-dimensional to a finite-dimensional optimization problem.

3 - A Max-Min-Max Algorithm for Large-Scale Robust Optimization
Kai Tu, Man-Chung Yue

Robust optimization (RO) is a powerful paradigm for decision making under uncertainty. Existing algorithms for solving RO, including the reformulation approach and the cutting-plane method, do not scale well, hindering the application of RO to large-scale decision problems. In this work, we devise a first-order algorithm for solving RO based on a novel max-min-max perspective.Convergence theorem and computation complexity have been estabilised under different cases. Extensive numerical experiments demonstrate the promising practical performance of the proposed algorithm.

4 - Derivative-based Global Sensitivity Analysis for Energy System Optimization Models via Implicit Differentiation
Patricia Mayer

Energy system optimization models (ESOMs) are valuable tools for guiding the energy transition. However, ESOMs rely on assumptions about the future. If this uncertainty is neglected, the solutions can lead to undesirable futures. Uncertainty can be addressed by Global sensitivity analysis (GSA). However, classical GSA methods are challenging for computationally intensive ESOMs. We propose an efficient GSA method using derivative-based global sensitivity measures and implicit differentiation. Our method outperforms classical GSA methods with 78% less computation time.

■ TE-24

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 03 (Building: HG)

Human-Centric, Sustainable and AI-Enhanced Operations Management in Industry 4.0/5.0

Stream: Human Aspects in Operations Management
Invited session
Chair: *Krzysztof Ejsmont*
Chair: *Bartlomiej Gladysz*
Chair: *Rodolfo Haber*

1 - Human-Centric Robotic Welding as a Tool for Sustainable Operations Management
Krzysztof Ejsmont, Julia Longwic, Rodolfo Haber, Bartlomiej Gladysz

Human-centric and sustainable operations management is a key direction in Industry 4.0/5.0 manufacturing. This case study examines the implementation of a collaborative welding robot working alongside operators. The solution integrates automation with manual workstations to reduce physical workload and improve ergonomics and occupational safety. The analysis demonstrates a 20-30% increase in process efficiency, a 15-20% reduction in defects, and improved product quality. Human-robot collaboration supported by Lean and Kaizen enhances operational performance and sustainability.

2 - The Effect of AI Communication Style on Human Reliance Under Task Complexity
Aran Nasiri, Geert van Kollenburg, Chris Snijders, Rob Basten

Effective human-AI collaboration requires operators to appropriately calibrate their reliance on AI recommendations. Yet little is known about how AI communication characteristics shape this behavior. We examine whether imperative versus suggestive phrasing affects operator reliance in process control. A 2×2 experiment manipulates communication style (between-subjects) and task complexity (within-subjects) in simulated drying tasks. Reliance is measured using Weight of Advice metrics. Findings inform Industry 5.0 design principles for human-AI interfaces.

3 - N-1 contingency analysis and action recommendation for power systems via graph neural networks with domain knowledge integration
Emiel Miedema, Costas Mylonas, Christos Emmanouilidis

Power system operations face increasing complexity in contingency analysis and control. Operators need to ensure that data-driven actions are consistent with domain knowledge. This study presents a graph neural network-based approach to predict post-contingency outcomes and generate control actions. The action generator integrates operational knowledge, derived from humans, to ensure feasibility and safety. Results demonstrate high predictive accuracy and reliable control actions. This highlights the potential of data-driven models that incorporate domain knowledge to support operators.

4 - Modeling the Impact of AI-Enabled Optimization on Enterprise Performance During Geopolitical Crises
Aneta Ejsmont, Krzysztof Ejsmont, Rafael Popper

Artificial intelligence (AI) and machine learning (ML) algorithms increasingly support optimization of business and production processes. This study examines how ML-based optimization affects operational efficiency, decision quality, financial stability, and long-term resilience of firms operating under geopolitical disruptions. Using operations research modelling, the research evaluates whether AI-driven decision support enhances sustainable and human-centric decision-making and improves enterprise performance in volatile global environments.

■ TE-25

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 16 (Building: HG)

Digital twins and Industry 5.0: Building Resilience

Stream: OR for Development
Invited session
Chair: *Sadia Samar Ali*
Chair: *Helper Zhou*

1 - Digital Twin Frameworks for Grassroots Entrepreneurial Resilience and Productivity in Industry 5.0
Helper Zhou, Evelyn Derera, Rairo Mukamuri

Industry 5.0's human-centric promise is untapped for Africa's informal SMEs. We propose a lightweight AI digital twin using sparse mobile data (transactions, voice, metadata) to model performance without IoT. NLP simulates resilience and prescribes interventions. Data from 2200 South African SMMEs shows our model correlates with 27% higher revenue sustainability, mitigating optimism bias to bridge advanced technology with grassroots entrepreneurship for antifragile African ecosystems.

2 - Building Resilient Internal Audit Systems in Developing Economies: A Digital Twin-Driven Industry 5.0 Model for Detecting Financial Red Flags in SMMEs
Banothile Nontsikelelo Dzanibe, Helper Zhou

This conceptual study proposes and tests a Digital Twin-driven Industry 5.0 framework to strengthen internal audit resilience in South African SMMEs. The model creates virtual simulations of financial processes to continuously analyse transactions and identify red flags indicating non-conformance. Testing utilised bank statements from 506 South African SMMEs to evaluate anomaly detection and internal control risks. Results demonstrate the framework significantly enhances real-time risk identification and audit efficiency, enabling proactive governance.

3 - Digital twins engine for SMEs sustainability through data driven decision making in South Africa
Amos C. Mpofu, Helper Zhou, Gordon Dash, Nina Kajiji

Informal SME businesses face inconsistent transaction recording, hindering data driven decision making. Leveraging WhatsApp's ubiquity to track owner/manager behaviour enables a digital twin for voice activated transaction processing and analysis. This study applied NN, RF, and SVM models to forecast spending behaviour comparing actual, budgeted and projected using ML to identify spending archetypes. While diverse factors influence forecasting acuracy for business spending, results showed improved budget alignment prediction, thus enhances data driven decision making for SME sustainability.

4 - Supply chain visibility, regulatory compliance and product quality/safety of selected dairy firms in lagos state
Naomi Ogbechi, Odigie Martins, Bolajoko Dixon-Ogbechi, Jonathan Ekpudu, Omotola Bamigbaiye-Elatuyi

This study investigated supply chain visibility and quality/safety of dairy products firms: the mediating role of regulatory compliance in Lagos State. It adopted a survey design to study a sample of 321 employees in supply chain units of selected dairy firms using stratified sampling. The data was analysed using descriptive statistics and Structural Equation Modelling. The findings revealed that traceability, information sharing, and real-time monitoring have a positive and a significant product quality/safety. Regulatory compliance significantly mediates this relationship.

■ TE-26

Tuesday, 14:15-15:45 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis III

Stream: Data Envelopment Analysis
Invited session
Chair: *Xun Zhou*
Chair: *Hiba Shakhashiro*

1 - Homogeneity in slacks-based DEA models
Jakub Hrdina

Homogeneity is one of the ten desirable properties of efficiency measures in data envelopment analysis (DEA). It requires that feasible scaling of the input and output vectors of the evaluated unit by a positive scalar results in the efficiency score being scaled by a corresponding power of that scalar. While this property has been extensively studied for path-based DEA models, the concept of homogeneity does not appear to transfer directly to slacks-based DEA models. In this work, we investigate the notion of homogeneity within the framework of slacks-based DEA models.

2 - Evaluating the Performance of Transportation Modes in the MENA Region: A Multi-Method Efficiency Analysis Using BoD and DEA
Hiba Shakhashiro, Maria Szalmane Csete, Tamás Koltai

This study evaluates the efficiency of transportation modes in the MENA region using the Benefit of Doubt (BoD) approach and Data Envelopment Analysis (DEA). Efficiency scores are estimated under models with and without weight restrictions to assess the robustness of performance rankings. Correlation analysis using SPSS examines relationships between transport inputs and outputs and supports interpretation of the efficiency results. The findings provide insights into operational and policy factors affecting transport efficiency and offer evidence-based guidance for improving sustainable transp

3 - Returns to Scale Identification in Multi-stage DEA: An Input-Output Variation Coefficient Approach
Shenzi Yang, Yong Yin, Tao Feng

While aligning operational scale with developmental capacity is pivotal for sustainability, assessing Returns to Scale (RTS) in complex subsystems remains a challenge for conventional Data Envelopment Analysis (DEA). We propose an RTS identification method based on input-output variation coefficients. Grounded in fundamental theory, our approach characterizes scale properties at both aggregate and subsystem levels. Empirical validation in the airline sector reveals markedly higher RTS volatility in R&D compared to operations, with the latter 's RTS are influenced by passenger services.

4 - A generalized multiplicative directional distance function model for centralized network DEA under cap-and-trade
Elnaz Azadi, Ali Emrouznejad, Xun Zhou

This study develops a centralized network DEA-DDF model combined with a second-scoring auction to enable fair and efficient reallocation of carbon permits under a cap-and-trade system. It evaluates performance, determines permit surplus and deficit, and derives endogenous pricing. Applied to a European bioenergy supply chain, results show improved fairness, reduced efficiency gaps, enhanced market liquidity, and better alignment between environmental and economic objectives.

■ TE-27

Tuesday, 14:15-15:45 - Room: JUR - Hörsaal 13 (Building: JUR)

Humanitarian OR/OM

Stream: Humanitarian Logistics
Invited session
Chair: *Dilek Gunnec*

1 - Dynamic Relief Provision Planning for En Route Refugees: Modeling Probabilistic Movements Using Migration Pull Drivers
Dilek Gunnec, Amirreza Pashapour, Sibel Salman, Eda Yücel

This study optimizes periodic relief delivery to migrating refugees using mobile facilities. Modeled as a Markov decision process driven by migration factors, our approach minimizes facility and refugee deprivation costs. We propose an approximate dynamic programming algorithm and a real-time threshold policy. Using Syrian crisis data, our stochastic model reduces expected costs by 25% vs. deterministic baselines and yields 12% savings via coordination. We also identify service hotspots, offering practical insights for resource prepositioning in future crises.

2 - Optimizing UAV-Base Station Deployment and Charging Infrastructure in Post-Disaster Scenarios
Betul Çoban, Safiye Aybala KiliÇ, Eda Yücel

Post-disaster communication failures severely disrupt emergency coordination. This study addresses the UAV-Base Station Deployment Problem by first developing a MILP model to optimize operational decisions, including service assignment, positioning, and charging cycles. To enhance infrastructure planning, a two-stage stochastic model is proposed to determine strategic charging station locations under demand uncertainty. While these models effectively maximize coverage and reliability in realistic settings, the findings emphasize the necessity of heuristic approaches for larger-scale fleets.

3 - Optimisation Frameworks for Emergency Response in Maritime Search and Rescue Operations
Grigorios Kasapidis, Dimitris Paraskevopoulos, Tolga Bektas

Maritime search and rescue (SAR) operations require rapid and well-planned intervention to improve the chances of survival of people in distress. A key difficulty is that the probable location of the target changes over time under the effect of wind, currents, waves, and tides. Motivated by these limitations, this work develops multiple mathematical and constraint programming models for emergency response planning in maritime SAR operations. Extensive computational experiments, compare the different formulations in terms of modelling strength and computational performance.

■ TE-28

Tuesday, 14:15-15:45 - Room: JUR - Hörsaal 17 (Building: JUR)

Data-Driven Analytics for Sustainable Maritime and Port Logistics I

Stream: Maritime Logistics
Invited session
Chair: *Qinghe Sun*
Chair: *Shuai Jia*

1 - A Dynamic Equilibrium Model of Fleet Renewal
Yanwei Jia

This paper develops a dynamic equilibrium model of the second-hand ship market. Firms optimize fleet composition across new and second-hand vessels characterized by differing productivity levels and salvage values. By solving the firm's intertemporal optimization problem, we derive a no-arbitrage condition for the user cost of capital. The model provides a theoretical foundation for understanding how depreciation, market expectations, and efficiency differentials endogenously determine vessel prices.

2 - Solar-hydrogen Energy System Design for Green Corridor Ports: A Data-Driven Robust Approach
Yibai Zhang, Jing Wang, Shuai Jia

Green shipping corridors (GSCs) are essential for maritime decarbonization. A key challenge is the mismatch between renewable fuel production and vessel demand. This study develops a solar-hydrogen energy system for port-side hydrogen supply. Using AIS vessel data and satellite weather records, a two-stage robust optimization model determines optimal capacities for solar PV panels and battery system. For the Rotterdam-Singapore GSC, about 4,000 tons of hydrogen storage and 16,700 MWp of solar PV are needed. The system is financially attractive when hydrogen profit margins exceed 1 USD/kg.

3 - Joint Liner Container Assignment and Speed Optimization with Elastic Demand and Service Differentiation
Qinghe Sun

Liner shipping offers standardized services to heterogeneous customers with varying sensitivities to transit time. In an increasingly competitive market, industry leaders are placing greater emphasis on catering to transit-time-sensitive (TTS) demand to enhance service attractiveness and retain market share. In this paper, we develop an optimization model and propose solution algorithms for service differentiation design that maximize the profit of operating a liner shipping network with heterogeneous TTS demands across origin-destination (OD) port pairs.

4 - Tactical and Operational Planning in Port Hinterland Networks
Orkun Tunay

This paper presents a decision-support tool for tactical hinterland transportation planning within the HAROPA port digital twin. The framework derives tactical decisions from repeated operational planning and introduces an efficient optimization model for large-scale intermodal networks. Results show that cost-efficient solutions are often also emission-efficient. The study highlights key policy levers for port authorities, including targeted capacity investments, pricing incentives, and flexible booking policies.

■ TE-29

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 30 (Building: HG)

Mathematical models

Stream: Combinatorial Optimization
Invited session
Chair: *Diego Delle Donne*

1 - Complexity of linear programs with a linearly varying constraint matrix
Laurie Boveroux, Margarida Carvalho, Andrea Lodi, Quentin Louveaux

Analyzing the variation of the value of an LP under varying data helps to understand how the choice of parameters impacts the optimal solution. We study the problem of determining the optimal value of a linear optimization problem whose constraint matrix varies linearly with a scalar t. This can be viewed as a bilevel problem where the upper level chooses the value of t, while the lower level corresponds to the original linear program. Both levels share the same objective function. We show in which cases solving this problem is NP-hard and propose algorithmic ideas to solve it.

2 - Online Assortment Optimization under the MNL Model: Balancing Revenue and Consumer Utility
Xiaoyue Zhang, Wenqiang Dai, Xiaoqiang Cai, Lianmin Zhang

This paper studies the online assortment optimization problem under inventory constraints, extending the classical revenue-maximization framework by incorporating customer utility. We develop a novel polynomial-time algorithm that provides personalized assortments based on real-time inventory levels and customer types. We establish a worst-case competitive ratio, ensuring robust performance under arbitrary arrival sequences. Numerical experiments demonstrate the effectiveness of our approach in balancing revenue and consumer utility.

3 - A park-and-loop routing problem with parking selection and multiple deliverymen
Alberto Santini, Luca Mencarelli, Maria Grazia Scutellà

We consider the problem of a last-mile operator delivering parcels to customers in a dense urban environment. The operator uses vans, which can only park in specific locations reserved for commercial vehicle loading and unloading operations. Each route visits a sequence of parking spaces. The operator partitions the set of customers by assigning each customer to a parking space. When a vehicle arrives at a parking space, on-foot deliverymen deliver parcels from the parked vehicle to the customers assigned to that parking space. We propose extended formulations and a column generation approach.

4 - Representative and Flow-Based Formulations for Colorful Components Problems
Diego Delle Donne, Carmine Sorgente, Martina Cerulli, Claudia Archetti

In a node-colored graph, a colorful component is a connected subgraph in which no two nodes share the same color. Colorful Components problems aim to transform a node-colored graph into colorful components by deleting edges. We study three variants from the literature (MOP, MCC, MEC) and propose new integer programming formulations based on representative nodes that remove symmetry present in assignment models. We also introduce flow-based constraints to enforce connectivity and a preprocessing procedure to reduce variables. Computational results show that the proposed models significantly out

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■ TE-30

Tuesday, 14:15-15:45 - Room: HG - Seminar-Raum 06 (Building: HG)

Portfolio optimization 2

Stream: Robust and Resilient Optimization in Finance and Businesses
Invited session
Chair: *Seongmoon Kim*

1 - Data-Centric Robust Portfolio Optimization: A Scenario Shapley and Warm-Start Framework
Pin-Ru Chen, Wen-Yi Lee

This study proposes a data-centric robust portfolio framework via Scenario Shapley to address the homogeneity assumption. By valuing market scenarios based on stochastic dominance contribution, it uses Shapley-weighted probabilities to filter noise. To overcome computational costs, a Naive strategy proxy and a warm-start cutting plane method with strategic discretization are developed. This tractable approach demonstrates superior out-of-sample robustness against market turbulence compared to traditional uniform-weighted models.

2 - Efficient Allocations with Risk-Averse Rank-Dependent Utilities
Michael Boyuan Zhu

We examine a novel characterizations of Pareto-optimal allocations when agents' preferences are given by risk-averse rank-dependent utilities (RDU). We find that Pareto-optimality is completely determined by each agent's Expected Shortfall of their marginal utility multiplied by the derivative of their distortion function. Under certain monotonicity conditions, we provide a closed-form expression. In a numerical study, we show how the payoffs of a joint investment can be efficiently allocated among a group of investors with rank-dependent preferences.

3 - A Regime-Switching HMM-Reinforcement Learning Framework for Dynamic Portfolio Allocation
Ilja Jurcenko, Igoris Belovas

This study proposes a dynamic portfolio management framework combining a regime-switching Hidden Markov Model (HMM) with deep reinforcement learning (RL). The regime-switching HMM detects latent market regimes and generates signals that guide asset reallocation and reduce exposure during unfavorable market states. A RL agent uses technical indicators and HMM signals and is evaluated through walk-forward backtesting across multiple timeframes. Results show improved risk-adjusted performance, with higher Sharpe, Sortino, and Calmar ratios than buy-and-hold and conventional trading strategies.

4 - A Portfolio Model Integrating News Sentiment Analysis in the South Korean Stock Market
Seongmoon Kim

This paper builds on Markowitz's mean-variance portfolio selection model and adjusts asset allocations using news sentiment analysis. We applied KR-FinBERT to news headline data collected from eight economic newspapers. The model's performance was evaluated using historical monthly stock return data from the South Korean stock market. The results show that our model outperforms benchmark portfolios, suggesting the usefulness of sentiment analysis for developing investment strategies.

■ TE-31

Tuesday, 14:15-15:45 - Room: JUR - Hörsaal 12 (Building: JUR)

Network design and line planning for public transport 3

Stream: Optimizing Transit
Invited session
Chair: *Cristian E. Cortes*

1 - An adaptive bus bridging method using fine-tuned and extended existing bus routes for urban rail transit disruptions
Yinfei Feng, Yong Yin, Tao Feng

To cope with urban rail transit (URT) disruptions, this study converts existing bus routes into bridging routes, allowing stops near disrupted stations to provide direct service. Two bridging strategies are proposed: fine-tuning parts of routes without skipping regular stops and extending routes from first or last stops toward disrupted URT stations. A rolling-horizon method adjusts strategies over time, while dynamic passenger allocation guides stranded passengers to designated areas based on demand and available trips.

2 - A multi-period asymmetric transit frequency design problem
Wai Yuen Szeto, Jun Gong

This study examines a multi-period asymmetric transit frequency design problem capturing a schedule-based user equilibrium transit assignment problem with elastic demand as a subproblem. In this problem, for each route in each period, a class of buses serves both directions while the other class only serves one direction with high travel demand. This problem is formulated as a bilevel program to determine the route frequencies of different classes of buses in each period. An artificial bee colony algorithm encapsulating the method of successive averages is proposed to tackle the problem.

3 - Strategic Planning of a Line Network with a Ridepooling Feeder Service
Lena Dittrich, *Anita Schöbel*

Demand responsive ridepooling services are becoming a more and more common addition to public transport systems. The operative aspects of ridepooling services are well-studied. In this talk, we disregard operative details and consider ridepooling from a strategic perspective. We present a model that, given a network of stops, determines a line-based public transport system comprising a subset of the stops. Each remaining stop is assigned to a line stop, such that passengers can travel to and from the line system by a demand responsive ridepooling service.

4 - A Bilevel Column Generation Heuristic for the Capacitated Transit Network Design and Frequency Setting Problem
Cristian E. Cortes, *Michel Gendreau*, *Daniel Orlando Martinez Quezada*, *Antonio Mauttone*

The Transit Network Design and Frequency Setting Problem (TNDFSP) optimizes transit routes and service frequencies. We propose a bilevel formulation capturing user-operator interactions under capacity-waiting-time trade-offs. A column generation method is proposed, with capacity constraints in the master and waiting time in the objective and user decisions. The scheme includes an initial solution, a column generation heuristic, and MIP solving via feasibility pumping or local branching for large instances. Tested on synthetic instances, the Mandl network, and real-world Rivera instances.

■ TE-32

Tuesday, 14:15-15:45 - Room: JUR - Hörsaal 14 (Building: JUR)

Urban Routing and Delivery Operations

Stream: City Logistics
Invited session
Chair: *Walid Klibi*

1 - Delivery tour length prediction based on urban spatial structure
Barbara Himstedt

Urban logistics is increasingly adopting sustainable delivery modes such as cargo bikes and delivery robots alongside conventional vans. Their efficiency, however, can vary across different urban environments. This talk presents a machine learning approach to predict delivery tour lengths from relevant spatial indicators of the built environment and transport network structure. Using Berlin as a case study, it is analyzed how spatial metrics and network characteristics influence the overall routing efficiency of delivery modes operating on pedestrian, bicycle, and road networks.

2 - Contextual Routing Decisions for Urban Delivery with Opportunistic Pickups
Nafe Moradkhani, *Walid Klibi*

We study a last-mile cargo-bike routing problem with deliveries and opportunistic pickups under tight capacity. We frame it as a contextual optimization problem in which the value of serving a stop depends not only on travel cost, but also on local conditions affecting delivery success and pickup attractiveness. The model captures the trade-off between serving deliveries now and preserving capacity for later pickup opportunities, and shows how context changes stop selection, capacity reservation, and delivery-pickup coordination during route execution in dense urban operations.

3 - A Two-Phase Optimization Model for Urban Construction Logistics
An Caris, *Yunyun Wang*, *Kris Braekers*, *Ruben D'Haen*
This study optimizes urban construction logistics by integrating a Construction Consolidation Center (CCC). We develop a multi-period, multi-material, multi-vehicle-use model to determine delivery plans and routing for suppliers and the CCC. A two-phase algorithm combining MILP and heuristics solves the optimization problem to obtain the minimal total cost. Experimental results compare baseline scenarios against various configurations, analyzing the impact of CCC integration and on-site time windows to provide a pathway for sustainable urban logistics.

4 - A Branch-and-Price Algorithm for the Two-Echelon Vehicle Routing Problem with Time Windows and Time-Dependent Travel Times
Jiri Spitzer, *Gonçalo Correia*, *Serge Hoogendoorn*, *Shadi Sharif Azadeh*
Urban logistics frequently relies on two-level distribution networks, where large vehicles deliver goods to intermediate facilities from which smaller vehicles complete last-mile deliveries in city centers, where travel times vary considerably throughout the day due to fluctuating traffic conditions, directly affecting route planning. Yet most VRP studies simplify or ignore this effect, assuming static travel times throughout the planning horizon. We propose a branch-and-price algorithm for the two-echelon vehicle routing problem with time windows and time-dependent travel times.

■ TE-33

Tuesday, 14:15-15:45 - Room: JUR - Hörsaal 15 (Building: JUR)

Advances in Railway Crew Planning

Stream: Passenger Railway Transportation
Invited session
Chair: *Bart van Rossum*

1 - Partial Integration of Crew Scheduling and Timetabling
Milan van Puffelen
In crew scheduling, there might not be enough crew available to operate all tasks of a given timetable. Consequently, several tasks will be cancelled. We partially integrate crew scheduling and timetabling by allowing to cancel tasks of an ideal timetable in the crew scheduling problem. The ideal timetable can be interpreted as the set of tasks one would ideally operate, but which is optimistic with respect to available crew. Several constraints related to task cancellation are imposed to capture important rolling stock aspects. We present preliminary results on real-world instances.

2 - Crew rescheduling in railway freight transport
Vera Hemmelmayr, *Valentina Cacchiani*, *Manuel Schlenkrich*
Disruptions in railway networks require the rapid rescheduling of operational resources. We study a crew rescheduling problem faced by an Austrian railway operator, incorporating detailed break regulations and the possibility of crew deadhead trips. We also account for drivers' section and locomotive knowledge. To solve the problem, we propose a decomposition-based matheuristic. The method is evaluated using data derived from a real-world freight locomotive scheduling problem and the impact of key parameters is investigated.

3 - Addressing Sequential Trip Failures in Railway Crew Scheduling with Machine Learning
Marco Banke

Crew scheduling in freight rail assumes all planned trips execute as assigned. In practice, a single trip failure renders subsequent trips in the same duty non-executable. We propose a failure-aware framework using a machine learning model to predict trip failure probabilities sequentially across duties using a small feature set. These probabilities enter a set-covering formulation as penalty costs. We propose a method to balance solution quality and computational effort while trading off costs and expected failure reduction. Simulations confirm superiority over deterministic buffers.

4 - Human centered rostering for railway crew
Veerle van den Hurk, Erwin Abbink, Marjan van den Akker, Egon L. van den Broek

Automatic approaches to personnel rostering have been widely studied. However, only a fraction of these approaches are used in practice. To increase their use, we identified an initial set of human centered targets for rostering algorithms. Netherlands Railways (NS) crew's working time preferences were assessed via both quantitative and qualitative methods. It showed feasible to include these in an integrated MIP model, which allowed the automatic generation of rosters meeting both CLA constraints and human preferences.

■ TE-34

Tuesday, 14:15-15:45 - Room: JUR - Hörsaal 16 (Building: JUR)

Order Picking Operations

Stream: Warehousing
Invited session
Chair: *René de Koster*

1 - Stochastic-dynamic forward-reserve allocation: Depalletization planning in a wholesale warehouse with uncertain retrieval sequence
Benjamin Riedel, Simon Emde

Depalletization planning is a key challenge in wholesale warehouses, where customer orders are picked from a forward area and replenished from reserve storage. Uncertainty in retrieval sequences, limited capacity, and item heterogeneity often cause inefficient and costly decisions. We propose a multiple-scenario approach that generates future demand realizations and solves a deterministic problem for each. As a single scenario is NP-hard, we have developed an efficient heuristic. This outperforms current policies by 70%, resulting in reduced delays and costs and improved service.

2 - Integrating Stochastic Waiting and Routing Heuristics for Improved Order-Picking in Warehouse Operations
Maximilian Barlang

Faster order fulfilment increases responsiveness of warehouses. This contribution tackles the online order picking problem (consisting of the subproblems batching, routing and waiting). Existing waiting strategies control the tour start time but ignore stochastic information that is readily available from historical data. We enrich them with stochastic estimates of order arrivals derived from historical data and couple these estimates with routing heuristics. In standardised experiments, we aim to show that this information can be used to improve results.

3 - High throughput buffered mesh sorter with single and dual drops
Ilan Estrugo, Tal Raviv, Yossi Bukchin

We propose a high-throughput sortation architecture with circular feeder belts positioned above linear primary sorting belts. Items are released from feeders onto their assigned primary belts and then sorted into destination bins. If the intended drop point is occupied, the item recirculates until it can be released. We analyze single- and dual-drop designs with optional buffers, derive key structural and performance properties, and study the buffer allocation problem. Extensive numerical experiments demonstrate that the proposed architecture substantially outperforms state-of-the-art sorters.

4 - How to pick and stack your pallet?
René de Koster, Tianrong Ding, Ioannis Fragkos

In warehouses supplying retail stores, order pickers typically travel with a pallet truck along the different rack locations to pick the boxes required for the orders. The pick pallets have to be stacked based on store specific sequence requirements, minimizing reshelving labor in the stores. We build algorithms that jointly optimize the warehouse travel time and the pallet stack height, meeting both store and various other 3D pallet stacking constraints. We evaluate our stacks against real picked pallets and can obtain both shorter travel time and lower pallet stacks.

■ TE-35

Tuesday, 14:15-15:45 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Sustainable Cities

Stream: Operations Research and Sustainability
Invited session
Chair: *Nezir Aydin*

1 - Optimization-Based Design of Urban Food Networks for Improved Accessibility
Meen-Sung Kim, Sofia Perez-Guzman, Carla Tejada, Otgoo Boldbaatar

This study presents an optimization framework for urban food networks by integrating diverse facility types, accessibility constraints, and multimodal travel behavior. The model identifies optimal facility configurations to meet consumption requirements within specific travel thresholds. By testing multiple objectives—such as minimizing unmet demand and maximizing coverage—the framework evaluates how alternative access measures shape network design. Applied to Chicago, the results demonstrate how multimodal assumptions and objective selection influence food accessibility outcomes.

2 - Optimizing Multi-Family Housing Portfolios for Decarbonization
Roman Delorme, Nico Fuchs, Kinga Poplawska, Marco Lübbecke

Housing companies play a key role in decarbonizing multi-family housing portfolios. Optimizing renovation pathways requires considering investment decisions, energy system operations, financial constraints, and regulatory requirements. We present a MILP model that optimizes renovation pathways for housing companies, capturing trade-offs between financial returns, emissions reduction, and tenant affordability. To reduce computational complexity, we develop a heuristic that computes feasible building states from single-building pathways and integrates them into portfolio-level optimization.

3 - A Dynamic Urban Metabolism Model for CO2 Mitigation Scenario Analysis in Santiago, Chile
Juan Francisco Venegas Gutierrez, Pedro Palominos

This work presents a dynamic model to analyze urban CO emissions using an integrated urban metabolism approach for Santiago, Chile. The model combines material and energy flow analysis with first-order

differential equations to represent population dynamics, energy use, transport fuels, and waste over 2025-2050. Results show that transport accounts for about 46% of carbon flows. Transport electrification alone increases emissions, while coupling it with a decarbonized power system enables reductions close to 70% by 2050.

4 - Stochastic Multiobjective Optimization for Sustainable Public Parking Lot Location
Nezir Aydin

Rapid urbanization increases traffic congestion and parking demand in metropolitan areas. This study proposes a multiobjective, decision-dependent two-stage stochastic model to determine the optimal number and locations of public parking lots. The model minimizes facility establishment and operational costs, unsatisfied parking demand, and CO emissions. Using the weighted-sum approach and stochastic programming, the framework supports sustainable urban planning under uncertainty and provides decision makers with robust insights for efficient parking infrastructure development.

■ TE-37

Tuesday, 14:15-15:45 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Combinatorial optimization

Stream: Nonlinear Optimization
Invited session
Chair: *Thi Huong Vu*

1 - An Exact Branch-and-Price Algorithm for the Quadratic Multiple Knapsack Problem with Item Conflicts
Qingyang Wang, Ying Meng, Lixin Tang

We study the quadratic multiple knapsack problem with item conflicts, where items generate individual profits and pairwise synergies while some pairs cannot be placed in the same knapsack. These conflicts change the problem structure and make classical formulations highly symmetric with weak relaxations. We propose an exact branch and price algorithm with a symmetry breaking decomposition that aggregates identical knapsacks. The pricing problem is solved by an exact labeling algorithm that embeds conflicts as pruning rules, supported by a multi level pricing strategy to speed column generation

2 - On the approximability of the balanced minimum evolution problem
Francesco Pisanu, Daniele Catanzaro, Raffaele Pesenti

The balanced minimum evolution problem is a highly nonlinear APX-hard network design problem in molecular phylogenetics that has attracted significant attention from the bioinformatics and mathematical programming communities. We present conditions under which its practical instances become efficiently approximable. We show that when all pairwise distances are positive and bounded, the problem admits a polynomial-time approximation algorithm with a performance guarantee linked to the interval width. We also characterize polynomially solvable instances.

3 - Adaptive Partitioning for Stochastic Bilevel Linear Programs: Implementation and Computational Study
Francisco Jara-Moroni, Carlos Muñoz-Rey

This work presents an extension of the Adaptive Partitioning Method (APM) to stochastic bilevel linear programs (SBLPs). The proposed algorithm iteratively classifies scenarios according to their corresponding dual solutions. Several variants are analyzed, including refinement based on optimal basis and initial partition heuristics using k-means and half-capacity schemes. Numerical experiments on knapsack-type problems show substantial reductions in computation time compared to an extended model. Results show that the proposed approach provides an efficient and scalable framework for SBLPs.

4 - On the solution of MINLP polynomial problems involving binary variables
Iria Rodríguez-Acevedo, Julio González-Díaz, Brais González Rodríguez, Alejandro Barros-González

This talk presents work extending the analysis of linearization patterns introduced in Elloumi and Verchere (2023), which focuses on the solution of unconstrained binary polynomial optimization problems, to general polynomial optimization problems. We study the tightness of the ensuing relaxations and compare them with those obtained by directly applying the Reformulation-Linearization Technique (RLT).

We also discuss how these reformulation strategies can be incorporated into an RLT-framework and present promising numerical results obtained after implementing them in an RLT-based solver.

■ TE-38

Tuesday, 14:15-15:45 - Room: JUR - Seminar-Raum 44 (Building: JUR)

OR in Large-Scale Industrial Systems and Platforms

Stream: The Practice of OR: Stories of Solutions, Setbacks, and Successes
Invited session
Chair: *Eduardo Moreno*

1 - Supply Demand Matching @ Google
Daniel Duque

Matching a diverse compute demand with physical machine supply is a massive operation at Google that involves multiple teams contributing to produce forecasts, UI tooling, data pipelines and optimization solvers. This presentation explores the evolution of our internal supply-demand matching solver, which drives procurement and capacity allocation decisions. We will discuss the practical hurdles of modeling real-world constraints while dealing with imperfect data, evolving user requirements and new data streams such as distributional demand forecasts.

2 - Optimizing parts logistics at PORSCHE
Andreas Reinholz

The huge variety of equipment options available when configuring new PORSCHE vehicles places significant demands on internal logistics. Parts are supplied via a multi-stage logistics network providing multiple alternative supply routes for all parts. Making all necessary parts available at the assembly line with minimal costs while considering multiple real world restrictions defines a complex optimization problem. We present a multi-stage solution method using pre-calculated process chains to efficiently solve the optimization problem in an IP realizing significant cost savings.

3 - Mathematical optimization of railway maintenance planning
Victor Brandsen, Alexander Madsen, Thomas Stidsen

Banedanmark (BDK) is responsible for renewal and maintenance activities on 3000 km of Danish railway infrastructure. To produce a realistic and reliable budget for the future, BDK currently relies on legacy software, which does not match real-world challenges. We present results from a pilot-project with BDK on using mathematical programming to take advantage of their practical experience in creating a realistic plan that takes both renewal costs and opportunity costs into consideration. The resulting model is tested on data from BDK on the current state of the Danish railway network.

4 - Accelerating Large-scale Network Capacity Planning at Google.
Eduardo Moreno

Modern network capacity planning for large-scale infrastructures, such as Google's network, relies on complex, large-scale MIP models to determine cost-effective capacity allocations while guaranteeing Quality of Service. Existing methods often struggle with long solution times due to the size and complexity of these models.

We propose a Benders decomposition framework to significantly enhance the performance of large-scale capacity planning solvers. Our preliminary results validate that this approach significantly reduces computational time, enabling rapid, high-quality network decisions.

■ TE-43

Tuesday, 14:15-15:45 - Room: JUR - Seminar-Raum 63 (Building: JUR)

LLMs, automated design and other AI

Stream: Metaheuristics
Invited session
Chair: *Alexander Kinast*
Chair: *Luca Di Gaspero*

1 - Large Language Models for the Automatic Design for Memetic Algorithms
Thomas Stützle, Pablo Contreras Estrada, Leslie Pérez Cáceres

We combine grammar-based automatic algorithm design with large language models (LLMs) to improve source-code efficiency. As an example we use memetic evolutionary algorithms, which are represented as compositions of interchangeable components encoded by a context-free grammar and automatically configured with an automatic tool within EMILI, our automatic algorithm design framework, and apply a constrained, component-wise LLM-guided optimization to accelerate individual operators while preserving algorithmic behavior.

2 - Automated Design of Relocation Heuristics for the Container Relocation Problem Using Genetic Programming
Marko Đurasević

The container relocation problem is a combinatorial optimisation problem in container terminals where containers must be retrieved in a fixed order while minimising relocations. This paper study a genetic programming based hyper-heuristic for automatically designing relocation rules. Priority functions are evolved using domain specific features and combined with predefined relocation schemes. Experiments on benchmark datasets show that the evolved rules consistently outperform state of the art manually designed heuristics and generalise well to unseen and large scale instances.

3 - An Integrated Metaheuristic and Supervised Learning Framework for OHT Rail Network Design in Semiconductor FABs
Sangsoo Lee, ByungDuk Song

This study examines how turntable and N-branch placement affects Overhead Hoist Transport (OHT) performance in semiconductor FABs. A WIP-based Genetic Algorithm (GA) explores optimal rail layouts, and top designs are simulated to gather training data per metric. Supervised learning models are embedded as metric-specific fitness functions within the GA, enabling optimization without extra simulation. Comparing WIP-based and surrogate-driven GAs reveals trade-offs between junction placement and logistics performance, validating the framework as a decision-support tool for OHT rail design.

4 - Generational approach for Metaheuristic discovery
Alexander Kinast, Michael Boegl

Experts are currently needed to develop, parameterize, and apply Metaheuristics on complex optimization problems. The solution quality found with these Metaheuristics strongly depends on the chosen parameters and the problem knowledge integration. Bad solutions can be costly for companies; therefore, experts spend lots of time on parameter tuning and problem adaptation. With new technologies, such as generative AI, the question is which of these parts can already be automated with consumer-grade hardware and local AI models. What are the limitations of current state-of-the-art approaches?

■ TE-45

Tuesday, 14:15-15:45 - Room: HG - Seminar-Raum 01 (Building: HG)

Data-driven optimization under uncertainty for transport problems

Stream: Data-driven Stochastic (Inverse) Optimization
Invited session
Chair: *Jie Gao*
Chair: *Yaoxin Wu*

1 - Air Freight Logistics under Uncertainty: Integrated Tail Assignment, Schedule Adjustment, and Shipment Routing
Felipe Delgado, Shurui Zhu, Alessandro Bombelli

Air cargo operations are highly exposed to flight time variability, which can disrupt schedules and delay shipments. We propose a two-stage stochastic model integrating aircraft tail assignment, departure time adjustment, and cargo routing under uncertainty. Scenarios are generated from three years of historical data, preserving temporal and spatial dependencies. Utilizing a large Chinese cargo network, the results show consistent profit gains over deterministic benchmarks, with improvements of up to 4.3% during high-variability winter operations.

2 - Learning from Operations in Smart Waste Collection
Dilay Aktas Dejaegere, Jan Fabian Ehmke, Remy Spliet, Sanne Wøhlk

In this work, we consider a smart waste collection system where sensor-equipped bins can transmit their fill levels. Decisions regarding which bins to equip with sensors are typically made at a higher level based on where they would provide the greatest value. However, waste deposition patterns may change over time, potentially reducing the effectiveness of these decisions. We design a continuous learning approach to detect structural shifts in waste deposition patterns that significantly affect system performance and signal the need for higher-level adjustments.

3 - Data-Driven Human-in-the-Loop Reinforcement Learning for Multi-Stakeholder Routing under Uncertainty
Xinyu Mao, Sebastian Piest, Engin Topan, Erwin W. Hans

Balancing costs with customer satisfaction and driver well-being is a complex challenge in logistics. Unlike traditional Vehicle Routing Problems treat with rigid constraints, we propose a data-driven RL framework using Human-in-the-Loop treating time windows and preferences as negotiable boundaries. The RL agent leverages customer and driver feedback to dynamically learn preference probabilities, addressing human behavior and uncertainty. We will demonstrate the interactive prototype and share preliminary results on the cost-benefit trade-offs of collaborative constraint relaxation.

4 - Integrated train scheduling and dynamic pricing with endogenous demand under uncertainty: A machine learning-enhanced Benders decomposition approach
Yahan Lu, Dongyang Xia, Shadi Sharif Azadeh

This study addresses the joint optimization of train scheduling and dynamic pricing in urban rail transit under demand uncertainty, where fare incentives reshape passengers' arrival time choices. We formulate a stochastic mixed-integer nonlinear program incorporating an arrival time choice model with fare-dependent probabilities. A machine learning-enhanced Benders decomposition approach embedded in a branch-and-cut framework is developed to solve the problem exactly. Experiments demonstrate reductions in passengers' waiting time and faster convergence over benchmark methods.

■ TE-46

Tuesday, 14:15-15:45 - Room: HG - Seminar-Raum 02 (Building: HG)

Applications 2

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Olga Battaia*

1 - A Mixed-Integer Programming Model for Optimizing Block Storage Planning in Shipyards
Shuhei Konno

Block storage planning in shipyards requires storing hull blocks in limited yard spaces based on erection schedules. This involves complex constraints, including block stacking, adjacent placement for grand assembly, and various work processes like painting. We propose a mixed-integer programming model to minimize transport and storage costs under these physical and temporal constraints. Simulations using historical data show that optimized plans obtained from the proposed model reduce costs by 30% compared to manual planning, effectively streamlining shipyard manufacturing processes.

2 - A Decision Support System for Improving Production Planning in a Make-to-Order Environment
Rui Borges Lopes, Patrícia Ferreira

Efficient production planning is critical in modern industries. This work presents a decision support system (DSS) developed for a make-to-order manufacturer of fastening components, focusing on the stamping process. The proposed DSS integrates a constraint programming-based scheduling model with a lexicographic optimization strategy to maximize output and minimize tardiness and setups. Its application resulted in a significant reduction in planning time and a 10% improvement in the On-Time In-Full indicator.

3 - Fast and Stable Rescheduling in Aircraft Final Assembly Lines Using Graph Neural Networks
Sergei Gladyshev, Olga Battaia, Romain Guillaume

This paper addresses fast rescheduling in aircraft final assembly line where many interdependent jobs must be assigned to workers under uncertain processing times. We propose a Graph Neural Network that learns a dispatching policy from solutions generated by a constraint programming solver using scenario-based optimization with buffer allocation. The trained model quickly predicts scheduling decisions from partial schedules. Experiments show that it produces solutions close to solver quality while dramatically reducing computation time, enabling practical online rescheduling after disruptions.

4 - The Car Resequencing Problem with Makespan Minimization
Xinyi Guo

The car resequencing problem involves using a buffer to rearrange the car sequence between two production shops. This study examines a buffer that has several forward lanes and a return lane (RL), allowing cars to loop within it. By positioning cars over time, the goal is to minimize the resequencing completion time. We propose a branch-and-price approach integrated with constraint programming to solve this strongly NP-hard problem, along with two reduced master problems to mitigate exhaustive branching. Experimental results show the effectiveness of the algorithm and the RL in resequencing.

■ TE-47

Tuesday, 14:15-15:45 - Room: HG - Seminar-Raum 03 (Building: HG)

Supply chain 1

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Ömer Faruk Yılmaz*

1 - From geopolitical shocks to adaptive outcomes: Capability-based responses in supply chains
Aleksandra Kania, Dominik Berbig

Geopolitical disruptions introduce persistent uncertainty into supply chain systems. This study analyses how such uncertainty is internalised through proactive and reactive dynamic capabilities and translated into structural design quality and operational resilience. Using survey data from Polish manufacturing firms and PLS-SEM estimation, the results show that disruptions affect outcomes only indirectly via capability activation. Proactive capabilities shape network design, while reactive capabilities drive resilience under uncertainty.

2 - Enhancing Line Design in Unreliable Production Systems Through Predictive Modeling and Multi-Objective Optimization
Masood Fathi, Ehsan Mahmoodi

This study addresses the buffer and resource allocation problem in production lines, focusing on optimal buffer sizing and resource distribution. Based on a real engine assembly case with high-mix, low-volume production and uncertainty, a decision-support framework is developed combining discrete event simulation, machine learning-based regression, and an enhanced NSGA-II optimization algorithm. Results show improved performance over conventional NSGA-II and particle swarm optimization, while pattern mining provides additional insights for buffer and resource allocation decisions.

3 - Value of Lean Applications (VLA): Effectiveness of Lean Transformation Under Uncertainty
Ömer Faruk Yılmaz, Beren Gürsoy Yılmaz

Lean production aims to eliminate waste and limit flexibility through standardization. By reducing complexity, lean practices mitigate the need for large-scale combinatorial optimization, although such problems may still arise under uncertainty. Lean applications narrow the gap between the EV solution and the EEV solution, defined as the Value of Lean Applications (VLA). Standardization and flow-supporting tools, including interior and exterior Heijunka, should be applied first, after which optimization methods can further reduce this gap. In this context, WS and RP should be analyzed.

■ TE-49

Tuesday, 14:15-15:45 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management Considering Specific Constraints and Risks

Stream: Data-Driven Demand Management
Invited session
Chair: *Matthias Soppert*

1 - Mean-Variance Optimization in Finite Horizon Markov Decision Processes and its Application to Revenue Management
Jochen Gönsch, Rainer Schlosser

The mean-variance (MV) criterion is widely accepted and often used to find the right balance between maximizing expected rewards and avoiding poor performances. In dynamic settings, however, it is challenging to efficiently compute policies under the MV objective and hence, surrogates like the exponential utility model are often used. In this paper, we consider MV optimization for discrete time Markov decision processes (MDP) with finite horizon. Our approach is based on a system of tractable subproblems with distorted variance that generates a bound.

2 - Optimization with constraint learning for pricing services under competition
José Ángel Martín-Baos, Antonio Alcántara, Carlos Ruiz, Ricardo Garcia-Rodenas

Revenue Management (RM) optimizes pricing and capacity allocation under demand uncertainty. We propose a data-driven RM framework that integrates neural networks or gradient boosting tree models with constraint learning to support joint pricing and capacity decisions. The approach adapts to arbitrary demand patterns learned directly from data, without requiring a predefined demand model, and captures competitive interactions between railway undertakings using only observable information. The methodology is illustrated through a case study of the Madrid-Barcelona high-speed rail corridor.

3 - Quantifying the Cost of Constraints in Dynamic Pricing
Matthias Soppert

In the context of dynamic pricing for capacitated, perishable products under stochastic demand, this paper studies the economic cost of constraints imposed due to business rules or fairness aspects. Synthesizing prior work, it introduces a general framework based upon the concepts of history-dependent and history-independent constraints. Further, it proposes a tractable minimal-state model capturing all relevant types of constraints discussed in the literature and quantifies their revenue losses in a systematic numerical study.

■ TE-50

Tuesday, 14:15-15:45 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Stochastic Optimization & Operational Strategies II

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Ali Noutash*

1 - Optimal Demand Scheduling Considering Demand Response
Yu-Chi Wu

To maximize demand response (DR) benefits, aggregating industrial, commercial, and residential users is vital to ease grid constraints during summer peaks. Upon receiving DR signals, users must schedule daily power usage to balance cost savings with personal comfort. This paper addresses this by proposing a Mixed-Integer Programming (MIP) model that was solved using a modified Particle Swarm Optimization (PSO) algorithm. Ultimately, this approach empowers consumers to achieve optimal load scheduling while maintaining user satisfaction during DR participation.

2 - Multi-Site Optimization for Battery Energy Storage Systems Using MILP
Hana Rudová, Jakub Drábik

This study presents a MILP model for the coordinated dispatch of battery storage across prosumer portfolios from a balance responsible party perspective. It features a sequential structure with day-ahead nomination and rolling horizon real-time dispatch at 15-minute resolution. The model accounts for multi-site optimization, customer interest protection, and the impact of imbalance settlements. The approach is validated using real-world data to evaluate specific objective functions for diverse stakeholders and the dynamics introduced by the rolling horizon.

3 - Operational Energy Optimization at Scale: Lessons Learned from Energy Systems with AMPL
Juan Bohorquez, Marcos Dominguez Velad, Eduardo Salazar

Energy optimization models often start as research prototypes but must scale to complex, operational systems. Traditional frameworks face challenges with slow setup, solver integration, and maintainability. AMPL enables fast, flexible, and scalable modeling for linear and nonlinear problems with access to many solvers, including GPU-accelerated ones.

Case studies from unit commitment and price forecasting for the Chilean national electricity system, gas networks ops, and battery storage demonstrate how AMPL scales optimization workflows in real-world energy systems worldwide.

4 - Optimal Operation of Hydrogen Energy Systems Using a Hybrid-Action Deep Reinforcement Learning
Ali Noutash, Gregorio Muñoz-Delgado, Javier Contreras

The integration of renewable energy sources and power-to-hydrogen technologies strengthens the coupling between power and hydrogen systems. Renewable energy can be stored as hydrogen and transported via hydrogen tube trailers (HTTs). However, HTT routing introduces spatio-temporal non-convex decisions, making the resulting optimization problem challenging. To address this issue, we propose a deep reinforcement learning approach that jointly determines HTT routing and hydrogen production using a hybrid-action soft actor-critic framework with separate discrete and continuous actors.

■ TE-51

Tuesday, 14:15-15:45 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Explainable Decision-Making through Mathematical Optimization

Stream: Mathematical Optimization for Transparent and Fair Decision Making
Invited session
Chair: *Marica Magagnini*

1 - Robustness in counterfactual explanations in classification and regression
Antonio Navas-Orozco, Emilio Carrizosa

Counterfactual explanations (CEs) find a minimal perturbation of an input so that a predictive model's output exceeds a threshold. In the framework of Generalized Linear Models, we propose two notions of robust CEs: robustness against data distribution shifts and validity under the ground-truth model. The former is solved via a tailored cutting-plane and Gaussian Variable Neighbourhood Search algorithm, while the latter is formulated as a Mixed Integer Second Order Cone Program. Numerical experiments validate our approach in regression, classification, and counting regression settings.

2 - Heuristics for Counterfactual Explanations for Optimization
Sebastian Merten, Marc Goerigk, Jannis Kurtz

The problem of determining optimal weak counterfactual explanations (CE) for integer programs has been proven to be S2P-complete, even for elementary special cases. We present a heuristic approach which exploits the observation that the feasible region of this problem has specific properties. This allows this region to be approximated by decision trees. Based on this approximation, a weak CE can be calculated, which is computationally much less demanding than solving the CE problem. We present computational results for different integer programs.

3 - Certified Optimal Graph Neural Network Explanations via Mixed Integer Linear Programming
Woo Seok Goh, Kyungsik Lee

We propose a mixed-integer linear programming (MILP) framework that computes optimal node- and edge-mask explanations for graph neural networks under a user-specified budget. Most existing explainers are heuristic-based, so quality is hard to verify. We prove that the exact explanation problem is NP-hard, yet our MILP solves practical instances to certified optimality, providing rigorous baselines. We incorporate formulation strengthening and optional connectivity constraints. Experiments on benchmarks confirm that certified optima are attainable and reveal gaps in existing heuristics.

4 - Diverse SHAP values for accurate prediction models
Marica Magagnini, Emilio Carrizosa, Renato De Leone

Feature importance plays a key role in explainable machine learning. Despite their extensive use, feature attribution methods are often unreliable for inferring predictive models' behaviors. Their explanations can differ for similar predictions or comparable models. We investigate the consistency and robustness of a set of equally accurate models with respect to their interpretability analysis. We consider the well-established feature attribution method SHAP based on Shapley values. We address the problem of building P accurate models maximizing a dispersion measure of their SHAP explanations.

■ TE-52

Tuesday, 14:15-15:45 - Room: KOL - PC Raum 1 (Building: KOL)

Energy Systems Modeling

Stream: Energy Markets & Systems
Invited session
Chair: *Alberto J. Lamadrid L*

1 - Cost Projections for Low-Carbon Power Technologies Using Learning-Curve-Based LCOE/LCOS Models
Robert Gaugl, Christoph Ertl, David Cardona-Vasquez, Sonja Wogrin

A framework is presented for projecting future costs of low-carbon power technologies by combining levelized cost metrics with experience curves. The general framework is applied and calibrated for Austria. Technology-specific models are developed for photovoltaic systems, onshore wind, and battery storage to derive long-term cost pathways under varying assumptions. Results indicate considerable cost reduction potential across all technologies, while also revealing substantial uncertainty, particularly for less mature storage options.

2 - Decentralized Real-Time Optimization of Electricity Grids
Wenqi Ni, Lars Schewe, Chris Dent

The growing integration of distributed energy resources into energy systems challenges the reliable real-time coordination of electricity transmission and distribution grids. We develop a decentralized stochastic optimization framework for decision making under renewable generation uncertainty. The model incorporates day-ahead scheduling and capacity reservation for real-time operations to address physical infeasibility of existing coordination schemes. Computational experiments based on a synthetic GB power system illustrate improved feasibility and operational reliability.

3 - Ellipsoidal Uncertainty Sets for Adaptive Robust Unit Commitment via Conformal Prediction
Panagiotis Andrianesis, Alex Wasilkoff, Michael C. Caramanis

In this work, we propose a data-driven method for forming ellipsoidal uncertainty sets tailored to renewable-rich systems. We estimate a covariance matrix from historical observations whose ex-ante forecasts exhibit feature-based similarity, and we size the ellipsoid by determining its radius using a conformal-prediction-based procedure providing system-level statistical guarantees. We showcase the applicability of our approach on the adaptive robust unit commitment problem emulating reliability unit commitment processes for the RTS-GMLC system and using ensemble wind forecasts.

4 - Exploiting Convexity to Explore All Near-Optimal Solutions of Energy Systems
Evren Turan, Stefano Moret, André Bardow

Optimization models are indispensable for decision-making. However, the optimal solution may not be practical due to real-world complexities. Stakeholders are therefore often interested in the near-optimal space: solutions that lie within a specified margin of the optimal objective value. We propose an algorithm to approximate the near-optimal space of quasiconvex programs by iteratively refining inner and outer approximations. The algorithm is benchmarked against existing methods on a sector-coupled Swiss energy model and consistently achieves better convergence with fewer iterations.

■ TE-53

Tuesday, 14:15-15:45 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Heuristic and Evolutionary Algorithms for Multiobjective Optimization

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Long Cheng*
Chair: *Hongsheng Liu*

1 - Improving reproduction efficiency by exploiting local mini-archives in the decomposition-based evolutionary multi-objective optimization
Michał Tomczyk

This work shows novel ways to enhance the efficiency of reproduction in decomposition-based evolutionary multi-objective optimization by exploiting subproblem-specific mini-archives. These structures preserve several best-found solutions and are used to perform gradient-based adjustments to offspring. A dynamic parent selection mechanism that shifts from early neighborhood-based exploration to more archive-based exploitation later is also presented. These developments are tested in a posteriori and interactive context, demonstrating the ability to build more promising populations faster.

2 - A Multi-Objective Procedure for Integrated Multi-Mode Activity Scheduling and Personnel Staffing Considering Diversity
Azin Rashidipour, Broos Maenhout

This research studies an integrated personnel staffing and multi-mode activity scheduling problem that jointly determines activity timings, modes, and team compositions. A bi-objective model minimizes personnel costs while maximizing personality-based team effectiveness using an MBTI-based diversity measure. An enhanced NSGA-II with tailored initialization and local search heuristics approximates the Pareto front efficiently. Experiments on PSPLIB-based instances show superior solution quality compared with classical multi-objective approaches and MOPSO.

3 - Optimality and algorithms for multiobjective optimization problems with state attributes
Kequan Zhao, Hongsheng Liu

We consider a class of multi-objective optimization problems with decision variables having state attributes, which are specifically determined by a complex network. Firstly, two subproblems are formulated and their global optimality is proved. Furthermore, equivalent characterizations and exact search algorithms for the nondominated point set are established. Finally, by utilizing the state vector space of a power system as an example, we demonstrate that the proposed theories and algorithms significantly enhance computational efficiency in power system operational reliability assessment.

4 - Natural Partial Order Properties and Optimal Coverage in the State Vector Space of Power Systems
Long Cheng, Yuanmei Xia

By virtue of the natural partial order, several partial order properties of the state vector set in the state vector space of power systems are obtained, and it is further proved that the critical state vector set is an effective reduced set. On this basis, several probabilistic properties of the state vector set are derived. In addition, a multi-objective optimization model is constructed to approximate the critical state vector set, and the optimal coverage problem of the state vector space of power systems is investigated.

■ TE-57

Tuesday, 14:15-15:45 - Room: HG - Seminar-Raum 07 (Building: HG)

Experiments in BOR

Stream: Behavioural Operational Research
Invited session
Chair: *Ayşegül Engin*
Chair: *Lea Trampitsch-Vink*

1 - Bargaining vs. Broadening: Does Procurement too often rely on Negotiations?
Dylan Gellert-Strobl, Nicolas Fugger, Sandra Hartmann

This study examines a critical procurement trade-off: investing in information to improve negotiations or in supplier qualification to foster competition. While theory favors competition, practitioners often overinvest in negotiation tactics. Using expert interviews, a game-theoretic model, and laboratory experiments, we investigate when prioritizing new entrants yields superior returns. By analyzing this strategic decision point, we provide a framework for managers to audit procurement spend and identify the most effective levers for price reduction in large-scale projects.

2 - Gender Differences in Newsvendor Behavior
Murat Kaya, Ümmühan Akbay

We study gender differences in newsvendor ordering behavior. To this end, we conduct human experiments where subjects face the classical newsvendor problem: They make order quantity decisions in the face of stochastic demand. We find female subjects to order lower quantities and achieve lower profits than male subjects, in both low-profit-margin and high-profit-margin treatments. Compared to male subjects, female subjects are shown to use the demand-chasing heuristic more frequently, whereas no conclusive result is obtained on the use of the mean-anchor heuristic.

3 - Is decision inertia a random pattern?
Ayşegül Engin, Verena Dorner

Decision inertia — the tendency to repeat a prior choice regardless of its outcome — may reflect systematic individual patterns rather than random behavior. Using a controlled computerized experiment in sequential decision-making, we investigate key antecedents of this bias: mental fatigue, divided attention, and individual psychometric profiles. We seek to identify for whom, and under what cognitive conditions, decision inertia reliably manifests — informing the design of personalized decision support systems.

4 - Auctions vs. Negotiations: The Role of Communication in an Experiment with Procurement Managers
Nicolas Fugger

We investigate how buyer-supplier communication affects procurement prices, comparing auctions without direct communication to negotiations allowing it. In controlled experiments involving students and procurement professionals, we find communication increases prices, disadvantaging buyers. Negotiation analyses show lower initial offers, negotiation-focused dialogue, and emphasizing competition help reduce prices.

■ TE-58

Tuesday, 14:15-15:45 - Room: HG - Seminar-Raum 08 (Building: HG)

Some Perspectives of IFORS

Stream: Moments in the History of OR and IFORS
Invited session
Chair: *Janny Leung*

1 - Looking back at the history of IFORS and OR
Andrés Weintraub

I will take this opportunity to review what I have seen after decades of work in the OR field. Our generation was the first one to develop operations research in Latin America. We founded the Latin American OR Association and later joined IFORS . There are good stories on how IFORS evolved, how it was viewed in different continents and cultures. At the same time, OR itself changed. Issues appeared, grew and then became less important. Given its history, where is OR headed?

2 - Reflections on INFORMS' recent international activities
Laura Albert

As the 2023 INFORMS President and former Board of Directors member, I have helped shape the INFORMS' global activities during a pivotal time. This talk explores INFORMS' international strategy following the COVID-19 pandemic, examining how we engaged with the global community. Key topics include the hosting of international meetings, support for OR in developing countries, and reflections on IFORS 2023 in Chile. I will share personal stories and insights from my presidency to highlight INFORMS' ongoing commitment to international collaboration.

3 - The Role of IFORS in Global Collaboration for Sustainable OR Impact
Chang Won Lee, Gerhard-Wilhelm Weber

IFORS has long supported the diffusion of operations research (OR) in developing countries through education, capacity-building, and international collaboration. Korea provides a successful example where strong investment in education was translated into industrial and public-sector applications, contributing to national development. This experience shows how educational capacity-building can create sustainable impact. This study also proposes accreditation frameworks for OR-related academic programs in developing countries, with IFORS as a key platform.

4 - Metaphilosophical challenges and conjectures of OR
Leonidas Sakalauskas

OR is a systematic study on the efficiency of the use of funds, resources, personnel and equipment (Gass and Assad, 2005). OR was heavily and effectively used emphasizing the role of game theory and rational decision making in shaping the strategic thinking in politics and business. It is natural to assume that in the current time, when many delicate socio-political challenges have to be dealt with once again, it is important to resort to OR again. The OR conjectures are discussed, overcoming which would allow us to design long-term OR development strategy towards a creative society.

■ TE-59

Tuesday, 14:15-15:45 - Room: KOL - Seminar-Raum 9 (Building: KOL)

Multicriteria ranking: methods and applications

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Nikos Tsotsolas*
Chair: *Athanasios Spyridakos*

1 - An e-DSS for Sustainable Construction Material Selection using MCDA
Nikos Tsotsolas, Athanasios Spyridakos, Yannis Psaromiligkos, Dimitris Papakyriakopoulos, Christos Kytagias, Isaak Vryzidis, Faidon Komisopoulos

This research develops an e-DSS for selecting sustainable refractory and construction materials. Integrating three MCDA methods (WAP, Stochastic UTAdis, MUSA), the system functions as a module in a web-based platform that supports full-path supply chain traceability, using Blockchain to ensure data integrity and transparency. The platform incorporates Life Cycle Assessment and Digital Construction Material Passports to enhance sustainability and circularity. This integrated framework optimizes material selection while providing a robust tool for the construction industry's green transition.

2 - Hybrid PROMETHEE-based mean-risk model for decision-making under risk
Frantisek Zapletal, Robert Hlavatý

In this study, we propose a novel framework that integrates Monte Carlo-based stochastic PROMETHEE with mean-risk modeling. It enables the incorporation of both risk preferences and internal data dependencies into the model. We show that correlations among criteria can substantially affect the ranking of alternatives, particularly under increasing levels of volatility. The experimental results indicate that the proposed approach provides deeper insights into the effects of uncertainty on decision outcomes and enables the differentiation of risk aversion levels.

3 - Fuzzy Belief-Based TOPSIS for Survey Data Analysis: Airline Satisfaction Insights
Marzena Filipowicz-Chomko, Ewa Roszkowska

This paper extends the Fuzzy Belief Structure-based TOPSIS (FB-TOPSIS) framework to analyze survey data measured on ordinal scales while accounting for response uncertainty (e.g., "I don't know"). Respondents' evaluations are aggregated as fuzzy belief distributions over predefined satisfaction levels. The method is applied to TripAdvisor reviews of 25 airlines from the Star Alliance network. The results show that Singapore Airlines, All Nippon Airways, EVA Air, and Air New Zealand rank among the top airlines.

4 - Belief Structure in a New TOPSIS-Based Approach for Rank Aggregation
Tomasz Wachowicz, Ewa Roszkowska

RA-TOPSIS (Rank Aggregation TOPSIS) is a novel method for rank aggregation problems, combining individual rankings from multiple decision-makers into a collective ranking. Based on B-TOPSIS, it integrates a belief structure model and a utility-based similarity measure. Decision-makers are assigned weights reflecting their expertise. The method offers computational simplicity and intuitive interpretation, serving as an alternative to complex optimization models. Its effectiveness is validated through a numerical example.

■ TE-60

Tuesday, 14:15-15:45 - Room: KOL - Seminar-Raum 10 (Building: KOL)

Managing Risk in Insurance and Pension funds

Stream: OR for Insurance, Banking and Financial Risk
Invited session
Chair: *Rita D'Ecclesia*

1 - Key drivers of multipillar pension system stability
Audrius Kabasinskas, Kristina Sutiene, Milos Kopa, Jurgita Cerneviciene, Aušrinė Lakštutienė

In this talk, we introduce key drivers of multipillar pension system (PS) stability. Moreover, we introduce framework to assess the long-term stability of the Lithuanian multi-pillar pension system. Key stability drivers across all three pillars are identified, and statistical evaluation of demographic, macroeconomic, financial, policy, and other factors are discused. A set of formally defined stability indicators is developed to capture short- and long-term risks that modern PS faces. The research has received funding from the Research Council of Lithuania (LMTLT), agreement No S-MIP-25-56.

2 - Risk Parity Portfolios with different risk aversion degrees
Sergio Ortobelli Lozza, Valentina Piantoni

This paper examines the properties and the behavior of risk parity portfolios. In particular, we investigate the structure of the risk parity portfolios under different degrees of risk aversion. We examine Gini-Type risk parity portfolios varying risk aversion and we compare the results with other alternative risk parity strategies. Empirical findings reveal that the optimal balance for risk-adjusted returns is sensitive to both portfolio dimensionality and the investor's specific risk preferences.

3 - Risks, Challenges, and Governance of Artificial Intelligence in Financial Services
Haidar Almohri

Artificial intelligence is reshaping financial services at a pace that has outrun the governance frameworks designed to manage it. This paper examines the full arc of that challenge: the genuine advantages AI delivers, the technical and regulatory obstacles that complicate its deployment, the risk categories that have emerged in practice, and the mitigation strategies that leading institutions are now putting in place. The paper draws on a review of the academic and industry literature alongside primary interview evidence gathered from senior banking executives in Kuwait.

4 - A Study on Systemic Risk Contagion Paths in Multilayer Bank-Real Estate Networks
Shan Li

The intricate interdependence between banking and real estate sectors poses systemic risks, yet traditional models often miss latent contagion channels in multilayer networks. This study proposes a GAE-GAN algorithm with graph structural learning to predict risk paths. the article construct a four-layer multiplex network integrating lending records and news sentiment. The framework employs cross-layer representation learning for robust embeddings, utilized within an SIR model to simulate propagation and identify critical nodes. Empirical results show our method significan.

■ TE-61

Tuesday, 14:15-15:45 - Room: KOL - Seminar-Raum 18 (Building: KOL)

Reporting, Auditing, and Financial Analysis

Stream: OR and Accounting
Invited session
Chair: *Matthias Amen*

1 - Complexity and weaknesses of segment reporting under IFRS 8
Matthias Amen

Segment reporting under IFRS 8 requires the aggregation of similar operating segments into "reportable" segments. Various quantitative criteria are given for aggregation, some of which can be fulfilled alternatively. However, not all operating segments must be assigned to a "reportable" segment. This is therefore a type of knapsack problem. It is necessary to clarify the accounting policy to formulate an objective function. We formulated the binary assignment problem, implemented it using AMPL. Analyzing the solution of a problem instance demonstrates weaknesses in the IFRS 8.

2 - Multiobjective Optimization of Auditor Scheduling and Routing Using NSGA-II
Eliana Maria Gonzalez-Neira, Andrés Santos-Tovar, Dante Lucio Volpedo-Matteucci, Juan José Rojas-Bonilla, Juan Diego Martínez-Roa

This study proposes a MILP model and an NSGA-II integrated into an interface to solve a workforce scheduling and routing problem in which auditors are assigned to client visits under constraints such as at most two visits per day, no weekend work, overnight stays, weekly return home, travel limits, among others. The objectives are to minimize makespan and costs. The MILP provides benchmarks, while NSGA-II solves real instances. The interface visualizes Gantt charts and Pareto fronts. NSGA-II outperforms MILP and the current plan in runtime and objective values.

3 - Financial Distress Warning by Integrating Textual Information: A XGboost + LSTM Based Machine Learning Approach
Ying Wang, Chen Gong

A multidimensional distress identification framework integrating textual disclosures and financial indicators is developed. By employing text mining and natural language processing techniques to extract linguistic features, the focal loss function to mitigate class imbalance issues, and a hybrid XGBoost + LSTM architecture for feature fusion and prediction, this text-enhanced framework is statistically validated using paired t-tests, demonstrating significantly better performances than the financial-data-only baseline model, especially in several typical financial distress scenarios.

■ TE-65

Tuesday, 14:15-15:45 - Room: HG - Hörsaal 27 (Building: HG)

Statistics and Mathematics in the age of Data Science - OR - Analytics II

Stream: Analytics
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Soumen Kumar Das*
Chair: *Jinal Parikh*

1 - Dirichlet Process Mixtures with Mixed Likelihoods via Variational Inference
Lok-Yung Wong

A Bayesian nonparametric mixture model for mixed likelihoods is developed to identify latent structure in mixed-scale survey data. A nonparametric Dirichlet Process prior under a stick-breaking construction specifies an infinite mixture which the number of components is inferred from the data, providing a deterministic and computationally efficient approximation to the posterior. Each cluster observations has its own specific likelihood distribution derived from the appropriate data type and is connected through one latent cluster indicator for all heterogeneous observations in the datasets.

2 - Nonlinear Data Integration via Kernel Methods for Data Collaboration Analysis
Yamato Suetake, Shunnosuke Ikeda, Yuichi Takano

Data collaboration analysis is a framework for collaborative analysis of distributed datasets without sharing the original data. In conventional approaches, each party first applies linear dimensionality reduction to obfuscate its data, then shares the resulting representations with an analyst, who then integrates the data using linear functions. We propose a kernel-based nonlinear integration method for data collaboration analysis. The proposed method enables data integration after nonlinear dimensionality reduction, improving data confidentiality in distributed data analysis.

3 - Quantitative Evaluation of Synergy Generated from Node Merging in Networks Using PageRank
Kazuki Kokubo, Hiroyuki Masuyama, Hiroshige Dan

In cases such as M&A and joint research, collaborative work can achieve better results than individual work. This effect is commonly called "synergy," and its quantitative evaluation in advance of collaboration would be difficult. In this study, we propose a method to quantify synergy using the framework of network analysis. Specifically, collaboration is modeled as node merging in a network, and the synergy is quantified by the difference in PageRank values before and after the merger. Through numerical experiments, we identified the characteristics of merging nodes that generate the synergy.

4 - Large Language Model Assisted Supply Chain Mapping
Cemalettin Ozturk, Bengisu Şahin, Emrah Inan

Modern supply chains are now spread across countries and consist of multiple tiers, which makes it difficult for firms to clearly understand their full structure. As a result, mapping supply chains and identifying hidden dependencies are critical for building resilient and sustainable supply chains, since this helps reduce fragmentation and improves overall visibility. In the proposed framework, entity recognition and relation extraction are handled as two consecutive tasks within an electric vehicle supply chain. We provide experiments to demonstrate the effectiveness of the framework.

■ TE-66

Tuesday, 14:15-15:45 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Applied Quantum Optimization

Stream: Quantum Optimization
Invited session
Chair: *Thorsten Koch*

1 - An iterative approach for solving the Traveling Salesman Problem with classical and quantum optimization
Alessia Ciacco, Luigi Di Puglia Pugliese, Francesca Guerriero

The Traveling Salesman Problem is a classical NP-hard combinatorial optimization problem, where a key challenge is the large number of subtour elimination constraints required for feasibility. We adopt an iterative approach, based on well-established Operations Research techniques, where subtour constraints are generated dynamically and combined with preprocessing to reduce arcs. We evaluate classical and quantum methods. Results show reduced model size and improved performance, demonstrating quantum approaches benefit significantly from these techniques over formulations without them.

2 - Computational Performance of QAOA to Optimize Mesh Networks for Disaster Preparedness
Emily Tucker, Jack Layton

We consider the motivating problem of prepositioning a mesh network of radio nodes in mountainous terrain prior to a disaster. A practical challenge is the obstructive effects of topology on the signal. We develop a mesh network design optimization model and implement the Quantum Approximate Optimization Algorithm (QAOA) as a heuristic. We evaluate QAOA's computational performance under different objective functions and warm-starting strategies across realistic terrain and equipment parameter settings. Analyses are conducted on quantum hardware as well as compared with classical simulations.

3 - Integrating Learned Risk Assessment into Staffing Optimization Models for a Hybrid Quantum Solver
Mansour Zarrin, Matthew Woolway

This article presents an optimization framework for multi-project staffing using integrated surrogate risk predictions. It allocates fractional full-time equivalents (FTEs) while satisfying capacity, project, and risk budget requirements. Given that project risk is often nonlinear, the approach constructs staffing-based features and embeds a trained multilayer perceptron (MLP) into the model. Optimized by the D-Wave Stride Hybrid Solver, the framework is detailed through mathematical formulations and a practical illustrative example.

4 - A Quantum Annealing Approach for the Unrelated Parallel Machine Scheduling Problem with Restrictive Due Dates
Miguel Ángel Chávez Robles, Yasmín Águeda Ríos Solís, José Andrés García González

This research develops a quantum ready framework for the Unrelated Parallel Machine scheduling problem with a restrictive due date. We reformulate the quadratic model into a Quadratic Unconstrained Binary Optimization framework for Quantum Annealing. The study addresses just-in-time industrial dynamics where classical solvers face non-convexity bottlenecks. By mapping discrete constraints into penalties, the system navigates energy landscapes via quantum tunneling. Preliminary results using quantum simulators validate the reformulation and benchmarks solutions against solvers like Gurobi.

■ TE-67

Tuesday, 14:15-15:45 - Room: KOL - PC Raum 3 (Building: KOL)

Optimization and Equilibrium Modeling in Energy: Part 2

Stream: Energy Markets & Systems
Invited session
Chair: *Steven Gabriel*
Chair: *Dominic Flocco*

1 - Stochastic Bilevel Optimization with Convex User Equilibrium Model: Reformulation and Application to Infrastructure Investment
Miguel Lejeune

We consider a stochastic bilevel network design optimization problem in which the lower-level problem is a user equilibrium model with a power function objective. We derive a new equivalent, convex, and single-stage reformulation of the problem. The proposed framework is motivated by an infrastructure investment problem with uncertainty due to the rise of the sea level and possible flooding.

2 - Do power markets provide the right investment incentives? Enabling detailed experiments with a new scalable decomposition algorithm for stochastic equilibrium problems
Emil Dimanchev, Filippo Pecci, Jesse Jenkins

Stochastic equilibrium models are increasingly used to analyze the ability of electricity markets to incentivize investment decisions that meet efficiency, reliability, and sustainability goals. However, computational constraints limit the usability of existing models. We introduce a new scalable decomposition algorithm for stochastic equilibrium problems. Our method solves faster than the existing state-of-the-art ADMM-based approach. It also comes with a convergence guarantee and addresses the problem of multiple equilibria by enabling systematic exploration of possible equilibria.

3 - A Successive, Proximal DC Penalty Method with Application to Mathematical Programs with Complementarity Constraints
Dominic Flocco, Steven Gabriel, Trine Krogh Boomsma, Martin Schmidt, Miguel Lejeune

We develop a successive, proximal difference-of-convex function (DC) penalty method for solving DC programs with DC constraints, and specialize the framework to mathematical programs with complementarity constraints (MPCCs). Numerical experiments on MPCCs arising from bilevel optimization show that the proposed method, referred to as SPDCA, reliably computes feasible solutions and achieves competitive solution quality, while often requiring significantly less runtime than conventional mixed-integer formulations.

4 - Grid Code Refinement in the Provision of Ancillary Services
Torine Reed Herstad, Jalal Kazempour, Lesia Mitridati, Steven Gabriel

System operators are introducing grid codes to allow the participation of stochastic technologies in reserve markets. In Denmark, the transmission system operator (TSO) implemented a reliability threshold on reserve provision; this requirement provides a clear participation criterion, but it does not account for the trade-off between procurement costs and the cost of reduced grid reliability. We investigate the optimal design of reliability by using bi-level optimization framework which models the interaction between the TSO and stochastic generation in the context of reserve procurement.

Tuesday, 16:15-17:45

■ TF-01

Tuesday, 16:15-17:45 - Room: HG - Audimax

Keynote Beril Toktay

Stream: Keynotes
Keynote session
Chair: *Kevin Tierney*

1 - Operations Research for Sustainability and Resilience in the Age of AI
L. Beril Toktay

The operations research community has long developed methods for optimizing complex systems under uncertainty. Today, two of the most consequential systems challenges demand these capabilities simultaneously: the rapid buildout of AI infrastructure is reshaping energy, water, and land systems faster than governance can adapt, while climate-intensified hazards are compounding across interdependent infrastructure networks in ways that single-hazard models cannot capture. This talk makes the case that sustainability and resilience present consequential problems in optimization and decision-making under uncertainty. Drawing on emerging work at Georgia Tech and partner institutions, I illustrate how these frontiers are being pursued through interdisciplinary teams that pair optimization and machine learning with community partnerships and argue that the OR community must expand its conception of decision support to include the participatory governance structures through which sustainability decisions are made.

■ TF-04

Tuesday, 16:15-17:45 - Room: HG - BIG-Hörsaal (Building: HG)

Operating room planning / surgery scheduling

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Gréanne Leeftink*

1 - Integrated operating room scheduling and reusable medical device management: a column generation approach
Elif Yenilmez, Elvin Coban

This study addresses the integrated scheduling of surgeries and the sterilization of reusable medical devices in a multi-OR, multi-day setting. While prior work treats these separately, the proposed model jointly optimizes surgery assignments, sterilization, and preventive maintenance. A Dantzig-Wolfe decomposition is applied, where each subproblem models a device lifecycle via dynamic programming. Branch-and-price recovers integer solutions. Experiments on instances with up to 375 surgeries show the method scales beyond compact formulations. TUBITAK funded this research under Grant No:125M591

2 - Surgeon-in-the-Loop Decision-Aware Learning for Operating Room Planning
Borzou Rostami, Roham Bahri, Vahid Roshanaei

We study elective operating room planning with uncertain surgery durations, treating surgeon-booked times as strategic reports rather than noisy forecasts. We develop an inverse optimization approach to infer surgeons' reporting incentives, a piecewise-linear model of surgeon adjustments, and an exact bilevel learning-and-optimization framework

that anticipates both editing and planning decisions. We also establish theoretical properties of the model and report computational results demonstrating that the framework can preserve private information while reducing downstream costs.

3 - A Robust Rolling Horizon Approach for Surgical Scheduling: Spatial Constraints and Real-Time Repair
Marc Chouraqui, Salma Makboul, Alice Yalaoui, Farouk Yalaoui, Lionel Amodeo, Virginie Roger

Operating room schedules face severe daily disruptions. We propose a Robust Rolling Horizon Framework to balance operational efficiency and schedule stability. Using data from the Hôpital Européen in Marseille, we compare five scheduling strategies combining varying structural constraints (e.g., room clustering) and temporal buffers. Our findings demonstrate that spatial restrictions, often viewed as inefficiencies, actually enhance practical robustness. We also introduce specialized reactive operators to enable fast, real-time schedule repair in complex surgical environments.

4 - The problem of operating-room scheduling: Exploring the gap between theory and practice
Gréanne Leeftink

Analytical decision-support methods promise improved planning and control in operating theaters, yet many fail to gain traction in practice. We combine insights from MS/OR literature with evidence from 9 hospitals and identify 6 mismatches between models and reality, including ambiguous objectives, dynamic environments and underdefined constraints. While core problem structures hold, these factors challenge optimization-based approaches. We propose relevant design principles emphasizing flexibility, coordination and satisficing, to strengthen alignment between scheduling theory and practice.

■ TF-05

Tuesday, 16:15-17:45 - Room: JUR - Hörsaal 18 (Building: JUR)

Battery Swapping and Rebalancing in Shared Micromobility

Stream: Shared Mobility
Invited session
Chair: *Sin C. Ho*

1 - Optimizing Battery Swapping and Bike Repositioning Strategies for Station-Based Electric Bike-Sharing Systems
Jia Cui, Wai Yuen Szeto, Yue Wang

This study addresses the joint optimization of e-bike relocation and battery swapping within a station-based electric-bike sharing system (EBSS). The problem is formulated as a mixed-integer linear program that minimizes the sum of user dissatisfaction, vehicle usage, travel, and handling costs, with vehicle capacity for batteries treated as a decision variable. A hybrid genetic algorithm with two problem-specific strategies is developed to efficiently solve large instances. Numerical results demonstrate its scalability and performance, offering practical insights for EBSS operators.

2 - Optimizing Bike Relocation and Battery Swapping Operations in Mixed Free-Floating Bike-Sharing Systems: A Coordinated Truck-and-Worker Operation Approach
Jia Cui, Mingxuan Chen, Wai Yuen Szeto

This study investigates an integrated rebalancing and battery-swapping problem in mixed free-floating bike-sharing systems. A strategy that coordinates trucks and worker for simultaneous bike relocation and battery swapping is proposed to minimize the sum of unsatisfied demand penalty costs, travel time costs, and service time costs. Numerical experiments show the enhanced flexibility of this strategy compared to existing methods, while the sensitivity analysis reveals key properties of the problem. An iterative solution approach is developed for efficient applications to large networks.

3 - A destroy and repair algorithm for the static multi-vehicle bike-repositioning problem with e-bikes
Sin C. Ho, Wai Yuen Szeto

This talk addresses the multi-vehicle bike-repositioning problem involving electric bikes and battery swapping, a pick-up and delivery vehicle routing problem that arises in connection with bike-sharing systems. We propose a destroy and repair algorithm for solving the problem. The heuristic is evaluated on instances with up to 200 stations and three vehicles. The results of the computational experiments are promising.

■ TF-06

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 07 (Building: HG)

Demand Forecasting in Retail

Stream: Retail Operations
Invited session
Chair: *Sandra Zajac*

1 - Recoding alternative-specific choice designs to generic choice designs for estimating preferences and willingness to pay: An illustration for electric vehicles
Winfried Steiner, Anastasia Mirow, Peter Kurz

Alternative-specific designs (ASD) allow the construction of more realistic choice situations in choice-based conjoint (CBC) studies. Yet, CBC studies based on ASDs result in complex models with a large number of parameters. Further, related willingness-to-pay calculations become less straightforward. To overcome these issues, we suggest recoding the ASD design prior to model estimation to a generic design. We compare both approaches for goodness-of-fit, predictive accuracy, shares-of-choice predictions and willingness-to-pay implications, using the mixed logit model for parameter estimation.

2 - The joint effects of a promotion on store traffic, conversion and expenditure: a prediction approach with subject-specific covariates.
Leonardo Epstein, Ignacio Inostroza-Quezada

We introduce a prediction approach to evaluate retail promotion effects on arrival traffic, conversion probabilities, and expenditures. We use a 3D stochastic process featuring shopper-specific arrival times, a filtered-marked process for conversions, and spending per conversion. With non-promotion data and regression models, we build counterfactual baselines to predict performance as if no promotion occurred. This method avoids direct promotion modeling, controls for covariates, and measures effects on observable quantities. We illustrate using video and register data.

3 - Robust Baseline Sales Forecasting for Large-Scale Retail Time Series
Güneş Altıner

Retail demand forecasting is difficult when sales are distorted by unlabeled promotional effects and abrupt fluctuations. This study proposes a robust baseline sales forecasting framework for retail time series with over 1 million store-item pairs observed over approximately three years. After robust preprocessing to suppress irregular shocks while preserving seasonal patterns, the framework segments the series based on recent average sales volumes. It then trains cluster-specific LSTMs for forecasting. The framework estimates no-promotion sales for the next months to support supply planning.

4 - Prediction Performance-based Grouping for Bubble Federated Learning in Retail Demand Forecasting
Hinata Moriyama, Jingqi Wu, Hayato Watanabe, Ochi Daito, Hayato Kawata, Shuto Kanai, Ryohei Daniel Niklai, Daichi Yokota, Ken Kobayashi, Kazuhide Nakata

Federated learning (FL) enables model training without sharing raw data, but heterogeneous client data can degrade the standard FedAvg performance. Bubble-based FL has been proposed to address this issue by allowing clients to form bubbles with selected clients. We extend this framework with an accuracy-based bubble construction using local search for demand forecasting. We also quantify client contributions to the bubble model based on model performance. Experiments show that our method outperforms local models and other FL methods, achieving accuracy close to models trained on shared data.

■ TF-07

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 21 (Building: HG)

Robust Mechanism Design

Stream: Auctions and Market Design
Invited session
Chair: *Halil Bayrak*

1 - Mechanism Design with Correlated Information
Daniil Larionov, Bruno Strulovici, Takuro Yamashita

We consider mechanism design problems in which the designer observes a signal that is correlated with agents' private information and faces standard Bayesian incentive compatibility and participation constraints. We study how correlation affects the structure of optimal mechanisms and develop a general framework for analyzing implementability in these environments. The analysis examines how correlated information shapes the trade-offs between surplus extraction, allocative efficiency, and revenue maximization in mechanism design problems.

2 - Envy-free Pricing of Seats in a Planetarium
Freija van Lent, Julian Golak, Alexander Grigoriev

We examine envy-free pricing for revenue maximization in concentric venues, such as planetaria. Customers have unit demand, a preferred seat and valuation decreases with distance from the center. The operator sets non-discriminatory prices to maximize revenue while ensuring an envy-free allocation. For a continuous version where all customers prefer the same seat, we develop a dynamic programming algorithm providing a 1/(1+epsilon)-approximate solution in polynomial time. For discrete layouts, we show connections to lattice theory and develop a pseudo-polynomial dynamic programming solution.

3 - Distributionally Robust Contract Design with Deferred Inspection
Halil Bayrak, Martin Bichler

A principal allocates a scarce resource to an agent, observes the agent's realized outcome ex post at no cost, and conditions transfers on this information through rewards. The principal faces ambiguity about the agent's value distribution and seeks to maximize her worst-case expected revenue. When the ambiguity set is defined by the first moment, we identify a robustly optimal contract with a concave allocation rule and a linear payment rule. Robustness does not uniquely pin down transfers, so we also construct a Pareto robustly optimal contract that extracts the maximal feasible payments.

■ TF-08

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 41 (Building: HG)

Location Theory and Methods

Stream: Location Analysis
Invited session
Chair: *Alberto Torrejón Valenzuela*

1 - On a Class of Nonlinear Facility Location Problems
Yiming Hou, Oleg A. Prokopyev, Bismark Singh, Tarkan Tan

We study a class of nonlinear facility location problems motivated by the siting of recycling centers. The proposed model aims to balance user accessibility while accounting for capacity congestion and user choice behavior. We analyze the structural properties of the model and develop exact and heuristic solution methods. Preliminary computational experiments on real-life data illustrate the value of the proposed modeling approach, its managerial implications, and the performance of solution methods.

2 - Revisiting transportation problems under Monge costs with applications to location problems
Simon Ramoser, Stefan Nickel, Justo Puerto, Alberto Torrejón Valenzuela

We investigate the transportation problem under a Monge cost structure and derive compact expressions for optimal dual solutions based on the northwest-corner rule. These expressions can be exploited to obtain structural insight and efficient algorithmic schemes for larger models. To illustrate this potential, we apply them to a class of facility location problems and develop new formulations using Benders decomposition. Computational experiments indicate strong performance across a range of instances.

3 - Bi-objective p maximal cover - p center problem. An application to ambulance location in Spanish rural areas.
Jesus Alberto Tapia, Juan Camilo Yepes-Borrero, Jesús M. Sáez-Aguado, Javier Sáez-Gallego

The Maximum Covering Location Problem (MCLP) locates p facilities to maximize demand within a critical distance dc. Its extension ensures every demand point lies within a maximum distance dmax, whose minimum equals the p-center solution. We study a bi-objective model combining coverage (efficiency) and p-center (equity). The efficient frontier is obtained via the ϵ-constraint method. A compact formulation reduces complexity and enables exact solutions, outperforming the classical model in a large Spanish case.

4 - The Optimal Order of Things
Alberto Torrejón Valenzuela, Víctor Blanco, Ivana Ljubic, Miguel Angel Pozo, Justo Puerto

Many optimization problems require aggregating outcomes associated with multiple agents, locations, or scenarios. We present a unified framework based on ordered measures, where outcomes are sorted before aggregation. This approach provides a flexible way to model different decision attitudes. We illustrate its use in location problems, including fair and obnoxious settings. Finally, we briefly discuss extensions of the framework to vehicle routing problems and robust linear regression, highlighting the versatility of ordered measures in optimization.

■ TF-09

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 50 (Building: HG)

From Decisions to Explanations: Optimization in Explainable Artificial Intelligence II

Stream: Data Science meets Optimization
Invited session
Chair: *Lukas Gosch*

1 - A multi-objective analysis for fairness-performance trade-offs in random forests
Guilherme Pelegrina, Edward Abel, Sajid Siraj

Multi-objective analysis offers a principled way to address fairness-performance trade-offs in machine learning. We propose a modification of Random Forests where individual decision trees are evaluated using both predictive performance and fairness metrics. A pool of trees is generated and analysed through Pareto dominance to identify non-dominated solutions, which form the final ensemble. Experiments show that selecting the trees that compose the non-dominated solutions improves fairness while maintaining competitive predictive performance.

2 - Structuring AI Adoption in Supply Chains: A DEMATEL-Based Study of SMEs in Eastern Europe
Dominik Berbig, Katarzyna Mroczek-Dąbrowska, Aleksandra Kania

Artificial intelligence offers significant optimization potential in supply chains; however, many firms lack a structured decision logic for prioritizing and sequencing AI adoption, particularly SMEs. This study proposes a systematic roadmap for AI implementation in logistics and evaluates it using DEMATEL-based causal analysis. Survey data from over 40 Eastern European companies identify key interdependencies, adoption barriers, and leverage points, providing actionable guidance particularly for SMEs seeking a coherent and resource-efficient AI implementation path.

3 - Provable Robustness of (Graph) Neural Networks Against Data Poisoning Using Neural Tangent Kernels and Mixed-Integer Linear Programming
Lukas Gosch, Mahalakshmi Sabanayagam, Debarghya Ghoshdastidar, Stephan Günnemann

The performance of machine learning models can be severely compromised by data poisoning, where adversarial changes are applied to the training data. This has led to interest in certifying (i.e., proving) that such changes up to a given magnitude don't affect test predictions. We show how bilevel and Mixed-Integer Linear Programming (MILP) can be leveraged to derive the first architecture-aware poisoning certificates for Neural Networks (NNs), and present results on graph learning tasks. More broadly, under certain assumptions, our methodology enables the integration of NN training into MILPs.

■ TF-10

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 31 (Building: HG)

Metaheuristics and learning-driven optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Jin-Kao Hao*

1 - Advanced Tabu Search for the Multi-depot Heterogeneous Vehicle Routing Problem with Backhauls
Wenjie Hu, Yang Wang, Rafael Marti, Anna Martínez-Gavara

This paper studies the Multi-Depot Heterogeneous Vehicle Routing Problem with Backhauls, motivated by large-scale distribution systems with multiple depots and diverse vehicle fleets. We propose a learning-enhanced tabu search with long-term memory, combining greedy randomized initialization, memory-based intensification and diversification, post-optimization of routes and vehicle types, and probability updating guided by high-quality solutions. Experiments on 144 benchmark instances show that the method outperforms state-of-the-art algorithms and produces 120 new best known solutions.

2 - Approaching the Dynamic Electric Autonomous Dial-a-Ride Problem with Large Neighborhood Search and Reinforcement Learning
Laurenz Tomandl, Maria Bresich, Günther Raidl, Yi Mei, Steffen Limmer, Tobias Rodemann

The Dynamic Electric Autonomous Dial-a-Ride Problem addresses shared real-time passenger transport from request-specific origins to destinations. Large Neighborhood Search (LNS) heuristics achieve state-of-the-art results for the static variant of this problem in which all information is given upfront. We extend this framework to the dynamic setting by controlling waiting times and the priorization of charging with a neural network trained by reinforcement learning. Experimental results show that our new approach consistently outperforms outperform the existing baseline approaches.

3 - A reinforcement learning based adaptive large neighborhood search for the multi stage cooperative agricultural machinery scheduling problem
Zequn Wei, Junhao Li, Yawen Li, Mengyu Zhuang, Suyao Kong

Large scale farming often involves scattered fields and sequential harvesting, plowing, and seeding operations, creating a need for coordinated machinery scheduling. We study a multi stage cooperative agricultural machinery scheduling problem with heterogeneous machines, synchronization constraints, and precedence across stages. A makespan minimization model is formulated, and a reinforcement learning based adaptive large neighborhood search is developed to adapt operator choice during the search. Computational results demonstrate clear advantages over the Gurobi solver.

4 - Hash-based Dual Probabilistic Tabu Search for the Job-Shop Scheduling Problem with Blocking and No-swap Constraints
Yunlong Huang, Qinghua Wu, Jin-Kao Hao, Mingjie Li

The Job Shop Scheduling Problem with Blocking and No-swap Constraints is an important, challenging classical variant. To address it, we develop a disjunctive model and a novel hash-based dual-probabilistic tabu search algorithm. The model delivers optimal solutions for 15 benchmarks, 10 being first proven optimal. Comprehensive tests on 120 benchmarks show the algorithm outperforms all state-of-the-art heuristics: it sets new best upper bounds for 98 instances and matches known optimal solutions for the remaining 22. Further analysis of its components deepens insights into effectiveness.

■ TF-11

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 32 (Building: HG)

Sustainable food systems I

Stream: OR in Natural Resources
Invited session
Chair: *Sonja Rohmer*
Chair: *Marjolein Buisman*

1 - Integrating Circular Economy Practices for Sustainable Profitability: A Simulation-Optimization Approach in Cocoa Cooperatives
Sofía Castro, Katherinne Quiroga-Duran, Andres Medaglia

In agro-industrial systems, competitiveness requires jointly addressing profitability and sustainability, motivating the evaluation of circular economy strategies in a cocoa cooperative through by-product valorization and reintegration into agricultural production. To assess their economic impact, we propose a combined simulation-optimization approach based on a mixed-integer linear programming model under price and yield uncertainty. Results quantify profitability and risk trade-offs across sustainability scenarios.

2 - Channel Selection in Agricultural Supply Chains: Managing Yield Uncertainty, Aesthetic Requirements, and Producer Information
Mirjam Meijer, Nina Mayer, Sandra Transchel

Selecting sales channels is a challenging decision for farmers, where uncertainties regarding crop yield and requirements imposed by retailers play an important role. We analyze farmers' channel choices and pricing decisions, considering demand uncertainty and yield uncertainty, regarding both quantity and esthetics. We explore the viability of a dual-channel strategy, and its impact on contractual agreements with retailers. We develop a game-theoretical modeling framework to examine the optimal channel choice of a farmer and, if applicable, the associated wholesale-price contract.

3 - Managing nearly expired products: A data-driven approach to reducing food waste in retail
Marjolein Buisman, Andreas Holzapfel

Retailers of perishable goods face a trade-off between high product availability and food waste. We study end-of-life inventory decisions for products approaching expiration, including regular sales, price discounts, third-party platform sales, and donations. We model the problem using deep reinforcement learning and train a Soft Actor-Critic agent to dynamically allocate nearly expired inventory across these options. Compared with rule-based heuristics, the learned policy achieves superior economic performance while reducing waste and adapting to product characteristics and retail preferences

4 - Designing Sustainable Menu Plans: Exploring Trade-offs Between Cost, Acceptability and Environmental Impact
Francisco Martos-Barrachina, Laura Delgado Antequera, Monica Hernandez

Sustainable food systems require diets that balance environmental impact, affordability, and consumer acceptance. This study addresses the Menu Planning Problem through a multiobjective optimization model that generates nutritionally adequate menus consistent with Mediterranean dietary patterns. Sustainability is assessed through greenhouse gas emissions, while palatability is approximated using a similarity function based on observed eating habits. A metaheuristic approach explores the efficient frontier, revealing trade-offs between cost, environmental impact, and acacceptability in reality.

■ TF-12

Tuesday, 16:15-17:45 - Room: JUR - Hörsaal 11 (Building: JUR)

Intra-Hospital Patient Routing and Scheduling

Stream: Health Care Logistics
Invited session
Chair: *Yang Wang*

1 - Real-time scheduling for outpatients with multiple diagnostic tests
Yang Wang, Yanan Zhu, Junpeng Wang, Erik Demeulemeester, Abraham Punnen

This study addresses the real-time scheduling problem for outpatients requiring multiple diagnostic tests in a clinical appointment setting. At each decision point, the problem involves routing an idle patient to the next test and assigning the next patient to an available device, with the objective of minimizing total patient waiting time. We propose a genetic programming approach to generate scheduling rules for these decisions. Using real data from a partner hospital, we evaluate the proposed approach against both the hospital's scheduling practice and literature methods.

2 - Collaborative Scheduling of Multi-Department Beds and Operating Rooms under Uncertainty
HongPu Wang, Yang Wang, Xiaolan Xie, Yong-Hong Kuo, Junhong Long

This paper studies collaborative scheduling of multi-department beds and operating rooms under uncertainty, where the modified operating room blocks policy and clustered overflow beds configuration are incorporated to improve utilization. A rolling-horizon framework is developed to capture intertemporal dependence and the optimizational model is solved using a logic-based benders decomposition algorithm. Extensive experiments show that the proposed approach improves computational efficiency, enhances the robustness of surgery schedules, and increases healthcare resource utilization.

3 - Surgery Scheduling with Surgeon-Team Familiarity: A Distributionally Robust Optimization Approach with Endogenous Uncertainty
Xiaoyue Gong, Jian-Jun Wang, Huan Zhuang

The collaboration between the surgeon and the supporting team is a key determinant of surgery duration. We propose a Distributionally Robust Optimization framework that models surgery duration as an endogenous uncertain parameter dependent on the surgeon-team assignment. The model jointly optimizes the assignment of surgical teams to cases and the sequencing of surgeries within operating rooms. A tailored Branch-and-Price algorithm is developed to solve this complex problem effectively. Numerical results highlight the value of considering team familiarity in robust surgery scheduling.

■ TF-13

Tuesday, 16:15-17:45 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Parallel Optimization Software

Stream: Software for Operations Research
Invited session
Chair: *Yuji Shinano*

1 - Multicores, Manycores, GPUs, HPC, and Quantum: Wishes, hopes, and reality. An Overview.
Thorsten Koch

It seems obvious to say "big problems need big computers." However, in practice, utilizing high-performance specialized computers to solve a particular problem can be challenging. We report on our experience over the last two decades to achieve "fast algorithms on fast computers", the overall state of affairs, and how to benchmark digital and quantum computers.

2 - Solving hard MIP instances on Supercomputers by using Smoothie
Yuji Shinano, Stefan Vigerske

The UG Framework is a software framework to parallelize state-of-the-art solvers. Based on UG, SCIP and its customized solvers for Steiner tree problems, QUBOs, and Pseudo-Boolean optimization have been parallelized. With the recently released version 1.0.0, the extended mechanisms that control parallelization allow to develop ensemble solvers, in which different solvers join hands to solve a single problem together in parallel. In this talk, we present the latest progress of Smoothie, which uses commercial solvers Xpress and Gurobi to jointly solve hard MIP instances.

3 - Massively Parallel and Distributed Solvers for Domain-Independent Dynamic Programming
Ryo Kuroiwa, Yuji Shinano, J. Christopher Beck

We develop distributed parallel general-purpose solvers for combinatorial optimization through the framework of domain-independent dynamic programming (DIDP), a model-based paradigm based on dynamic programming. In particular, we propose distributed parallel state space search algorithms to develop such solvers. We demonstrate the scalability of our solvers using up to 186.4 TB of RAM and 49152 CPU cores, while previous work has used up to 10.5 TB and 2400 cores. Using the developed solvers, we close open instances in the shared benchmarks of combinatorial optimization problems.

4 - Computational Insights into Solving Optimization Instance Sets with MIP Solvers on Multi-Core Hardware
Willi Leinen, Andreas Fink, Philipp Neumann

High-performance computing systems offer ever-increasing core counts, yet most mixed-integer programming (MIP) solvers still rely on limited shared-memory parallelism with only modest speedups beyond a few cores. Many decision-support applications, however, require solving large collections of MIP instances. This talk reports on computational experiments with leading MIP solvers for managing such workloads on modern multi-core CPUs, offering practical guidance on thread allocation, degrees of job-level parallelism, and solver configurations to improve throughput and energy efficiency.

■ TF-14

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 01 (Building: HG)

Integrated Lot Sizing Models

Stream: Lot Sizing, Lot Scheduling and Production Planning
Invited session
Chair: *Wilco van den Heuvel*

1 - Integrating Production Lot and Returnable Transport Item Fleet Sizing: An Open-Lot Approach
Marion Lemke, Heinrich Kuhn

Sustainability considerations and regulatory requirements are driving the adoption of returnable transport items (RTI) in supply chains. Determining the optimal RTI fleet size is a strategic decision with substantial cost and process effects. As fleet and lot sizes are interdependent, an integrated approach early in the product life cycle is required. This study presents a mixed-integer nonlinear programming model for joint lot and fleet sizing under an open-lot strategy. Automotive case studies show notable cost-saving potential and confirm the model's practical and managerial relevance.

2 - Solving the Lot-sizing and Parallel Machine Scheduling Problem in Co-production Systems
Eyüp Ensar Işık, Semra Agrali, Z. Caner Taşkın

In co-production systems, different products are produced simultaneously in the same production process. Co-production is strongly related to the circular economy, which aims to minimize waste and the use of raw materials. This study proposes novel MIP formulations to solve the lot-sizing and parallel machine scheduling problem in co-production systems, thereby significantly reducing raw material consumption and environmental impacts. Finding optimal production plans establishes a collaborative framework that can be covered through industrial symbiosis and enables sustainable development.

3 - A hybrid inventory policy for non-stationary lot-sizing problems with lateral transshipment
Xiyuan Ma, Roberto Rossi, Thomas Archibald

We study a non-stationary stochastic lot-sizing problem with two stocking locations. Each period, proactive lateral transshipment precedes warehouse replenishment, followed by demand fulfilment. Costs include fixed and unit transshipping, ordering, holding, and backordering. We minimise expected total cost via stochastic dynamic programming, using a two-stage decomposition to separate transshipment and replenishment decisions and reduce computational cost. A MILP-based receding-horizon heuristic yields near-optimal policies, which are validated by computational experiments numerically.

4 - Adaptive large neighborhood search for the integrated production and distribution problem with order consideration and cargo arrangement
Giovanna Abreu Alves, Guilherme Tonon, Victor Claudio Bento Camargo

This study addresses an integrated production and distribution planning problem in textile manufacturing, incorporating order fulfillment and cargo arrangement. A mixed-integer programming model is proposed that accounts for critical operational constraints, including item grouping within orders, sequence-dependent and carryover setups, and pallet loading. Given the NP-hard nature, an Adaptive Large Neighborhood Search with tailored destroy operators is developed to obtain near-optimal solutions. Results confirm their effectiveness and computational efficiency for complex planning problems.

■ TF-15

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 34 (Building: HG)

Information and Calibration in Human-AI Interactions

Stream: Algorithmic Game Theory
Invited session
Chair: *Yiding Feng*

1 - Beyond the Black Box: Unraveling the Role of Explainability in Human-AI Collaboration
Caner Canyakmaz, Tamer Boyaci, Francis de Véricourt

We develop an analytical model examining how explainable AI influences human reliance and cognitive effort by integrating limited yet flexible human cognition with imperfect algorithmic predictions and explanations that reflect their quality. We find that low explainability reduces cognitive effort without affecting accuracy, whereas high explainability improves accuracy by mitigating overreliance but increases underreliance. Surprisingly, although gains are larger under cognitive limitations and task complexity, high explainability can raise overall cognitive burden and induce user fatigue.

2 - Confusion Matrix Design for Downstream Decision-Making
Yiding Feng, Liuhan Qian, Wei Tang

We initiate the study of confusion matrix design, where a designer chooses a classifier's stochastic confusion matrix to guide heterogeneous decision makers who take binary actions based on context, prediction, and the matrix. The goal is to maximize a general net utility combining designer & agents' payoffs under feasibility constraints. Viewing model training as constrained information design, we connect the problem to public persuasion and develop convex programming algorithms under post-processing and ROC constraints, along with structural and numerical insights.

3 - Dynamic Learning in Human-Machine Decision Making Under Uncertainty
Huseyin Gurkan, Francis de Vericourt, Benjamin Legros

We study dynamic learning in human-machine decision making when the reliability of algorithmic recommendations is uncertain. A decision maker repeatedly chooses whether to rely on human judgment or follow a machine's recommendation while gradually learning about the machine's effectiveness from observed outcomes. For two environments that differ in the decision maker's ability to use information, we characterize the resulting decision policies and the evolution of trust in machines.

4 - The Impact of Algorithmically Rational AI on Evolutionary Consensus
Jingyu Lv, Yuanxiang Dong, Luqi Wang, Shuning Pan, Hangyang Li

Strategic interactions among heterogeneous agents shape consensus formation in complex networks.This study models the consensus reaching process (CRP) as a networked public goods game.Boundedly rational human agents rely on pairwise comparison opinion adjustments, whereas algorithm-driven AI agents perform systematic adjustments to improve consensus.Simulation results show that the presence of AI agents mitigates the free-riding behavior observed in purely human networks, with the AI-to-human proportion acting as a critical determinant of consensus formation.

■ TF-16

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 42 (Building: HG)

Branch-and-price and column generation approaches for routing problems I

Stream: Vehicle Routing and related problems
Invited session
Chair: *Noémie Cartier*

1 - Bucket-Based Column Generation for Nested Path Problems
Bart van Rossum, Rolf Van Lieshout, Alexandre Jacquillat

We propose bucket-based column generation for nested path problems, where columns decompose into subpaths. Instead of enumerating non-dominated subpaths, we partition the subpath space into buckets and price using one representative per bucket. The algorithm alternates between pessimistic and optimistic pricing, yielding upper and lower bounds on the minimum reduced cost, respectively. Bucket refinement ensures finite convergence to optimality. We demonstrate computational gains on balanced multi-period vehicle routing instances and investigate the impact of refinement and merging strategies.

2 - A Branch-and-Price Framework for the Home Health Care Routing and Scheduling Problem with Synchronized Services
Xiangjun Cao, Carlos Lamas-Fernandez, Stephan Onggo

The Home Health Care Routing and Scheduling Problem assigns caregivers to patients at their homes under operational constraints. Some patients require simultaneous care from multiple caregivers, creating synchronized services. A key difficulty arises when multiple synchronized services occur within a caregiver's route, which makes timing decisions highly interdependent. We propose a Branch-and-Price framework to solve this problem and show its capabilities compared to previous exact algorithms.

3 - Meta-Solver: Extending VRPSolver with Customizable Resources
Aurélien Froger, Ruslan Sadykov, Eduardo Uchoa, Artur Pessoa, Teobaldo Bulhões, Daniel de Araujo

VRPSolver is a branch-and-price solver for a generic model involving resource-constrained shortest path (RCSP) pricing subproblems. To extend its applicability beyond standard vehicle routing problems, Meta-Solver refactors the dynamic programming algorithm that solves RCSP, separating its core from resource-specific components such as label extension, dominance and concatenation. It allows users to define new resources to assess path feasibility or cost provided they adhere to a generic interface and meet specified conditions. We demonstrate its application on several problems.

4 - Branch-cut-price methods for routing problems in Hexaly
Noémie Cartier

Hexaly is a model & run mathematical optimization solver based on exact and heuristic techniques. Its modeling formalism includes list variables that can be used, for example, to model routes in routing problems in a compact way that is well-suited to a heuristic search.

This talk will focus on how Hexaly automatically reformulate such structures and uses branch-cut-price techniques to generate lower bounds on a wide variety of routing problems. We will present the mathematical tools used and some benchmarks on some classical routing problem families.

■ TF-18

Tuesday, 16:15-17:45 - Room: JUR - U 21 (Building: JUR)

Trustworthy and Explainable AI in Business Analytics

Stream: Data-driven Operations Research
Invited session
Chair: *Sureyya Ozogur-Akyuz*
Chair: *Koen W. De Bock*

1 - Interpretable Profit-Driven Spline-Rule Ensembles for Credit Scoring
Sureyya Ozogur-Akyuz, Eren Berk Aytac, Koen W. De Bock

Credit analytics has long relied on predictive models evaluated mainly by accuracy. Recent advances in explainable artificial intelligence have highlighted the need for models that are both interpretable and aligned with business goals. This paper proposes Profit-Driven Spline-Rule Ensembles for Credit Scoring, a novel approach that maximizes profitability while preserving interpretability. Using Expected Maximum Profit and spline functions, the model captures nonlinear patterns and delivers transparent, profit-oriented credit scoring decisions.

2 - A Causality-Aware Framework for Counterfactual Explanations: CausalCERTIFAI
Ferhan Çelik, Cankut Yaman, Sureyya Ozogur-Akyuz
This study proposes CausalCERTIFAI, a causality-aware counterfactual explanation framework for tabular classification. CausalCERTIFAI extends CERTIFAI by adding causal consistency to the search process. A causal effect matrix is learned with DirectLiNGAM, and feature changes are propagated to downstream variables during mutation and crossover. The method is evaluated on 10 classification datasets with Decision Tree, XGBoost, and LightGBM, and assessed in terms of predictive accuracy, normalized CERScore, fairness, and runtime.

3 - Learning Counterfactual Trajectories in Differentially Private Latent Spaces
Özen Yilmaz, Sureyya Ozogur-Akyuz, Qazaleh Afrough
Counterfactual methods often rely on fixed-structure search and fail to model valid transitions. This issue worsens under differential privacy due to noise. We propose a world model approach that learns a private latent space via an autoencoder and uses JEPA for transition dynamics, generating coherent, stepwise counterfactuals under privacy constraints.

■ TF-19

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 05 (Building: HG)

Stochastic Optimization in Power Systems

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Anil Kaya*

1 - Coupling European Capacity Markets
Kamaldeen Adekola, Laurens de Vries, Kenneth Bruninx
We propose a novel conceptual design for a coupled European capacity market that leverages the logic of flow-based market coupling, currently used to couple Europe's day-ahead and intraday electricity markets. In a comparative analysis of different market design scenarios in an illustrative multi-zone case study, using a bespoke long-run equilibrium problem, we show that the proposed flow-based coupling of capacity markets reduces system costs by harnessing available capacity in neighbouring market zones while ensuring deliverability with respect to network constraints in scarcity situations.

2 - Reinforcement learning for three-phase unbalanced microgrids
Pablo Cortes, Alejandra Tabares
This work proposes a reinforcement learning-based energy management system for unbalanced three-phase AC microgrids. A Soft Actor-Critic algorithm is extended with an adaptive Lagrangian penalty mechanism to enforce voltage and current constraints during learning. The approach explicitly accounts for phase unbalance and stochastic operation without relying on explicit optimization models or forecasts. Simulation results on a benchmark unbalanced microgrid show that the proposed method achieves cost-effective and feasible operation.

3 - Adequacy-constrained Stochastic Capacity Expansion using decomposition and HPC
Marilena Zampara, Daniel Avila, Anthony Papavasiliou
Recent amendments to ENTSO-e's European resource Adequacy Assessment (ERAA) require the calculation of volume of capacities to procure to address identified adequacy gaps. This has motivated the development of a pan-European stochastic capacity expansion model, including constraints that limit load shedding to legislated levels. To tackle the model, we implement a variety of decomposition algorithms in a high-performance computing infrastructure, compare their scalability and benchmark results against heuristics, highlighting the value of stochastic optimization for policy applications.

4 - Scenario Reduction for the Two-Stage Stochastic Unit Commitment Problem
Yannick Werner, Juan Miguel Morales, Salvador Pineda, Line Roald, Sonja Wogrin
The two-stage stochastic unit commitment problem is an important tool to support decision-making under uncertainty in power systems. Representing the uncertainty with many scenarios guarantees accurate results but challenges the solution process. In this talk, we recap the classical scenario reduction theory based on the distance of probability distributions, the optimal mass transportation problem, and the Forward Selection Algorithm. We then review and compare various formulations of problem-driven cost functions for scenario reduction using a modified version of the IEEE 24-Bus System.

■ TF-20

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Orienteering and routing with profits

Stream: Vehicle Routing and related problems
Invited session
Chair: *Qiuzi Chen*

1 - Mathematical Formulations for the Clustered Team Orienteering Problem with Time Windows
Elçin Kayacı, Tusan Derya, Kumru Didem Atalay
This study introduces the Clustered Team Orienteering Problem with Time Windows, a routing problem where nodes are organized into clusters and visits must satisfy time window constraints. To the best of our knowledge, this problem is formulated for the first time in the literature. We propose alternative mathematical formulations and evaluate them on well-known benchmark instances. Computational experiments compare their performance in terms of solution quality and computational efficiency, providing insights into the effectiveness of alternative formulations for clustered routing problems.

2 - Mobile sensing as an orienteering arc routing problem with non-simple paths and correlated arc profits
Qiuzi Chen, Kenan Zhang
We propose a new variant of orienteering arc routing problem motivated by mobile sensing, where a sensing vehicle is routed to maximize a submodular utility function subject to a time budget. This problem differs from the classic orienteering problem by allowing non-simple paths and correlated arc profits. The problem is formulated as an MINLP and solved via branch-and-cut algorithm. For large-scale instances, we propose a heuristic that reduces the network by solving a submodular knapsack problem, whose effectiveness is demonstrated on real networks.

■ TF-21

Tuesday, 16:15-17:45 - Room: JUR - U 22 (Building: JUR)

Harnessing OR and AI for Smarter Decisions: Application Agnostic Methodologies

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Ron Hirschprung*

1 - Temporal State Memory Architecture for Long-Term Conversational Agents
Jisu Kang, Jiyoung Kim, Kangbae Lee

Long-term conversational agents often struggle to reason about temporal state changes in evolving contexts, especially when past information conflicts with recent observations. Existing memory mechanisms rely on unstructured histories or flat retrieval strategies, making it difficult to detect state transitions and resolve recency conflicts. This paper proposes a temporal state memory architecture that structures conversational facts into time-normalized states, detects conflicts, updates state lifecycles, and routes temporal queries to specialized retrieval strategies.

2 - Novelty Evaluation by Using an AI-agent to Enhance Privacy Protection
Ron Hirschprung, Shani Alkoby, Benji Azaria

This research focuses on the novelty of published information, rather than on the common issue of veracity. The novelty, together with the sensitivity of the information, is required to evaluate the effect of a privacy violation on an individual. The research introduces an AI-based methodology for measuring novelty and extends the fundamental idea by incorporating negation. The empirical study demonstrated a precision of 96.3%. The proposed methodology is a critical component in automated privacy protection solutions, paving the way to a more sustainable world.

3 - Privacy Concerns in Agentic AI: Proposed APPLY Framework
Saurabh Kumar, Nishant Garg

This paper analyzes the distinctive privacy challenges posed by agentic AI, evaluates the adequacy of existing legal instruments such as the European Union AI Act, the General Data Protection Regulation (GDPR), and United States consumer protection laws, and highlights emerging gaps in governance. It then proposes a regulatory framework, termed the A.P.P.L.Y. framework, which integrates auditability, proactive risk assessment, privacy by design, liability allocation, and enforceable transparency obligations.

4 - Integrating AI-Based Red-Light Running Prediction with Adaptive Signal Control: A Predict-to-Act Framework
Yen-Yu Chen, Jin-Yuan Wang, Shan-Jou Chen, Yun Lo

This study develops a predict-to-act framework integrating AI-based red-light running (RLR) prediction with real-time signal control. Using real-world trajectory data, the system predicts RLR risk to trigger proactive safety interventions. Upon identifying potential violations, all-red extensions are dynamically determined by vehicle speed to ensure safe clearance while minimizing unnecessary delay. A detection-based override enhances robustness under prediction uncertainty, bridging data-driven risk prediction with structured decision rules to improve safety and efficiency at intersections.

■ TF-22

Tuesday, 16:15-17:45 - Room: KOL - Seminar-Raum 5 (Building: KOL)

Forecasting in Energy Markets: Probabilistic and Combination Methods

Stream: Forecasting in Energy
Invited session
Chair: *Souhir Ben Amor*

1 - Electricity price volatility forecasting in the Australian electricity market
Cristina Pizarro-Irizar, Bernardo Pennacchio, Ainhoa Zarraga

This paper examines whether traditional volatility models can adapt to electricity markets with high renewable penetration, where negative prices and strong intraday variability are common. Using five-minute data from Australia's Electricity Market (2021-2025), we test the HAR framework and three jump-detection methods. While volatility persistence is captured, strong ARCH effects and fat-tailed errors remain. Results indicate that GARCH-type extensions with fat-tailed distributions are needed to forecast the realized volatility in renewable-dominated electricity markets.

2 - A probabilistic merit order for electricity price forecasting
Paul Ghelasi, Florian Ziel

Probabilistic forecasting is essential for electricity prices, where uncertainty varies with renewables, fuel prices, demand etc. We propose the first fully probabilistic fundamental model that captures individual sources of uncertainty by fitting distributions to key drivers: load, renewable generation, fuel prices, and capacities. Sampling these within a fast merit-order model yields realistic day-ahead price scenarios. Calibrated to historical data, the approach makes no price distributional assumptions, produces complex multimodal forecasts, and retains full interpretability and causality.

3 - GAMLSS in electricty price forecasting
Peru Muniain, Aitor Ciarreta, Ainhoa Zarraga

This paper applies GAMLSS models to forecast electricity prices in the Spanish Day-Ahead Electricity Market using data from 2020 to 2024. Flexible distribution families are used to dynamically model the mean, variance, skewness, and kurtosis of prices, capturing the complex and non-normal behavior of electricity price series. Each distributional parameter is modeled as a function of relevant exogenous variables. The approach is used to generate both point forecasts and probabilistic forecasts of day-ahead electricity prices.

4 - Fast Training of Mixture-of-Experts via Expert Loss Integration and Online Learning
Btissame El Mahtout

This paper proposes a novel Mixture-of-Experts (MoE) framework that incorporates the individual loss of each expert into the training process to improve expert specialization and utilization. We introduce an online learning strategy that incrementally updates the gating mechanism and expert weights, reducing training time by avoiding repeated full retraining. The approach is applied to European day-ahead electricity price forecasting, where expert-level loss information and online optimization improve learning efficiency, achieving faster convergence and better expert balance than standard MoE

■ TF-23

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 02 (Building: HG)

Stochastic Programming in Finance and Decision Theory

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Milos Kopa*
Chair: *Sebastiano Vitali*

1 - Integrated Market and Option Selection Under Uncertainty: A Structural Decision Support Framework
Yasemin Merzifonluoglu, Tjum van Dijck, Tijn Fleuren

We study a two-stage profit problem for an intermediary choosing markets to serve and option capacity to reserve from suppliers under uncertain demand and stochastic spot prices. After uncertainty is revealed, it

exercises options and buys on the spot market. We prove a cost-ordered policy and an echelon recourse-cost form. For uncapacitated Normal demand, the optimum follows from checking nested market subsets. For capacitated and mean-variance DRO cases, we develop scalable MILP approximations that cut runtime dramatically versus scenario-based models and exact conic models.

2 - Multistage Stochastic Optimisation with Fractional Brownian Motion
Gioele Barbano, Milos Kopa, Vittorio Moriggia, Sebastiano Vitali

Stochastic optimization problems strongly depend on the scenario generation technique and the stochastic process assumed for uncertain parameters. In portfolio optimization, asset returns are commonly modeled through geometric Brownian motion, although this assumption is often unrealistic in markets where returns exhibit trend persistence. We investigate geometric fractional Brownian motion, which captures this feature, and propose an innovative algorithm for generating multistage scenarios. Numerical results show that this assumption significantly affects the optimal solution.

3 - A practical prioritization scheme for goal-based asset-liability management
Sebastiano Vitali, Vittorio Moriggia, Giorgio Consigli

We present an individual asset-liability management problem characterized by goals whose achievement probability is maximized under a rich set of constraints. The decision maker will determine an optimal multistage asset-liability strategy based on a mean-risk paradigm. We introduce a simple scheme based on subjective priority levels to enforce and then estimate after solution the probability to attain the targets. Computational evidences show that solution times do not depend on the number of goals, nor goals achievement probabilities do depend on the risk-reward trade-off.

■ TF-24

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 03 (Building: HG)

Equity and Fairness in Decision-Making for Production and Operations Management

Stream: Human Aspects in Operations Management
Invited session
Chair: *Nabil Absi*
Chair: *Romain Guillaume*
Chair: *Olga Battaia*

1 - A Simulation Framework for Equitable and Efficient Engineering Task Allocation in Semiconductor Manufacturing
Josephine Bähr, Tristan Becker

This study examines how different task assignment policies influence efficiency and workload equity in highly skilled engineering support operations in semiconductor manufacturing. A simulation model evaluates various assignment policies under varying demand and capacity conditions. Results show that demand variability across process groups, combined with rigid assignments, causes systematic bottlenecks. Conversely, alternative routing policies drastically improve throughput and fairness, allowing managers to balance operational gains against organizational impact.

2 - Managing equity in work distribution in aircraft assembly lines
Olga Battaia, Damien Lovato, Romain Guillaume

This study addresses the task scheduling problem in an aircraft Final Assembly Line with the objective of improving operators' ergonomic working conditions. To support decision-makers in incorporating ergonomic aspects into scheduling decisions, we develop two optimization models aimed at enhancing workplace conditions for operators. The first model relies on the discrete Choquet integral to represent ergonomic preferences regarding task sequences. The second model applies a min-max approach together with the Gini coefficient to evaluate how evenly tasks are distributed among operators.

3 - Manufacturing scheduling optimization for personalized medicine with fairness consideration
Meng Wan, Songsong Liu
Personalized medicine supply chain (PMSC) faces challenges from customization and patient priorities. This study optimizes manufacturing scheduling with fairness. A multi-objective model minimizes cost, waiting time, and uncovered rate under allocation and scheduling constraints. Then, Nash bargaining integrates priorities to balance waiting time fairness. Results show reducing uncovered rate increases cost and waiting time. And the fairness model improves fairness and coverage, as coverage status itself impacts fairness. This framework guides fair, efficient PMSC design.

4 - Achieving Ex-Ante and Ex-Post Fairness: Design of Allocation Rules for Nonprofit Operations
Yuanzheng Ma, Jinpeng Liang, Guodong Lyu, Tong Wang
We study a sequential resource allocation problem motivated by mobile food pantry operations, where limited resources must be allocated to communities with uncertain demands. We propose a framework that maximizes the expected minimum fill rate (ex-post fairness) while ensuring target expected fill rates for each community (ex-ante fairness). The problem is reformulated as a stochastic dynamic program with randomized weights, and the optimal policy exhibits a two-threshold structure. Numerical experiments demonstrate strong performance.

■ TF-25

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 16 (Building: HG)

Optimization for Climate Transitions

Stream: OR for Sustainability
Invited session
Chair: *Rei Yamamoto*

1 - Multi Hub Conference
Michal Ben David, Tal Grinshpoun, Michael Hassoun
We study a multi-hub conference model in which events are held simultaneously at several locations connected via video communication. The problem is formulated as a bi-level optimization model in which organizers select hub locations, and participants decide whether and where to attend. We develop clustering-based heuristics to reduce problem dimensionality and compare them with an optimal brute-force solution under environmental constraints through semi-synthetic experiments. The framework supports sustainable conference planning while maintaining participant utility.

2 - Estimating GHG Emissions by Advanced Industrial Classification Systems
Rei Yamamoto, Akifumi Isogai, Masatoshi Nozaki, Kosuke Ishikawa
This study proposes a method for estimating corporate GHG emissions using the FactSet Revere Business Industry Classification System (RBICS). Unlike traditional models relying on broad industry codes, our approach uses a multi-segment, revenue-weighted framework across 1,800 granular product categories. Using an OLS model to ensure transparency, we demonstrate that Level 6 classification significantly improves explanatory power for Scope 1, 2, and 3 emissions. The results show that granular business modeling enhances interpretability for financial climate risk management.

3 - Mapping the Interdependencies of Barriers to Decarbonization in Iron and Steel Across Transition and Transformation Horizons: A Network-Based Expert Assessment
Biswadeep Bhattacharjee, Alexander Fleischanderl, Subrata Saha

The Steel Industry faces challenges to decarbonize due to high emission & technological risk and limited access to Scrap, Natural Gas & Hydrogen. This study examines how 18 barriers across Technology, Economy, Social, Sustainability & Strategy interact over time - 2025-2035 & post 2035 using repeated expert survey & consequent rigorous Factor & Network Analysis. Results show interconnected barriers before 2035 due to technology readiness, weak Green Steel demand and policy gaps, while barriers become more systemic post 2035, concentrated on resource availability, renewables & market creation.

4 - Retailer Strategies for Driving Supplier Carbon Footprint Reduction via Internal Carbon Price
Ozgen Karaer, Z. Pelin Bayindir, Dilara Sadikoglu

We study a setting where a brand product and a private label compete under stock-out-based substitution at the retailer shelves. The retailer uses internal carbon price in her order decisions. We analyze a two-stage game where given the private label's carbon footprint, the supplier decides how much to reduce his own carbon footprint. Then, the retailer determines her order quantities. We find that internal carbon price is effective in pressuring the supplier unless the private label is too competitive.

■ TF-26

Tuesday, 16:15-17:45 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis IV

Stream: Data Envelopment Analysis
Invited session
Chair: *Martin Flegl*
Chair: *Panagiotis Mitropoulos*

1 - Adversarial Kernel DEA: Robust Efficiency Measurement Under Feature-Space Uncertainty
Gordana Savic, Boris Delibasic, Sandro Radovanović

DEA in kernel-induced feature spaces offers flexibility in modeling nonlinear production technologies, yet the choice of kernel function remains an unexamined source of modeling uncertainty. We propose Adversarial Kernel DEA, a framework that treats kernel selection as a source of uncertainty and evaluates each DMU under a family of kernel representations rather than a single fixed mapping. For each DMU, we define robust efficiency as the worst-case score across the kernel family, optimistic efficiency as the best-case score, and the ambiguity gap as their difference.

2 - Longitudinal Assessment of Educational Performance in European Countries: Is There Convergence?
Ioannis Mitropoulos, Alexandros Mitropoulos, Ioanna Siampali, Panagiotis Mitropoulos

This study investigates the evolution of educational performance across European countries, focusing on identifying patterns of convergence or divergence over time. Utilizing data from the PISA Assessment and Eurostat for the period 2006-2022, we evaluate the efficiency of national education systems and analyze their longitudinal shifts. Methodologically, this research introduces a robust framework that integrates Data Envelopment Analysis (DEA) with convergence club clustering techniques, enabling a systematic and multidimensional comparison of educational performance.

3 - The Impact of COVID-19 on the Efficiency of NHS Trusts in England: Evidence from 2017/18 to 2024/25
Doudou Zheng

This study evaluates the efficiency of 118 NHS trusts in England from 2017/18 to 2024/25 using data envelopment analysis and regression models. Efficiency fell sharply during COVID-19 and recovered afterwards, but persistent inefficiencies and substantial variation remained across trusts and regions. COVID-19-related pressures were negatively associated with efficiency. The findings provide operational and policy insights for improving NHS resilience and resource allocation.

4 - Public Administration Efficiency in Mexico: DEA Analysis Across Regional and Municipal Classifications
Martin Flegl, David Güemes-Castorena, Jaime Alarcón

Streets, parks, and public spaces reflect government capacity to shape safety, mobility, and quality of life. In Mexico, satisfaction differs across urban and rural areas. Using DEA and census data from 2021 and 2023, we assess municipal efficiency in 279 regions under the four tier classification defined by ECLAC and UN Mexico. Results show overall low but improving efficiency, rising from 0.487 to 0.523, with Semi Urban regions improving by 0.148 to 0.641, Southwest most efficient, and North Central least.

■ TF-27

Tuesday, 16:15-17:45 - Room: JUR - Hörsaal 13 (Building: JUR)

Food Bank Operations

Stream: Humanitarian Logistics
Invited session
Chair: *Lauren Davis*

1 - Advancing Equity in Food Bank Networks Through Data-Driven Partner Recruitment
Lauren Davis, Funda Samanlioglu, Rabiatu Bonku, Shubhra Paul

Food banks distribute food to people in need through networks of partner agencies. Locations of partner agencies can create inequitable distribution and low accessibility for certain populations. We aim to improve accessibility and equity by expanding network capacity through strategic recruitment. We identify geographic areas of unmet need and develop a data-driven framework for identifying potential agencies to recruit. Using k-means clustering and optimization modeling, we determine optimal recruitment strategies considering food bank goals regarding target populations and program types.

2 - Characterizing Food Insecurity and Health to Inform Logistics
Julie Ivy

We employ a multidimensional approach to understand food insecurity (the lack of sufficient access to nutritious food) and its impact on health. We apply cluster analyses to characterize a nationally representative sample of U.S. households using U.S. Department of Agriculture Food Security survey. We analyze electronic medical records to evaluate food insecurity incidence and outcomes among maternal and cancer patients. We explore unmet need as a function of geographic and demographic attributes and develop an integrated equity measure to inform distribution as a function of these attributes.

3 - Multiperiod Distribution by Food Banks with Uncertain Supply and Operational Capacity
Irem Sengul Orgut, Julie Ivy, Reha Uzsoy, James Wilson

Food banks must equitably distribute limited, stochastic donations to growing food-insecure populations while facing uncertain distribution capacity and excess demand. Motivated by collaboration with the Food Bank of Central and Eastern North Carolina, we develop a stochastic dynamic programming model to allocate time-varying donations across counties, minimizing multi-period storage and waste costs while ensuring fairness. Numerical experiments, calibrated with partner data, show the heuristic achieves near-optimal performance and remains practical for real-world implementation.

4 - Data-Driven Demand Forecasting and Food Allocation Planning for Food Banks: Insights from a Canadian Food Bank
Eman Almehdawe

Food banks face operational challenges due to uncertain donations and fluctuating demand. This study develops a data-driven framework to forecast weekly hamper distribution and estimate category-level food requirements at a Canadian Food Bank. Linear Regression, Random Forest, and XGBoost models are compared, and results show that ensemble methods improve forecasting accuracy and support better inventory planning and resource allocation.

■ TF-28

Tuesday, 16:15-17:45 - Room: JUR - Hörsaal 17 (Building: JUR)

Data-Driven Analytics for Sustainable Maritime and Port Logistics II

Stream: Maritime Logistics
Invited session
Chair: *Qinghe Sun*
Chair: *Shuai Jia*

1 - Robust Deployment of Mobile Roadside Units Under Traffic Uncertainty
Bing Shan, Jun Xia, Zhou Xu, Ning Zhu

The deployment of roadside units (RSUs) plays a crucial role in enabling efficient vehicle-to-road communication. To adapt to spatiotemporal traffic variations, mobile RSUs have been dynamically deployed to meet changing demands. This study focuses on the optimal spatiotemporal deployment of mobile RSUs under traffic uncertainty. A distributionally robust chance-constrained model is proposed and studied. Numerical results demonstrate the proposed model's effectiveness in reducing delay violations, enhancing system reliability, and outperforming other benchmark approaches.

2 - Robust data-driven Dry Dock Scheduling
Zhuoran Ao, Shuai Jia, Shengnan Shu

Dry dock scheduling is challenged by uncertain ship service times. To mitigate tardiness, we minimize the Service Fulfillment Risk Index (SRI), capturing both the probability and magnitude of delays. We formulate a set partitioning model for this problem, incorporating complex constraints like parallel services and setup times. To solve it, we develop an exact Branch-Price-and-Cut algorithm enhanced by heuristic pricing, cross-dock injection, and ng-route. Extensive tests show our algorithm's efficiency and that SRI-optimized schedules significantly outperform deterministic models.

3 - Dry dock scheduling under decision-dependent knapsack-constrained uncertainty
Shuai Jia, Shengnan Shu, Lubin Fan, Qiang Meng

One key challenge in dry dock scheduling is the lack of precise ship service time estimates until ships are positioned on the dry dock blocks and have undergone thorough inspections. The actual service times of ships depend on the ship-to-dock assignment decisions and their physical conditions, indicating a form of decision-dependent uncertainty. Incorporating service time uncertainty in the dry dock scheduling process holds a great practical value.This study tackles the challenge of formulating and solving the robust dry dock scheduling problem under DDU in service times.

■ TF-29

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 30 (Building: HG)

Combinatorial Optimization Models

Stream: Combinatorial Optimization
Invited session
Chair: *Claudio Arbib*

1 - Fairness vs. efficiency for scheduling jobs with utilities decreasing over time
Ulrich Pferschy, Gaia Nicosia, Andrea Pacifici

We consider a new family of multi-agent, single-machine scheduling problems, in which each job is associated with an agent. Each agent has a utility function that depends on the completion time of the agent's job. All utility functions are decreasing in completion time. We want to find either a fair schedule that maximizes the minimum utility experienced by any agent, or an efficient schedule maximizing the sum of utilities. Beside classical scheduling environments we also consider the perspective of a single agent trying to improve its solution as well as a bi-level setting.

2 - A Multi-objective Capacitated Facility Location Problem in Public Services
Katiuscia Pellone, Stefano Smriglio, Fabrizio Rossi

We investigate a Multi-objective Capacitated Facility Location Problem arising in the public sector. Two typical conflicting objectives to be minimized are the number of facilities to open and a function of the distance travelled by customers to access them. We sample the Pareto frontier using a MIP-based procedure in which travel distances are modelled as customers' preferences. This gives rise to a variant of well-studied location problems with a special structure. We discuss both algorithmic and modelling issues through an extensive experimental study based on real data.

3 - Sparsity Constrained Linear Minimax Optimization with Application to Sparse Boosting and Sparse Game Theory
Deniz Akkaya, Bora Çetin, Mustafa Pinar

We study minimizing the maximum of finitely many linear functions over the probability simplex with explicit sparsity constraints. Using optimality insights from the literature, we analyze a sparsity-regularized formulation to construct candidate k-sparse solutions for the original combinatorial problem. We develop a concave surrogate suited to the simplex and a tailored DC algorithm. Applications include sparse strategies in bimatrix games and sparse maximum-margin classifiers, with comparisons to MILP solutions.

4 - The Median String Problem under Levenshtein Distance for Non-binary Strings
Claudio Arbib, Oya Ekin-Karasan, Andrea Pizzuti, Andrea D'Ascenzo

Given a set S of non-binary strings, we wish to find a string (not necessarily in the set) that minimizes its average distance from S. The problem is NP-hard if distances are measured according to the Levenshtein edit model. We propose three original 0-1 Linear Programming formulations that, unlike those in literature, project out the variables that assign characters string positions, and then exploit a property allowing to reconstruct the string obtained. These models are compared to each other and to literature in extensive numerical tests that illustrate the improvement obtained.

■ TF-30

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum 06 (Building: HG)

Machine Learning and Optimization in Logistics 1

Stream: Machine Learning and Optimization
Invited session
Chair: *Ozgur Ozpeynirci*

1 - What do delivery drivers know, that optimization algorithms don't?
Sophie Martina Blum, Ahmad Hemmati

In last-mile delivery routing it is often observed that drivers deviate from the routes planned by a decision-support system. We assume that those deviations follow patterns that can help improve the optimization algorithms creating the routes. We use Machine Learning to predict for a given planned route, if a driver is likely to deviate from it. We show how the choice of measurement for deviation influences predictability but also interpretability for decision-support system providers.

2 - Estimating next-day delivery probabilities for e-commerce shipments
Burak Onal, Ahmet Çınar, Betül Ahat

In this study, we develop a shipment-level classification model to estimate the probability of NDD in an e-commerce logistics network. The model uses historical shipment data with temporal, route, and seller features to produce probability scores indicating when an NDD promise should be shown. Performance is evaluated using precision-recall curves and confusion matrices across operational segments such as same-city lanes and order time windows. The final decision is based on optimizing an asymmetric cost-benefit framework reflecting business impact rather than accuracy alone.

3 - Learned Cargo Flow
Simon Urbak Pedersen, Richard Lusby, Natalia Rezanova, Fabricio Oliveira

The Maersk CargoFlow problem is a large-scale multi-commodity flow problem solved using column generation. Currently, tractability requires tight resource constraints that limit solution quality. We propose using deep graph neural networks to prune the solution space per commodity, enabling the solver to operate under softer resource constraints without prohibitive runtimes. Our models reduce the network by 95% while retaining 95% of optimal flow routes. We present the integrated pipeline combining learned pruning with column generation and evaluate its impact on solution quality and runtime.

4 - Beyond Volume and Weight: Clustering and Compression Factors in Loading Meter-Based LTL Planning
Ozgur Ozpeynirci, Simge Avci, Sinem Tokcaer

In partial shipments, discrepancies often arise between the declared loading meter and actual usage. In this study, a weakly supervised machine learning model where constraints serve as the primary supervisory signal was developed to estimate hidden compression factors. A tailored loss function was designed using a gradient-based continuous-parameter optimization algorithm to minimize capacity overruns and idle-space penalties. The obtained ratios were clustered and evaluated using Decision Tree to derive interpretable rules for more space-efficient load planning.

■ TF-31

Tuesday, 16:15-17:45 - Room: JUR - Hörsaal 12 (Building: JUR)

Challenges in transit planning

Stream: Optimizing Transit
Invited session
Chair: *Jörn Schönberger*

1 - Multimodal Multiobjective Transport Planning: Analysis of Special Cases
Anita Schöbel

In order to make future transport fast and environmentally sustainable at a reasonable price, the different modes for passengers' transport have to be coordinated. We present a network design model for planning different modes simultaneously while optimizing the travel times of the passengers, the emissions of the vehicles and the costs within a multi-objective framework. The model will be analyzed by looking at very special cases: Already on a single edge the problem contains a variety of challenging problems depending on the shape of the objective functions.

2 - Where Should the Hyperloop Go? Designing the Hyperloop Transit Network
Alexander Rave, Pirmin Fontaine

Hyperloop enables passenger transport at speeds of up to 1225 km/h but requires very costly infrastructure, which strongly affects fares and demand: too few connections cause detours and reduce time savings, while too many connections increase fares. We study the design of a Hyperloop transit network with time- and fare-dependent demand using a nonlinear bilevel model, reformulated and linearized for computation. Additionally, we introduce a tailored Branch-and-Cut approach. For major German cities, the optimized network yields 9.0 % higher profits than a previously proposed concept network.

3 - Ferry traffic optimization for regional transport planning
Bernardo Martin-Iradi, Tomas Lidén

Ferry services are critical transport means in archipelago regions, yet planning is largely manual. We present an optimization model jointly planning ferry schedules, land connections, fleet assignments, and crew shifts, and we solve it via column generation on a space-time-shift network. The model balances operational costs and passenger and vehicle service levels, while respecting crew work regulations. Applied to a real-world case study, results show improvements in service quality, operational efficiency, and environmental impact relative to current planning.

4 - Priming a Tram Network Representation For Finding Optimal Vehicle Repositioning Travel Paths Using Dijkstra's Optimal Path Algorithm
Jörn Schönberger

Acute angles challenge the identification of optimal tram paths through a given track network. We propose priming a directed graph representation of the tram track network to enable the Dijkstra algorithm to find optimal paths in tram networks. The priming step comprises identifying feasible inbound-outbound arc pairs at switch nodes and other nodes. We demonstrate the applicability of this preparation through experiments on real-world tram networks.

■ TF-32

Tuesday, 16:15-17:45 - Room: JUR - Hörsaal 14 (Building: JUR)

Policy, Urban Freight and Urban Mobility

Stream: City Logistics
Invited session
Chair: *Kris Braekers*
Chair: *An Caris*

1 - Evaluating the Impact of In-Building Deliveries on Urban Vehicle Routing
Germán Paredes-Belmar, Andrés Bronfman, Guillermo Latorre, Carlos Conteras-Bolton

This study evaluates the impact of in-building deliveries on urban logistics systems. We propose a time-dependent vehicle routing model that integrates vertical (in-building) and horizontal (street-level) operations, capturing congestion effects in elevators and urban traffic. Computational experiments show that neglecting in-building dynamics may underestimate delivery times and reduce routing efficiency. Results highlight the importance of jointly modeling both layers to improve last-mile performance and support better urban logistics planning.

2 - Evaluating urban freight policies through modeling and simulation: A systematic literature review
Tingting Su, An Caris, Kris Braekers

Urban freight policies are increasingly introduced to regulate freight activities and improve urban sustainability. However, their operational impacts on logistics systems remain difficult to evaluate. This study presents a systematic review of research that assesses urban freight policies using vehicle routing models or simulation methods. The study develops a classification of policy measures, examines how these policies are represented in analytical models, and analyzes their impacts on firm operations and urban sustainability outcomes, while identifying underexplored decision areas.

3 - Optimized Enforcement in Adaptive Curb Management
Elham Heydarigharaei, Matthew J. Roorda

Adaptive curb management dynamically allocates curb space among competing users such as freight deliveries, passenger pickups, and private vehicles. However, its effectiveness depends on driver compliance with curb regulations. This study develops an optimization framework that jointly determines curb allocation and enforcement policies. The model captures heterogeneous curb users, compliance behavior, and enforcement costs. Results provide insights on how targeted enforcement can improve compliance, increase curb utilization, and enhance efficiency in urban curb and freight operations.

4 - On solving a share-a-ride problem with forbidden passenger detours
Ana Beatriz Herthel, Teobaldo Bulhões, Anand Subramanian, Richard Hartl

We study a variant of the share-a-ride problem that integrates passenger and parcel transport while forbidding passenger detours. A branch-cut-and-price algorithm is proposed, combining an efficient labeling pricing routine, two-phase strong branching, rank-1 cuts with limited memory, and ng-paths. An adapted matheuristic provides high-quality primal bounds in under one minute. The method solves over 80% of instances with up to 90 requests and improves heuristic results on 12% of larger cases. Instance space analysis identifies key factors driving instance difficulty.

■ TF-33

Tuesday, 16:15-17:45 - Room: JUR - Hörsaal 15 (Building: JUR)

Train Timetabling

Stream: Passenger Railway Transportation
Invited session
Chair: *Rolf Van Lieshout*

1 - A Branch-and-Repair algorithm for Short-term Train Timetable Adjustment with Rolling Stock Connection Constraints
Valentina Cacchiani, Yuan Gao, Lin Yang

We focus on adding extra trains to an existing timetable to cope with increased passenger demand. Besides satisfying constraints that avoid train conflicts, we incorporate connection requirements between train pairs to account for the available rolling stock resources. The goal is to schedule as many extra trains as possible, while minimizing the deviation from the existing timetable. We propose an exact Branch-and-Repair (B&R) algorithm. Tests on real-world instances from the China Railway Shanghai Group show that the B&R algorithm solves all instances to optimality within about 15 minutes.

2 - A two-stage stochastic programming algorithm for creating robust freight train schedules
Casper Loman, Han Hoogeveen, Marjan van den Akker, Roel van den Broek

Freight trains are highly prone to delays due to many intermodal dependencies and limited infrastructure capacity. We propose a two-stage stochastic programming algorithm using a progressive hedging heuristic. Our algorithm creates a schedule for a set of freight trains, while considering a set of delay scenarios for these trains to increase the robustness. We develop a discrete event simulation framework to test the robustness of the schedules created by this algorithm. We found that our algorithm is able to create an acceptable trade-off between quality of service and utilized capacity.

3 - Optimization of Train Timetable within Railway Hub Considering Convenient Passenger Direct and Transfer Travel
Zixin Li, Huiling Fu, Zhenhuan He

A large railway hub often contains multiple stations with many trains running in different directions, complicating train connection plans thus affecting passenger travel efficiency. We build an integer programming model to optimize timetable by adjusting train ODs and stops within a hub. Versus existing timetable, Beijing railway hub tests show the number of same-station connecting trains, new passing trains connected from previous originating and terminating trains, and total stops within the hub are increased by 34.2%, 40%, and 7%, improving passenger direct and transfer travel convenience.

4 - A Compact Cycle Formulation for the Multiperiodic Event Scheduling Problem
Rolf Van Lieshout, Niels Lindner

The Periodic Event Scheduling Problem (PESP) is central to periodic timetabling but assumes a single shared period, while real transport networks have varied service frequencies. We study the Multiperiodic Event Scheduling Problem (MPESP), where each event recurs at its own period. We give a cycle-based formulation that extends the strongest PESP model, is valid for every instance, and relies on a spanning tree with structural properties we formalize and construct. It solves nearly all tested instances, including large real-world networks, to near-optimality, outperforming arc-based models.

■ TF-34

Tuesday, 16:15-17:45 - Room: JUR - Hörsaal 16 (Building: JUR)

Order Batching and Picker Routing

Stream: Warehousing
Invited session
Chair: *Eduardo G. Pardo*

1 - Batching and Routing in Irregular Warehouse Layouts: A Comparative Study of Decomposed and Integrated Metaheuristic Approaches
Sergio Gil-Borras, Eduardo G. Pardo

The Order Batching Problem significantly affects warehouse efficiency and picking costs, yet most research assumes regular rectangular layouts with parallel aisles and symmetric cross-aisles. In practice, many warehouses have irregular geometries, such as non-parallel aisles and asymmetric structures, whose impact on batching and routing decisions remains largely unexplored. This study examines this issue by comparing two batching methods (FCFS, BVNS) and three routing strategies (heuristic, metaheuristic, exact) across five irregular warehouse typologies using well-known order instances.

2 - ware_ops_algos: An Open-Source Algorithm Library for Order Fulfillment in Warehouse Operations
Janik Bischoff, Özge Nur Subas, Fabian Dunke, Anne Meyer, Stefan Nickel, Kai Furmans

Order fulfillment in warehouses involves interdependent decision problems, yet open-source algorithm implementations remain scarce, limiting reproducibility. We present a modular repository with 25 heuristic, metaheuristic, and exact implementations for item assignment, order batching, picker routing, and scheduling. All algorithms share a unified interface designed for configurability and extensibility. We validate our implementations by comparing results to established benchmark instances from the literature. The code is made available at https://github.com/kit-dsm/ware_ops_algos.

3 - Scaling-up the resolution of order batching : a branch-and-cut and the limits of OR
Hadrien Cambazard, Maxime Ogier, Nicolas Catusse

The order picking problem is to determine a shortest tour for collecting items in a warehouse. A key extension with a capacity and order's prizes, is at the heart of set-partitioning formulations for batching and routing. We propose a new IP model for this variant, inspired by dynamic programming and Steiner TSP models. It is solved by branch-and-cut and outperforms state-of-the-art methods for layouts with more than four cross-aisles. We will conclude by analyzing a number of fundamental limits of this research, its societal meaning and detrimental impact that seems related to OR itself.

4 - Integrated Optimization of Batching, Scheduling and Routing in AGV-assisted Picking Warehouses
Ying Liu

This study investigates the integrated optimization of batching, scheduling, and routing in AGV-assisted picking warehouses. A novel AGV-assisted picking policy and a mixed-integer programming model are developed to minimize total picking time. To solve the problem efficiently, an adaptive variable neighborhood search algorithm with customized encoding schemes, neighborhood operators, and an adaptive adjustment strategy is proposed. Computational experiments validate its effectiveness and analyze the impacts of picking strategies, storage policies, and AGV fleet sizes on system performance.

■ TF-35

Tuesday, 16:15-17:45 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Sustainable Manufacturing

Stream: Operations Research and Sustainability
Invited session
Chair: *Cagri Koc*

1 - Co-opetition Strategy between Manufacturer and Internet of Things Platform with Data Service
Bo Li, Ruidong Zhao

This paper considers a model consisting of an IoT platform and a smart product manufacturer. The IoT platform not only cooperates with the manufacturer to sell his smart product by providing data service, but also makes her own smart product to encroach the manufacturer's market. Through game theory, the different models considering IoT platform's encroachment or not are analyzed and the decision comparisons are performed. We find that under the higher value of data service, the IoT platform more prefers to introduce her smart product into the market although the encroachment cost is high.

2 - Optimal internal channel structure decision: The case of remanufacturing operations
Qin Zhou, Hao Dong

How manufacturing and remanufacturing functions perform in practice would relate to the supply chain system's channel structure, which can be decentralized or centralized (called "integrated"). Through building formal game theoretic models, we investigate in this paper the economic performance and environmental impact between these two internal channel structures. We find that the decentralized structure consistently improves the environment outcome by encouraging early entry into remanufacturing and full remanufacturing strategies.

3 - Sustainable human centric robot collaboration with different level of interactions in assembly line optimisation
Rhitankar Saha Roy, Mahdi Bashiri, Benny Tjahjono

This study assesses the impact of human centricity in human robot interaction (HRI) through four levels of interaction including traditional, coexistence, cooperation, and collaboration using a decision-making framework to generate sustainability scores feeding to a mathematical model. The aim is minimizing cost and cycle time while maximizing sustainability. Analysis on case studies confirms that higher levels of HRI can reduce completion time and cost with an increase in sustainability. These findings support strategic deployment for human focused design in advancing assembly manufacturing.

4 - Interactive Preference-based Optimization with Unknown Value Function: Application to Sustainable Sourcing in the Apparel Supply Chain
Mirel Yavuz, Charles Corbett

Optimization in sustainability is inherently multi-criteria and the underlying value function used to indicate preferences is usually unknown and difficult to elicit. We consider the example of sustainable sourcing in the apparel industry and assume the economic and environmental preferences of a consistent and rational decision maker are based on an unknown implicit value function. We propose a new interactive optimization approach that asks pairwise comparison questions to the DM to determine the sourcing mix that is most aligned with her preferences.

■ TF-37

Tuesday, 16:15-17:45 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Nonsmooth optimization

Stream: Nonlinear Optimization
Invited session
Chair: *Ziyan Luo*

1 - Advanced Strategies for Structured Optimization and Their Practical Uses
Carisa K.W. Yu

Structured optimization problems are essential for addressing real-world challenges across various fields. In particular, sparse optimization is key for obtaining solutions from under-determined linear equations and is widely used in various applications. This study examines

a subset of structured sparse optimization that leverages synchronous group effects to enhance recoverability and stability. We propose novel proximal gradient algorithms to tackle these issues and establish their convergence properties. Our methods help identify master transcription factors for cell fate conversion.

2 - Proximal nonlinear conjugate gradient methods for minimizing nonconvex composite functions
Shodai Hamana, Yasushi Narushima

We propose a proximal nonlinear conjugate gradient (CG) method that extends the classical nonlinear conjugate gradient method effective for standard unconstrained optimization to unconstrained composite optimization problems consisting of smooth nonconvex functions and nonsmooth weakly convex functions. Our method is based on the three-term Hestenes-Stiefel type CG direction and a gradient-like quantity derived from the proximal mapping. By adjusting the parameter of the proximal mapping and incorporating a line search, we establish the global convergence of the method to a stationary point.

3 - Cardinality-constrained quadratic optimization
Ademir Ribeiro, Mael Sachine

We study a cardinality-constrained quadratic problem. We decompose the feasible set into simpler sets that satisfy the cardinality constraint. Then we maximize a concave piecewise quadratic function by a subgradient method and use this to find the solution of the original problem. Numerical experiments show that this strategy may be successful for a significant number of problems. We also establish nonlinear optimization results in order to provide a rigorous mathematical analysis of the ideas involving the reformulation of problem, the proposed method and its convergence properties.

■ TF-38

Tuesday, 16:15-17:45 - Room: JUR - Seminar-Raum 44 (Building: JUR)

OR Innovations in Policy Making

Stream: Soft OR and Problem Structuring Methods
Invited session
Chair: *Ine Steenmans*
Chair: *Irene Pluchinotta*

1 - Mapping to Modelling: Strengthening Cross-Sector Net Zero through System Dynamics
Irene Pluchinotta, Ke (Koko) Zhou, Mike Davies, Nici Zimmermann

The UK government has adopted systems thinking to support net zero policy and is further exploring its potential to address cross-sectoral impacts.This talk shows a structured engagement between academia (PAICE project) and DESNZ, combining systems mapping, model development, data review, and scenario design. A causal loop diagram was translated into a system dynamics model linking housing retrofits, heat pump adoption, fuel poverty, and health outcomes. We reflect on how this process advances our knowledge on model boundaries and we discuss implications for OR supporting cross-sectoral impact

2 - Surfacing Systemic Blind Spots in Cybersecurity Governance: A Participatory Systems Approach for Higher Education Policy
Waseq Ziaie, Ine Steenmans

Cybersecurity governance in higher education institutions is shaped by distributed authority and fragmented organisational visibility of risk. This study applies Operational Research and Problem Structuring Methods to explore systemic blind spots in cybersecurity governance within a UK HEI. Using survey diagnostics (n=92) and participatory Group Model Building workshops with key stakeholder roles, the research elicits and compares causal maps of governance dynamics to identify misaligned assumptions, feedback structures, and leverage points for improving cybersecurity policy and practice.

3 - Activating Transformative change with Participatory System Dynamics and Dynamic Leverage Analysis
Laura Selicato, Virginia Rosa Coletta, Raffaele Giordano

Dynamic Leverage Analysis, embedded in Participatory System Dynamics Model, is used to support collective problem framing and public policy design. Drawing on the BIOTRAILS project and applied to Ghana's gold mining sector, the approach operationalises the Biodiversity-Climate-Society Nexus. The approach reveals critical patterns like leverage exhaustion and late dominance, enabling stakeholders to co-design sequenced, adaptive policy roadmaps and shift from incremental to transformative systemic change.

4 - AI and the collapse of structured reasoning: implications for Operational Research in public policy
Ine Steenmans

OR's contribution to policy lies not in structured outputs but in its structuring process: eliciting assumptions, negotiating framings, building shared understanding. AI produces similar artifacts with causal maps, scenarios etc, but bypasses the epistemic work that gives them quality. Drawing on engagement with government analysts using OR methods, I identify a 'help-and-hinder' effect: AI increases productivity while eroding capacity for independent reasoning. I argue this is an OR problem, and propose an OR research agenda on decision quality, process design, and analyst capability.

■ TF-43

Tuesday, 16:15-17:45 - Room: JUR - Seminar-Raum 63 (Building: JUR)

Metaheuristics for Scheduling and Timetabling

Stream: Metaheuristics
Invited session
Chair: *Roberto Maria Rosati*

1 - HCPGA-II: Upper Bound Heuristics and Constraint Handling Techniques for Hybrid JSSP Optimization
Chiara Camilla Rambaldi Migliore, Giovanni Iacca, Marco Roveri

The Job Shop Scheduling Problem (JSSP) is an NP-hard problem critical to Industry 4.0, yet a gap persists between academic research and real-world deployment. Lorenzi et al. (GECCO 2025) proposed hcpga, a hybrid approach combining a CP solver (cp-sat) for initial feasible solutions with a Genetic Algorithm for refinement. We extend this work by evaluating industry-like instances, introducing heuristic upper bounds as CP constraints to accelerate initial solution search, and analyzing constraint handling techniques in the GA compared to the repair mechanism first introduced in hcpga.

2 - Multi-Layer Scheduling for the Hospital Inpatient Process: A Patient Flow Optimization Approach
Cristian Belfiore, Rosita Guido, Domenico Conforti

In recent years, the need to address healthcare scheduling within integrated frameworks has become increasingly evident. Hospital resources are heterogeneous and strongly interdependent. Mathematical models capturing these systems are typically large scale and NP-hard, and remain difficult to solve even with advanced commercial solvers. This paper proposes a novel multi-layer scheduling model for the hospital inpatient process within a Patient Flow framework, capturing the coordination of surgery, diagnostics, and ward resources, and outlines an efficient heuristic solution approach.

3 - Revisiting Local Search for Curriculum-Based Course Timetabling
Andrea Schaerf, Sara Ceschia, Francesca Da Ros, Luca Di Gaspero

We address the Curriculum-Based Course Timetabling problem, a well-known benchmark in educational timetabling, and we propose a Simulated Annealing approach based on a new neighborhood, LectureKick, extending the classic LectureMove to allow more flexible lecture relocation. The method includes probabilistic biases targeting soft constraints and a cut-off mechanism in the cooling schedule. After parameter tuning on artificial datasets, experiments on real-world benchmarks show that the approach outperforms previous local search methods and competes with state-of-the-art algorithms.

4 - Multi-Neighborhood Search for the AGV Scheduling Problem with Battery Constraints
Roberto Maria Rosati, Maurizio Boccia, Adriano Masone, Claudio Sterle

The Automated Guided Vehicle (AGV) scheduling problem with battery constraints consists of determining the scheduling of jobs and charging operations of a fleet of AGVs, such that the makespan is minimized.

Our solution method relies on an implicit solution representation and a greedy decoder. The implicit search space is explored by a composition of six neighborhoods: Move, Swap, Kick, Two-Opt, Three-Opt, and Rotate.

Experimental results demonstrate that our method finds nearly optimal solutions in short computing times, while handling multiple problem variants at the decoder level.

■ TF-45

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum 01 (Building: HG)

Advances in Calibrated Optimization

Stream: Data-driven Stochastic (Inverse) Optimization
Invited session
Chair: *Jerry Chua*

1 - Optimize-via-estimate: Finite-sample corrections for sampling uncertainty in data-driven optimization
Gar Goei Loke, Taozeng Zhu, Ruiting Zuo

We propose a procedure for deriving the optimal decision function of data set for the out-of-sample cost function in data-driven convex optimization. Optimality conditions require this decision function to be a function of the sufficient statistic, that is pointwise optimal for an adjusted objective that is corrected for sampling uncertainty. Our framework generalizes a number of approaches in the literature. We obtain a close to (but not) zero ex-ante regret against a perfect information oracle in numerical illustrations on the newsvendor and portfolio optimization problems.

2 - Optimal EV Charging Station Placement Using a Rank-based Choice Modeling Approach
David Pinzon, Okan Arslan, Yossiri Adulyasak, Margarida Carvalho, Amira Dems, Shabnam Mahmoudzadeh Vaziri

Electric vehicle adoption requires efficient charging infrastructure planning. We propose an optimization model to determine the location and capacity of EV charging stations while accounting for user behavior. The framework uses rank-based choice models to represent user preferences along feasible paths and incorporates capacity limits, seasonal demand, and budget constraints. Structural properties of the payoff function yield stronger formulations. Experiments using our industrial partner data demonstrate the model's effectiveness for supporting charging network expansion decisions.

3 - Inverse Optimization with Discrete Decisions
Jerry Chua, Ian Yihang Zhu

Inverse optimization (IO) has emerged as a powerful framework for analyzing prescriptive model parameters that rationalize observed decisions. Existing work has focused on continuous and convex models, for which the corresponding IO problems are easier to solve compared to their discrete counterparts. In this work, we propose a new approach for approximating the inverse-feasible region of solutions to discrete optimization problems (DOP) by exploiting their linear relaxations, and through the lens of IO, provide a fresh perspective on the sensitivity analysis of solutions to DOP.

4 - Decision-Focused Bias Correction for Fluid Approximation
Can Er, Mo Liu

We revisit the multi-period newsvendor network problem with correlated, time-varying demands. Fluid approximation replaces the joint demand distribution with its mean, biasing performance estimates, and decisions. We ask whether another point statistic, a decision-corrected point estimate, recovers the optimal decision. Unlike the single-item critical fractile, such a statistic may not exist for networks. We give necessary and sufficient conditions for existence and an algorithm to compute it. On real data, it achieves substantially lower cost than fluid and sample average approximation.

■ TF-46

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum 02 (Building: HG)

Compact Storage Systems

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Simone Neumann*

1 - Expected Retrieval Time in Compact Storage Systems with Side Access
Asra Dia

In typical robotic compact storage and retrieval systems (RCS/RS), top-down retrieval often requires relocating buried bins. In contrast, the system considered here uses side access and two lifts: a side-lift to position the robot and a top-lift to raise blocking bins and create temporary access aisles. As this RCS/RS design is novel, its performance is largely unexplored. This study develops an analytical model to estimate expected retrieval time, deriving a closed-form expression that includes horizontal travel, side-lift movement, and stochastic top-lift travel across blockage scenarios.

2 - Order Retrieval in a Compact Storage System with Side Access
Yagmur Gül

We examine a compact storage system where bins are stacked without aisles. Retrieval involves lifting blocking bins to create a tunnel for a robot. While fast, this requires substantial energy. We formulate the side-access compact retrieval problem, optimize retrievals for energy consumption, and prove it strongly NP-complete. We propose a MIP formulation, a dynamic programming algorithm, and a greedy heuristic. Experiments show dynamic programming outperforms MIP solvers on small to medium instances, while the greedy heuristic yields near-instant solutions when exact methods are impractical.

3 - Workstation Design for Parts-to-Picker Systems: A Laboratory Experiment on Human Picking Performance
Sebastian Schiffels, Christian Jost, Nils Boysen

With the expansion of e-commerce, efficient order fulfillment has driven the adoption of parts-to-picker systems that autonomously deliver stock-keeping units (SKUs) to picker workstations. At these workstations, human picking remains essential. While optimization models typically assume constant human speed and accuracy, we experimentally quantify how workstation setups—particularly the number of parallel SKU bins and customer bins—affect picker performance, aiming to bridge the gap between theoretical optimization and actual human picking behavior.

4 - Picking Operations in Warehouses With Dynamically Arriving Orders
Alena Otto, Catherine Lorenz, Michel Gendreau

E-commerce operations are essentially online, with customer orders arriving dynamically. We establish analytical performance bounds with worst-case and probabilistic analysis for a prominent algorithm Reopt, which reoptimizes the current solution each time a new order arrives. We examine Reopt in the Online Order Batching, Sequencing, and Routing Problem (OOBSRP), both for a manual and a robotic cart. We demonstrate that, under generic stochastic assumptions, Reopt is almost surely asymptotically optimal and validate its near-optimal performance in experiments.

■ TF-47

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum 03 (Building: HG)

Supply chain 2

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Shaghayegh Ramezanpour Shalmani*

1 - Two-Stage Stochastic Optimization for Closed-Loop Supply Chains with Third-Party Return Services
Sangjun Yoon, Younsoo Lee, Youngchul Shin

We propose a two-stage stochastic optimization model for a closed-loop supply chain with third-party return service providers. The model considers uncertainty in end-customer demand, secondary market demand, and returned product conditions. Based on product conditions, providers choose recovery options. To address uncertainty, we use the Sample Average Approximation method and develop a stabilization and root-cut based Benders decomposition algorithm to improve computational efficiency. Computational experiments show the effectiveness of the proposed approach and provide practical insights.

2 - Risk-Aware Multi-Period Supply Chain Planning: Biomethanol in Italy
Marcello Bozzini, Cátia da Silva, Ana Barbosa-Povoa, Flavio Manenti

Methanol is a basic chemical and a promising biofuel associated with decentralised production requiring national planning under uncertain demand. In this setting, techno-economic and supply-chain decisions are often made separately, limiting policy insight. We develop an end-to-end methodology linking process modelling and techno-economic assessment to a spatial multi-period supply-chain MILP considering uncertainty and risk aversion. The model is applied to Italy to identify policy drivers to reach competitiveness with fossil-based methanol, while meeting national demand targets sustainably.

3 - Robust product fulfillment with returns for an omnichannel retailer during supply chain disruption
Shaghayegh Ramezanpour Shalmani, Laurent Alfandari, Sara Rezaee Vessal

Omnichannel retailing integrates online and physical stores but faces major challenges during supply chain disruptions. This paper studies an omnichannel retailer with one online and multiple physical stores, focusing on optimal fulfillment and return under physical stores closures and limited online inventory. We propose using selected physical stores as inventory depots to support online demand. A robust optimization model with a constraint-generation algorithm is developed, along with sensitivity analysis. Results show improved resilience and provide practical guidance for retailers.

■ TF-48

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum 04 (Building: HG)

Innovative Applications in Data-Driven Operations Research

Stream: Data-driven Operations Research
Invited session
Chair: *Sandjai Bhulai*

1 - Chemotherapy Outpatient Scheduling and Process Management for Reduced Patient Waiting and Improved Resource Utilization
Nihat Öner, Joachim Arts, Çağıl Koçyiğit

This study optimizes patient scheduling and operational decision-making at a chemotherapy center in Luxembourg. We develop a data-driven framework that generates daily appointment schedules and makes dynamic operational decisions (such as treatment production ordering and infusion seat assignments) based on real-time observations to minimize patient waiting times and the latest discharge time. We evaluate our method using real data and compare it against the current policy as well as the best policy in hindsight.

2 - An Adaptive Partition-Based Method for Decision-Focused Learning: Application to Microgrid Energy Management
Cristofer Lizama, Tito Homem-de-Mello, Guido Lagos, Francisco Jara-Moroni

This work develops an Adaptive Partition-Based Method for bilevel decision-focused learning with many lower-level subproblems under uncertainty. The proposed methodology improves scalability by clustering training observations with similar operational decisions, reducing computational complexity while maintaining high solution quality. In a residential microgrid application with photovoltaic generation and battery storage, it achieves substantial reductions in solution time and small optimality gaps, lowering operational costs and facilitating the adoption of renewable energy systems.

3 - Optimizing maintenance of heavy equipment: A data-driven approach
Sandjai Bhulai, Laith Wehbi

Timely maintenance of heavy equipment is essential in construction, but constrained by limited data-driven approaches. This study presents a framework combining priority scoring, predictive modeling, and routing optimization. Machine learning models achieve MAPE values of 4.24% for labor cost and 9.32% for service duration. Routing is formulated as a Multi-Depot Capacitated VRP and solved using Cluster First, Route Second with ALNS, 2-opt, and a Self-Organizing Map adaptation. Results show a 41.93% reduction in service time and 43.86% improvement in high-priority job positioning.

4 - Matheuristics for Overland Search and Rescue with Rectangular Search Area Selection
Saeid Abbasiparizi, Michael Morin, Irene Abi-Zeid

Most search planning models assume a search unit covers one area per mission. We propose an approach where a search unit is allocated to multiple areas to maximize the probability of success (POS) by selecting candidate areas and their visit order. We develop matheuristics combining an area selection strategy (greedy, random, or GRASP) with an optimization approach (MIP, MIP with cuts, or Benders decomposition). GRASP with Benders shows a 38% average improvement in mean relative POS and runs 26.6% faster compared to random selection with MIP on 30 overland scenarios in southeast Canada.

■ TF-49

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management under Flexibility and Choice Aspects

Stream: Data-Driven Demand Management
Invited session
Chair: *Michelle Mitter*

1 - Bayesian Demand Forecasting for Tour Operators: A Case Study with AlignAlytics Data
Mohammad Aminjarahi, Sheldon Dee, Huan Yu, Christine Currie

Accurate tour-operator demand forecasts are crucial for pricing, departures scheduling, and revenue management. We develop Bayesian forecasting models using real booking data from AlignAlytics, a revenue management consultancy. We compare three approaches: a volume-and-shape booking-curve model, direct weekly demand models with flexible lead-time patterns, and a choice-based market allocation model that enforces substitution within competitive sets. Our evaluation separates final volume accuracy from booking-curve accuracy and highlights trade-offs in structure and interpretability.

2 - Handling Flexibility - Revenue Management with Flexible Products
Henrik Nordhaus, Thiemo Wasielewski, Jochen Gönsch

Flexible products consist of predefined menus of component products, with assignment delayed until demand uncertainty is largely resolved, creating a risk-pooling benefit for the seller. Most revenue management approaches, including DLP- and RLP-based methods, ignore this advantage by assigning components immediately, leading to biased opportunity costs and lower revenue. We present an RLP-based control approach that captures menu-specific opportunity costs and demonstrate its value and computational cost through numerical experiments.

3 - Opaque Products in a Generalized Market Model
Michelle Mitter, Jochen Gönsch

Opaque products are becoming increasingly common across various industries. They comprise a pre-defined set of component products, which are typically also available separately, and the specific product is assigned to the customer after purchase. Existing research in Strategic Operations Management typically analyzes opaque products using Hotelling-type models, in which consumer preferences for component products are inherently linked. We address this limitation by introducing a more general market model in which preferences for component products are independent and uniformly distributed.

■ TF-50

Tuesday, 16:15-17:45 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Stochastic Optimization & Operational Strategies III

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Doriana Vizzini*

1 - A Relax-Fix-and-Exclude Algorithm for the Global Optimization of MINLP Problems with Piecewise Multilinear Interpolation Functions
Eduardo Camponogara, Bruno Machado Pacheco, Pedro Marcolin Antunes, Vinicius Rosa, Bruno Ferreira Vieira

This paper proposes a relax-fix-and-exclude (RFE) algorithm for MINLP problems involving piecewise multilinear interpolation of look-up tables. We derive a tight piecewise-linear MILP relaxation of the interpolants and exploit it within an iterative variable-fixing and exclusion framework. Global convergence is guaranteed. Applied to an offshore oil production optimization problem, RFE outperforms SCIP, BARON, and Gurobi, solving 20% more instances to optimality within one hour and achieving faster runtimes or smaller optimality gaps.

2 - Optimal EV Charging Under Price and Demand Uncertainty: A MDP Approach
Tobias Kers, Ece Cigdem Karakoyun

We study the optimal weekly EV charging strategy of a commuting household facing dynamic day-ahead electricity prices and stochastic trip demand. The problem is formulated as a finite-horizon MDP in which the consumer decides each evening whether to charge overnight, trading off price arbitrage and reduced battery wear against the risk of costly highway emergency charging. Overnight charging costs are determined via a linear program over 15-minute price slots. We establish monotonicity of the value function in battery state, prices, and price forecasts, and characterize a threshold-type optima

3 - Coordinated Expansion Planning of T&D Systems Considering Multiple DERs and Emissions
Nahid-Ur-Rahman Chowdhury, Gregorio Muñoz-Delgado, Natalia Alguacil, Javier Contreras

This work presents a coordinated transmission and distribution (T&D) expansion planning model under uncertainty. The proposed MILP-based model jointly optimizes investment in generators, lines, and energy storage systems at both T&D levels, while integrating electric vehicle charging stations and demand response programs at the distribution level. Additionally, emission analysis at both T&D levels incorporates emission penalty and emission cap mechanisms for multiple pollutants. Numerical results illustrate the relevance and effectiveness of the proposed approach.

4 - Electricity distribution network design with solar panels: hedging against failures
Doriana Vizzini, Simona Mancini, Alessio Sclafani

Electricity distribution networks are critical infrastructures that must be capable of supplying power from high-voltage transmission networks to consumers in a hierarchical system of substations and transmission lines. We propose a stochastic optimization model explicitly considering solar panels that both can satisfy local demand at installation sites while also serving as distributed generation points that reinject excess capacity into the network. With larger sets of experiments we show the benefit of using solar panels.

■ TF-51

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Counterfactual Explanations for Decision Making

Stream: Mathematical Optimization for Transparent and Fair Decision Making
Invited session
Chair: *Jasone Ramírez-Ayerbe*

1 - Directional Counterfactual Explanations for Black-Box Models
Javier MartÍn ChÁvez, Emilio Carrizosa, Cristina Molero-Río

We propose a novel framework for directional counterfactual explanations to interpret black-box models. This approach identifies an optimal direction of change that maximizes robust predictive improvement. By evaluating finite-jump perturbations under one-dimensional random smoothing via an Upper-tail CVaR functional, the method focuses on gains in best-case scenarios. We establish regularity guarantees, derive exact evaluation schemes for common model classes, and propose vMF-VNS, a derivative-free stochastic optimizer.

2 - From Infeasibility to Optimality: Logic-based Explanations for Power Dispatch Decisions
Benjamin Fritz

In decision-making problems addressing complex, safety-critical infrastructure, explainability is key to ensure transparency and fairness towards stakeholders. We propose the use of logic-based explanations for dispatch decisions in electricity markets and apply our methods to well-established problems such as the optimal power flow. Our work covers abductive and counterfactual explanations and links optimality with infeasibility explanations, enabling users to answer questions such as "Why (not) this decision?" by identifying IF-THEN relations between inputs, constraints and solutions.

3 - Understanding Decisions in Contextual Optimization
Jasone Ramírez-Ayerbe, Emma Frejinger

Many optimization problems arise in environments where decisions depend on contextual information and uncertain outcomes. While optimization identifies the best solution for a given context, decision makers may wish to understand how alternative decisions could become viable under slightly different circumstances. In this talk, we study methods to identify minimal contextual changes that make alternative decisions feasible while maintaining comparable performance. These explanations provide insights into the structure of decisions in contextual optimization problems.

■ TF-52

Tuesday, 16:15-17:45 - Room: KOL - PC Raum 1 (Building: KOL)

Topics in Electricity Markets

Stream: Energy Markets & Systems
Invited session
Chair: *Thomas Hübner*

1 - The value of storage in electricity distribution: The role of markets
Dirk Lauinger, Deepjyoti Deka, Sungho Shin

Electricity distribution companies deploy battery storage to defer grid upgrades by reducing peak demand. In deregulated jurisdictions, such storage often sits idle because regulatory constraints bar participation in electricity markets. Here, we develop an optimization framework that, to our knowledge, provides the first formal model of market participation constraints within storage investment and operation planning. Applying the framework to a Massachusetts case study, we find that market participation could deliver similar savings as peak demand reduction.

2 - Pricing Nonconvexities in Sequential Electricity Markets
Quentin Lété, Thomas Hübner

Short-term electricity markets are non-convex due to start-up and no-load costs of thermal generators, as well as constraints such as minimum output and ramping. Most studies analyze pricing mechanisms in a single market-clearing problem, typically day-ahead. In reality, electricity markets operate as a sequence of interconnected markets where commitment decisions occur early and real-time mainly adjusts dispatch. This work examines how such sequential market structures affect the interpretation of prices and uplift payments used to recover nonconvex costs.

3 - Ex Post Calibration of Flow-Based Domains from Hybrid European Market Clearing Outcomes
Pierre Arvy, Florin Capitanescu, Amélie Lambert, Daniel Porumbel, Nicolas Omont

Flow-based market coupling determines cross-zonal exchanges in the European day-ahead electricity market. An optimization-based calibration method is proposed to construct a flow-based domain for which a prescribed dispatch becomes optimal for zonal market clearing. The reference dispatch is obtained from a hybrid model combining zonal prices and nodal security constraints. Calibration enforces the remaining KKT conditions through a feasibility problem. Numerical results show the calibrated domain reproduces the hybrid outcome, eliminates ex post redispatch, and reduces total system cost.

■ TF-53

Tuesday, 16:15-17:45 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Robust Multiobjective Optimization

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Guillermo Cabrera-Guerrero*

1 - A minimax theorem for set-valued maps and its application to multi-objective uncertainty
Yousuke Araya

In this presentation, we propose two-person games with set payoffs. Then we introduce several concepts of saddle points and equilibrium points of two-person games with set payoffs. We also present an existence theorem of saddle-point by using Kakutani-Glicksberg-Fan's fixed-point theorem. We also present a new type Minimax theorem for set-valued maps. The proposed theory described above can be interpreted as uncertain multi-objective game theory. We also formulate an uncertain multi-objective game.

2 - Solving Two-stage Robust Biobjective Linear Program with Uncertainties using parametric Benders' Decomposition
Rakhi Goswami

Two-stage robust biobjective linear programs (TSBOLPs) model decision situations under uncertainty with conflicting objectives at every stage. A novel methodology- parametric Benders' decomposition (pBD) is developed to solve TSBOLPs, which produces an approximate first-stage sub-robust efficient solution set, a convex or non-convex two-stage sub-robust Pareto outcomes set and a unique second-stage sub-robust efficient solution in a two-dimensional first and second-stage decision space. A vehicle design and drivetrain TSRBOLP is solved using pBD.

3 - Assessing robustness as a decision criterion in a bi-objective approach for a dynamic and stochastic job shop scheduling problem
Žiga Letonja, Nikolaus Furian, Siegfried Voessner

Production systems must cope continuously with various disruptions and uncertainties, arising from both internal and external sources. To temper their impact on realized schedule performance, we examine the use of a robustness measure as a secondary decision criterion when choosing among degenerate solutions from an approximated Pareto front. A simulation of a job shop dealing with random machine breakdowns and varying repair times on a benchmark instance evaluates realized makespan and tardiness. The results support the expansion of more robust production scheduling strategies.

4 - MO Robust Optimisation of Positively Homogeneous Functions
Guillermo Cabrera-Guerrero, Sebastian Muñoz, Mauricio Moyano

Robust multi-objective optimisation addresses decision-making under uncertainty when several conflicting objectives must be considered simultaneously. This work studies robust formulations for optimisation problems with positively homogeneous objective functions. Exploiting their scaling properties, we show that robust feasibility under scenario-based uncertainty can be recovered by scaling nominal efficient solutions. The proposed approach reduces the robustification process to computing a single scaling factor while preserving the trade-off structure of the nominal solution set.

■ TF-57

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum 07 (Building: HG)

AI in Behavioral OR

Stream: Behavioural Operational Research
Invited session
Chair: *Wieland Müller*

1 - The Behavioral Building Blocks theory in Times Series
Konstantinos Nikolopoulos

The Behavioral Building Blocks theory argues and positions on the non-existence of Random Walks in Social Sciences And Humanities Time Series through proposing a behavioral Operations lens.

2 - Enhancing Algorithmic Advice Taking Through Effort Investment
Shuang Shi, Andreas Fügener, Ulrich Thonemann

Decision-makers frequently override algorithmic advice, limiting the operational benefits. We argue that advice use depends not only on accuracy but also on users' psychological engagement. Drawing on effort justification theory, we propose that requiring effort to finalize algorithmic advice fosters psychological ownership and increases reliance on it. Our two studies show that effort raises intention to use advice through psychological ownership, increases actual advice taking, and improves performance. User effort thus serves as a design lever for enhancing human-algorithm collaboration.

3 - Human-Algorithm Collaboration to Incorporate Contextual Private Information
Gozdenur Buyuk Habaci, Christina Imdahl, Eirini Spiliotopoulou, Willem van Jaarsveld

Human planners can improve algorithmic solutions using private information, but may also introduce biases that may lead to ineffective adjustments. These biases are particularly strong when private information is contextual rather than structured statistical information. In a laboratory experiment on scheduling, we examine how human planners revise algorithmic solutions when they possess contextual private information, under what conditions these adjustments enhance the quality of the decision, and which design interventions can help mitigate biases and support human adjustment effectively.

4 - From Co-Existence to integration: Examining human-AI interaction across task types
Michael Leyer, Wieland Müller, Oliver Behn, Johannes Wichmann, Bayu Nuswantoro

This study examines how task, technology, and individual factors jointly shape the depth of Human-AI Interaction (HAII). Building on Task-Technology Fit theory, it introduces the HAII Stage Continuum, a framework describing interaction from simple coexistence to full integration. Using survey data, the study investigates interaction depth across eight task types, focusing on LLMs. Results show that task characteristics significantly influence interaction stages, while technology-related differences are minimal.

■ TF-58

Tuesday, 16:15-17:45 - Room: HG - Seminar-Raum 08 (Building: HG)

Moments in the History (and Future) of OR - 1

Stream: Moments in the History of OR and IFORS
Invited session
Chair: *Andres Medaglia*

1 - Optimization is harder than stone
Jan Karel Lenstra

In the early 1970s, Cook, Levin and Karp established the probably inherent difficulty of many important computational problems. I will discuss the advent of complexity theory in combinatorial optimization and describe the work of Livshits and Rubinetsky, who, simultaneously and independently, developed an informal approach to computational complexity. They presented linear reductions of the partition problem to several scheduling problems and argued that, since partition is found to be hard, these scheduling problems are hard as well. Their work has received little attention.

2 - Review of the 7 decades of the Interior Point Method (IPM) Revolution
Tamás Terlaky

In 1954, Ragnar Frish proposed a "Logarithmic Potential Method" to solve LO problems and soon extended it to convex optimization. In the 1960's Fiacco & McCormick studied and expanded the logarithmic barrier methodology as SUMT. The modern age of polynomial time IPMs was launched by Karmarkar in 1984. Since then, IPMs transformed the way we think of optimization; expanded the scope of efficient IPMs to smooth-convex and conic LO. The powerful methodology of IPMs impacted most areas of optimization, and most recently emerged as key methodology in quantum computing optimization.

3 - Trust region algorithms – the contributions of M.J.D. Powell
Ya-xiang Yuan

In this talk, the contributions of late professor M.J.D. Powell on trust region algorithms will be presented. Powell was one of the pioneers of trust region methods for optimization. His creative techniques for proving the convergences of trust region algorithms are fundamental to the theoretical analysis of trust region methods. He gave many excellent results on trust region algorithms for many different optimization problems, including unconstrained optimization, constrained optimization, nonsmooth optimization and derivative-free optimization.

4 - Paper and pencil. Early calculation techniques in operations research
Richard Vahrenkamp

This article asks what calculation techniques operations research scientists used. Until the 1970s, most scientists at universities did not have access to computers. Even Georg Danzig, who worked at the Rand Corporation, did not calculate the so-called diet problem on an electronic digital computer until 1953. Previously, he had used an electric desktop calculator. There are also no convincing reports from Stafford Beer's OR group at United Steel in Great Britain about which problems he solved with the Ferranti computer that had been available to him since 1956.

■ TF-59

Tuesday, 16:15-17:45 - Room: KOL - Seminar-Raum 9 (Building: KOL)

MultiCriteria Decision with Partial Preference Information 1

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Adiel Teixeira de Almeida*

1 - Multi-Criteria Decision Making with Partial Preference Information and Recent Applications
Adiel Teixeira de Almeida, Eduarda Frej, Lucia R P Roselli, Jonatas A. de Almeida, Ana Paula Costa, Danielle Morais

This presentation explores MCDM/A methods with partial preference information, integrating theoretical contributions with practical applications. The study highlights the use of linear programming for analyzing alternatives with partial information on criteria weights. A key feature is the use of Decision Support Systems and their evolution through behavioral experiments and neuroscience tools. It offers innovative insights into MCDM with partial preference information for improvement of decision processes. References at https://link.springer.com/book/9783032192837.

2 - Multi-Criteria Decision Making with Partial Preference Information and Recent Applications and Cases with the FITradeoff Method
Jonatas A. de Almeida, Adiel Teixeira de Almeida, Eduarda Frej, Lucia R P Roselli, Ana Paula Costa, Danielle Morais

This presentation considers practical applications of an MCDM method with partial preference information. It includes areas such as energy, health systems, security, sustainability, industrial contexts, supplier selection, and more. The focus is on the preference modeling process using partial information using the FITradeoff Method with emphasis for insightful applications, which can be reached at https://link.springer.com/book/9783032192837.

3 - Multi-Criteria Decision Making with Partial Preference Information and their use for Group Decision and Negotiation
Danielle Morais, Adiel Teixeira de Almeida, Eduarda Frej, Lucia R P Roselli, Jonatas A. de Almeida, Ana Paula Costa

It is shown how preference modeling with partial information Is considered for MCDM/A problems related to Group Decision and Negotiation (GDN. The presentation covers Multi-Criteria Group Decision Making/Aiding and Negotiation processes with Decision Support Systems (DSSs), which are made available. The use of these DSSs are illustrated with some applications that can be seen at https://link.springer.com/book/9783032192837.

4 - Multi-Criteria Decision Making with Partial Preference Information and the use of Behavioral Studies to Improve Decision Support Systems
Lucia R P Roselli, Adiel Teixeira de Almeida, Eduarda Frej, Jonatas A. de Almeida, Ana Paula Costa, Danielle Morais

This presentation shows the advantages of approaches that use partial preference information for Multi-Criteria decision Making/Aiding. The interactive process for preference modeling is made feasible by using Decision Support Systems (DSS). Behavioral tools and Decision Neuroscience is applied to bring innovative insights into improvement of the decision processes and their DSS. References can be reached at https://link.springer.com/book/9783032192837.

■ TF-60

Tuesday, 16:15-17:45 - Room: KOL - Seminar-Raum 10 (Building: KOL)

Optimization and Strategic Portfolios

Stream: OR for Insurance, Banking and Financial Risk
Invited session
Chair: *Sergio Ortobelli Lozza*

1 - Impact of Key Global Risk Factors and Gold Price on Ethereum Returns: A Quantile Regression Analysis and NARDL
María de la O González, Francisco Jareño

This paper investigates Ethereum's sensitivity to key global risk factors, including S&P500, interest rates, oil prices, and financial stress indicators, to assess its potential as a diversifier or safe-haven asset. Applying quantile regression and NARDL models (2016-2025), results show Ethereum's linkages intensify under market distress, while its short-term asymmetric relation with gold lacks long-run cointegration. Ethereum's post-protocol upgrade behaviour aligns more with Bitcoin, indicating context-specific diversification but limited safe-haven potential.

2 - Core-periphery analysis of risk dependence among cryptocurrencies
Giulia Rotundo

Synthetically adopting breakpoints detection, Value-at-Risk estimation methods and backtesting, and complex networks, our research uncovers significant insights into how tail risk dependence among cryptocurrencies is evidenced by core-periphery network structures. The data set includes 221 cryptocurrencies in the time interval Jan. 1st. 2022 - Nov. 21st, 2025, which is split into four parts after the detection of breakpoints. Each node of the network is representing a cryptocurrency, and the weight of the link among couples reports the conditional risk CoVaR, estimated through the EWMA.

3 - Modeling Real Estate Market Prices: A Machine Learning Approach
Raducu Florin

This paper aims to develop machine learning models that use Lasso regression and XGBoost to estimate prices in the real estate market. These methods are more advanced machine learning models that can be successfully applied to a wide range of data sets in various fields. Estimating real estate market prices using machine learning models is critical for optimizing property valuation and prediction processes, as well as decision-making behavior. Machine learning can detect hidden patterns and correlations that traditional analysis might miss, thereby improving decision-making processes.

4 - Estimation of Cox processes intensities for modeling catastrophic risks
Alexandra Moura

In insurance risk management, problems such as optimal reinsurance, risk-measure optimization are typically modeled assuming claims follow a Poisson process with constant intensity. While effective, this assumption is increasingly unrealistic considering emerging risks. Catastrophes create short-term spikes in claim arrivals and evolving exposures. Since claim intensity is often unobservable and data are sparse, we propose a nonparametric Bayesian framework using compound Poisson and Cox processes to estimate surplus dynamics while explicitly incorporating model uncertainty in risk assessment.

■ TF-61

Tuesday, 16:15-17:45 - Room: KOL - Seminar-Raum 18 (Building: KOL)

Valuation

Stream: OR and Accounting
Invited session
Chair: *Matthias Amen*

1 - Intangible Assets and Stock Market Valuation: Evidence from Patent and Trademark Shocks Using Local Projections
Hitoshi Takehara

This study examines how firms' intangible assets, specifically patents and trademarks, affect stock market valuation. Using an unbalanced panel of Japanese firms, I analyze the dynamic responses of EPR and stock returns to shocks in intangible asset measures through the local projection method. The results show that patent shocks generate a persistent positive market reaction, suggesting that investors value technological strength, while trademark effects are weaker and less consistent.

2 - Valuation of Employee Stock Options with IPO-Contingent Vesting
Mina Ishii, Junichi Imai

Employee stock options (ESOs) in private firms often vest upon IPOs, limiting the use of standard valuation methods. We develop a tractable valuation framework for ESOs with IPO-contingent vesting, modeling IPO arrival as a threshold-triggered Poisson process and incorporating early exercise and forfeiture via state-dependent intensity. We derive semi-analytical formulas showing that IPO-contingent vesting can increase ESO value. We further find that the accounting Black-Scholes model systematically underestimates ESO value, with the bias increasing with IPO timing uncertainty.

■ TF-65

Tuesday, 16:15-17:45 - Room: HG - Hörsaal 27 (Building: HG)

Statistics and Mathematics in the age of Data Science - OR - Analytics III

Stream: Analytics
Invited session
Chair: *Gerhard-Wilhelm Weber*
Chair: *Sheldon Jacobson*

1 - Dynamics of Tax Collection Efficiency: OECD versus Emerging Economies
Ebrahim Rezaei, Josef Jablonsky

This study aims to address tax collection efficiency in OECD and emerging economies using a new version of a four-component frontier model. We introduce an autoregressive process to account for dependence in transient inefficiency. we use Maximum Simulated Likelihood to estimate the parameters. Our findings indicate that this study will help to standardize tax performance assessment. Moreover, it is perceived that a dynamic four-component stochastic frontier model has more precise results compared to the two-component model.

2 - Multimodal Demand Forecasting for New Eyewear Products
Tsukasa Ueshima, Naoki Nishimura, Tsugumi Honda, Takeshi Matsumoto, Shunnosuke Ikeda, Noriyoshi Sukegawa, Yuichi Takano

Forecasting demand for new products is important for product development and inventory management, but is difficult because historical sales data is not available. Recent studies have used multimodal information such as images and text, but their application to eyewear products is still limited. We propose a demand forecasting model for new eyewear products by integrating structured data, text embeddings of product descriptions, and visual features extracted from product images. The predictive performance of the proposed model is evaluated using actual sales data from a Japanese company.

3 - Personalizing PureRank for Recommender Systems via Matrix Factorization
Shogo Kamiyama, Hiroyuki Masuyama, Hiroshige Dan

Recently, Masuyama [arXiv:2501.00417] proposed PureRank, a parameter-free alternative to PageRank, which uniquely determines node importance from the network structure. In this study, we apply PureRank to a recommender system. In network-based recommender systems, PageRank achieves personalization through random jumps to provide recommendations. However, since PureRank does not employ random jumps, it cannot be personalized in the same way as PageRank. To address this issue, we propose a personalization method for PureRank using matrix factorization.

4 - Analyzing Collection Problems and its impact on Money
Sheldon Jacobson, James Crumpacker

This presentation describes a collection problem associated with banknotes printed by the United States Bureau of Engraving and Printing. Given that every banknote contains a unique eight-digit serial number, the objective is to build models that inform banknote collectors how much effort they must expend to find banknotes with matching serial numbers. Analytical and computer simulation models provide insights that inform how much data is needed to obtain the desired prize. This talk provides a glimpse of new data opportunities exist that may be flying "under the radar".

■ TF-66

Tuesday, 16:15-17:45 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Modelling and Methods for Quantum Optimization

Stream: Quantum Optimization
Invited session
Chair: *Conrad Haupt*

1 - Influence Maximization With Precedence and Conflict Constraints - Quantum Approaches
Evren Guney

The Influence Maximization Problem (IMP) selects a small set of seed nodes that maximizes expected influence spread in a social network. Practical campaigns often impose operational constraints such as precedence and mutual-exclusion among influencers. We study IMP under these constraints using a reverse-reachable sample-average approximation. We derive QUBO and high-order formulations suitable for quantum optimization and introduce a constraint-reduction technique that removes slack variables in coverage constraints to reduce model size significantly.

2 - On the Computational Dynamics of Quantum Approximate Optimization Algorithm
Alexey Bochkarev, Laura Wendel

The work aims to develop a metaheuristic perspective on Quantum Approximate Optimization Algorithm (QAOA). We analyze the amplitude dynamics of different computational basis states theoretically, investigating the connection between QAOA angles and resulting solution probabilities. This necessitates a description of the interplay between the evolution operators within a single layer, and between the consecutive layers. Such point of view contributes to a better understanding of QAOA (regardless of the connection to the adiabatic theorem), and highlights the effects of entanglement.

3 - Quantum-Ready Reformulation of the Simple Assembly Line Balancing Problem via Dynamic Cycle-Time Cuts
Utku Koc, Evren Guney

We study the Simple Assembly Line Balancing Problem type 1 from a quantum optimization perspective. Standard QUBO models require many slack variables for cycle-time and precedence constraints, producing large and dense formulations. We propose a slack-free reformulation using dynamically generated cover cuts and precedence-based exclusion constraints. Preliminary results show a smaller model and a more practical structure for hybrid quantum-classical methods, including quantum annealing and QAOA.

■ TF-67

Tuesday, 16:15-17:45 - Room: KOL - PC Raum 3 (Building: KOL)

OR and Optimization in Energy Systems

Stream: Energy Markets & Systems
Invited session
Chair: *Alberto J. Lamadrid L*

1 - Retail Electricity Competition with a Regulated Benchmark and Inattentive Consumers
Alberto J. Lamadrid L

We study competition in retail electricity markets motivated by two robust empirical patterns. First, most competitive supplier offers are priced above the default service rate (SO/PTC), indicating persistent positive markups rather than Bertrand marginal-cost pricing. Second, offer prices exhibit substantial dispersion, including a heavy right tail. We model a market with a regulated default offer and fringe suppliers serving attentive and inattentive consumers. Firms compete strategically, and we characterize the Nash equilibrium pricing outcomes across suppliers

2 - T&D System Planning: The Perspective of the Distribution Planner
Abdolazim Yaghooti, Gregorio Muñoz-Delgado, José Manuel Arroyo, Javier Contreras

This paper studies the investment planning problem faced by a distribution system operator(DSO). As a salient modeling aspect, the reaction of the transmission system operator (TSO) to the DSO's expansion plans is explicitly modeled while recognizing that both entities pursue their own objectives. A stochastic bilevel programming framework is proposed to represent this hierarchical decision-making process under uncertainty. Three instances, each reflecting a practical operational scheme for interface nodes and distribution substations, are analyzed and solved using a novel sequential method.

3 - Power distribution expansion planning under energy transition pathways and partially constrained flexibility
Alfredo Ernesto Oneto, Blazhe Gjorgiev, Giovanni Sansavini

To support the energy transition, we propose a mixed-integer multistage model for distribution grid expansion. We develop tractable methods for 2050 pathway analysis in Switzerland, combining grid-tailored clustering to reduce spatial complexity with an extended Lp-Box ADMM algorithm for integer decisions. Results show that transition pathways drive investment needs (from 367 to 1,705 MCHF). Partially constrained demand shifting can halve investments, highlighting the value of distributed flexibility.

4 - Congestion Management in Distribution Grids with Sector-Coupled Flexibility
Ali Nikseresht, Reza Rahimi Baghbadorani, Jehum Cho, Yashar Ghiassi-Farrokhfal

Mid- and low-voltage grids face congestion and computational bottlenecks when ACOPF is used under high electrification. We propose a flexibility-aware optimization framework that co-optimizes network operation with hydrogen production and transportable hydrogen resources across selected nodes, improving both tractability and solution quality. The method combines a physics-based power flow model with a tighter optimization strategy. Initial results show reduced congestion, improved relaxation behavior, and near-ACOPF accuracy with substantially better computational performance.

Wednesday, 8:30-10:00

■ WA-04

Wednesday, 8:30-10:00 - Room: HG - BIG-Hörsaal (Building: HG)

Pandemic OR and cybersecurity

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Patrick Hirsch*

1 - A Generalized Decision System for Optimal Lockdown Timing during an Epidemic
Noura El Hassan, Bacel Maddah, Fouad Ben Abdelaziz

In an epidemic situation, decision-makers may impose a lockdown restricting social interaction to limit the spread of infections. Deciding when to initiate a lockdown is challenging since health and economic costs should be considered, as observed during COVID-19. In our previous work (El Hassan et al., 2025), we use a Markov Decision Process (MDP) with a Susceptible-Infected-Susceptible (SIS) process and derive a threshold-based policy for optimal lockdown timing. In this work, we extend the model to account for unreported infections, time-dependent transmission rates, and vaccination effects

2 - A scalable data pipeline for infectious disease phenotyping for outbreak preparedness and response
Leonardo S. L. Bastos, Tomoe Gusberti, Pedro Barbosa, Enzo Gurrieri, Felipe Delpino, Sarah Freire, Igor Peres, Carlos Lima, Silvio Hamacher, Otavio Ranzani

Effective outbreak preparedness and response requires real-time data and AI-driven decision support. Disease phenotyping enables identification of population heterogeneity, supporting segmentation for targeted interventions and resource prioritization. We propose a scalable phenotyping pipeline (ISARIC RAPID) integrating unsupervised learning and statistical resampling to determine an optimal phenotypes for infectious diseases case-level clinical data. The approach was applied to over 8 million dengue cases from the Brazilian national surveillance system (2024-2025).

3 - Fair Allocation of Pandemic Patients Accounting for Regular Care Backlogs
Victor Ploeg, Eyal Castiel, Anna Dankers, Sander Dijkstra, Anne Zander, Richard Boucherie

We present a dynamic patient allocation rule to assign pandemic patients to hospitals in a network with the aim of balancing the load of regular patient backlogs. The rule accounts for hospital capacity, accumulated backlog, and patient urgency levels. We analyze the long-term behavior of the resulting system using fluid scaling techniques, which enable representing the patient-level dynamics as a deterministic continuous model of two interacting ordinary differential equations. This framework allows study of the stability, fairness, and robustness of the allocation policy across the network.

4 - Simulating Cyberattack Impacts on the Austrian Pharmaceutical Supply Chain
Larissa Schachenhofer, Patrick Hirsch

The pharmaceutical supply chain is critical to societal health. As business operations in the drug supply chain are highly dependent on inventory management and logistics systems, digital incidents, such as cyberattacks targeting strategically relevant supply chain actors, can seriously threaten the supply of medicines. Using real-world data, this model simulates the Austrian drug supply chain and product flows under cyberattack conditions, thereby (1) testing the system boundaries under extreme conditions, and (2) evaluating measures for business continuity from a supply chain perspective.

■ WA-05

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 18 (Building: JUR)

Planning and Designing Shared and Multimodal Mobility Systems

Stream: Shared Mobility
Invited session
Chair: *Rym M'Hallah*
Chair: *Jian Zhang*

1 - Station location decisions in bike-sharing systems: the value of accounting for public transport options
Soukaina Bayri, Kris Braekers, An Caris

Bike-Sharing Systems (BSS) have been widely adopted in cities due to benefits such as reduced emissions and improved public health. Stations are often located near Public Transportation (PT) stops, enabling multimodal travel and expanding PT coverage, especially in poorly connected areas. However, limited research exists on how to design bike-sharing networks while considering PT. For this problem, a mathematical model is developed and used to evaluate the impact of accounting for PT under different network densities, demand patterns, and cost structures.

2 - Which combination of bike-train strategies is most suitable in a city? A continuous approximation approach to demand allocation
Regine Tejada, Andres Fielbaum

Bike-train integration can involve shared bikes, private bike parking, and bicycles on trains. This study develops a continuous approximation model to determine the cost-minimizing mix of strategies when demand includes fixed users and cost-responsive users allocated through a logit model. Case studies in Pasig City and Parramatta show that limited train capacity can make the bike-on-train option infeasible, shifting demand to shared bikes and private bike parking. With fixed demand, the lowest-cost strategy attracts most demand. Other strategies serve fixed demand and capacity constraints.

3 - A new taxonomy of demand responsive transport services
Rym M'Hallah, Julia Bennell, Christine Currie, Chiara Calastri, Jian Zhang

Demand Responsive Transport (DRT) is a shared mobility solution that enhances social inclusion and supports sustainability. Existing typologies focus on operational dimensions, e.g. fleet configuration, depot location, time-windows, deterministic or stochastic demand, and static or dynamic service models. Some classify DRT systems by their degree of flexibility or overarching objectives. This paper proposes a new taxonomy around eight characteristics and demonstrates how this taxonomy provides a clearer conceptual thereby offering a more systematic approach to the design of DRT systems.

■ WA-06

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 07 (Building: HG)

Omnichannel and Online Retailing

Stream: Retail Operations
Invited session
Chair: *Rob Broekmeulen*

1 - Is the design of an omnichannel network sensitive to e-commerce market share? An answer by robust optimization
Moein Qaisari Hasan Abadi, Laurent Alfandari

We study whether optimal warehouse and store locations in omnichannel retailing are sensitive to the e-commerce market share. A robust optimization model is developed to jointly determine facility location and channel fulfillment under uncertain online demand. Using a cardinality-constrained uncertainty set, the model balances resilience and efficiency. Computational experiments and a case study based on the Carrefour retail network in the Paris suburbs show that the gap between nominal and robust solutions is small, suggesting strong structural stability of facility location decisions.

2 - Dynamic Fulfillment Policies in Integrated Omnichannel Systems
Bahriye Cesaret, Armagan Bayram

Omnichannel retailers integrate online and store channels via ship-from-store, buy-online-pickup-in-store, and buy-in-store-ship-to-home, creating dynamic inventory allocation challenges. We develop a stochastic model that jointly captures all three fulfillment modes under demand and shipment cost uncertainty, margin heterogeneity, and customer switching. We characterize optimal policies in small networks and propose a scalable margin-based heuristic for larger systems. Results show synergistic gains from integration and that the proposed heuristic consistently outperforms myopic rules.

3 - Dare to share? Accuracy and transparency of in-store product availability in omnichannel retail
Fredrik Eng Larsson, Olov Isasson, Alireza KabirMamdouh, Melika Khandan

Many omnichannel retailers share in-store availability information online despite substantial inventory accuracy challenges. While prior research examines whether availability should be shared, it largely assumes accurate underlying data. But what is the value of improving the accuracy of the underlying data? Using a difference-in-differences framework, we show that accuracy improvements enhance operational performance in the store and, more crucially, when shared it shifts customers from online to brick-and-mortar stores, significantly increasing sales across the store network.

4 - Tiered Refunds and Return Restoration for Seasonal Products: Profit and Environmental Impacts
Oben Ceryan, Yuyun Zhong, Wenjing Shen

The surge in product returns, especially for seasonal products with short selling seasons, creates financial and environmental challenges. We propose a tiered refund policy combined with return restoration; early returns receive full refunds (enabling restoration and resale), while late returns receive partial refunds. Using a two-period model capturing valuation uncertainty and early-return disutility, we characterize optimal late refund, inventory, and restoration decisions. We find the policy may improve both profitability and sustainability by reusing returns and reducing inventory needs.

■ WA-07

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 21 (Building: HG)

Market Equilibria

Stream: Auctions and Market Design
Invited session
Chair: *Aleksandrs Smilgins*

1 - Why Symmetric Platform Markets Tip
Janik Bürgermeister, Martin Bichler

Standard two-sided market models predict coexistence when platforms are symmetric and network effects are weak. We show that this fails once platforms face a survival risk under incomplete information. In a dynamic Bayesian model, platforms privately observe costs and exit when cumulative performance falls below a viability threshold. Pricing then affects rivals' survival probabilities, inducing risky cross-subsidization to capture the market. Failed attempts trigger exit and lasting concentration, so tipping arises with positive probability even in symmetric markets.

2 - Optimal pricing policy under random draw sales mechanism considering speculative reselling behavior
Hyeonjun Kim, Jihyeok Jung

In markets for high-demand goods, speculative resellers can crowd out genuine consumers. From the seller's perspective, this exceeds a mere fairness issue, as it distorts allocation and weakens market efficiency. Thus, sellers have used a random draw mechanism to mitigate these issues. This study models the interaction between a seller and resellers under such a mechanism as a sequential game, assuming that uncertainty is present in resale-market demand. Through equilibrium analysis of reseller entry into the draw, we derive an optimal pricing policy balancing profit and social welfare.

3 - Robust Dynamic Staffing with Predictions
Yiding Feng, Rad Niazadeh, Vahideh Manshadi

We study a dynamic staffing problem with sequential hiring under demand uncertainty, where forecasts improve over time while worker availability declines. Modeling predictions as adversarial uncertainty intervals, we pose a minimax problem to control worst-case staffing imbalance. We characterize the minimax value via a polynomial-size linear program against a restricted adversary and show how to emulate this solution for general adversaries, yielding a simple online algorithm that is provably minimax optimal. We further prove optimality under extensions including multiple demands and beyond.

4 - Performance Evaluation in Competitive Settings
Aleksandrs Smilgins

We study reward allocation in competitions where agents are evaluated across activities and performance is relative. Rank-based schemes create discontinuous incentives and unstable rewards. We propose a three-step method: convert outcomes to relative efficiency scores against a benchmark, aggregate them with weighted geometric means across activities, and distribute a fixed reward pool proportionally. The method is benchmark-independent. We apply the method to the Danish Debt Management Office's Primary Dealer reward program using price quotation data.

■ WA-09

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 50 (Building: HG)

Large Language Models for Optimization

Stream: Data Science meets Optimization
Invited session
Chair: *Yaoxin Wu*
Chair: *Zhenkun Wang*
Chair: *Jie Gao*

1 - Discovering Heuristics For Highly Constrained Routing Problems with LLMs
Nayeli Gast Zepeda, André Hottung, Kevin Tierney

LLM-driven code generation shows promise across domains, including heuristics for routing problems. VRPAgent embeds LLM-generated operators in a metaheuristic framework, keeping tasks manageable and ensuring correctness, while refining them via genetic search. We extend VRPAgent to a highly constrained problem where deep reinforcement learning (DRL) struggles to find any feasible solutions: the heterogeneous capacity vehicle routing problem with time windows and limited vehicles. We evaluate on challenging instances, comparing to DRL methods, established metaheuristics, and exact solvers.

2 - LLM-Driven Discovery of Heuristic Operators for Vehicle Routing Problems
André Hottung, Federico Berto, Nayeli Gast Zepeda, Daniel Wetzel, Davide Zago, Michael Römer, Kevin Tierney

Designing strong heuristics for vehicle routing usually demands expert intuition and years of domain knowledge. We propose VRPAgent, a framework that integrates LLM-generated components into a metaheuristic and refines them through a novel genetic search. Across several vehicle routing problem variants, VRPAgent discovers efficient strategies that outperform handcrafted and learning-based baselines while requiring only a single CPU core.

3 - Using small LLMs to translate natural language problem formulations into optimization models: A tree-based approach?
Hermann Gerzen, Michael Römer

Formulating optimization models from natural language problems is a time-consuming and iterative process that requires interdisciplinary expertise. The emergence of large language models (LLMs), particularly their use in interactive chats, opens up the possibility of an automated and streamlined process. However, current approaches yield unsatisfactory results and are often computationally intensive. We adapt a prompt-based heuristic tree search using a local LLM running on off-the-shelf hardware. To evaluate its potential, we test its performance on state-of-the-art benchmarks.

4 - Large Language Models as End-to-end Combinatorial Optimization Solvers
Yaoxin Wu, Xia Jiang, Yingqian Zhang

This work introduces a framework that enables LLMs to act as end-to-end CO solvers by mapping natural language descriptions directly to solutions. A two-stage training strategy combines supervised fine-tuning with feasibility- and optimality-aware reinforcement learning to reduce constraint violations and improve solution quality. Experiments on seven NP-hard problems show high feasibility and strong performance, outperforming several general and domain-specific methods.

■ WA-10

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 31 (Building: HG)

Vehicle Routing II

Stream: Combinatorial Optimization
Invited session
Chair: *Lavinia Amorosi*

1 - A Bilevel Split Based Heuristic for Vehicle Routing with Private Fleets and External Drivers
Juan G. Villegas, José-Fernando Camacho-Vallejo, Alejandro Montoya

This study addresses a bilevel vehicle routing problem with private fleets and external drivers motivated by parcel delivery operations. The leader (parcel company) minimizes operational costs while followers (external drivers) maximize profits. We propose a multi-space sampling heuristic (MSH) integrating route-first cluster-second and a set partitioning formulation. A bilevel split partitions giant tours into feasible routes for both levels. Results show that MSH compares favorably with an alternating matheuristic that iteratively solves leader and follower problems using a MIP solver

2 - An Optimization-Based Drone Routing Problem with an Application to Wildlife Monitoring
Annunziata Esposito Amideo, Lavinia Amorosi, Paula Carroll

We present an ad-hoc variant of the Capacitated Vehicle Routing Problem for wildlife management. It accounts for drone battery capacity and identifies minimum cost routes for the drones to collect data for the seal pup count. We solve the proposed model via both exact and heuristic approaches: we consider an adapted Clarke-Wright heuristic, which is also used as a warmstart to an off-the-shelf optimization software Branch-and-Cut; moreover, we propose an adapted Hybrid Genetic Search (HGS) algorithm. Results are discussed in a real case study in the Kosterhavet National Park area in Sweden.

3 - A Reinforcement Learning Approach to Grocery Delivery Vehicle Routing optimization
Omar Elsherif, Kenneth Sörensen, Bryan David Galarza Montenegro, An Caris

Grocery logistics face unique challenges: perishable inventory, tight time windows, and cost efficiency. We formulate a multi-depot, multi-compartment TD-VRPTW, solved via a novel VNS-LNS metaheuristic guided by multi-armed bandit reinforcement learning, which adaptively selects VNS neighborhoods and LNS destroy/repair operators. Tested on Belgian grocery delivery instances (10-50 customers), our algorithm matches Gurobi's optimal solutions while cutting computation time by 90%.

4 - Drone Coverage Path Planning with Altitude Selection and Preemption
Lavinia Amorosi, Dell'Olmo Paolo, Justo Puerto, Carlos Valverde

We present a second-order cone mixed-integer programming model for a drone-based monitoring system. A single drone must cover a set of non-overlapping polygonal areas via tours starting and ending at a depot while respecting limited endurance. For each area the model selects an inspection altitude and allows exits from a limited set of candidate points to reach nearby areas. When the energy level is low, the drone returns to the depot for battery replacement. The objective is to minimize the total mission completion time. Preliminary computational results on synthetic instances are reported.

■ WA-11

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 32 (Building: HG)

Sustainable food systems II

Stream: OR in Natural Resources
Invited session
Chair: *Sonja Rohmer*
Chair: *Marjolein Buisman*

1 - A branch-and-bound algorithm for maximizing diversity in agricultural landscapes
Thijmen van Loon, Peter Kirst, Argyris Kanellopoulos

Increasing crop diversity is a promising measure to improve the sustainability of agricultural landscapes. It can boost yields, biodiversity, and crop pollination. Designing diverse landscapes requires optimization of the spatio-temporal crop composition while respecting farm constraints. Although MILP models have been used to optimize diversity in agricultural landscapes, computational constraints limit their scalability for large landscapes. In our study, we introduce a branch-and-bound algorithm to efficiently decompose and solve large-scale landscape diversity maximization problems.

2 - Optimizing sustainable fertilization plans for cocoa crops
Katherinne Quiroga-Duran, Andres Medaglia, Karla Parra

Cocoa is a key crop for family farming, providing income and stability for smallholders. Productivity depends on proper fertilization and soil nutrient balance; however, intensive chemical fertilizer use creates economic and environmental challenges. This study develops two complementary optimization models to identify cost-efficient combinations of organic and chemical amendments that meet nutrient requirements and assess the viability of organic fertilizers. We illustrate the design of sustainable fertilization plans in a cocoa plantation in San Pablo, Santander (Colombia).

3 - Agricultural operations planning for diverse farming systems: a resource constrained scheduling and routing problem
Alfaima L. Solano-Blanco, , Raf Jans, Tom van Woensel

Agricultural operations planning, central to sustainable food production, remains inherently challenging. Involving the scheduling of diverse tasks across multiple fields and routing of the related heterogeneous resources, it needs to account for skill compatibility, time windows, resource synchronisation, precedence, and preemption. We address these joint challenges in a resource-constrained scheduling and routing problem. Furthermore, through experiments on diverse farming configurations, we explore how more sustainable practices affect decision-making and operational efficiency.

4 - Agricultural planning for mixed cropping systems
Sonja Rohmer

Combining multiple crops within a single field, mixed cropping systems present an interesting alternative to conventional agriculture promoting biodiversity and soil health. However, from a planning and logistics perspective these systems pose new challenges. In addition to accounting for geographical conditions at farms as well as the growth requirements of multiple crops, they do require the consideration of crop interactions and cultivation thresholds to realise potential benefits. This in turn introduces new complexities from an optimization perspective.

■ WA-12

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 11 (Building: JUR)

New Trends in Health Services

Stream: Health Care Logistics
Invited session
Chair: *Fangyuan Cao*
Chair: *Yong-Hong Kuo*

1 - Cooperative solutions for capacity challenges in neonatal care: A case study in the region of Utrecht, the Netherlands
Marieke Rikkert

Healthcare systems face growing pressure, especially in neonatology where timely access is critical. To tackle this challenge, we adapt a three-patient-type model (TPTM) as a framework to evaluate two cooperative capacity policies: a Virtual Medium Care (VMC), and a threshold-based bed reservation scheme. Results show that coordinated policies improve access and reduce care pressure, with the optimal threshold policy yielding 45 fewer refusals and 35 fewer overbed days per year while remaining robust to arrival fluctuations, emphasizing the role of cooperation in improving neonatal care.

2 - Telehealth's double-edged sword: Hidden costs of expanding virtual access to care
Masoud Kamalahmadi, Jong Lim

Leveraging the variation in telehealth adoption rates across physicians in a major health system, we show that telehealth's potential to expand access may come at the cost of increased workload for physicians and revenue losses for healthcare organizations.

3 - Dual-channel Competition in Healthcare under Information Asymmetry
Fangyuan Cao, Yong-Hong Kuo, Feng Tian, Jie Wang

Healthcare platforms, such as HealthTap and Dingxiang Doctor, have gained popularity in recent years due to their convenience and flexibility, competing with in-person hospitals within the market for medical consultations. Although platforms can verify the qualifications of physicians, physicians' actual performance remains unknown to the public. We develop a sequential game theory model to study the value of information, the value of mechanism design as well as the impacts of online healthcare on the entire healthcare system.

■ WA-13

Wednesday, 8:30-10:00 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Column Generation & Decomposition

Stream: Software for Operations Research
Invited session
Chair: *Christopher Hojny*

1 - Branch-Price-and-Cut in SCIP and GCG
Marco Lübbecke

The implementation of column generation (CG) and branch-price-and-cut (BPC) is a frequent use case of the open source framework SCIP. While CG can be easily implemented against any LP solver, implementing BPC is trickier. For the latter, one may lose a lot of performance (or has to work really hard) when not using an open source solver. When you are lucky (your problem is well suited), GCG can do most of the work for you. We also briefly discuss what to do when you are unlucky. Parts of the talk highlight some developments in the most recent major versions of SCIP and GCG relevant for BPC.

2 - Using VRPSolver's Price-and-Cut Engine within GCG
Erik Mühmer, Marco Lübbecke, Eduardo Uchoa

GCG and VRPSolver are branch-price-and-cut solvers that serve complementary needs. GCG is a general-purpose mixed-integer linear programming solver built on the SCIP framework. It automatically applies a Dantzig-Wolfe reformulation. VRPSolver directly works with the reformulated model for a wide range of vehicle routing and related problems. It deeply integrates a labeling algorithm for resource constrained shortest path subproblems with cutting plane separation. We experiment with joining these solvers, discuss challenges, early results, and a potential roadmap towards a unified framework.

3 - Column Generation with Domain-Independent Dynamic Programming
Ryo Kuroiwa, Edward Lam

Column generation and branch-and-price are powerful exact methods for large-scale optimization, but they often require custom pricing algorithms tailored to each problem, which limits generality. We show that domain-independent dynamic programming (DIDP) can serve as a generic pricing solver. We introduce new modeling features and a solving algorithm for DIDP, and show on four problem classes that branch-and-price with DIDP pricing outperforms an automated branch-and-price solver and branch-and-price using mixed-integer or constraint programming for pricing.

4 - A Framework for Handling and Exploiting Symmetry in Benders Decomposition
Christopher Hojny, Cédric Roy

Benders Decomposition (BD) is a framework for solving optimization problems by removing some variables and modeling their contribution to the original problem via Benders cuts. Since Benders cuts are not known explicitly, classical symmetry handling techniques fail in the context of BD. This presentation therefore demonstrates a general tool for computing symmetries in an oracle setting such as BD, and how to exploit symmetries in the separation of Benders cut. Computational experiments show the effectiveness of this approach.

■ WA-14

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 01 (Building: HG)

Lot Sizing - Applications 1

Stream: Lot Sizing, Lot Scheduling and Production Planning
Invited session
Chair: *Margaretha Gansterer*
Chair: *Anton Klymenko*

1 - Forecast-based Rolling Horizon Optimization in Sawmill Production Planning
Sebastian Schmalzer, Michael Boegl, Stefan Minner, Sophie Parragh, Roman Stainko

Uncertain round timber supply makes production planning and order allocation in sawmills difficult. In our study, we optimize production scheduling and log allocation to cutting orders, considering uncertain raw material supply. We propose a mixed-integer linear programming (MILP) model and apply it on a rolling horizon basis in real-world case study. Initial results verify the importance of accurate round timber forecasts for robust and efficient production planning, and that an in-depth examination of combining forecasting and optimization opens up further savings potential.

2 - Multi-Item Perishable Lot-Sizing with Heterogeneous Shelf Lives
Egecan Aktan, Mehmet Onal, Duru Balpınarlı, Erhun Kundakcıoğlu

We consider multi-item capacitated lot sizing problem for perishable goods that have different shelf lives and a consumption policy that follows a last expired first out principle. We present a branch and price method where we decompose the problem into independent single item subproblems that share a common production capacity. In our approach we incorporate several heuristics to improve upper bounds. Recent experiments we conducted show that the MIP formulation leaves large optimality gaps, motivating the decomposition method.

3 - Decentralized Coordination for Multi-Level Lot Sizing with Minimal Information Sharing
Anton Klymenko, Margaretha Gansterer

Centralized lot sizing guarantees optimality but demands full cost disclosure, which is often impractical due to competitive sensitivity. We propose a decentralized coordination mechanism for multi-level lot sizing relying on minimal information sharing. We investigate conditions for key incentive properties, specifically individual rationality and incentive compatibility. Computational experiments assess the trade-off between privacy preservation and system efficiency, quantifying the optimality gap relative to centralized and alternative decentralized benchmarks.

■ WA-15

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 34 (Building: HG)

Game Theory and Economic Models

Stream: Algorithmic Game Theory
Invited session
Chair: *Rashmi Singh*

1 - Cyber Wars and Budgets: A Game Theory Guide to Smarter Security Spending
Rashmi Singh, Santanu Mondal

Amidst escalating cyber threats, resource optimization is critical. This study develops a game-theoretic simulation model integrating real-world data (Verizon DBIR, MITRE ATT&CK, NIST CSF) to optimize adaptive defense strategies across industries. Simulating 500 time steps reveals that customized, risk-aligned defense portfolios significantly improve financial efficiency and resilience. For example, financial services achieve a 140% payback by prioritizing high-prevalence threats like phishing. Results highlight the cost asymmetry between attack innovation and defense deployment.

2 - Platform Competition with AI Technology Adoption and Driver Welfare: Government Intervention in Food Delivery Markets
Ashish Kumar, Suresh Kumar Jakhar

This study examines AI adoption in online food delivery platforms, where improved delivery-time accuracy enhances service quality but entails high costs and safety externalities for delivery workers. We develop a sequential game integrating AI adoption, consumer social responsibility preferences, driver safety risks, and government subsidies or taxes to characterize equilibrium pricing, competition, and social welfare outcomes.

3 - Procurement Contracts as Strategic Levers: Resolving the Innovation Free-Riding Dilemma under Price Volatility
Chen Yang, Songsong Liu

Literature overlooks how price volatility links procurement and innovation. This study analyzes how spot or fixed price contract choice shapes innovation responsibility allocation via a Markov game. While spot contracts create free-riding, fixed price contracts function as strategic levers to shift innovation responsibility upstream. To resolve the resulting coordination conflict, decentralized and bargaining-based revenue sharing are compared; Nash bargaining dominates by expanding total supply chain surplus. Procurement contracts thus govern innovation responsibility under volatile markets.

4 - Adoption strategies of blockchain technology in competitive supply chains under different power structures
Zijing Yang, Songsong Liu

Blockchain technology (BT) enhances trust but faces adoption barriers from costs, power structures, and consumer sensitivity. Using game theory, this study explores BT adoption strategies in a competitive supply chain under three power structures: manufacturer-led, retailer-led, or centralized. Key findings:1) manufacturer-led need a cost threshold, while retailers-led or centralize favor mutual adoption.2) centralized maximizes supply chain profit and quantifies decentralization loss.3) Intense competition enables BT-driven quality differentiation and high-price strategies.

■ WA-16

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 42 (Building: HG)

Heuristic approaches for vehicle routing problems I

Stream: Vehicle Routing and related problems
Invited session
Chair: *Yuan Yuan*

1 - An Adaptive Large Neighborhood Search Method for the Combined 3D Loading and Vehicle Routing Problem with Split Delivery and Time Windows
Semih Toközlü, Vildan Ozkir

This study examines the Three-Dimensional Loading Vehicle Routing Problem with Time Windows by adding Split Delivery (3L-VRPTW-SD) to maximize capacity utilization. We present an Adaptive Large Neighborhood Search algorithm supported by Simulated Annealing, combined with a rapid packing heuristic that incorporates vertical rotation while strictly enforcing static stability and LIFO constraints. The results clearly show a notable advantage over current methods, especially in optimizing fleet usage and significantly reducing total travel distances. Supported by TÜBİTAK Project No: 123M504

2 - A Decomposition Approach for Large-Scale Capacitated Vehicle Routing Based on Location-Based Heuristics
Soma Toki, Naoshi Shiono

We study the large-scale Capacitated Vehicle Routing Problem (CVRP). To obtain practical high-quality feasible solutions under strict runtime limits, we propose a Location-Based Heuristic (LBH)-guided decomposition framework that partitions an instance into capacity-balanced clusters using location information (e.g., via a p-median). Each subproblem is solved independently by efficient heuristics or exact methods, and routes are recombined to ensure global feasibility. Computational results on standard benchmarks show improved time-to-solution over monolithic approaches.

3 - A Matheuristic Approach for Optimizing Airport Baggage Transport with Drop-and-Pull Vehicles
Yuan Yuan, Xintong Zhao, Diego Cattaruzza

Airport baggage transportation is a critical component of ground handling operations. This study addresses an integrated routing and scheduling problem for tractors and trailers operating in drop-and-pull mode, explicitly considering empty trailer repositioning and parking capacity at stands. A mixed-integer programming formulation is developed and solved using a two-stage matheuristic integrating adaptive large neighborhood search, column generation, and branch-and-check. Results based on real airport data demonstrate the effectiveness of the approach and advantages over manual scheduling.

■ WA-17

Wednesday, 8:30-10:00 - Room: JUR - Dach-Geschoss (Building: JUR)

Hexaly

Stream: Sponsors
Sponsored session
Chair: *Léa Blaise*

1 - Hexaly Workshop: Modeling and Solving Packing Problems with Hexaly Studio
Léa Blaise

Hexaly Optimizer is a hybrid mathematical solver that integrates both exact and heuristic techniques to tackle complex optimization problems. At its core is an innovative modeling formalism based on nonlinear and set-oriented expressions, enabling users to write compact, expressive models for a wide variety of optimization problems. This formalism not only simplifies the modeling process but also provides the solver with higher-level structural information, allowing it to leverage advanced algorithmic techniques from the literature to obtain state-of-the-art performance on classic optimization domains such as routing, scheduling, and packing. In this hands-on workshop, we will focus on the application of Hexaly to packing problems, showcasing how the solver's set-based modeling capabilities naturally align with the structure of these problems. Participants will be guided through building and solving real-world packing problems using Hexaly Studio, a web-based integrated development environment designed specifically for optimization modeling. Hexaly Studio features intuitive dashboards, interactive widgets, and graphical solution visualizations, making it easy to both formulate models and interpret results. Through guided examples and interactive problem-solving, participants will gain hands-on experience with Hexaly and will be equipped to explore it further in their own research or applied projects.

■ WA-18

Wednesday, 8:30-10:00 - Room: JUR - U 21 (Building: JUR)

OR Contributions to National Security I

Stream: OR in Military, Defense, and International Security
Invited session
Chair: *Max Krueger*

1 - On the optimal defense resource allocation for the critical infrastructure protection
Vladimir Norkin

The report examines numerical methods for solving optimal resource allocation problems for critical infrastructure protection from the work: Gaivoronski, A.A., Knopov, P.S., Norkin, V.I., and Zaslavskyi, V.A. (eds) (2025). Stochastic Modeling and Optimization Methods for Critical Infrastructure Protection, Volume 2: Methods and Tools: Wiley - ISTE. Nonlinear discrete Attacker-Defender and Weapon-Target Allocation models with expected loss difference criteria and risk constraints are considered. Branch and Bound type methods are developed.

2 - Patrolling the Amazon River Navigation Network
André Bergsten Mendes

This research develops patrolling routes for the Amazon River navigation system, formulated as a variation of the Periodic Arc Routing Problem (PARP) and modeled as a profit-collection problem in which benefits arise from monitoring and securing specific arcs. A Mixed Integer Programming (MIP) formulation is proposed and evaluated using real-world data. Heuristic solutions are also developed, combining a construction heuristic with local search procedures. The proposed methods support fleet size decisions for patrol vessels.

3 - Extracting Operational Assessments from a LLM for Parameterization of a Bayesian Network Application for Smuggler Detection
Max Krueger

Bayesian Networks are used for a variety of classification tasks, but require parameterization by operational experts when no training data is available. Using a smuggler detection task from maritime surveillance as an example, this contribution examines whether the required parameterization can be obtained by ChatGPT rather than an operational expert. In addition to presenting a suitable procedure for extracting the required probabilities, the classification performance of the ChatGPT-parameterized Bayesian Network Classifier is compared with that of an expert-parameterized Bayesian Network.

■ WA-19

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 05 (Building: HG)

Energy Operations under Uncertainty

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Jehum Cho*

1 - Optimal Hybrid Storage Management for Stochastic Dual-Commodity Energy Systems
Ece Cigdem Karakoyun, Ehsan Aghamohammadzadeh, Yashar Ghiassi-Farrokhfal, Merieke Stevens

Renewable electricity is becoming the primary energy source and is increasingly converted into secondary energy carriers, such as hydrogen, to meet diverse demand profiles. We address this stochastic resource allocation problem in which two interconnected energy streams have separate storage systems and allow bidirectional conversion under efficiency losses. Using a Markov decision process, we characterize the optimal dispatch policy and show that cross-carrier storage assets act as substitutes, while hydrogen serves as a key strategic backup for electricity, challenging static priority rules.

2 - Two-Stage Stochastic Energy System Planning with Movable Assets: The Dutch Case
Aart Winthorst, Arpan Rijal, Ward Romeijnders

Achieving net-zero emissions by 2050 requires a significant transformation of the power system, driven by large-scale integration of renewable energy. The intermittent nature of renewable generation and evolving demand poses challenges for planning and management of the energy system. We develop a stochastic optimization-based Integrated Energy System Model to jointly determine grid investments and operational decisions under uncertainty. The model is geared towards providing insights into the role of flexibility options such as hydrogen and movable assets in reducing grid investment costs.

3 - A Bilevel Optimization Model for Bottom-Up Coordination of Multiple Low-Voltage Energy Communities and the Medium-Voltage Network
Fernando García

This paper proposes a bottom-up bilevel optimization framework for the coordinated operation of multiple LV energy communities and an interconnected MV network. A local market operator aggregates multiple LV communities and acts as a single leader, determining DER operations and boundary energy exchanges, while the MV network serves as the follower, ensuring system feasibility, including conventional and utility-scale PV generation. An algorithm that combines Lagrangian Dual Decomposition with ADMM is developed to coordinate LV communities in parallel while preserving data confidentiality.

4 - Assessing Operational Uncertainty of Nuclear Power and Its Implications for the Energy System
Xiaoming Kan

The reliability of nuclear power is critical for energy security as countries expand nuclear capacity to meet net-zero goals. This study examines unplanned outages across 536 reactors worldwide, analyzing global patterns and estimating drivers using Poisson pseudo-maximum likelihood regression. On average, reactors experience about two weeks of unplanned outages annually, with over 10% exceeding one month. They decline with operational experience but are higher for first-of-a-kind deployments. Greater planned maintenance and accumulated industry experience are associated with fewer outages.

■ WA-20

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Heuristic approaches for vehicle routing problems II

Stream: Vehicle Routing and related problems
Invited session
Chair: *Patricia Zech*

1 - Modeling and Optimizing the Flat Yard Shunting Problem: A Linear Approach and Multi-Stage Heuristic
Felix Rauschert, Jörn Schönberger

The efficiency of shunting operations in flat yards is a critical component of industrial railways and freight transportation networks. In this study, we outline our progress in modeling this problem using a linear approach. We introduce a multi-stage heuristic as an alternative approach. By iteratively exploring and exploiting the graph-represented solution space, the heuristic improves the shunting sequences. Empirical results show that increasing time budget leads to greater convergence of the objective value, which enhances robustness and reliability over time.

2 - Aggregation-based complexity reduction for large-scale capacitated vehicle routing problems
Patricia Zech, Christian Almeder

We study node aggregation heuristics that reduce large-scale capacitated vehicle routing problems (CVRP) to smaller capacitated general routing problems (CGRP), where demand may occur at nodes, edges, or arcs. Various aggregation strategies are tested on benchmark instances with known optimal solutions. The goal is to generate aggregates of multiple nodes that preserve optimal route structures while avoiding segments that degrade solution quality. Our results provide insights into the trade-off between computational complexity reduction and route efficiency.

■ WA-21

Wednesday, 8:30-10:00 - Room: JUR - U 22 (Building: JUR)

Trustworthy Decision Making in High Stakes Domains

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Claudia Goldman*

1 - [LATE CANCELLATION] Robust and Adaptive Decision-Making for Societal-Scale Systems
Ayan Mukhopadhyay

Principled decision-making under uncertainty for societal-scale systems, such as disaster response, energy management, public transit, and healthcare, is critical for ensuring efficiency, sustainability, resilience, and equity. These application areas are inherently complex due to incomplete data, dynamic and non-stationary environments, and competing objectives from diverse stakeholders, requiring robust and scalable algorithmic approaches. Dr. Mukhopadhyay will present the fundamental mathematical models for resource allocation; successful case studies and discuss theoretical insights.

2 - Trustworthy Stochastic Decision Making Solutions
Claudia Goldman

High-stakes decision-making in stochastic environments faces a dual challenge as AI-driven solutions scale across industry and society: the computation of optimal sequential policies and the achievement of calibrated trust in those solutions. This talk addresses this gap by integrating Reinforcement Learning with Explainable AI algorithms to provide action-level interpretability, mitigating disuse (under-trust) or misuse (over-trust). Aligning local explanations with human decisions is vital for trustworthy AI in high-stakes areas.

3 - Embedding AI Safety into Decision-Centric AI Systems
Young Lee, Kenneth Boyce, Sudhi Sinha

AI models are increasingly embedded in operational decision-making, yet safety and trust concerns often limit their effective use. This talk reframes AI safety as an enabler of innovation in decision-making rather than a barrier to it. Drawing on lessons from the development of AI safety frameworks and standards, it shows how technical, ethical, and governance-related AI safety measures enhance trustworthiness and support responsible AI-assisted decisions, highlighting strong alignment with core OR principles.

4 - Predicting No-shows for MRI appointments: The Impact of Forecast Horizon and Cancellation History
Neta Rabin, Liat Kaufman Milo, Royi Barnea, Yossi Bukchin

Optimizing healthcare efficiency requires managing high-impact no-shows, particularly for MRI services with complex prep. This study analyzes 439,000 MRI appointments (2021-2023) to compare machine learning models at two horizons: booking date and 72 hours prior. Results show short-term models are slightly more accurate, but booking-date predictions enable earlier interventions. A unique behavioral finding shows that patients with exactly one prior cancellation are least likely to no-show. This comparison of prediction horizons offers a strategic framework for diagnostic imaging scheduling.

■ WA-22

Wednesday, 8:30-10:00 - Room: KOL - Seminar-Raum 5 (Building: KOL)

OR Dynamics and Games in Finance 1

Stream: OR Dynamics and Games in Finance
Invited session
Chair: *Alberto Pinto*
Chair: *Gulfem Er*

1 - What Sustains Partnerships? Formation and Stability of Government Venture Capital Co-Investment Networks
Shihui Chen

This study investigates how Government Venture Capital establishes sustainable collaborations with market investors under innovation strategies. Employing TERGM on 2009-2023 Chinese co-investment networks, we distinguish mechanisms of tie formation versus persistence, examining strategic similarity, resources, and proximity effects. Findings reveal: (1) pronounced relationship continuity and path dependence; (2) polycentric decentralized evolution enhancing resilience; (3) proximity drives new ties while resource heterogeneity differentially impacts formation versus persistence.

2 - Mandatory disclosure in oligopolistic market making
Jin Hyuk Choi

We develop a multi-period Kyle-type model that incorporates both mandatory disclosure of informed trades and imperfect competition among market makers. We prove the existence and uniqueness of a linear equilibrium and show that the liquidity-enhancing effect of disclosure is linked to the degree of market-making competition. Disclosure lowers trading costs by reducing price impact, and its marginal benefit is larger when competition is weak. These results are aligned with documented evidence that disclosure is more effective in environments where market-making competition is limited.

3 - Coalition structure formation and profit allocation in horizontal collaboration under uncertainty
Mauricio Varas, Franco Basso, Juan Pablo Contreras, Raul Pezoa

This work studies coalition structure formation and profit allocation in horizontal collaboration under uncertainty. We formulate the problem as a two-stage adaptive robust optimization model, in which coalition structures are selected in the first stage, and profits are allocated in the second under worst-case realizations. The uncertainty affecting the collaboration is modeled as a polyhedral set. We derive equivalent reformulations and implement a Benders decomposition algorithm. Results show that uncertainty significantly affects the structures formed.

■ WA-23

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 02 (Building: HG)

Exact and Heuristic methods for Stochastic Optimization

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Francesca Maggioni*

1 - Consensus fixing for two-stage stochastic optimization
David Pisinger

We consider two-stage stochastic optimization problems with binary variables. A parallel heuristic is presented based on consensus fixing: The problems are solved independently for each scenario using an exact or heuristic method. Then, the scenarios try to reach consensus about fixing a single first-stage variable, using various score and select functions. The process of alternating between solving independent scenarios and variable fixing is repeated until all first-stage variables have been fixed. Computational results are reported for various routing and scheduling problems.

2 - Diversifying Stochastic Candidates Objective (DiSCO): Exploring Near-Optimal Solutions to Two-Stage Stochastic Problems
Mikkel Linneberg Lassen, Francesca Maggioni, David Pisinger

Stochastic programming typically seeks a globally optimal solution, yet this solution may not align with a decision-maker's preferences, particularly in two-stage models with long-term first-stage decisions.

We propose the Diversifying Stochastic Candidates Objective (DiSCO) framework, which generates a portfolio of near-optimal solutions with diverse first-stage decisions. Using the optimal solution as a benchmark, DiSCO identifies structurally distinct alternatives. We present three model variants and distance measures to promote diversity.

3 - Scenario decomposition for integer stochastic problems - consensus methods and bundling strategies
Kristine Børsting, David Pisinger

Progressive Hedging is a well-known scenario decomposition scheme for solving convex stochastic problems. The method has been successfully applied in the literature as a metaheuristic for stochastic problems with integrality constraints with only few modifications. We present

novel modifications developed for problems with integer first stage decisions and present computational experiments that demonstrate how these modifications can vastly improve computational times. Additionally, we show how new bundling methods can improve the dual bound quality at low time costs.

4 - A novel L-shaped refinement chain cuts method for two-stage stochastic programs
Francesca Maggioni, Mike Hewitt, Andrea Spinelli

L-shaped decomposition is a standard approach for large-scale two-stage stochastic programs, iteratively solving a relaxed master problem and adding Benders cuts. A major limitation is the generation of cuts for each scenario, which increases computational effort. We propose the L-shaped refinement chain cuts method, integrating scenario refinement chains into the decomposition. Scenarios are grouped at successive levels and optimality cuts are derived from group subproblems. Computational experiments on a mean-risk stochastic multicommodity network design problem show promising results.

■ WA-24

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 03 (Building: HG)

Designing Inclusivity through Human Centricity in Planning and Operations Management

Stream: Human Aspects in Operations Management
Invited session
Chair: *Daria Battini*
Chair: *Serena Finco*

1 - Human - Centric Assembly Line Balancing: integrating physical and cognitive metrics in task assignment
Giulia Caprari, Niloofar Katiraee, Nicola Berti, Ami Ogawa, Daria Battini

Enhancing production efficiency requires not only technological innovation but also consideration of workers' well-being and performance. This study develops an optimization model for assembly line balancing and workers' assignment in order to allocate each task considering psychophysical factors and workers' characteristics. In this study, physical and cognitive demands are quantified using subjective and objective measurement tools to identify the optimal assignment. The proposed model is tested through a practical case.

2 - Give Me Some Space: A Preliminary Exploration of Modeling the Impact of Decision Task Spacing on Cognitive Workload in Human-Cobot Teams
Aswin Balasubramaniam, Berry Gerrits

This exploratory empirical study investigates the impact of extraneous cognitive load on user workload using a scaled-down cobot and conveyor demonstrator. Grounded in Cognitive Load Theory, we test task spacing effects while fixing intrinsic and germane loads during a discrete task-switching decision task. Workload is evaluated via subjective and objective measures. Modeling this behavior using Generalized Additive Modeling serves as a foundational step to better design self-organizing systems that dynamically balance cognitive demands, optimizing human-centered decision-making.

3 - Human Factors Identification for Industry 5.0: From Systematic Literature Review to Experimental Plan
Yacine Hefied, Hind Bril El Haouzi, Guillaume Demesure, Emmanuel Zimmermann

Industry 5.0 has been introduced as a shift from the techno-centric approach of Industry 4.0 toward a more human-centered paradigm. However, this transition is hindered by several barriers, including unclear human factor (HF) concepts and poor observability of these factors. Hence, this study extracted HF across various domains using the PRISMA methodology. Through expert consensus, three main classes were defined: external factors, internal factors, and human effects, providing the basis for the development of an experimental framework supporting the structural identifiability of HF.

4 - Human-Centered Shelf Space Allocation in Just-in-time Warehouses
Gül Gündüz Mengübaş

Just-in-time warehouses face conflicts between space efficiency and manual handling. While ergonomics is vital, existing shelf space allocation models rarely incorporate physical risks. This study formulates a human-centered model using mixed-integer optimization that embeds weight-based placement, shelf accessibility, and ergonomic penalties. It highlights the role of ergonomics-aware allocation as a decision-support tool for designing human-centered warehouse systems under Industry 5.0, balancing operational efficiency with worker well-being in modern logistics environments.

■ WA-25

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 16 (Building: HG)

Sustainable Systems Optimization

Stream: OR for Sustainability
Invited session
Chair: *Fernando Alberto Freitas Ferreira*
Chair: *Leon Binder*

1 - Strategy to avoid food waste: trade-off between food donations and discounting
Z. Pelin Bayindir, Ozgen Karaer, Ayser Akgunes

In this study, we analyze two major food waste mitigation strategies for a retailer that sells a perishable product that depreciates over its two periods of lifetime, under regulatory policies: markdowns and food donations. We model two different retailer practices and characterize the retailer's optimal decisions under each practice. We also perform a numerical study to compare the environmental and economic outcomes.

2 - Reducing Empty Space in E-Commerce Packages: A Comparison of Digital Technologies for EU Regulatory Compliance
Leon Binder, Michael Scholz

The Packaging and Packaging Waste Regulation of the European Union sets a 50 percent empty space ratio limit for e-commerce packages starting 2030. To determine how well this goal can be achieved, we simulated companies with varying item dimensions and order sizes. We then solved the 3D-Bin Set Selection Problem and 3D-Open Dimensional Problem. Our results show that only individual bin creation can achieve near-perfect compliance rates. However, in practice, the compliance rate is lower, because automated packaging machines are currently limited in the package sizes they can produce.

3 - Parameter Calibration Framework of an Underwater Turbine Simulator via a Surrogate Embedded in an Optimization Model.
Zheng Ting Wang, I-Hsuan Hong, Jack C.P. Su

Marine current energy poses a challenging calibration problem because physical experiments are costly and high-fidelity simulations are computationally expensive. This study proposes a framework integrating

sampling, surrogate modeling, and optimization, where a neural network surrogate is embedded within an optimization model to search for the global optimum. The results show that the proposed approach reduces the sample size required to calibrate the turbulence parameters of the OpenFOAM simulator by 33.67% compared with Nurdiansyah et al. (2023), while achieving a low final error of 14.44%.

■ WA-26

Wednesday, 8:30-10:00 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis V

Stream: Data Envelopment Analysis
Invited session
Chair: *Zuzana Chladná*
Chair: *Maria Trnovska*

1 - Modeling Stochastic Dependencies in Two-Stage DEA: A Copula-Based Framework for Efficiency Analysis with Undesirable Outputs
Aarti Yadav, *Aparna Mehra*

Traditional two stage Data Envelopment Analysis models assume independence among production variables, often overestimating performance. This paper proposes a novel copula-based stochastic DEA framework that captures dependencies among inputs, intermediate outputs and final outputs, including undesirable outputs. The model integrates Frank, Clayton, Gumbel and Gaussian copulas within a chance constrained framework. Results from simulated data and 32 Indian banks show that accounting for dependencies changes efficiency rankings and reveals resource misallocation.

2 - Technical Efficiency in employment rates among Uneducated Black Women across Brazilian Macro Regions: A Stochastic Frontier Analysis
Alexandre Marinho

We study the technical efficiency in employment rates of Black Brazilian women workers with no schooling across Brazilian macro regions. We apply Stochastic Frontier Analysis to a quarterly panel data from 2012 to 2024. Results show persistently low employment, strong regional disparities, and high sensitivity to economic cycles, like the recession caused by the COVID-19 pandemic. Wages and experience have limited influence on the efficiency scores, suggesting that structural barriers — rooted in discrimination, sexism, and labor precarity - may drive efficiency in labor market inclusion.

3 - Data Envelopment Analysis for Performance Assessment of Basketball Lineups
Anito Joseph, *Kweku-Muata Osei-Bryson*, *Ronny Aboudi*, *Mary McKenry*, *Tallys Yunes*

Data envelopment analysis (DEA) is applied to performance evaluation of basketball lineups. Basketball team lineups are the on-court decision making units pursuing the team's objective of winning the game. Team lineups can share multiple players and have different scales of operation due to time spent on court or number of games played. With DEA, lineups can be selected based on efficiency at achieving outcomes from inputs expended and mathematical optimization models used for coaching management comparison and decision support.

4 - A Data Envelopment Analysis of Country Performance in the International Mathematical Olympiad
Zuzana Chladná, *Maria Trnovska*

IMO rankings rely on aggregate scores, offering a limited view of performance. We use output-oriented, slack-based DEA methods to evaluate countries from a multidimensional perspective. Treating GDP and population as inputs and scores in geometry, algebra, combinatorics, and number theory as outputs, we measure efficiency across 100+ countries. We quantify category-specific slacks to pinpoint underperformance and identify benchmarks under comparable macroeconomic conditions. Longitudinal analysis reveals shifts in performance trends, providing a a nuanced evaluation of mathematical excellence.

■ WA-27

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 13 (Building: JUR)

Public Policy, Practice, and People in Humanitarian Decision-Making

Stream: Humanitarian Logistics
Invited session
Chair: *Patience Saungweme*

1 - Fairness-constrained Optimization for Refugee Settlement Planning in Complex Crises
Patience Saungweme, *Stefan Spinler*

In this study, we integrate facility location science, political feasibility, and fairness-driven optimization to improve settlement planning and long-term shelter outcomes for both refugees and host communities in protracted displacement contexts. We aim to articulate approaches for explicitly accounting for the cost of political contingency on optimality of settlement location selection for displaced populations, effectiveness of approaches towards shelter reconstruction that support self-recovery, as well as fair resource distribution for refugees in relation to their host community.

2 - The Transition from the humanitarian response to long term development - Iraq case study
William Holden, *John McCarthy*, *Yvonne Delaney*

Shattered institutions, reduced aid budgets and a litany of failed localisation programs have hindered Iraq's shift from post ISIS disaster crisis response to a sustainable development phase. A need to invest in supply chain systems and human capital is paramount to long term resilience. The proposed study intends to follow the Delphi model, interviews with key interdisciplinary Iraqi stakeholders, identify pathways for a locally led transition, which will guide future research in risk analysis and preparedness.

3 - Psychological Distress and Decision Making
Julie Niederhoff, *Llord Brooks*

The quality of humanitarian supply chain operations depends fundamentally on the decision-making of logistics workers, yet the psychological factors that shape those decisions under chronic stress and traumatic exposure remain largely unmeasured. This study examines how organizational coping resources, individual coping strategies, and psychological distress combine to influence decision-making styles among humanitarian aid logistics workers. Managerial implications include modified decision support and operational measures to encourage collaboration and rational, timely decision-making.

4 - Post-Earthquake Emergency Treatment Sites: A Hybrid Optimization-Heuristic Approach using a GIS-Based Decision Support System
Simona Cohen Kadosh, *Sagit Kedem-Yemini*, *Zilla Sinuany-Stern*, *Yuval Bitan*

The study presents an ArcGIS-based Decision Support System (DSS) for optimal Emergency Treatment Site (ETS) deployment during the 72-hour post-earthquake response phase. As a stand-alone tool for local authorities, it requires a preparatory stage for geographic infrastructure and population layers. Validated using local municipality data,

the hybrid engine utilizes Mixed-Integer Linear Programming (MILP) (Stage A) for optimal ETS positioning and a heuristic (Stage B) to expand coverage as new damage data emerges. Its dual-mode functionality for training and response enhances urban resilience.

■ WA-28

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 17 (Building: JUR)

Applied Maritime Logistics

Stream: Maritime Logistics
Invited session
Chair: *Peter Schütz*

1 - Dynamic Optimal Routing for Emergency Evacuation in Distressed Passenger Vessels
Chen Li

Maritime safety incidents on open-sea passenger vessels have become a critical challenge. Evacuating large numbers of passengers within a limited time is extremely difficult, especially on ships with complex internal structures. To minimize the total network clearance time, we propose a cell-transmission-based MIP model that captures evacuation dynamics, congestion, and balanced exit outflows. The problem is decomposed into two tractable sub-problems using Lagrangian relaxation. Numerical experiments verify the computational efficiency and practical applicability of the method.

2 - Optimization of Tugboat Assignment for Vessel Arrival and Departure Operations
Chuan-Tsen Lee, Chia-Yun Chen, Yi-Chun Chen

Vessels rely on tugboat assistance for port entry and departure. While effective assignment can reduce congestion and improve throughput, current practices often lack systematic planning, making it difficult to balance vessel requirements with operational workflows. This study employs network flow techniques and a binary integer programming model to optimize the tugboat assignment problem, along with a heuristic algorithm to enhance computational efficiency. A case study of an international port in Taiwan demonstrates that the proposed approach is effective and practical for decision-making.

3 - The Value of Customer-Related Features in Container Dwell Time Prediction
Amine Jemni, René de Koster, Jan van Dalen

Existing container dwell time prediction research is essentially based on operational variables, such as container type, discharge date and port of origin. This study explores the predictive potential of customer-related features. Using dwell time information from more than 135,000 containers processed by a US terminal, we show that the proposed approach achieves a 20% higher predictive accuracy. Customer-related features persistently rank among the best predictors, demonstrating that dwell time is driven not only by container characteristics, but also by customer features.

4 - Container management in the Norwegian aluminum industry: A multi-commodity network flow approach
Peter Schütz, Lukas Georg Österlin Dalhaug, Tobias Schwabe Jortveit, Didrik Næss

We present a deterministic multi-commodity, multi-period network flow model to analyze the composition of the fleet of containers in the logistics network of a Norwegian aluminum producer. The network consists of 5 production plants and 8 ports that are connected through shipping routes with weekly or bi-weekly schedule. The containers are used to transport different raw materials and biproducts and share vessel capacity with finished products. We study how changes in number of initially available containers, available vessel capacity, and turnaround time impact logistics costs.

■ WA-29

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 30 (Building: HG)

Combinatorial optimization in management

Stream: Combinatorial Optimization
Invited session
Chair: *Frits Spieksma*

1 - Adding Relations with Long Communication Lengths between a Delegate and Every Other Member of the Same Level in an Organization Structure
Kiyoshi Sawada

This study proposes a model of adding relations with long communication lengths between a delegate and every other member of the same level in an organization structure. When edges between one node and every other node of depth N in a complete K-ary tree of height H are added where lengths of adding edges are longer than lengths of edges of the complete K-ary tree, an optimal depth N is obtained by maximizing the total shortening distance which is the sum of shortening lengths of shortest paths between every pair of all nodes by adding edges.

2 - Enhancing population localization through assignement of buildings to census grids
Alexandre Kerff, Jan Weymeirsch, Morgane Dumont, Elise Vandomme

Dynamic spatial microsimulations project individuals over time and space. The German model Mikrosim currently represents populations at the regional level but would benefit from assigning households to individual buildings. As no complete building database exists, data from multiple sources must be combined to build a coherent dataset of building locations, areas, and capacities. We model the geo-referencing of buildings to census grids under constraints as an optimization problem and present mathematical formulations and solution approaches.

3 - Huge-Scale Assortment Optimization with Customer Choice: A Parallel Primal-Dual Approach
Donghao Zhu, Hanzhang Qin, Ching-pei Lee, Yuki Saito, Takahiro Kawashima, Kenji Fukumizu

We study huge-scale assortment optimization under customer choice in transportation, retail, and healthcare. While choice-based linear programming (CBLP) is a powerful framework, it becomes computationally intractable at very large scales. We propose a first-order primal-dual method, SPFOM, with low per-iteration cost, near-optimal convergence, and parallelizability. Numerical experiments and a ZOZOTOWN case study show that SPFOM outperforms existing solvers and improves revenue while maintaining balanced inventory.

4 - Price of Diversity: the case of the TSP
Frits Spieksma, Mark de Berg, Andres Lopez Martinez

We describe a framework for quantifying the trade-off between diversity and optimality in combinatorial optimization problems, which we refer to as the Price of Diversity (PoD). We apply this concept to the Traveling Salesman Problem with the triangle inequality, and show how the demand for multiple diverse solutions influences tour quality. Specifically, we consider the problem of finding two edge-disjoint tours while minimizing the length of the longer tour. For this setting, we show that the PoD, is asymptotically 8/5 in a (special) one-dimensional case and exactly 2 in general.

■ WA-30

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum 06 (Building: HG)

Machine Learning and Optimization in Logistics 2

Stream: Machine Learning and Optimization
Invited session
Chair: *Jan Saro*

1 - Automated Crop Rotation Planning Using ReAct Pattern with Large Language Models: A Multi-Method Comparative Approach
Jan Saro

Crop rotation planning is a constrained combinatorial optimization problem. We propose a ReAct LLM agent that orchestrates three approaches: rule based assignment, linear programming, and heuristic multi criteria scoring. The agent uses tools for data loading, soil analysis, rotation and erosion checks, and plan verification. Tested on a real farm with 178 fields, 2653 ha and 8 crops, the LP approach achieves 100 percent constraint satisfaction with score 1954.2, while the rule based method fails farm level balance. Three level verification confirms plan validity.

■ WA-31

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 12 (Building: JUR)

Flexible and semi-flexible transport modes

Stream: Optimizing Transit
Invited session
Chair: *Jian Zhang*

1 - Minimizing the vehicles' traveling times in the skip-stop problem
Ricardo Reicherz, *Anita Schöbel*

In public transport optimization, an increasing passenger demand must be satisfied based on a given and fixed infrastructure. Skip-Stop operation can be used to replace an existing public transport line with two new lines, both operating on subsets of the set of stops of the original line. We introduce a skip-stop model minimizing the vehicles' traveling times and discuss conditions ensuring that no vehicle can overtake another vehicle. The decision version of the resulting problem is NP-complete. However, we are able to give dynamic programming approaches running in pseudo-polynomial time.

2 - A Three-Phase Framework for Semi-Flexible Public Bus Systems with Mixed Requests
Yuhang Wu, *Dilay Aktas Dejaegere*, *Pieter Vansteenwegen*

This study optimizes a Semi-Flexible Public Bus (SFPB) system handling pre-booked and dynamic requests. A three-phase rolling-horizon framework divides the decisions: pre-booking for fast admission, offline pre-operation setting of baselines and narrow commitment windows, and day-of-operations real-time control with a freezing mechanism for past actions. Three phase-specific mixed-integer models are formulated. To solve each problem efficiently, a Large Neighborhood Search algorithm is developed. The model and algorithm are validated with realistic instances, yielding reliable schedules.

3 - Designing Optimal Public Transport Subsidies: Supply, Demand, and Hybrid Policies
Leonardo J. Basso, *Hugo Silva*

We study the rationale and effects of public transport subsidies, comparing supply-side and demand-side approaches in terms of efficiency, equity, political feasibility, and resulting transit design and transport equilibrium. Using a calibrated economic model for Buenos Aires, we simulate alternative subsidy schemes. Results show that current subsidies are fiscally inefficient and redistributively suboptimal. A hybrid policy combining moderate supply subsidies with progressive, income-differentiated fares yields the highest welfare gains, balancing efficiency and redistribution.

4 - Accelerating Logic-Based Benders Decomposition for the Dial-a-Ride Problem
Jian Zhang, *Rym M'Hallah*, *Julia Bennell*, *Christine Currie*, *Chiara Calastri*

For the dial-a-ride problem (DARP) and its variants, we propose a Benders decomposition (BD) model with a master problem deciding request-to-vehicle assignments and multiple subproblems optimizing individual service routes. The integer variables in subproblems necessitate the development of a logic-based BD (LBBD) algorithm. Within a branch-and-cut framework, we accelerate the LBBD algorithm by proposing strengthened logic-based optimality cuts and several classes of strong dual-based Benders cuts. Experiments on two DARP benchmark datasets validate the effectiveness of the proposed cuts.

■ WA-32

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 14 (Building: JUR)

Cutting and packing I

Stream: Cutting and Packing
Invited session
Chair: *Carlos Lamas-Fernandez*

1 - Three Scheduling and Placement Applications Formulated as Specific 2D Packing Problems
Zdenek Hanzalek, *Josef Grus*, *Antonin Novak*, *Premysl Sucha*, *Claire Hanen*

We will introduce applications formulated and solved as simplifications or extensions of 2D packing problems. First, we tackle non-preemptive periodic scheduling with a harmonic set of periods, arising in the design of industrial communication protocols. Second, many of these applications contain tasks with different criticalities, which can be represented as triangles. Third, we present a placement of Analog and Mixed-Signal Integrated Circuits, including their possible merging, and parametrizable minimum device distances.

2 - A mathematical formulation for the two-dimensional bin packing problem with minimization of total order completion time
Kelly Cristina Poldi, *Daniel Schulmeister*

Efficient operations planning is essential in production contexts where both the effective use of raw materials and customer satisfaction are critical. This study addresses a combination of two-dimensional bin packing and scheduling, minimizing the costs associated with the number of bins used and the total order completion time. The problem is formulated as an integer linear programming model that incorporates two-stage guillotine cutting patterns. Computational experiments are conducted to compare solution quality under integrated and non-integrated approaches.

3 - An Effective Set Covering Matheuristic for the Distributor's Pallet Loading Problem
Mauro Dell'Amico, Andrea Corsini, Matteo Magnani

The Distributor's Pallet Loading Problem involves packing 3D boxes into horizontal pallet layers while minimizing the number of pallets and satisfying stability, stackability and load-bearing constraints. We enhance an underexplored matheuristic that creates many candidate layers and selects a subset covering all boxes by improving the created layers and proposing a stronger mathematical model. Experiments on diverse benchmarks show better performance than existing heuristics and exact methods and provide the first evaluation with respect to optimality.

4 - Models and Decomposition methods for the Balanced Vector Bin Packing Problems with configurable items
Carlos Lamas-Fernandez, Antonio Martinez Sykora

Bin Packing is one of the most studied combinatorial optimisation problems, with deep connections to scheduling, resource allocation, and cutting-stock applications. In this work we advance the study of the balanced one-dimensional bin packing problem with heterogeneous bins, multiple capacities and multiple item configurations. We introduce a unified and flexible mathematical formulation, analyse the structural properties of the problem that influence solvability and study its decomposition potential. In our experiments, we solve a problem aiming at packing helicopter fleets.

■ WA-32

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 14 (Building: JUR)

Urban Logistics Network Design and Service Systems

Stream: City Logistics
Invited session
Chair: *Praveen Muthukrishnan*

■ WA-33

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 15 (Building: JUR)

Short-term timetabling (EU-Rail: Motional)

Stream: Passenger Railway Transportation
Invited session
Chair: *Dennis Huisman*

1 - Optimized short-term railway residual capacity management
Karim Terfasse, Nabil Absi, Remy Chevrier, Stéphane Dauzere-peres, Christelle Lérin

The insertion of additional trains into existing timetables is traditionally handled by exploiting the residual capacity of the railway infrastructure. While modern simulation tools (e.g., Last-Minute Request by SNCF Réseau) efficiently process train insertions, further capacity can be unlocked through optimized adjustments in the originally planned timetables. This work proposes an algorithm to accommodate insertions that initially fail under residual capacity search. A case study on the French railway network is discussed to demonstrate the effectiveness of the approach.

2 - Short-term rescheduling of cyclic passenger train timetables
Gabor Maroti

We study the problem of adjusting the generic annual train timetable for planned maintenance possessions. Our problem setting features a cyclic timetable with a time period of 1 hour, and it includes both passenger and freight services. We develop a macroscopic optimisation model, and we extend it for the stations' track capacity. We report the lessons learned when the models were tested by practitioners on real-life instances of Netherlands Railways. This research is part of the Europe's Rail Motional project.

3 - Solving Train Timetabling Adjustment Problems with integrated track assignments
Khue Nguyen, Paul Bouman, Dennis Huisman

We study the Train Timetabling Adjustment Problem with integrated track assignments in response to planned maintenance. Building upon existing models that primarily operate at a macroscopic level, we propose a mesoscopic approach that allows for assigning tracks, modelling short-turning and track capacity directly, and accounting for partial open track possessions. The problem is formulated as a mixed-integer linear programming model and tested on real-world instances. Results indicate that the model can find optimal alternative timetables and feasible train routings within reasonable times.

4 - A chance-constrained heuristic for stochastic train scheduling
Bianca Urso, Giorgio Sartor, Bjørnar Luteberget

We consider a train scheduling problem modeled via an alternative graph with stochastic edge weights. Here, the goal is no longer to produce a schedule but to construct a policy that minimizes expected cost or delay. We restrict our attention to non-clairvoyant policies, whose decisions depend only on information available at execution time. This means not admitting negative-weight arcs. We propose a novel heuristic approach that substitutes each negative-weight arc with one or more positive arcs whose weights are calculated based on a chance constraint on the feasibility of the policy.

■ WA-34

Wednesday, 8:30-10:00 - Room: JUR - Hörsaal 16 (Building: JUR)

Order Picking Operations under Scattered Storage

Stream: Warehousing
Invited session
Chair: *Cihan Butun*

1 - A multi-picker routing problem with scattered storage and precedence constraints
Bernis Colakoglu, Davide Croci, Ola Jabali, Joe Naoum-Sawaya

Picking operations are fundamental in warehouse logistics. Motivated by our industrial partner, we assume that a sequence of SKU quantities to be picked by a single picker is established by a precomputed 3D-bin packing solution. Considering a general warehouse layout with scattered storage and limited stock, we optimize the total length of multiple picker routes. We propose a branch-and-cut algorithm with multiple cutting strategies for resulting problem. Experiments on generated and real-world instances demonstrate the effectiveness of our algorithm.

2 - Measuring the effect of order batching on the item location selection in a large-scale warehouse
Fikret Batu Sagay, Ahmet Çınar, Betül Ahat

In this study, we optimize order picking in a large-scale e-commerce warehouse utilizing a mixed-shelves storage strategy. This strategy aims to reduce picker travel distances by storing diverse items across multiple accessible locations. While the current approach separates item location selection and picker routing, we investigate integrating order batching into the location selection problem. Using a mathematical programming formulation, we analyze how batching can further minimize picker route lengths by grouping items according to warehouse locations.

3 - Stowing under uncertain shelf capacity: Stochastic, dynamic stower routing for scattered-storage warehouses
Fabian Hennig, Tobias Kroll, Nils Boysen

Scattered storage assigns individual items to open shelf locations, increasing picker proximity but complicating replenishment because free shelf space is only partially observable. We model stowing as a dynamic stochastic routing-replenishment problem where each shelf visit yields a random accepted quantity. Building on an efficient solver for the deterministic core problem, formulated as a prize-collecting TSP, we develop routing policies for the stochastic setting that minimize expected stowing tour length. Computational results show notable improvements over baseline practices.

4 - A Heuristic Algorithm with Dynamic Programming and Estimation for Order Picking Optimization in Scattered Storage Systems
Zhiyang Liu, Rupal Mandania, Cihan Butun

Warehouses use scattered storage systems in which a product is stored in multiple locations, leading to a reduction in distance travelled by order pickers. We propose a hybrid heuristic algorithm based on simulated annealing, dynamic programming, and a regression model to minimize the distance walked by the pickers. Dynamic programming determines the best picking locations for each product sequence searched in the heuristic. The regression model estimates the route distances in most iterations and serves as a time-saving alternative for applying dynamic programming.

■ WA-35

Wednesday, 8:30-10:00 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Energy and Emissions

Stream: Operations Research and Sustainability
Invited session
Chair: *Linda Canales-Bustos*

1 - Optimising a Hydrogen Refuelling Infrastructure on Airports: Heuristic Solutions to the Liquid Hydrogen Aircraft Refuelling Problem
Jörn Serrer

In order to meet the EU's climate neutrality goal by 2050, liquid hydrogen has emerged as the leading candidate for decarbonising air travel. However, loading times for LH2 are substantially longer than for jet fuel, and airport space is limited for constructing an LH2 infrastructure.

A Liquid-Hydrogen-Aircraft-Refuelling-Problem is formulated, to determine optimal infrastructure requirements needed to satisfy scenarios of real life airports varying future aircraft departure schedules and hydrogen demands. To solve the optimisation problem, an Iterated Local Search heuristic is employed.

2 - Distributionally Robust Renewable Energy Location. Case Study: Colombia
Camilo Rodriguez, Carlos Ramirez, Carlos Valencia, Camilo Gomez, Sergio Cabrales

The transition to renewable energy requires planning decisions that balance economic costs and environmental benefits. This project analyzes renewable energy location in Colombia within the context of climate change. Statistical downscaling techniques are used to project climate variables that affect photovoltaic energy generation, while distributionally robust optimization addresses uncertainty in climate projections. The proposed model enables the evaluation of trade-offs between energy costs—measured through the levelized cost of energy (LCOE)—and reductions in greenhouse gas emissions.

3 - Optimising Mining Supply Chains under Energy Transition: A Multi-Period MILP Approach
Linda Canales-Bustos, Ana Barbosa-Povoa

This work addresses the need for integrated decision support in mining supply chains under increasing decarbonisation pressures. It proposes a multi-period optimisation model for mining supply chain planning under energy transition, formulated as a MINLP and reformulated as an MILP. The model captures a multi-echelon, multi-product, multi-grade network and optimises investment decisions in renewable energy and energy-efficient technologies, jointly with mineral flows. The objective maximises NPV, considering CAPEX and OPEX. A copper mining case study shows economic and emissions impacts.

■ WA-36

Wednesday, 8:30-10:00 - Room: JUR - Seminar-Raum 42 (Building: JUR)

Optimization in Resilient Planning and Operations

Stream: Building Resilient Systems
Invited session
Chair: *Yun Lu*

1 - Navigating Last-Mile Disruption: Balancing Logistical Value Drivers with Operational Resilience in Developing Economies
Shikha Aggarwal

Hyperlocal supply chains promising ultra-fast delivery remain underresearched regarding their long-term stability and resilience. This study investigates the logistical value drivers and operational risks underlying these supply chains and how they influence their stability. We use rigorous qualitative methods on empirical data from India, and our analysis reveals that while speed drives adoption, concerns like service quality make them vulnerable. We establish a link between service value and resilience, offering strategies to balance speed with robust risk-mitigation frameworks.

2 - Stochastic Bilevel Optimization for Resilience Planning in Aerospace Supply Chains
Candice Destouet, Walid Klibi, Olivier Labarthe

We study resilience planning in aerospace supply chains using a stochastic bilevel optimization framework that captures leader-supplier interactions. The aircraft manufacturer determines demand allocations and resilience investments, while suppliers respond by optimizing their production and resilience decisions. Resilience is evaluated through Time-To-Survive (TTS) and Time-To-Recover (TTR) metrics, enabling the analysis of disruption propagation and the assessment of proactive resilience strategies under uncertainty in multi-supplier supply networks.

3 - Solving Set Covering Problems with Conflict Constraints
Yun Lu

The classic set covering problem (SCP) is a NP-hard binary integer optimization problem with diverse business and industrial applications. Historically, if two columns in a SCP solution were considered in "conflict", then how to resolve this conflict was handled after the solution was generated. In this presentation, using 240 test instances of the set covering problem with conflict constraints, we demonstrate the benefit of "warm starting" Gurobi when solving these 240 SCP-CC instances.

■ WA-37

Wednesday, 8:30-10:00 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Theoretical analysis for optimization

Stream: Nonlinear Optimization
Invited session
Chair: *Kevin Huang*

1 - Local convergence of inexact proximal quasi-Newton-type methods for minimizing composite functions
Yasushi Narushima, *Shummin Nakayama*, *Hiroshi Yabe*

We investigate the local convergence of inexact proximal quasi-Newton methods for minimizing composite objective functions comprising a smooth term and a nonsmooth convex term. We introduce a practical inexactness condition for solving the subproblems, which is significantly milder than existing ones in the literature. Under a Dennis-More-type condition, we demonstrate that the unit step size is eventually accepted and prove that the convergence rate is superlinear. Numerical experiments validate the alignment between our theoretical analysis and the practical behavior of the algorithm.

2 - Convergence Analysis via ODE Approach for Convex Optimization with Linear Constraints
Chise Ishii, *Yasushi Narushima*

We propose a novel dynamical system derived as the continuous-time limit of primal-dual algorithms for a linearly constrained convex optimization problems. Using the Lyapunov framework, we analyze convergence properties of the dynamical system under mild assumptions. By imposing Kurdyka-Łojasiewicz (KŁ) type geometric conditions, we derive the local inverse-quadratic convergence rate. Furthermore, we propose a numerical scheme through the discretization of the proposed ordinary differential equation and provide experiments to verify our theoretical results.

3 - An Accelerated Variance Reduced Extra-Point Approach to Finite-Sum Hemivariational Inequality Problem
Kevin Huang

In this paper, we develop stochastic variance reduced algorithms for solving a class of finite-sum hemivariational inequality (HVI) problem. We show how to apply variance reduction in our algorithms when the HVI problem has a finite-sum structure for both monotone mapping and convex function, and the gradient complexities can match the best bound established for finite-sum VI problem and near-best bound for finite-sum optimization. We demonstrate the application of our algorithms through solving a finite-sum constrained finite-sum optimization problem and provide preliminary numerical results.

■ WA-38

Wednesday, 8:30-10:00 - Room: JUR - Seminar-Raum 44 (Building: JUR)

Impact of AI on Soft OR

Stream: Soft OR and Problem Structuring Methods
Invited session
Chair: *Leroy White*

1 - A Semi-structured Agentic Framework for Automated Requirement Elicitation in Industrial Digital Transformation
Gokcen Yilmaz, *Jiawei Zheng*, *Saeema Ahmed-Kristensen*

Manual requirement elicitation is a costly bottleneck for organisations in digital transformation. This research proposes a semi-structured agentic framework to automate the elicitation and reporting process. The AI chatbot's performance was benchmarked against proprietary and open-source LLMs for manufacturing SMEs in South Korea and Türkiye. Expert surveys and a comparative study with human consultants show the framework effectively captures current practices, aligning closely with human-elicited ground truth. This provides a scalable, low-cost alternative for SMEs seeking digital maturity.

2 - Interview Agent Environment (IAE): A unified framework for automating knowledge elicitation interviews via Large Language Models
Jiawei Zheng, *Gokcen Yilmaz*, *Saeema Ahmed-Kristensen*

Interviews are widely used in operational research and problem structuring to elicit stakeholder knowledge, but they require significant expertise and are difficult to conduct consistently. This work presents the Interview Agent Environment (IAE), a framework that enables LLM-driven interview agents to support knowledge elicitation through structured, semi-structured, and unstructured interviews. The framework integrates user simulation and systematic evaluation to analyse how LLMs can assist problem structuring and improve the effectiveness of knowledge elicitation processes.

3 - An AI-Driven Framework for Automating the Causal Loop Diagram Construction in System Dynamics
Burak Çetiner

In recent years, data science has advanced rapidly and the rise of Large Language Models (LLMs) has significantly accelerated AI research. System Dynamics has followed a similar trajectory, with increasing interest in data-driven methodologies. Today, machine learning algorithms are widely used in System Dynamics for parameter estimation, model validation, and output analysis. In this study, we propose a novel framework to automate the generation of Causal Loop Diagrams and their subsequent translation into Stock and Flow Diagrams, enabling greater automation of the conceptual modeling phase.

4 - Rethinking facilitation in AI-mediated workshops
Leroy White, *Katharina Burger*

Debates about facilitation have long shaped Soft OR, particularly questions about the influence of facilitators in PSM interventions. As generative AI increasingly creates modelling artefacts and supports interactive workshop processes, the distinctive role of human facilitators becomes less clear. This paper explores how facilitation may evolve in hybrid human-AI problem structuring processes and invites discussion on designing meaningful collective inquiry in AI-mediated workshops.

■ WA-45

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum 01 (Building: HG)

Data-driven methods for Transport Problems

Stream: Data-driven Stochastic (Inverse) Optimization
Invited session
Chair: *Breno Alves Beirigo*

1 - Bootstrap Enhanced Scenario Optimization for Two-Echelon Logistics, a Case Study in Large-Scale Retail
Vittorio Maniezzo, Livio Fenga

We present an application of Bootstrap Enhanced Scenario Optimization (BESO), a distributionally robust optimization framework, to supply chain optimization in a real-world two-echelon retail network. BESO addresses decision-making under uncertainty from short, volatile, non-stationary time series. Uncertainty is modeled through Maximum Entropy Bootstrap combined with bagging, preserving autocorrelation and generating coherent scenarios. We extend MEB via an objective-augmented resampling scheme incorporating recourse signals. The resulting scenarios drive a deterministic inventory allocation.

2 - Who Fits with Whom? Learning Customer Compatibility for Vehicle Routing Problems
Berry Gerrits, Giovanni Campuzano

We propose a framework that jointly learns and optimizes vehicle routes when customers have rich attributes such as time windows and delivery options across eligible days. Bootstrapped sampling learns compatibility beliefs over small customer subsets, capturing which customers fit well together. These beliefs form vector representations analogous to word embeddings. A routing phase uses them to guide solution construction, while global objective feedback refines compatibility estimates. The two processes run concurrently, linking local compatibility learning with global routing performance.

3 - A Learning-Based Energy-Aware Fleet Management Approach for Water Mobility Systems
Breno Alves Beirigo, Bilge Atasoy

Research on on-street ridesharing often abstracts away the physical capacity of network nodes to host vehicles. This constraint is particularly important in water transportation systems, where vessels must share limited docks and mooring facilities. At the same time, the absence of street-specific edge constraints, such as lane-based traffic interactions, affords greater flexibility in vessel trajectories and speeds. This study incorporates and leverages these unique features to develop a data-driven fleet management approach that proactively dispatches and rebalances water taxis.

4 - Predicting Auctioneers' Behavioral Reserve Prices in Procurement Auctions: A Dynamic Machine Learning Approach with Feature Attribution
Zhihao Xu

This study proposes an AI-driven methodology to predict auctioneers' reserve price decisions in both ex-ante and ex-post formats.We implement Machine Learning models integrated with the SHAP framework for high-precision predicting and feature attribution.Moving beyond static environmental parameters,we introduce two lagged feedback variables (Prior-round transaction status and Prior-round accumulated earnings) to capture adaptive strategic behaviors.We evaluate the model through two distinct experimental cost environments: a baseline uniform distribution and a left-skewed distribution.

■ WA-46

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum 02 (Building: HG)

Scheduling and Balancing in Assembly Systems

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Sergey Kovalev*
Chair: *Simon Emde*

1 - Fast MILP and Column Generation for the Single-Machine Scheduling Problem with Periodic Maintenance
Meriem Touat, Arthur Kramer

We adress the single-machine scheduling problem with periodic maintenance to minimize the maximum tardiness. We propose a new fast Mixed Integer Linear Programming (MILP) model and an Extended Formulation (EF). The linear relaxation of EF is solved by a Column Generation (CG) where the pricing problem aims to find subsequences of jobs and is solved using a dynamic programming. The MILP outperforms the literature results by solving instances up to 80 jobs in less than 12 min. CG finds the optimal solutions in 32% of cases and the lower bound will be used in a future branch-and-price algorithm.

2 - Dynamic programming frameworks for two-machine flow shop scheduling with convex resource consumption
Taemin Cha, Myoung-Ju Park, Byung-Cheon Choi, Kyungsik Lee, Sungwon Hong

This paper studies a two-machine flow shop scheduling problem with convex resource-dependent processing times to minimize makespan and resource costs. To solve this NP-hard problem, we propose a heuristic dynamic programming framework. Unpromising states are pruned using geometric bounds derived from pivot-path structures and Johnson-type completion. Using state values estimated via linear interpolation between these bounds, a beam-search retains the top partial sequences. Experiments show our method consistently outperforms existing constructive heuristics.

3 - Double-constrained distributed permutation flow-shop scheduling problem with sequence-dependent setup time and flow shop eligibility restriction
Yanfeng Chu

For the distributed permutation flow-shop scheduling problem with sequence-dependent setup times and eligibility restrictions, a mixed-integer linear programming model is built to minimize makespan. An improved genetic algorithm (IGA) is proposed, integrating variable neighborhood descent. The IGA employs enhanced initialization to lift population quality and design evolution operators for eligibility constraints. Local search via variable neighborhood descent further boosts solution precision. Comparative results show the IGA efficiently explores the global space and yields better solutions.

4 - Optimal part supply of assembly lines in anticipation of sequence disruptions
Simon Emde, Julian Baals, Ola Jabali

We study an LSP managing JIT inbound logistics for an OEM via fixed milk-runs. While routes are pre-defined, shipment due dates at the OEM are only known shortly before execution, and production sequence changes often disrupt these. We propose a two-stage stochastic program minimizing earliness-tardiness and express-delivery costs under uncertainty. Using an integer L-shaped method with valid inequalities and Benders cuts, we solve 62 of 70 realistic instances to optimality. Results show express deliveries and overlapping milk-run routes effectively mitigate sequence uncertainty.

■ WA-47

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum 03 (Building: HG)

Supply chain 3

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Masoumeh Kazemi Zanjani*

1 - A Multi-Stage Stochastic Programming Approach for Sourcing in Product Assembly Supply Chains Under Demand and Supply Uncertainty
Ashutosh Kumar Thakur, Indrajit Mukherjee

Global supply networks face increasing demand volatility and supplier disruptions, challenging sourcing in product assembly supply chains. This study develops a multi-objective multi-stage stochastic programming model for sourcing in assembly systems, capturing demand uncertainty and supplier disruptions risk via hybrid scenario tree. A rolling horizon approach reduces computation by about 86% while maintaining competitive solutions. EVPI ranges from 3.15%-18.48% (avg. 10.90%) and VMSS from 0.58%-16.86% (avg. 10.49%), highlighting the value of adaptive multi-stage stochastic planning.

2 - A Two-stages Stochastic Energy Portfolio Model for a Viable Supply Chain
Samaneh Golara, José-Fernando Camacho-Vallejo

Small and Medium Enterprises (SMEs) face increasing energy volatility and disruptions, where traditional supply chain paradigms prove insufficient. This study adopts a Viable Supply Chain framework to address SME viability under energy uncertainty. We propose a two-stage stochastic model integrating strategic energy investment with adaptive operational planning. A dual-layer viability mechanism controls financial and production risks. Preliminary results indicate that diversified energy portfolios enhance system viability and operational stability.

3 - Modeling Agricultural Supply Chains under Supply and Demand Uncertainty: A Supply Chain Network Equilibrium Approach
Erny Rahayu Wijayanti, Yasushi Narushima

Agricultural supply chains face significant uncertainty from stochastic production and volatile market. This study develops a multi-tier supply chain network equilibrium (SCNE) model that integrates production and demand uncertainty. Farmers determine farmland allocation and delivery quantities. Due to yield uncertainty, realized production may deviate from the committed transaction quantities resulting shortage and salvage penalty. The equilibrium conditions are formulated as a variational inequality. Incorporating supply and demand uncertainty provides insights into supply chain resilience.

4 - Adaptive Robust Optimization for Mitigating the Risk of Disruptions in Multi-Firm, Multi-Echelon Supply Chain Networks
Masoumeh Kazemi Zanjani, Mohammadreza Hassani, Hossein Hashemi Doulabi

Driven by rising demand for highly customized products, this study develops an Adjustable Robust Optimization-based coalition game to enable horizontal collaboration and resource sharing in multi-echelon supply chains. Uncertain processing compatibility is modeled via budgeted uncertainty on facility availability. The resulting adjustable robust mixed-integer model jointly optimizes capacity activation, production, and logistics to maximize worst-case profit. A Column-and-Constraint Generation algorithm and Monte Carlo simulations demonstrate enhanced resilience under disruption.

■ WA-48

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum 04 (Building: HG)

Data-Driven Inventory Management

Stream: Data-driven Operations Research
Invited session
Chair: *Christian Larsen*

1 - Inventory routing problem under demand uncertainty: two-stage globalized distributionally robust optimization approach
Yuqiang Feng, Ada Che

We construct inner and outer ambiguity sets to characterize the distribution ambiguity of uncertain demand in IRP. We develop a two-stage globalized distributionally robust IRP model, regardless of whether demand follows a discrete distribution or an unspecified type. The proposed model, characterized by strong flexibility, generalizes the existing distributionally robust IRP, robust IRP, and stochastic IRP models by adjusting some inputs accordingly. The results indicate that the developed model can provide a delivery solution superior out-of-sample performance compared to benchmark models.

2 - Learning-Based Inventory Control for Cross-Border Supply Chains with Order Crossover
Zihan Ma

We study inventory control with stochastic, stage-controllable lead times in cross-border logistics. Replenishment is modeled as a Coxian pipeline, and decisions jointly determine ordering and stage acceleration. We propose a compact Coxian health state that captures effective supply, shortage pressure, phase imbalance, and normalized in-transit volume. We justify the state through aggregate reparameterization and a residual value-loss bound. DirectBackprop algorithms built on this state reduce cost, training time, and memory relative to full-state benchmarks.

3 - How to ace your next service level contract review?
Tarkan Temizoz

We study how suppliers should set inventory under service level agreements when aggregate fill-rate targets are reviewed over finite horizons. For multi-item systems, we improve the standard greedy heuristic by finding the cost-minimizing steady-state target for static base-stock policies, then add a dynamic deep reinforcement learning method using composite actions. Experiments show lower penalties and costs, with dynamic policies cutting costs about 4% versus the best static policy while maintaining similar service.

4 - A data-driven analysis of an (R,s,Q) policy when only having access to sales data
Christian Larsen, Johan Bjerre Bach Clausen

This paper explores a multi-period inventory control setting and assumes the decision maker applies an (R,s,Q) policy but only sales, i.e. demand is censored, are observed. We demonstrate an iterative data-driven algorithm that in each iteration, as new data is collected, computes an optimal re-order point based on a fill rate target. The core of the algorithm is maximum likelihood estimation using observed sales data as input but assuming that the (censored) demand is negatively binomially distributed. Numerical results obtained by using the algorithm will be presented.

■ WA-49

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management: EWG-PRM Session

Stream: Data-Driven Demand Management
Invited session
Chair: *Benny Mantin*

1 - Dynamic Pricing of Quality-Driven Products Under Stochastic Preferences
Arik Sadeh

Consider a single product with varying quality levels. Products, by quality, are sold over time. The expression of an agent's choice is made by using a stochastic preference utility. Agents maximize their preference utility from product quality. They have a defined sensitivity random parameter for both product quality and cost. This stochastic dynamic pricing problem is solved in a dynamic programming framework. With this dynamic pricing scheme, decision makers can leverage insights from pricing policy, product lifecycle management, and capacity management to address strategic questions.

2 - Double Debiased Machine Learning in Estimating Price Elasticity: Results and Learnings from a Large-scale Field Experiment
Darius Walczak

We present a novel modeling paradigm for dynamic pricing of airline seats that can be integrated into existing RM systems. Our approach employs a two-stage process combining causal inference and advanced machine learning techniques to generate robust price elasticity estimates. We report on performance of the approach in a large-scale online field experiment with automated A/B testing and demonstrate its potential for increasing airline revenues. The approach can be used in the calculation of tailored offers, by including more booking attributes in the optimal price determination.

3 - Optimal booking acceptance and container repositioning in a shipping liner network
Jan Overberg

This paper studies network revenue management in container liner shipping, where mobile container inventory, long voyage horizons, empty-container repositioning, and contract commitments make decisions more complex than in air cargo requiring maritime-specific policies. I develop an infinite-horizon stochastic dynamic program that jointly manages contract and spot bookings across the network. To overcome the large state space, I propose a look-ahead "inventory lifetime" value decomposition that yields an explainable bid-price-like policy and outperforms industry heuristics in a case study.

4 - A Cost Function Approximation Approach to Stochastic Multi-product Markdown Optimization
Leonardo Ribeiro, Maarten Oosten

Retail markdown optimization balances revenue and inventory clearance. To overcome suboptimal deterministic methods, we propose a Cost Function Approximation (CFA) framework. The approach combines probabilistic demand forecasting, simulation, and a rolling-horizon planner with business constraints such as inventory limits, monotone markdowns, limited price changes, and no-split coupling (forcing identical markdown paths for previously co-priced items). Decisions are parameterized and tuned via a gradient-free stochastic algorithm, improving expected profits.

■ WA-50

Wednesday, 8:30-10:00 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Flexibility management in local energy systems

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Johann Hurink*

1 - Energy flexibility through the lens of submodularity
Martijn Schoot Uiterkamp

To accommodate more devices such as electric vehicles and batteries in local distribution grids, much research focuses on optimal coordination of device flexibility. The resulting optimization problems are usually modeled ad-hoc and solved using off-the-shelf solvers. However, decision-making problems in energy flexibility often have natural marginal diminishing returns, i.e., submodular constraints. We discuss how this perspective leads to new insights for single-device problems, (dis)aggregation of profiles for groups of devices, and simultaneous optimization of multiple objectives.

2 - Theoretical Optimality and the Reality of Coordinated EV Charging
Leoni Winschermann

To accommodate the rapidly increasing charging demand of electric vehicles (EVs), researchers and practitioners alike have developed mechanisms to coordinate EV charging. Among other developments, this has resulted in exact algorithms for EV scheduling problems. However, as we explore in this talk, the closer our assumptions come to reality, the further optimality moves out of reach. We discuss how exact deterministic subroutines interact with increasingly uncertain inputs and highlight the implications of moving from theory and simulation to real-world testing.

3 - Optimal Corporate Renewable Energy Procurement Under Uncertainty and 24/7 Targets
Gülin Yurter, Alessio Trivella, Daniela Guericke, Martijn Mes, Selvaprabu Nadarajah

Corporate renewable procurement often relies on annual matching, which can hide hourly reliance on grid electricity. 24/7 carbon-free matching solves this but increases costs and reduces flexibility. This study examines two intermediate targets: a minimum renewable share each hour, or full renewable coverage for a fraction of hours. Using stochastic programming and constrained Markov decision processes, the study shows that no single target is always cost-optimal and that target design strongly influences procurement, storage use, and grid reliance.

4 - Optimal Electricity Market Participation and Off-Taker Fulfillment of Energy Communities and Hydrogen-Enabled Virtual Power Plants under Uncertainty.
Albert Solà Vilalta, Andrea Ademollo, Carlo Carcasci, F.-Javier Heredia, Ignasi Mañé, Cristian Pachón García

We propose two multi-stage stochastic programming models for energy communities and hydrogen refuelling stations to satisfy their electricity and hydrogen demand through optimal participation in day-ahead, reserve, and intraday electricity markets under uncertainty. The models capture the sequential disclosure of renewable generation and market prices with 34 stages. Realistic case studies show the importance of reserve market participation and highlight efficiency losses in the hydrogen chain. The framework is adaptable to other market participants with demand and renewable generation.

■ WA-51

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Understanding Decisions through Mathematical Optimization

Stream: Mathematical Optimization for Transparent and Fair Decision Making
Invited session
Chair: *Cristina Molero-Río*

1 - Supervised Hyper-Rectangle Clustering: Integer Programming Models and Objective Trade-offs
Sebastián Taboh, Diego Delle Donne, Javier Marenco, Cristina Molero-Río

We study Supervised Hyper-Rectangle Clustering (SHRC), where labeled data are partitioned into axis-aligned hyper-rectangles associated with predictions. We propose mixed-integer programming models for SHRC and investigate alternative objective functions capturing different modeling goals, including minimizing the number of clusters, the geometric span of rectangles, and the number of misclassified points. We analyze the relationships between these objectives through Pareto-front explorations.

2 - The Rashomon Set for Routing Problems: From a Single Optimal Route to a Diverse Portfolio
Claudia Rodriguez, Emilio Carrizosa, Isabel Mendez Fernandez, Cristina Molero-Río

This work proposes a decision-support approach for a Vehicle Routing Problem, generating a small set of feasible, near-optimal solutions in cost, yet diverse in overtime distribution across drivers.

Algorithmically, the proposal integrates into an existing industrial process built on a two-phase metaheuristic (parallel GRASP construction and VND improvement) and incorporates a diversity-aware acceptance rule, requiring each solution to satisfy both a near-optimality threshold and a minimum separation from previously accepted alternatives.

3 - Explainable Multi-Task Clustering via Optimization Models
José Carlos Castro, Emilio Carrizosa, Vanesa Guerrero

This work introduces Multi-Task Learning approaches for distributed networks where nodes store data locally. We partition the network into connected clusters sharing an interpretable model. Unlike existing methods that assume linear relations, our framework supports a broader class of algorithms through two strategies: Model Selection (adopting a node's pre-trained model) and Model Building (training a model from clustered nodes' data). We propose a Variable Neighborhood Search heuristic and show that specific layouts can be solved exactly via Dynamic Programming to assess its performance.

4 - On the efficient construction of risk scores
Cristina Molero-Río, Claudia D'Ambrosio

The widespread adoption of machine learning models in high-stakes domains underscores the need for interpretable and trustworthy predictive systems. Mathematical optimization has emerged as an effective tool for designing such models, offering explicit control over model structure and constraints. In this talk, we focus on the construction of risk scores—linear classifiers based on integer-weighted logistic regression—via convex mixed-integer non-linear optimization. In particular, we will leverage this convexity and explore an outer-approximation method.

■ WA-52

Wednesday, 8:30-10:00 - Room: KOL - PC Raum 1 (Building: KOL)

Capacity Expansion Planning I

Stream: Energy Markets & Systems
Invited session
Chair: *Sheng Lun Cao*

1 - Capacity Generation Planning Considering Reserve Provision Associated with the Integration of Renewable Energies
Ángela María Cano Sánchez, Luis Baringo, Raquel García-Bertrand

This paper presents a stochastic bi-level generation capacity expansion planning framework that explicitly accounts for operating reserve provision under increasing wind penetration. The upper level determines long-term investment decisions in conventional and wind generation by minimizing total system cost, while the lower level represents short-term operation through sequential reserve and energy market clearing. A key feature is the endogenous determination of system-wide upward and downward reserve requirements, enabling a cost-aware representation of operational security.

2 - Compact formulation for modelling technology vintages in multi-year investment models: correctness and computational efficiency
Jiangyi Huang, Ni Wang, Maaike B. Elgersma, Germán Morales-Espana, Russell McKenna

Representing technology vintages for individual energy generation technologies is gaining increasing importance in multi-year investment planning models. This study presents a compact formulation for the operation of the technology vintages. Using the Fourier-Motzkin elimination algorithm, we prove the equivalence between the compact formulation and the original problem and identify the underlying conditions. Furthermore, we analyse the computational complexity improvements achieved by the proposed method, which is numerically demonstrated in a synthetic model instance.

3 - Generation and Transmission Expansion under Aspects of Cooperation: Insights from Offshore Wind Integration in Baltic Region
Akshay Singh Yadav, Hannes Hobbie

We study investment and market coordination in offshore hybrid interconnectors using equilibrium modeling. The focus is on financing mechanisms incentivizing cooperation between market zones. We compare four market designs —a centralized planner, decentralized equilibrium, explicit Financial Transmission Right (FTR) allocation, and market-based FTR trading— for Germany, Denmark, and Sweden. Decentralized equilibria lead to overinvestment and price divergence, while FTR-based compensation compresses welfare disparities, providing key insights on cooperative offshore grid development.

4 - Representative Period Selection for Incorporating Future Weather Data in Capacity Expansion Modeling
Sheng Lun Cao

Capacity expansion planning must account for future weather uncertainties to ensure renewable resource adequacy, using representative selection to simulate typical future grid operations at lower data resolutions. In 1120 ERCOT capacity expansion cases, the impact of scenario reduction and 4 clustering-based methods are assessed under uncertain futures. Scenario reduction outperformed all clustering methods in total system cost, and fuzzy clustering systematically overbuilt wind and underbuilt PV capacity. Representative selection can result up to B$376.59 in total system cost overestimation.

■ WA-53

Wednesday, 8:30-10:00 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Scalarization and MILP-based methods for MCDA

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Lucas Kletzander*

1 - Inducing Augmented Tchebycheff Scalarizing Functions from Decision Maker Preferences
Maria Barbati, Salvatore Greco

We propose a model to induce the parameters of an augmented Tchebycheff scalarising function from decision maker preferences expressed through pairwise comparisons. The model is embedded in an iterative search procedure that uses mixed-integer linear programming to estimate parameters and guide exploration of the solution space. Computational experiments on classical multiobjective optimisation problems illustrate the effectiveness of the proposed approach.

2 - Constructing Low Discrepancy Point Sets for Representations of the Nondominated Set
Renée Lamsfuß, Carola Doerr, Kathrin Klamroth, Michael Stiglmayr

In this talk, we construct low discrepancy point sets on the triangle and discuss applications for multiobjective optimization problems. We generalize low discrepancy measures from the unit square to triangles and introduce a mathematical programming formulation to construct point sets with a minimal discrepancy on arbitrary triangles. Moreover, we use these points for different scalarizations to define representations of the nondominated set for multiobjective optimization problems. We evaluate the quality of the representations and test the approach on various test problems.

3 - Performance Normalization Using Relative and Absolute Assessments: A New Scalarizing Function based on Multiple Reference Levels
Ana Belen Ruiz, Mariano Luque, Francisco Ruiz, Francisca García-Pardo, Elena Bárcena-Martín

Normalizing variables with distinct units is essential, for e.g. constructing composite indicators. While traditional distance-based achievement scalarizing functions assess performance in absolute terms, they often overlook the distribution of values across the units. This research introduces a new scalarizing function that incorporates relative assessments into the multiple reference point approach. With the hybrid model that integrates both absolute and relative measures, this approach enhances the evaluation of societal issues where comparative performance is critical.

4 - Automated Weight Setting for Interactive Exploration in Multi-objective Combinatorial Optimization
Lucas Kletzander, Marco Foschini, Tias Guns

In this work we propose an interactive method to explore the solution space of multi-objective combinatorial optimization problems. The decision maker interacts with one particular solution at a time in the form of requesting objective changes. A Pareto front of solutions encountered so far combined with a set of weights is maintained in the background, allowing to use established single-objective optimization methods. Dynamic weight setting and pairwise preference elicitation are combined for efficient weight updates that minimize the number of queries to the underlying optimization method.

■ WA-57

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum 07 (Building: HG)

Developing BOR approaches in health settings

Stream: Behavioural Operational Research
Invited session
Chair: *Ana Vieira*
Chair: *Mónica Oliveira*

1 - Enhancing Behavioral Operational Research within Multicriteria Value Measurement in Health settings: a Novel Multi-Methodology Based on an Argumentative Delphi
Monica Oliveira, Constança Pinto, Edgar Mascarenhas, Rui Infante, Rui Tato Marinho

In this study we propose a novel multi-methodology based on an Argumentative Delphi process to promote the co-creation and discussion of initiatives and the identification of value dimensions to evaluate those initiatives, as well as to enable behavioural research. Behavioural research features enable understanding participants' preferences for distinct visual formats, the impact of literacy on participation, and differences across groups of participants. The multi-methodology was applied in the gastroenterology service of ULS Santa Maria.

2 - Scaling Priority Elicitation: Online Protocols for Health Decision Analysis
Gilberto Montibeller, Jose Geraldo Vieira

Public health decision processes increasingly seek to elicit priorities among competing objectives from patients and service users. At the same time, large-scale online surveys are adapting elicitation protocols originally designed for individual, face-to-face Decision Analysis. Are these methods fit for purpose at scale? This talk examines the challenges of large-scale priority elicitation in Health Decision Analysis and explores survey-based protocols that can deliver reliable, high-quality preference judgments for public health policy. [Research supported by FAPESP Grant #202502902-9]

3 - Does knowing who thinks what matter? A real-world Delphi experiment in Health Technology Assessment
Ana Vieira, Liliana Freitas, Mónica Oliveira

Advice-discounting is a key bias in Delphi. It can be reduced by recognising others' expertise, but aggregated feedback may hinder this. We designed a stakeholder-focused feedback format disaggregating results by stakeholder group, tested in a real-world Delphi on medical device evaluation. This format reduced opinion change disparities across groups, with some groups showing greater willingness to change opinions versus those receiving aggregated feedback; and itincreased engagement and transparency, offering a promising design for more inclusive multicriteria evaluation.

■ WA-58

Wednesday, 8:30-10:00 - Room: HG - Seminar-Raum 08 (Building: HG)

Moments in the History (and Future) of OR - 2

Stream: Moments in the History of OR and IFORS
Invited session
Chair: *Elise del Rosario*

1 - Moments of OR in China
Yu-Hong Dai

This talk traces key moments in the development of operations research (OR) in China. We begin with ancient Chinese insights that echo modern OR thinking, such as strategic resource allocation and combinatorial ideas in classical mathematics. Then we review the formative years when OR was established as a discipline in China to address national industrial and economic needs. Finally, we highlight the recent accelerated growth in both theory and applications across energy, logistics, telecommunications, and manufacturing. Emerging trends, like AI integration, and challenges are also discussed.

2 - Some historical aspects of OR
Ulrike Leopold-Wildburger

To point out historical aspects of Operations Research we could start already in the middle age with Leonardo Fibonacci. His research dealt with describing the growth of populations in 1202. Gottfried Wilhelm Leibniz discussed as the first ever in the beginning of the 18th century problems of transportation and Johann von Neumann together with Oskar Morgenstern founded the new field of mathematical theory of games about one hundred years ago. We will try to find out some more outstanding personalities building up the broad area of Operations Research. significantly important way.

3 - The Past and Future of Operations Research in Quantitative Finance
Rita D'Ecclesia

Operations Research has played a foundational role in shaping modern quantitative finance, from early portfolio optimization and stochastic control to the development of risk-management frameworks that guide today's regulatory and industry practices. This contribution revisits pivotal moments in that evolution and highlights emerging challenges—climate-related risks, market complexity, and the demand for interpretable AI in decision processes, which open to new opportunities for OR to strengthen the resilience and transparency of financial systems.

4 - The Journey from Subjecting Problems, to Connecting Decision-Makers, to Projecting Solutions, to Protecting the Future Global Good
Cathal MacSwiney Brugha

We describe a journey through four moments in the history of Operations Research. Linear Programming, from mathematics, maximised gain in WW2 bombing operations research missions. Multiple-Criteria draws from Psychology, Sociology, Philosophy, to connect decision-makers' objectives, minimize their pain. Management, projects problems onto Routing, Strategy, Natural Computing, Conflict Resolution systems, minimizing cost, blame. Global Common Good, is drawn by public concern to minimize shame, protect people and the planet from war, poverty, ill health, resource and environmental destruction.

■ WA-59

Wednesday, 8:30-10:00 - Room: KOL - Seminar-Raum 9 (Building: KOL)

MultiCriteria Decision with Partial Preference Information 2

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Salvatore Corrente*

1 - Fairness in Portfolio Decision Analysis Problems
Nikolaos Argyris, Juuso Liesiö

Portfolio Decision Analysis (PDA) supports resource-allocation decisions among competing projects under multiple objectives and uncertainty. In many applications, such decisions affect large and diverse populations, and their impacts may differ substantially across groups, making distributive fairness an important concern. We present preliminary results on incorporating fairness into PDA, discussing alternative conceptual approaches, the corresponding mathematical formulations, and initial computational results, including promising results for an approximation scheme for large-scale instances.

2 - Comparative analysis of decision rules and value functions as preference models in multiple criteria sorting
Silvano Zappalà, Salvatore Corrente, Salvatore Greco, Roman Slowinski

In this study we compare decision rules from the Dominance-based Rough Set Approach with value functions from the UTADIS model in sorting problems of different complexity. Using identical datasets, we analyze how each framework represents preferences and supports decision aiding. Through real-world examples we highlight differences in outcomes and interpretation. Rather than claiming superiority, we show how the two methods provide complementary insights and encourage a broader understanding of decision rules and value functions in sorting contexts.

3 - Robust Preference Representation in Multiple Criteria Decision Aiding with Seven-Valued Logic
Salvatore Greco, Roman Slowinski

We consider a seven-valued representation of preferences in Multiple Criteria Decision Aiding using value functions and outranking models under uncertainty and parameter indeterminacy. We propose a fuzzy-logic reformulation that smooths the seven-valued preference structure and improves the stability of recommendations with respect to perturbations of data and model parameters. The theoretical properties of the approach are discussed and illustrated by a didactic example.

4 - Breakpoint Selection in Ordinal Regression
Salvatore Corrente, Salvatore Greco, Silvano Zappalà, Roman Slowinski

We discuss how the selection of breakpoints may influence the behavior of ordinal regression methods in ranking and sorting problems within multicriteria decision aiding. In particular, we consider the UTA and UTADIS methods and their extension through the Deck-of-Cards-based Ordinal Regression (DOR) framework. A set of computational experiments is used to illustrate how different breakpoint configurations may affect the balance between model expressiveness and transparency, as well as the ability to capture aspects of the Decision Maker's preference structure.

■ WA-60

Wednesday, 8:30-10:00 - Room: KOL - Seminar-Raum 10 (Building: KOL)

Dynamic Portfolio Management

Stream: OR for Insurance, Banking and Financial Risk
Invited session
Chair: *Ana Escribano*

1 - Analysis of the effect of selling behavior on investor returns for robo-advisor users
Norio Hibiki, Yusuke Ushijima

This study examines selling behavior among robo-advisor users and analyzes its effects on investor returns. We analyze data from approximately 336,000 WealthNavi users, a robo-advisory service in Japan. We identify that users who do not sell their portfolios achieve higher investor returns than those who have sold them, as shown by regression

analysis, suggesting that selling behavior negatively affects investor returns. Moreover, we find one reason for the lower returns of users who have sold is that their portfolios are sold when unrealized returns are low at the first sale.

2 - LP Approaches for Portfolio Optimization with Distorted Expectations
Sally Giuseppe Arcidiacono, Salvatore Greco

Distortion risk measures are widely used in portfolio selection because they capture investors' attitudes toward extreme events while preserving coherence. We address the portfolio optimization problem under distorted expectations through two complementary formulations. The first is a direct linear programming reformulation, while, the second is a convergent numerical procedure that greatly reduces computational complexity while preserving high solution accuracy.

3 - The Financial Information Embedded in ESG Scores within Label-Agnostic Portfolios: Evidence from Anti-ESG ETFs
Carlos Esparcia Sanchís

This study tests whether ESG ratings still explain performance in portfolios that avoid sustainability mandates. Using ETFs marketed as anti ESG, we build a label agnostic universe and a dynamic framework aligned with monthly ESG data. Sorting ETFs by ESG quartiles, we form optimized portfolios. Green portfolios outperform brown ones on risk adjusted metrics and show smaller drawdowns. Governance, innovation, and product responsibility emerge as strong signals, suggesting ESG conveys asset quality and tail risk information even without explicit mandates.

4 - Gender as a tool of diversification
Ana Escribano, Antonio Díaz, Rocio Hidalgo

This study examines the effect of managerial gender on portfolio risk, assuming women are generally more risk averse than men. It asks whether such aversion appears in the stock performance of firms mainly led by women. We formed two portfolios by gender: one largely female led and one exclusively male led. Firms are selected from MSCI annual global gender diversity reports, covering 2018 to 2022. Risk was measured using value at risk, applying dynamic optimisation with an AR(1)-EGARCH(1,1) model to reduce variance. Findings show lower VaR in female led portfolios than in male only portfolios.

■ WA-62

Wednesday, 8:30-10:00 - Room: KOL - Seminar-Raum 19 (Building: KOL)

From Values to Cities: MCDA Approaches for Sustainable Urban Planning 1

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Francesca Abastante*
Chair: *Marta Bottero*
Chair: *Isabella Lami*

1 - New perspectives on mathematical modelling for decision aiding in spatial planning and project design
Elena De Angelis, Vanessa Assumma, Marta Bottero, Ana Jacinta Soares

This contribution offers some open reflections on mathematical modelling for analysing models that capture the time-evolution of Socio-Ecological Systems.The class of models we are working with is that of systems of Ordinary Differential Equations, which allow to predict the evolution in time of state variables and enable predictive studies of future transformations.This study examines how this class of models can integrate Multicriteria Analysis and how they can successfully aid public bodies in monitoring system conditions related to transformation policies in urban and peri-urban areas.

2 - Evaluating the effectiveness of Inclusive Climate Actions for Nature-based Solutions: An interactive decision-support tool
Virginia Pellerey, Sara Torabi, Patrizia Lombardi

Inclusive Climate Actions (ICAs) address climate challenges through inclusive approaches, yet research on their impacts is limited. This study proposes and validates a self-assessment framework for researchers and urban actors for ICAs and Nature-based Solutions, and evaluates four ICAs in Torino (Italy). Using mixed methods across 20 indicators, results reveal trade-offs between environmental, economic, and social impacts. Additionally, an interactive decision-support tool is developed for dissemination and co-creation. Findings discuss key challenges in assessing the effectiveness of ICAs.

3 - Opening Schoolyards, Structuring Decisions: MCDA for Urban Climate Shelters
Bruna Pincegher, Francesca Abastante, Ombretta Caldarice, Beatrice Mecca

Framed within the EU DUT MAINCODE project and the concept of urban climate shelters, this research investigates the transformation of schoolyards into accessible, nature-based climate refuges supporting heat-resilient cities. Children's design proposals constitute the starting point for defining decision alternatives, which are then assessed against the needs of public and private stakeholders using the IBTool, a multicriteria software developed in the PRIN GLOSSA project, structuring questionnaires, Best-Worst method and TOPSIS to elicit values, weight criteria and rank planning scenarios.

4 - The Overflowing City. Rural Landscapes Under Real-Estate Pressure
Salvatore Giuffrida

The research focuses on the urban sprawl into high landscape value rural areas the value representation of which over a 12-year period integrates databases from the Italian Revenue Agency and the Regional Technical Cartography for the built environment. A large set of attributes coordinated in a hierarchical model is synthesized in the Rural Landscape Complex Value Index and in the Building Real-Estate Pressure Index associated to 420 Cadastral Units. Their value profiles, summarized by the Rural Landscape Resilience Conjoint Index, are the reference of a rural landscape policy fair evolution.

■ WA-65

Wednesday, 8:30-10:00 - Room: HG - Hörsaal 27 (Building: HG)

Applications in machine learning and optimization for Industry

Stream: Analytics
Invited session
Chair: *Luis Aburto*

1 - Uplift Modeling for Email Marketing: Targeting High-Value Customer in Airline Allways-On Communications
Thomas Buddemberg, Luis Aburto, Veronica Diaz, Sebastian Orellana

This paper proposes a comprehensive uplift-modeling framework to maximize airline email marketing effectiveness for high-value customers. It systematically compares meta-learners (S/T/X/R/DR), class variable transformations (CVT, MOA, ITA), and causal ML methods (Causal Forest, Uplift Random Forest). In a randomized controlled

trial with 65,000+ customers, an ensemble uplift model achieved the best uplift performance, improving 7.6% over the top single model, enabling better targeting than conventional prediction and reducing unsubscribes.

2 - Revenue Optimization in the Sharing Economy: Dynamic Pricing Policies - A Case Study of Airbnb
Paloma Galaz, Veronica Diaz, Dana Pizarro

This study examines dynamic pricing in the sharing economy using Airbnb as a case study. We estimate demand using reservation-level data and analyze how prices affect booking behavior across anticipation windows and listing characteristics. Based on the estimated demand, we develop a dynamic pricing optimization framework that determines revenue-maximizing prices under realistic operational constraints.

3 - Preference Learning with real-data in Last-Mile Delivery: A Multi-Objective Framework
Víctor Bucarey

Real-world vehicle routing problems require incorporating the preferences of drivers and planners, whose operational knowledge is often not captured by optimization models.

We identify key challenges in learning such preferences from last-mile delivery data and propose a two-stage multi-objective framework that generates route plans with high driver acceptance. In particular, we address data scarcity and the estimation of an appropriate utility function. Computational results on real data demonstrate the practical value of the proposed approach.

4 - Using neural networks for capturing drivers' preferences for improving adherence in a VRP
Luis Aburto, Victor Bucarey, Felipe Lago

This project uses GPS data to train a multilayer perceptron (MLP) to predict driver route preferences. These predicted preferences are integrated into a VRP optimization model to adjust route recommendations and customer-to-vehicle assignments accordingly. We apply this methodology in collaboration with a VRP service provider in Latin America. Empirical results show a significant improvement in route adherence, increasing from 24% to 48%. This work presents a novel integration of machine learning and optimization techniques to enhance solution quality and incorporate user preferences.

■ WA-67

Wednesday, 8:30-10:00 - Room: KOL - PC Raum 3 (Building: KOL)

Energy market design

Stream: Energy Markets & Systems
Invited session
Chair: *Alberto J. Lamadrid L*

1 - Market Power and Price Formation in the European Electricity Market
Anthony Papavasiliou

In the summer of 2024, the European electricity market exhibited extraordinarily high electricity prices in its Southeastern region. This electricity market behavior undermines the energy affordability objectives of the European Union, thus triggering an action plan in response. Motivated by these incidents, and in collaboration with the Joint Research Centre (JRC) of the European Commission, we develop mathematical programming models for simulating the European electricity market under conditions of both perfect competition as well as strategic behavior (monopoly or oligopoly conditions).

2 - An Electricity Market Design with Uncertainty and Unit Commitment that is Revenue Adequate
Alberto J. Lamadrid L

We study financially adequate pricing in electricity markets with uncertainty in the variables considered. Using a chance-constrained optimization framework, we derive prices that ensure expected revenue adequacy for the market operator and cost recovery for suppliers. Both producers with variable renewable energy sources VRES and consumers are active participants with scheduling and real-time decisions. The operator can curtail generation. Prices are uncertainty-uniform-independent of real-time outcomes. A case study compares this approach with other revenue adequate schemes

3 - Pricing in Discrete Markets Using Copositive Duality
Joshua Taylor

We use copositive programming (COP) to design market mechanisms for unit commitment. COP is a conic optimization class that is both convex and NP-hard, and has been shown to generalized MILP (Burer, 2009). As such, it does not provide a better way to solve MILPs like unit commitment; being more general, COP is even less tractable. Its convexity does however provide a new notion of duality for discrete problems, as well as tools like strong duality and the KKT conditions. We use these tools to establish properties like efficiency and budget balance of the new market mechanisms.

4 - Reliability-Differentiated Grid Access for Congestion Management in Zonal Electricity Markets
Antoine Springael, Quentin Létê, Jehum Cho

Zonal electricity markets ignore internal network constraints and rely on costly redispatch to manage congestion. We propose an optimization-based framework in which transmission operators design flexible grid connection contracts with reliability-differentiated access rights. Contract activation is modeled as a bilevel optimization problem. Under benchmark assumptions, we show that the resulting dispatch replicates the efficiency of nodal pricing and characterize the resulting efficiency loss when these assumptions are relaxed.

Wednesday, 10:30-12:00

■ WB-01

Wednesday, 10:30-12:00 - Room: HG - Audimax

Funding from ERC - opportunities and personal experience

Stream: Special Sessions
Workshop session
Chair: *Frits Spieksma*
Chair: *Gerhard-Wilhelm Weber*

1 - Funding from ERC - opportunities and personal experience
David Pisinger

The European Research Council (ERC) is the EU's flagship funding programme for frontier research, supporting high-risk, high-gain projects across all scientific disciplines.

ERC grants are open to researchers of any nationality and age, provided the research is carried out at a host institution in an EU Member State or associated country.

Funding is awarded on a "bottom-up" basis, meaning there are no predefined thematic priorities and applicants can propose projects in any field.

The programme offers several grant schemes, including Starting, Consolidator, Advanced, and Synergy Grants, targeting different career stages and collaborative ambitions.

Scientific excellence is the sole evaluation criterion, with proposals assessed through highly competitive peer review.

As a current recipient of an ERC advanced grant, I will share my experiences with the application, evaluation and leadership of an ERC project. An overview of funding opportunities within the ERC programme will also be provided.

2 - Funding from ERC - valuable information from an insider perspective
Adriana Cristoiu

The European Research Council provides research funding a competitive basis to creative researchers of any nationality and age interested to run projects based across Europe.

A distinctive feature of the ERC grants is that there are no predetermined priorities; grants are curiosity-driven, researchers being free to pursue any research topic of their interest. Advanced Grants is one of the funding schemes targeting established leaders with a proven record of significant research achievements.

This session brings together complementary views on obtaining ERC grants.

Adriana Cristoiu from the ERC Executive Agency will provide an overview of the background, procedures, novelties, and any key considerations regarding the application process for the Advanced Grants scheme.

■ WB-04

Wednesday, 10:30-12:00 - Room: HG - BIG-Hörsaal (Building: HG)

Staff planning and patient admission

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Anne Zander*

1 - Emotional labour and nurse rostering model
Kajari Mukherjee, *Bhavinkumar Shah*

Nurse rostering problems (NPRs) include a variety of constraints and complexities that allow for flexible algorithms and intuitive solutions for a dynamic environment. In the optimization model, we focus on soft constraints like emotional labour inherent in the job. Incorporating parameters reflective of the lived-in experience of nurses' role, including attendant debilitating effects of emotional labour, input personnel quality, importance of display rules in health-care setting and its work processes, on-stage and off-stage periods, make NPR model spontaneous and reflective of real world.

2 - Integer programming approaches for a real-world shift planning problem
Maude Bersier, *Philipp Baumann*

We study a real-world shift planning problem from the Swiss healthcare sector. The problem consists of assigning shifts to employees subject to various operational and employee-specific constraints. Existing approaches from the literature are not applicable to this planning problem. We propose two mixed-integer linear programming formulations for the problem and compare their performance in a computational analysis based on real-world instances.

3 - Deciding on patient admission in aftercare organizations
Chris Petri, *Daniela Guericke*, *Anne Zander*, *Richard Boucherie*

The ageing population in the Netherlands is causing increasing pressure on healthcare services. Aftercare facilities, such as nursing homes or rehabilitation clinics, are essential to enable timely hospital discharges. However, aftercare facilities face challenges in managing workload for limited staff capacity with fluctuating patient inflow. We aim to develop a decision-support framework for aftercare providers to support short-term decisions on patient admissions and staff allocation, while considering staff availability, workload, bed occupancy, and predicted patient inflow.

4 - A Follow-Up Care Queueing System with Waiting-Time Dependent Service Requirements
Anne Zander, *Anouk Beursgens*, *Richard Boucherie*

We model the patient flow from a hospital to a follow-up care organization as a queueing system in which waiting time in the hospital may reduce the remaining care requirement in follow-up care by a certain factor. For exponential service times, the system corresponds to an overflow system with immediate repacking. For general service times, we propose approximation models based on finite- and infinite-server queues, where the service requirement is determined through a distributional fixed-point equation to estimate the expected number of blocked hospital beds.

■ WB-05

Wednesday, 10:30-12:00 - Room: JUR - Hörsaal 18 (Building: JUR)

Pricing, Incentives, and Control in Shared Mobility

Stream: Shared Mobility
Invited session
Chair: *Sara Momen*

1 - Incentive design for flexible transit services with meeting points
Haoran Jiang, Kenan Zhang, Shaozhi Hong

We study the incentive design problem in a flexible transit service where passengers are picked up and dropped off at designated meeting points and receive incentives that compensate for walking and trip detours. To solve large-scale instances with endogenous demand and meeting point selection, we develop a solution framework that iteratively updates incentive design via a surrogate model and evaluates it through detailed vehicle routing. A context-aware surrogate model based on continuous approximation is further proposed and benchmarked against model-free Bayesian optimization.

2 - User-Centric Pricing and Trip Recommendation for Intermodal Mobility: A Bilevel Optimization Framework
Mesut Can Köseoğlu, Shadi Sharif Azadeh, Luce Brotcorne

This paper develops a hierarchical optimization framework for the Capacitated Pricing and Trip Recommendation Problem (CPTRP) to reduce car travel by promoting public transportation (PT) and intermodal PT-bike sharing (BS) trips. We formulate CPTRP as a bilevel program where the operator sets BS prices and curates a menu of trip alternatives, anticipating user choices. We derive an exact single-level reformulation and, to scale, a column generation inspired matheuristic with dual-guided batching heuristic. We validate the framework on a case study using real Geneva transportation network data.

3 - Hybrid Predictive Rebalancing Control of Perceived Usability in Shared E-Scooter Systems
Sara Momen, Yousef Maknoon, Bart van Arem, Shadi Sharif Azadeh

In e-scooter systems, fleet size overstates true availability, which relies on location, charge, and user choice (usability). We present a Direct Look-ahead Hybrid Rebalancing framework coordinating truck relocations, battery swapping, and user drop-off incentives. A Markovian model predicts zone usability under stochastic demand and battery-dependent choices to minimize expected demand loss. Using European operator data, this rolling-horizon approach reduces unmet demand and improves spatial supply-demand alignment over truck-only methods, while maintaining cost discipline.

■ WB-06

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 07 (Building: HG)

Livestreaming Commerce and Influencers in Retail

Stream: Retail Operations
Invited session
Chair: *Arvind Shroff*

1 - Selling in Real Time: Strategy and Pricing in Livestreaming Commerce
Arqum Mateen, Asmita Mukherjee

The rapid growth of livestreaming commerce is transforming digital retail. We develop a game-theoretic model to examine retailer strategies across self-hosted livestreams on social media and influencer-led streams on e-commerce platforms. Consumer sensitivity to livestream environments shapes optimal channel use and pricing decisions. When retailers livestream across platforms simultaneously, equilibrium prices diverge across channels based on consumer participation and price sensitivity, generating strategic implications for cross-platform livestream commerce.

2 - Beyond Stockouts in Livestreaming: How Spillover Effects Shape Incentive Design
Shandong Mou, Xiaoyu Jin, Cheng Qian

This paper studies inventory coordination in livestreaming e-commerce, analyzing platform incentive mechanisms and merchant decisions under demand spillover. Key findings are: (1) Merchants set zero inventory when spillover effects are sufficiently strong; (2) The quota-bonus mechanism achieves first-best inventory without compromising merchant profit; (3) Spillover intensity moderates the inventory-increasing effect. Platforms can coordinate toward optimal inventory while preserving merchant profitability.

3 - Dynamic Promotion Planning in Live Streaming Commerce
Lijue Lu

We study a promotion-planning problem in the context of live streaming commerce. Consumers' purchasing decisions are influenced not only by current prices but also by their reference price, shaped by past promotions. We formulate a dynamic game with impulse controls between a brand and an influencer: the brand, acting as the leader, chooses the retail price and visibility investment to attract viewers, while the influencer, as the follower, sets the discount rate during promotions.

4 - Regulating Misinformation in Influencer Markets
Mengchu Li

Influencers play a crucial role in shaping consumers' purchase decisions by evaluating and recommending products in exchange for sales commissions. However, misinformation about products, whether due to intentional deception or a lack of expertise to accurately evaluate products, can mislead consumers into purchasing low-value products. This paper investigates how regulations can mitigate misinformation through two mechanisms: penalizing influencers for misrecommendations and improving their expertise.

■ WB-07

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 21 (Building: HG)

Markets and Pricing

Stream: Auctions and Market Design
Invited session
Chair: *Ben Lubin*

1 - Addressing the Spectrum Crunch at the U.S. Federal Communications Commission
Karla Hoffman, Brian Smith

The demand for more wireless connectivity continues to grow exponentially. These uses often require dedicated spectrum, but much of the available spectrum has already been allocated. Resolving the "spectrum crunch" will require creative solutions and new approaches. In this talk, we present three ways the U.S. Federal Communications Commission has sought to use available spectrum more efficiently: repacking television stations, reconfiguring 37 and 39 GHz licensees, and creating dynamic licenses in 3.5 GHz. We present how optimization was applied to each scenario and suggest future uses.

2 - Clearing Multi-Unit Markets with Simple Pricing
Sasa Pekec

We study multi-unit markets cleared with a single per-unit price. In such markets, even small departures from submodularity can destroy Walrasian equilibrium (WE). We define a t-approximate WE: a market-clearing supported by a single price where each buyer's utility is larger than the maximum under t-scaled valuations. Any t-approximate WE achieves at least a t-fraction of optimal welfare. We design a PPTAS for the tightest t for general valuations and an FPTAS for single-peaked marginals.

3 - Pricing Valid Cuts for Price-Match Equilibria
Robert Day, Ben Lubin

We use valid inequalities of the binary integer program for winner determination in a combinatorial auction (CA) as artificial items that can be interpreted intuitively and priced to generate Artificial Walrasian Equilibria. We thus provide a method for converting a CA problem that admits only non-anonymous, nonlinear bundle prices into one that admits anonymous linear prices over an augmented item space, forestalling complaints about discriminatory pricing. We introduce a "price-match equilibrium" in which prices are justified by an iso-revenue outcome after removing any one bidder.

4 - Iterative Vickrey Auctions via Linear Programming
Ben Lubin, Sebastien Lahaie

We develop a general method for constructing iterative auctions that achieve VCG outcomes. By transforming linear programs characterizing competitive equilibrium prices into ones characterizing universal competitive equilibrium (UCE) prices, and applying primal-dual algorithms, we derive iterative Vickrey auctions maintaining a single price path, eliminating overhead and incentive problems of multiple price paths. We demonstrate versatility through a novel multi-unit iterative Vickrey auction and an iterative Product-Mix auction variant, combining transparent price discovery with efficiency.

■ WB-08

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 41 (Building: HG)

Predictive Analytics, Forecasting and Causal Modeling

Stream: Descriptive, Diagnostic and Predictive Analytics
Invited session
Chair: *Thomas Setzer*

1 - An Ensemble-Based Decorrelation Strategy for Learning Robust Forecast Combination Weights Using Data Subsampling
Veronika Wachslander

Combining forecasts can improve predictions and two approaches are assigning equal weights (EW) or optimal weights (OW) to the forecasters. While estimating OW relies on past error data by exploiting (random) correlations, EW ignore the past. A compromise is shrinking OW towards EW, with the optimal shrinkage tuning as open question. The introduced weighting method draws error data subsamples, with rows and columns randomly removed for decorrelation. Each subsample estimates OW and shrinks these to EW out-of-subsample. The weight ensemble is averaged to obtain more robust combination weights.

2 - From Prediction to Causality in Customer Churn Analysis
Luísa Silva, Vera Miguéis

Customer churn, the decision to end a subscription, poses a major threat to firms in subscription-based industries such as paid journalism. Accurately identifying customers at risk of cancellation is therefore a key managerial priority. In this study, we first benchmark several machine learning models for churn prediction. Contrary to expectations, results suggest that higher customer engagement is associated with higher churn. Motivated by this unexpected finding, we move beyond prediction to study causality, estimating the effect of receiving different offers on subsequent churn behavior.

3 - Fairness of Machine Learning Models in Predicting Telemedicine Service Demand
Ozgur Araz, Emirhan Uzunlar, Christian Haas

Healthcare systems are increasingly utilizing predictive models to anticipate whether patients will prefer telemedicine or in-person visits, as these predictions can improve scheduling, resource allocation, and patient satisfaction. However, these predictive models can unintentionally raise existing disparities if fairness is not considered. We address this challenge by focusing on demographic parity (DP) across race, sex, age, and insurance coverage as protected attributes.

4 - A more realistic and simpler alternative to ordinary multiple regression for estimating relationships
Chris Tofallis

All observations have an associated measurement error, yet ordinary regression assumes all variables are measured exactly apart from the dependent variable. We present impartial equation fitting, a more realistic method that assumes all variables contain error and which does not require choosing a dependent variable. Coefficients are found using a closed form analytic expression. In 2 dimensions the slope is the geometric mean of the 2 regression line slopes; this extends naturally to multiple dimensions using partial rates of change. The resulting equation is units-invariant and unique.

■ WB-09

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 50 (Building: HG)

(Deep) Reinforcement Learning for Combinatorial Optimization I

Stream: Data Science meets Optimization
Invited session
Chair: *Kevin Tierney*
Chair: *Yingqian Zhang*

1 - Reinforcement Learning for Assembly Scheduling
Jan-Niklas Doerr, Samuel Schott, Steven Bilaj, Yichen Lou, Atreju Tauschinsky

Assembly scheduling addresses the coordinated production of components that are combined into finished goods according to bill-of-materials (BoM) precedence relations. Motivated by recent advances in reinforcement learning (RL) for scheduling, we investigate RL for minimizing total tardiness in this setting. Learning effective policies is challenging because components can be produced in parallel but must synchronize for final assembly, while only completed products incur tardiness. We propose improvements in exploration, information propagation, and reward design to address these challenges.

2 - Solving the Dynamic Berth Allocation Problem Using Reinforcement Learning and Graph Neural Networks
Carlos March Moya, Frederik Schulte, Kevin Tierney, Neil Yorke-Smith

Efficiently assigning vessels to berths in a busy port is a hard scheduling problem: decisions must be made in real time, under uncertainty about future arrivals, and with the goal of minimising how long ships spend in the port. We present a learning-based approach in which an agent is trained, purely through trial and error, to perform these assignments one at a time as the vessels arrive. The agent represents the current port state as a graph and learns which assignments are promising via graph neural networks, resulting in a 20% improvement over the best-performing heuristic.

3 - Provably Efficient Kernelized Reinforcement Learning for Inventory Control with Contextual Covariates
Mohammadjalal MirbeygiShahabad, Moritz Fleischmann, Sebastian Müller

Inventory decisions are increasingly shaped by signals such as weather, promotions, and market conditions, yet existing theory largely treats such signals either myopically or under strong assumptions on how they evolve over time. This project studies how to make dynamic inventory decisions when contextual signals are informative, exogenous, and only locally predictable. The goal is to develop a rigorous learning framework with performance guarantees for feature-aware inventory control under realistic operational constraints.

■ WB-10

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 31 (Building: HG)

Applications to Logistics and Transportation

Stream: Combinatorial Optimization
Invited session
Chair: *Francisco Saldanha-da-Gama*

1 - A Two-Stage Solution Approach for the Electric Vehicle Routing Problem with Uncertain Waiting Times
Merve Keskin, Nursen Aydin, Bülent Çatay

Motivated by growing environmental concerns, the adoption of electric vehicles (EVs) in transport has increased despite the operational challenges they pose. This study addresses the Electric VRP with Time Windows by incorporating an energy consumption function that accounts for vehicle load and speed, as well as capacitated charging stations with uncertain waiting times. Upon recharging, the EVs may adjust their speed and skip some customers to recover from delays. To solve the problem, we propose a two-stage approach that combines Adaptive Large Neighborhood Search with Dynamic Programming.

2 - Sensor-Enabled Intelligent Distribution for Cold Chain Operations
Haitao Li

With the rapid pathogen sensor technology being deployed throughout an end-to-end poultry supply chain, Salmonella testing results can be obtained and shared in real time. We develop a mixed-integer programming (MIP) model to optimize processing, distribution, and cold chain operations, e.g., transportation modes, temperature setting, while utilizing real-time information from pathogen sensors and temperature sensors. A case study shows that our model and solution can simultaneously address food safety and operating efficiency with significant benefit over benchmark heuristics in practice.

3 - The latency location-or-routing problem
Francisco Saldanha-da-Gama, Alan Osorio-Mora, Eduardo Álvarez-Miranda

The latency location-or-routing problem is introduced. It consists of selecting up to a certain number of depots to serve a set of customers, which can be visited as part of routes also to be decided. Direct service is an option for the customers lying within a certain coverage range from an open depot. A homogeneous fleet is assumed. The goal is to minimize the latency, i.e., the sum of the waiting times of the customers. Several MILP formulations are developed, as well as two lower bounds. The tradeoff between cost and latency is also studied. Extensive computational results are discussed.

■ WB-11

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 32 (Building: HG)

Sustainable food systems III

Stream: OR in Natural Resources
Invited session
Chair: *Marjolein Buisman*
Chair: *Sonja Rohmer*

1 - Modeling and Optimizing Collaborative Delivery with Workload Equity in Short Food Supply Chains
Adrien Callico, Jean-Charles Billaut, Pierre Desport, Caroline Prodhon

This study models collaborative delivery in French short food supply chains, where logistics is a major constraint for producers. Sharing tasks among partner producers reduces total distance but may create workload imbalances. We explicitly integrate equity into a multi-objective framework combining distance minimization and fair workload distribution. A two-stage hybrid metaheuristic optimizes partnerships and delivery routes, achieving substantial equity gains with only a moderate increase in total distance, supporting efficient, fair, and sustainable collaborative logistics solutions.

2 - Decision support systems for sustainable operations of local food networks
Christian Fikar, Christine Mendoza Pardo

Local food networks, i.e., associations of producers and consumers that aim to facilitate local food sourcing, are an interesting alternative to conventional food supply chains. Related initiatives, however, are often short-lived or struggle when it comes to scaling, particularly from an operational perspective. With a focus on the hospitality sector and communal catering, this work presents highlights from multiple research projects in close cooperation within various initiatives from Germany, Austria and Italy to facilitate sustainable and efficient future operations.

3 - A stochastic optimization approach to food distribution commitments
Marc Juanpera, Thomas Breugem, Laia Ferrer-Martí, Frans Cruijssen, Rafael Pastor

Food banks help address food insecurity but face highly variable in-kind donations, making reliable distribution planning difficult. We develop a stochastic optimization model using Sample Average Approximation and chance constraints to determine feasible, near-constant weekly distribution commitments. Results indicate that robust and stable commitments can be achieved despite donation uncertainty, with outcomes strongly influenced by storage capacity and product shelf life. The work supports more reliable planning for food bank operations.

4 - Robust Multi-Product Hub Location under Spoilage Uncertainty
Brenda Cobena, , Raf Jans

Reducing food loss in fresh agri-food supply chains is critical for sustainability, with product perishability being an important driver of this loss. The rate of spoilage, however, is often subject to uncertainty and may differ depending on products suppliers and chosen transportation links. Reducing losses and ensuring the supply of high-quality products thus depend on the locations of hubs and flows in the network. To address this, we propose a robust optimization model determining hub locations and flow allocations under spoilage rate uncertainty.

■ WB-12

Wednesday, 10:30-12:00 - Room: JUR - Hörsaal 11 (Building: JUR)

Health Care Scheduling

Stream: Health Care Logistics
Invited session
Chair: *Linhui Fu*
Chair: *Jiangxue Han*

1 - Optimizing Nurse Team Compositions for Long and Short-term Demand in Home Care
Asal Karimpour, Daniela Guericke, Amin Asadi, Erwin W. Hans

The demand for short-term home care is increasing. This is due to, e.g., treatment and monitoring activities moving from hospitals to home. Our research addresses the complexity and conflicting objectives that arise from the integration of short-term and long-term care in home care scheduling and nurse team composition. The assignment of jobs and composition of teams are influenced by several factors, including skill levels, preferences, and demand types. To capture these aspects, we propose a mixed-integer linear program and present results based on real data from a home care organization.

2 - On the Equivalent Formulations of the Appointment Scheduling Problem
Linhui Fu

We study the appointment scheduling problem (ASP) for optimal outpatient scheduling. While Denton and Gupta (2003) reformulated ASP as a stochastic linear program (SLP), we prove that these formulations are not equivalent for general cost structures, providing a counterexample for illustration. We derive a necessary and sufficient condition for SLP-ASP equivalence and show that ASP is non-convex without this condition. We analyze ASP variations under different objectives and constraints, investigating convexity properties and providing analytical and experimental results.

3 - Data-driven Inference and Optimization for Imputing Non-observable Human Preferences in Staff Scheduling
Jiangxue Han, Yong-Hong Kuo

In staff scheduling, challenges like model uncertainty, bounded rationality, and compromised infeasibility complicate optimal solutions for planners (agents). We identify soft constraints that can be violated to address infeasibility and develop a data-driven inverse optimization framework to minimize estimation errors. Our theoretical findings address the existence, uniqueness of optimal solutions, and sampling criteria. Computational experiments highlight that optimizing the maximum error between two schedules is more effective than minimizing total errors during the ranking process.

■ WB-13

Wednesday, 10:30-12:00 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Nonlinear Optimization

Stream: Software for Operations Research
Invited session
Chair: *Timo Berthold*

1 - Off-the-Shelf Global Optimization for Combinatorial Geometry Problems
Gioni Mexi, Timo Berthold, Dominik Kamp, Sebastian Pokutta, Imre Polik

Many geometric packing and distance-geometry problems have a combinatorial flavor and admit compact nonlinear formulations. For a long time such models were regarded as computationally intractable, and best-known solutions were found by specialized search algorithms and, recently, by LLM-driven algorithm discovery. We revisit several problems using nonlinear models solved with global optimization solvers FICO Xpress and SCIP. Across multiple benchmarks, the solvers reproduce and in some cases improve reported best solutions, highlighting the maturity of modern global optimization technology.

2 - Yet Another Implementation of Automatic Differentiation for Large-Scale Nonlinear Optimization
Hiroshige Dan, Yoshifumi Kusunoki, Tomoharu Nakashima

Automatic differentiation (AD) is a technique for computing derivatives of functions. AD plays an essential role in nonlinear optimization, machine learning, and various scientific computing applications. The fundamental principle of AD is the chain rule for composite functions, which is intuitive and has led to the development of many AD implementations. In this presentation, we introduce the details of our AD software implementation. Our approach targets large-scale nonlinear optimization problems and exploits spatial locality in indexed variables and functions.

3 - Heilbronn's Triangle Problem on the Unit Square Using Mixed-Integer Optimization
Nathan Sudermann-Merx

The Heilbronn triangle problem asks how to place points in the unit square so that the smallest triangle area is maximized. We propose an optimize-then-refine framework combining mixed-integer nonlinear optimization with exact symbolic computation. A new symmetry-breaking strategy yields a model that solves the nine-point problem orders of magnitude faster than existing approaches. We also prove optimality of the configuration found by Comellas and Yebra and derive exact solutions, revealing structural patterns and new research questions.

■ WB-14

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 01 (Building: HG)

Lot Sizing - Applications 2

Stream: Lot Sizing, Lot Scheduling and Production Planning
Invited session
Chair: *Safia Kedad-Sidhoum*

1 - Tactical Material Allocation at the Border of Line in Mixed-Model Automotive Assembly Lines
Simon Gruber, Richard Oberkofler, Clemens Gutschi, Nikolaus Furian, Siegfried Voessner

Decreasing production volumes and the growing coexistence of conventional and electric vehicles force automotive manufacturers to use shared mixed-model assembly lines, thereby increasing planning complexity. A key challenge arises at the border of line, where assembly and logistics decisions intersect. We present a simulation-optimization approach based on simulated annealing for tactical material allocation that outperforms current planning practice while helping planners keep the complexity of the planning task manageable.

2 - A decomposition model for a truck loading and supplier selection problem
Onur Ozturk, Najat Bara, Laurent Alfandari, Can Akkan

Faced with reducing inventory levels and satisfying just-in-time delivery requirements, the partial batch delivery approach improves the efficiency of means of transportation. This study offers mathematical models for consolidating heterogeneous items loaded onto the same truck while respecting capacity constraints and choosing the appropriate suppliers. The orders can have different lead times and production costs depending on the suppliers, as well as different transportation costs. We proceed with a column generation strategy that yields high-quality solutions in short computation times.

3 - A Practical Algorithm for Worker-Machine Task Assignment in a Plastic Injection System
Ana Raquel Xambre, Carolina Correia

This work presents an algorithm to assign workers to tasks, required by specific machines, in a plastic injection section. Workers set up machines (only on shift 1), collect parts, and perform quality control. The section runs three shifts, five days a week, producing over 1700 components, using 70 machines, 800 molds, and 2 to 4 workers per shift. Product diversity causes variations in production rates and task times and it is also critical to consider travel distance between machines when assigning the tasks. The complexity of the problem justifies the need for a decision-support algorithm.

■ WB-15

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 34 (Building: HG)

Algorithms and Game Theory

Stream: Algorithmic Game Theory
Invited session
Chair: *Leandro Rêgo*

1 - Computing Bayesian Nash Equilibria in Behavioral Strategies for Bayesian Extensive-Form Games
Chuangyin Dang

Bayesian Nash equilibrium in behavioral strategies (BNEBS) involves the maximization of non-convex multilinear payoff functions. To address this non-convexity, the traditional approach simply converts a Bayesian extensive-form game with perfect recall into its associated Bayesian normal-form representation, whose size is often exponential in the size of the Bayesian extensive-form game. To overcome this deficiency, this paper develops a characterization of BNEBS through local sequential rationality and presents differentiable path-following methods to compute such an equilibrium.

2 - A newly proposed power index connected with PCA
Dani Samaniego, Xavier Molinero, Enric Monsó

Measuring the influence of a player in a simple game is a widely studied topic. Shapley-Shubik power index is perhaps the maximum exponent in terms of relevance. Furthermore, other power indexes have been proposed over time. In this paper, we propose a new power index, defined in terms of winning coalitions that has a strong relation with the supervised Principal Component Analysis method, a broadly used technique in data science to determine the influence of different features over a target given a dataset. Furthermore, this power index can be characterized in terms of four properties.

3 - Using Integer Linear Programming Models for Maximin Equilibrium with Minimal Preference Adjustment
Leandro Rêgo, Hugo Victor Silva, Carlos Diego Rodrigues

The maximin criterion is the unique stability criteria used in the Graph Model for Conflict Resolution to represent conservative decision-makers (DMs) who defend themselves against severe reactions. In order to create new preference profiles that make a pre-selected state a maximin equilibrium while making the fewest modifications to the DMs' initial preferences, this article suggests a novel method based on integer linear programming. Two optimization models are presented: one assuming strict preferences and the other permitting indifference relations.

■ WB-16

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 42 (Building: HG)

Last-mile delivery applications

Stream: Vehicle Routing and related problems
Invited session

1 - Last-mile delivery with Public Transport and Crowdshipping: A Taipei Metro Case Study
Soumen Kumar Das, Vincent F. Yu, Gemilang Santiyuda, Hsiu-I Ting

This study explores last-mile logistics by integrating public transportation, various delivery options, and crowd-shipping facilities. We propose a mixed-integer linear programming model to optimize routing plans by minimizing total travel and transfer costs. While small instances are solved using Gurobi, a hybrid ALNS is developed for large-scale optimization. The algorithm is validated through numerical experiments and a real-world case study using the Taipei Metro system. The findings offer strategic insights into urban delivery integration and suggest directions for further exploration.

2 - Public Transport-Assisted Truck-Drone Last-Mile Delivery Problem
Nguyen Truc Quyen Vo, Vincent F. Yu, Tuan Anh Pham

We introduce a last-mile delivery problem integrating trucks, drones, and public transportation (PT). Heavy parcels exceeding drone capacity are assigned to trucks, while drones serve truck-inaccessible locations. A heterogeneous drone fleet with payload-dependent energy consumption is considered for more realistic operations. The objective minimizes total operational costs, including routing and PT usage. We formulate a mixed-integer nonlinear programming model and design an adaptive iterative local search with problem-specific operators to efficiently find high-quality solutions.

3 - A combinatorial auction framework for bundle bidding in last-mile delivery
Oussama Dribel, Souleymane Balde, Fouad Riane, Abdessamad Ait El Cadi

We study an e-commerce last-mile delivery problem integrating crowdshipping through bundle bidding. Crowdshippers submit bundles of customers anchored at relay points with requested compensation. We formulate a winner determination problem (WDP) that selects compatible bundles while the remaining customers are served by the regular fleet. A post-treatment negotiation reuses rejected bundles by projecting them onto uncovered customers and updating prices. We demonstrate that the approach enhances coverage and reduces total system cost by up to 25% compared to vehicle-only delivery.

■ WB-17

Wednesday, 10:30-12:00 - Room: JUR - Dach-Geschoss (Building: JUR)

AMPL

Stream: Sponsors
Sponsored session
Chair: *Juan Bohorquez*

1 - Getting Optimization into Production with AMPL: From Prototype Models to Operational Decision Systems
Juan Bohorquez, Marcos Dominguez Velad, Jake Letwin

Optimization models developed in academic and research settings often begin as compact analytical prototypes designed to study a particular decision problem. However, translating these models into operational decision systems introduces additional challenges related to scalability, maintainability, integration with external systems, solver performance, and reproducibility.

In this AMPL presentation, we explore how optimization models can evolve from research-oriented prototypes into production-ready decision applications. Using a power generation portfolio optimization example, we begin with a simple linear programming formulation and progressively extend it toward a more realistic operational setting.

As the model increases in complexity, the session highlights practical considerations that arise when moving optimization into production environments, including model organization, data integration, feasibility management, computational performance, and maintaining robustness and transparency in optimization-driven decisions.

The presentation will demonstrate how modern modeling workflows in AMPL can support both rapid prototyping and scalable deployment, helping bridge the gap between academic modeling practices and operational implementation. We will also discuss how optimization models developed for teaching or research can serve as foundations for real-world decision support systems.

Attendees will gain insight into the lifecycle of applied optimization projects and practical strategies for translating optimization research into operational impact across industry and public sector applications.

■ WB-18

Wednesday, 10:30-12:00 - Room: JUR - U 21 (Building: JUR)

OR Contributions to National Security II

Stream: OR in Military, Defense, and International Security
Invited session
Chair: *Youssef Masmoudi*

1 - Nations communities detection at the United Nations General Assembly
Stefano Benati

We analyze voting pattern emerging from 1946 at the United Nations General Assembly. First, we develop a new index, called the Alignment, to measure the similarity between nations. Then, the index is used as input of Clique partitioning to find the most relevant voting blocks of the Assembly. In this way we can recover the evolution of the international alliances in the last century. Finally, the Clique partitioning is embedded in the framework of the Community detection model, discussing the possibility of fine-tuning its application through the resolution parameter.

2 - Explainable ML for Identifying Risk and Protective Factors in Cadet Performance: Evidence from the Hellenic Air Force Academy
Charis Ntakolia, Despoina Fragkopoulou

Cadet performance in military academies depends on psychological and behavioral factors. This study applies explainable machine learning to identify predictors of cadet performance at the Hellenic Air Force Academy. Using data from first-semester cadets, models incorporated psychological distress, resilience, organizational citizenship behavior, personality traits, and demographics. Explainability techniques identified key risk and protective factors influencing performance. Results indicate that these characteristics enable performance monitoring and early risk detection in military training.

3 - Multi-Drone Analytics for Real-Time Crowd Management
Youssef Masmoudi

This case study presents a framework for managing high-density crowds at large events. Using drones, the system transforms visual data into decisions via a two-stage approach. First, a binary search algorithm optimizes image stitching for a seamless view with 94.77% accuracy. Next, deep learning models quantify density in real-time. These analytics enable authorities to make data-driven decisions on flow and access, showcasing a practical application of optimization for public safety.

■ WB-19

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 05 (Building: HG)

Electricity Markets: Pricing and Mechanism Design under Nonconvexities

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Mohammad Hesamzadeh*
Chair: *Bo Yang*

1 - A Bilevel Optimization Model for Energy Communities
Maria João Alves, Carlos Henggeler Antunes, Inês Soares, Ana Soares

We propose a bilevel optimization model for an energy community, in which a central entity (leader) maximizes profit by setting internal buying/selling electricity prices, operating an energy storage system and procuring energy from the wholesale market. At the lower level, the community first minimizes the maximum individual cost (fairness) and then total cost, ensuring no consumer pays more than in the first stage. The consumers schedule appliance operation, PV generation, stationary storage and electric vehicles. Energy sharing among consumers is allowed, prioritizing self-consumption.

2 - A Novel Pricing Mechanism based on Augmented Lagrangian and Duality for European Day-ahead Markets
Zhen Wang

The European day-ahead electricity market faces challenges due to block orders. To address these, we propose a novel pricing mechanism based on Augmented Lagrangian Duality (ALD), which establishes strong duality for mixed-integer linear programming. The ALD-based mechanism provides transparent price signals and inherently eliminates paradoxically rejected and accepted orders on the supply side. Numerical results demonstrate its computational tractability, offering a rigorous and practical framework for future European market design.

3 - Event-Based Scheduling of Pumped-Storage Hydropower With Finite-Grid Linear Program Approximation and Branch-and-Bound
Bo Yang

This paper presents an event-based framework for deterministic single-unit pumped-storage hydropower scheduling with reservoir, ramping, and commitment constraints. Plant operation is represented as a dynamic program over events, while intra-event dispatch is determined by mode-specific linear programs (LPs). The framework yields an exact reformulation of the conventional time-indexed model, supports hydraulic short-circuit operation, and leads to a finite-grid LP approximation and an exact branch-and-bound method with strong numerical performance in considered instances.

4 - Duality-based Profit Allocation Mechanisms in Sector-Coupled Energy Community Games
Seokwoo Kim, Yuin Moon, Jan Kronqvist, Mohammad Hesamzadeh, Dong Gu Choi

Sector coupling links electricity, heat, and gas, enabling local energy communities to coordinate multi-energy resources. Its sustainability requires stable and fair mechanisms for profit allocation. We formulate the profit allocation problem as a cooperative game and examine the relation between marginal pricing and the Owen solution. We prove that marginal pricing yields stable allocations in linear models. For non-convex models, we show that convex-hull pricing via a Dantzig-Wolfe reformulation can improve the stability of cooperation. Numerical experiments illustrate our findings.

■ WB-20

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Truck and drone routing problems

Stream: Vehicle Routing and related problems
Invited session
Chair: *Chieh Ju Juan*

1 - Multi-objective Multi-depot Cooperated Truck-Drone Routing Problem with Time Windows and Resource Sharing
Yanru Cui, Mengjun Ming, Yiang Liu, Tao Wang

This paper introduces a multi-depot cooperated truck-drone routing problem considering flexible time windows. A multi-objective mixed-integer programming model is formulated to describe the problem. To address this issue, a hybrid multi-objective evolutionary algorithm embedding adaptive pareto local search is devised. This algorithm combines the framework of NSGA II with an adaptive Pareto local search algorithm to achieve effective search in the solution space. Numerous experiments and analyses are conducted to demonstrate the superiority and practicability of the proposed algorithm.

2 - Vehicle Routing Problem Considering Drone Resupply and Transfer
James Chu

This study proposes a dynamic vehicle routing problem considering drone resupply and transfer operations to enhance traditional truck-based delivery models. The operational collaboration is designed such that drones are launched from customer locations visited by the truck to either resupply from the depot or transfer goods from other trucks. A mixed integer linear programming model is formulated to minimize total delivery costs. A dynamic re-optimization algorithm is developed to solve the problem. The proposed model is validated through various cases.

3 - A Mixed-Integer Programming Model for a Truck-Drone Routing Problem with Sortie-Based Operations and Split Delivery
Chieh Ju Juan

Integrating drones with trucks is a promising approach for improving last-mile logistics efficiency. While coordination mechanisms have been widely studied in truck-drone routing, limited attention has been given to drone payload limitations. This study investigates a truck-drone vehicle routing problem under a flying sidekick framework. A mixed-integer linear programming model with sortie-based drone operations and split delivery is developed. Preliminary results indicate improved delivery efficiency and highlight the potential of the proposed framework for drone-assisted logistics.

■ WB-21

Wednesday, 10:30-12:00 - Room: JUR - U 22 (Building: JUR)

Real-world applications of combining AI and OR/MS

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session

1 - Research on Intelligent Optimization of Natural Gas Industry Chain Operation Plan Based on the OR and AI
Chao Yang

To solve the natural gas industrial chain production management decision problems, CNPC successful build and sustained application the multi-scale management plan of intelligent optimization model based on the OR and AI, collaborative large language model (LLM) of general cognitive ability and small models of dedicated computing power, Business logistically complex optimization process can be converted to can understand, interactive, executable intelligent decision-making process, significantly improve the business benefits, rich technical methods of the energy optimization system.

2 - Application of Multi-Layer Agent Architecture in Complex Energy System Dispatch: Research on Collaborative Mechanisms Based on Large Language Models and Operations Resear
Xifeng Ning, Chao Yang

To address the high uncertainty in decision-making environments within China's natural gas industry chain—arising from resource fluctuations, complex pipeline network constraints, and peak-valley demand patterns—this study proposes an intelligent scheduling technology based on a mixed-integer programming model and an agent-based collaborative architecture. This approach enhances scheduling decision efficiency by over 94%, simultaneously ensuring energy security and stable residential gas supply while achieving synergistic improvements in both economic and social benefits.

3 - Scheduling Agile projects with AI support
Claudio Szwarcfiter

Agile projects face scheduling challenges under cost, resource, and time constraints. This study introduces a two-stage framework combining Mixed-Integer Linear Programming and Reinforcement Learning to optimize sprint planning. Results show improved efficiency and value delivery compared to traditional methods, demonstrating AI-driven decision support enhances agile project management.

4 - Variations in factors affecting judicial efficiency: A two-stage DEA approach
Nomesh Bolia, Maansi Gupta

The present work evaluates and compares the impact of judges on court performance across India. The study conducts a two-stage analysis: DEA is used to determine efficiency scores in the first stage, followed by truncated regression to estimate the relationship between the efficiencies and various factors. We also examine the effect of demand-side factors through litigation and crime rates and include socio-demographic factors through literacy rate. Simar and Wilson's procedure with double bootstrapping is applied to estimate bias-corrected efficiency scores and robust regression estimates.

■ WB-22

Wednesday, 10:30-12:00 - Room: KOL - Seminar-Raum 5 (Building: KOL)

OR Dynamics and Games in Finance 2

Stream: OR Dynamics and Games in Finance
Invited session
Chair: *Alberto Pinto*
Chair: *Jing Fu*

1 - Decomposing coalitional values through interactions
Álvaro de Prado Saborido, Carmen Quinteiro Sandomingo, Estela Sanchez-Rodriguez

Recent approaches to feature attribution in explainable ML address the problem from the perspective of cooperative game theory, using classical solutions to allocate feature contributions to a prediction. To capture interactions, we define interaction values between players through different game-theoretic solutions. We extend these results to obtain interaction values between coalitions. This framework recovers interaction-based representations previously introduced for the (positively weighted) Shapley value. An axiomatic approach characterizes some matrices of interaction values.

2 - Balancing Economic, Environmental, and Autonomy in Residential Energy Systems with Battery Storage
Paulo Rotella Junior, Arthur Leandro Guerra Pires, Rafael Miranda, Luiz Celio Souza Rocha, Karel Janda

This study proposes a multi-objective model for the optimal sizing of residential energy systems, considering economic, autonomy, and environmental criteria. The model integrates PV-Wind systems with battery storage, employing the Normal Boundary Intersection method in the optimization stage. A case study is conducted in cities in Northeast Brazil, under changes in energy compensation rules, indicating that investments remain viable, especially with PV energy, and that small-scale wind power can increase self-sufficiency with less environmental impact in regions with favorable wind conditions.

3 - Asymptotics of a Two-sided Limit Order Book in the High Frequency Regime
Peter Lakner

We study a limit order book for a security modeled as a pair of coupled measure-valued stochastic processes representing the bid and ask sides of the order book. Limit and market orders arrive to the book according to individual processes and the distribution of the prices at which limit buy and sell orders are placed depends on the best bid and ask at the time of their arrival. We study the behavior of this model in a high frequency regime where the arrival rate of incoming orders is large and limit buy and ask orders are placed in close vicinity to the current best price.

4 - Delegated Networking for Maturity-Structured Financial Networks
Jing Fu

This research applies delegated networking to design maturity-structured financial networks under asymmetric information. Rather than centralized reporting, a regulator offers catalogs of financing options and delegates borrowing and lending choices to firms with private investment characteristics. A borrowing-lending-repayment application and simulation show how adaptive catalogs steer firms toward stable, incentive-compatible network structures, delivering a practical alternative to centralized mechanism design for financial systems to support policy evaluation of maturity risk.

■ WB-23

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 02 (Building: HG)

Optimization under uncertainty in logistics and transportation

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Paolo Beatrici*
Chair: *Francesca Maggioni*

1 - From Reinforcement Learning to Interpretable Rules: Scalable Perishable Inventory Allocation
Damien Vo, Thomas Archibald, Roberto Rossi

We study daily allocation of a fixed shelf-life perishable product from a regional distribution center to a network of stores, minimising shortage and outdating. We train a reinforcement learning allocation policy and benchmark it against a classic myopic rule. Analysing the learned policy reveals a key weakness of the myopic approach, which we distil into an interpretable heuristic that reduces outdating without sacrificing shortage performance and remains tractable at realistic network sizes. We outline ongoing work on joint allocation-transshipment control.

2 - A Column Generation-Based Approach for Vehicle Routing Problems with Flexible Deliveries and Uncertain Travel Times
Duygu Tas, İhsan Sadati

We study a vehicle routing problem with stochastic travel times where customers may specify multiple delivery locations with time windows. We develop a mathematical model and a column generation-based solution approach. Computational results on benchmark instances demonstrate the effectiveness of the proposed solution approach. We extend our problem to allow shared delivery points and adapt the approach, evaluating it on newly generated instances. Acknowledgements: This study was supported by Scientific and Technological Research Council of Türkiye (TÜBİTAK) under the Grant Number 223M102.

3 - Car-Sharing with Substitution and Risk-Aware Service Level Constraints
Esra Koca, Beste Basciftci

We study a reservation-based car-sharing system offering round-trip and one-way services with a mixed fleet of vehicle types. The problem involves determining station locations, fleet allocation, and operational decisions under demand uncertainty. We model demand with scenarios in a two-stage stochastic program and incorporate substitution options using a utility-based customer preference framework. Quality-of-service constraints are introduced through CVaR to ensure risk-aware operations. A decomposition-based branch-and-cut algorithm is proposed, showing strong computational performance.

4 - Distributionally robust facility location problem in disaster response logistics
Shen Peng

This paper studies the distributionally robust facility location problem, considering facility disruptions, transportation costs, and demand fluctuations in both uncapacitated and capacitated settings. For disruptions, disaster occurrence probability and propagation effects are integrated into the ambiguity set. A joint ambiguity set with scenario-based disruption parameters adjusts transportation costs and demand across disruption scenarios. The problem is reformulated as a mixed-integer linear program. The model is validated on hurricane and earthquake disaster scenarios.

■ WB-24

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 03 (Building: HG)

Applications of Knowledge and Technology 1

Stream: Knowledge, Technology, and Innovation Decisions
Invited session
Chair: *A. D. Amar*
Chair: *Boris Belov*

1 - Governing Enterprise Search as Knowledge Infrastructure for Innovation Decisions
Boris Belov, *Petr Panfilov*, *Rima Kocharyan*

Enterprise search is moving beyond document retrieval to grounded answers and multi-step evidence-gathering workflows. We model it as organizational knowledge infrastructure that changes how firms coordinate, access expertise and make innovation decisions. Increasing autonomy shifts coordination objects to cited outputs and moves dependence from experts to corpus quality and platform governance. Benefits require evidence accountability, traceability, permission legitimacy and observability. Otherwise error diffusion and fragile adoption dominate.

2 - Target-Driven Public Procurement for Innovation: Micro-Evidence from Local Government Annual Reports
Ying Kou

This study examines the impact of government innovation targets on public procurement for innovation (PPI). We employ the share of R&D investment mentioned in annual government work reports as a proxy for government innovation targets and analyze their influence on PPI, based on 18,774 firm-year observations of Chinese listed firms. We find a positive association between government innovation targets and PPI. The effect is particularly significant for non-state-owned enterprises, cities in core regions, and procurement processes characterized by decentralization and localization.

3 - The Intelligent Production and Service Network System and the Intelligent Industry Meta-unit: A Novel Industrial System Framework
Qingmei Tan

The study proposes the theory of "Intelligent Production and Service Network System" and the concept of "Intelligent Industry Meta-unit", establishing an independent theoretical framework. It elucidates the conceptual definitions, existential forms, systemic functions, operational mechanisms, system boundaries, and integration strategies of both the Intelligent Production and Service Network System and Intelligent Industry Meta-units. The research posits that: 1) The Intelligent Production and Service Network System will emerge as the dominant industrial organizational framework in future ****

■ WB-25

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 16 (Building: HG)

Optimization for Sustainable Transitions

Stream: OR for Sustainability
Invited session
Chair: *Wissam EL Hachem*

1 - Policy mix coherence and the stability of socio-technical transitions
Wissam EL Hachem

Sustainability transitions require coordinated policy mixes, yet policy instruments often evolve inconsistently with their objectives. Policy coherence is defined as the directional alignment between policy evolution and policy objectives. We build a dynamic simulation model showing how coherent policy evolution can simultaneously stabilize transitions, accelerate technological change, and improve distributive outcomes in socio-technical transitions. Analytical results reveal a coherence threshold below which credibility collapses and system instability rises.

2 - The Impact of Sustainability and Digitalization on the Financial Performance of Industrial Companies: the European Case
Raminta Vaitiekuniene, *Aiste Lastauskaite*, *Inga Kartanaite*, *Algirdas Justinas Staugaitis*, *Rytis Krusinskas*

This study examines the joint impact of sustainability practices and digitalization on the financial performance of European industrial firms. Using panel data and fixed effects models, we analyze the effects of ESG performance and digital investment on return on equity (ROE) for regional differences between Western and Eastern Europe. The results show that both ESG performance and digitalization positively affect financial performance, while digitalization strengthens the ESG-performance relationship, particularly in Western Europe.

3 - Optimizing First-Mile CO2 Transport for Carbon Capture and Storage: A Capacitated Facility-Location Approach
Moritz Fierke, *Sonja Rosenberg*, *Frank Schultmann*

As regions pursue climate neutrality, managing unavoidable CO emissions requires effective carbon capture and storage (CCS) transport systems. This study develops a mixed-integer linear programming model to determine the cost-efficient allocation of regional CO sources to connection points of a predefined backbone pipeline network. Candidate injection points serve as hubs where emissions are aggregated before entering the backbone. A case study for Baden-Württemberg, Germany, demonstrates how source allocation and hub selection shape regional CCS transport systems.

4 - Competitive Industry's Response to Environmental Taxation
Dmitry Krass, *Anton Ovchinnikov*

We study the response of N firms producing a commodity good with a polluting by-product to environmental taxes. The firms vary in operational and environmental efficiency. Under Cournot competition, we examine two demand functions: iso-elastic and linear. We establish the existence and uniqueness of the equilibrium and examine how it changes with tax levels and environmental efficiency. We show that taxes may not always benefit "green and efficient" firms. Additionally, total and per-unit emissions may increase with higher taxes or improved environmental efficiency.

■ WB-26

Wednesday, 10:30-12:00 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis VI

Stream: Data Envelopment Analysis
Invited session
Chair: *Salvatore Greco*

1 - Unsupervised machine learning approach for identifying DMUs on efficiency frontier of DEA
Chiyen Li, Ping-Yu Hsu, Dong Shang Chang

We propose an unsupervised machine learning framework to identify efficiency-frontier decision-making units in data envelopment analysis. Conventional DEA solves a linear program for each unit, becoming costly as sample size and dimension grow. Our method infers frontier structure directly from data, without pre-labeled scores or repeated optimization, while staying consistent with slack-based measurement under variable returns to scale. Benchmark and large real-data tests show frontier sets closely match standard DEA results, with much lower computation time.

2 - Total factor productivity growth and its determinants in the greek pharmaceutical industry: a malmquist productivity index approach
Roxani Karagiannis

This study measures total factor productivity growth in the Greek pharmaceutical industry from 2007-2024 using the Malmquist Productivity Index (MPI) and DEA. The research analyzes determinant factors influencing productivity levels, investigates dynamic evolution, evaluates contextual factors' impact, and identifies efficient firms for benchmarking to support evidence-based policy. A two-stage analysis employs econometric techniques and nonparametric statistical tests. Results show most pharmaceutical firms improved primarily through positive technical change effects.

3 - Bootstrapping under imperfect knowledge of data: An integrated approach for performance assessment using composite indicators
Guilherme Vara, José Rui Figueira, Salvatore Greco, Diogo Cunha Ferreira

This study proposes a robust, dual-layered methodology for performance assessment using composite indicators. It improves the Benefit-of-the-Doubt (BoD) method, rooted in DEA, by combining a procedure for preprocessing (capturing structural uncertainty) with a novel Bootstrap framework for postprocessing (correcting bias). This integrated approach outperforms classical BoD, significantly enhancing reliability and offering a superior alternative to current methods.

■ WB-27

Wednesday, 10:30-12:00 - Room: JUR - Hörsaal 13 (Building: JUR)

Optimizing Care Delivery in Crisis and Healthcare Settings

Stream: Humanitarian Logistics
Invited session
Chair: *Alborz Hassanzadeh*

1 - Vehicle routing problem for early infant diagnosis of HIV
Hamed Jalali, Ata Jalili Marand, Jens Lysgaard

HIV remains a major health challenge in Africa, where expanding early infant diagnosis is essential to achieving the goal of ending HIV by 2030. Motivated by a real-world logistics problem, we study a vehicle routing problem for transporting blood samples from clinics to a central PCR laboratory. The objective is to reduce turnaround time (TAT) which is the time between sample collection and result delivery. We minimize both average and maximum TAT by solving a convex reformulation of an initially nonconvex problem. A case study from Mozambique highlights the resulting public health benefits.

2 - Natural Disaster Preparedness and Response with Heterogeneous Group Service Levels: The Case of San Antonio, Chile.
Alejandro Lamas, Pamela P. Alvarez, Andrés Bronfman, Alborz Hassanzadeh

After a natural disaster, population groups have different needs, and planners may assign distinct service levels to each group. We propose a two-phase methodology: (i) a shelter and warehouse location model with prepositioning, and (ii) a novel re-optimization model that accounts for post-disaster disruptions to facilities and inventory. Our objective is to minimize travel, inventory, and facility setup costs while satisfying group-specific service levels. We apply the framework to the city of San Antonio, Chile.

3 - Robust Facility Location in Disaster Preparedness for Earthquakes with Aftershocks
Minakshi Punam Mandal, Laurent Alfandari, Ivana Ljubic

We study the problem of locating facilities under earthquakes and aftershocks. A two-stage budgeted-robust Mixed-Integer Linear Programming model is developed, where the first stage captures the impact of a major earthquake and the second stage accounts for aftershocks. We solve the model using a Branch-and-Cut approach. Computational experiments on synthetic instances and a case study in Turkey evaluate its performance. A method for determining facility capacities is also proposed, and managerial insights on how aftershocks influence optimal location and capacity decisions are discussed.

4 - From Forecast to Coordinated Action: A Platform-Based Anticipatory Stock Repositioning Framework
Birce Adsanver, Burcu Balcik, Valérie Bélanger, Marie-Ève Rancourt

Motivated by a partnership with ESUPS, this study proposes a platform-enabled anticipatory action framework for cyclone response, enabling humanitarian organizations to adaptively reposition inventories based on cyclone forecasts. We combine a regression model with a two-stage stochastic optimization embedded in an optimal stopping framework to predict demand and guide decisions on relocation and timing. A Madagascar case study shows the proposed approach can reduce response time by up to 50% compared to non-anticipatory approaches, with the largest gains from platform-enabled collaboration.

■ WB-28

Wednesday, 10:30-12:00 - Room: JUR - Hörsaal 17 (Building: JUR)

Maritime logistics for offshore wind turbines

Stream: Maritime Logistics
Invited session
Chair: *Vibeke Hvidegaard Petersen*

1 - A Workforce Focused Optimization Model for Short Term O&M Operations in Offshore Wind Farms
Paulo Cesar Ribas

Existing studies have mainly focused on minimizing transportation costs; a critical resource remains relatively underexplored in optimization models: skilled offshore technicians. The present paper proposes a Workforce-Focused Optimization Model and evaluates it in realistic offshore wind O&M cases. Compared with the traditional formulations, it substantially reduces technician idle time while maintaining high service levels. The evaluation also shows strong computational performance and effective worker deployment, confirming the value of prioritizing labor - opening new research direction.

2 - Mission-Level Fuel Breakdown for Offshore Wind Service Operation Vessels
Komeyl Baghizadeh, Julia Pahl

Offshore wind farm maintenance uses service operation vessels (SOVs), yet fuel use is hard to attribute per activity. We fuse 10 Hz engine logs, AIS/navigation tracks, and 3-hourly met-ocean data, and label operating modes from operator reports. Random Forest predicts fuel rate (R-squared=0.857, RMSE=8.9 L), beating linear, polynomial, and SVR baselines. A mission audit shows transit drives 74 percent of fuel, while push/port maneuvers are inefficient per nautical mile. Speed and relative wave angle dominate, enabling weather-aware speed/routing, supporting greener SOV operations planning now.

3 - Learning-based approximations for minimum latency vessel routing in offshore wind turbine maintenance
Vibeke Hvidegaard Petersen, Magnus Stålhane, Stein W. Wallace

We study a two-stage stochastic operational maintenance planning problem for offshore wind turbines, where failures are uncertain. The first stage selects technicians and spare parts for service vessels, while the second stage routes them through a minimum latency vehicle routing problem (ML-VRP). Because solving the ML-VRP is computationally expensive, we develop approximations that use machine learning to predict service time distributions and expected latency costs. These approximations enable evaluation of first stage loading decisions without solving the full ML VRP for each scenario.

■ WB-29

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 30 (Building: HG)

Combinatorial optimization for healthcare

Stream: Combinatorial Optimization
Invited session
Chair: *Greet Vanden Berghe*

1 - Reconfigurable matchings and recourse actions in kidney paired exchange programs
Carmine Sorgente, Domenico Serra, Monica Gentili, Raffaele Cerulli

Kidney paired donation programs match incompatible recipient-donor pairs through donor exchanges, typically identified by solving combinatorial optimization problems on compatibility graphs where bounded-length cycles represent feasible exchanges. We introduce reconfigurable exchanges and provide a hierarchical bi-objective integer linear program to identify exchanges with backup plans allowing a subset of transplants to proceed if failures occur. Simulations show competitive transplant rates and waiting times, while significantly increasing recourse transplants for pairs in failed exchanges.

2 - A column generation approach for automated treatment planning of scalp brachytherapy with 3D-printed applicators
Björn Morén, Freja Alpsten, Apostolos Raptis, Michael Gubanski, Åsa Carlsson Tedgren

We consider the problem of skin radiotherapy dose optimization when designing 3D-printed applicators. The main difficulty is finding smooth and non-intersecting catheter trajectories that can be combined to a high-quality treatment plan. A column generation approach is formulated where the subproblem is used to generate the trajectories. To speed up a naive, integer programming-based approach, we solve the subproblem with a problem-specific constrained shortest path algorithm with forbidden paths. We use a relaxed model for benchmarking and show that we obtain high-quality designs.

3 - A New Integer Optimization Model for Nurse Rostering Across Multiple Units
Maristela Santos, Guilherme Ramon, Greet Vanden Berghe

Hospitals must efficiently schedule nursing teams to optimize resources while maintaining quality. Organized into departments with functional units, nurses start in a home unit but may be reassigned based on availability and demand, known as the Nurse Rostering Problem with Multiple Units (NRPMU). This study examines NRPMU in Brazil, proposing an optimization model inspired by UH-UFSCar's Pediatric Department, including the ICU, Infirmary, and ER, with over 70 staff for 35 beds.Validation uses scenarios solved with Gurobi, proving its effectiveness.

■ WB-30

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum 06 (Building: HG)

Machine Learning and Optimization in Humanitarian Logistics

Stream: Machine Learning and Optimization
Invited session
Chair: *Franco Basso*

1 - Consistent Home Healthcare Routing with Patient Fluctuation
Shohre Zehtabian, Marlin Wolf Ulmer

Home healthcare (HHC) delivers in-home care to aging populations, reducing hospital use. Agencies face the challenge of assigning nurses to geographically dispersed patients over time, respecting work constraints, ensuring care continuity, and adapting to uncertain demand like arrivals and cancellations. We model this as a sequential decision problem to maximize expected service value. Our solution combines cluster-based sampling to handle the exponential assignment space with a value function approximation (VFA). Numerical results show our policy outperforms common geography-based heuristics.

2 - Boosted Distributional Reinforcement Learning: Analysis and Healthcare Applications
Wesley Marrero

Reinforcement learning has achieved extraordinary success in complex decision problems by learning policies that optimize expected cumulative rewards. However, expectation-focused objectives are often inadequate in uncertain environments and can lead to substantial variation among similar agents. We present a boosted distributional reinforcement learning algorithm that enforces similarity in outcome distributions across comparable agents. We analyze its asymptotic properties and demonstrate its effectiveness through a hypertension management case study in a large adult population.

3 - Simulation of earthquakes and aftershocks with clustering to estimate the reliability of a telecommunications network
Dora Jimenez

We used machine learning clustering to construct spatially coherent seismic scenarios and simulate a main earthquake and a nearby aftershock in a PSHA-based Monte Carlo model for REUNA. A GMPE model calibrated in Chile determined node fragility (HAZUS) and segmented damage of buried fiber links (PGD/Poisson). Source-to-terminal connectivity reliability was estimated from the final state of the main and aftershock earthquakes, revealing region-specific losses and vulnerable nodes for mitigation prioritization.

4 - Severity prediction of crashes requiring medical assistance: a multimodal machine learning and natural language processing approach
Franco Basso, Felipe Villa-Rodríguez, Raul Pezoa, Mauricio Varas

Road traffic crashes are a major global public health challenge. Identifying crashes likely to require medical assistance is essential for prioritizing road safety interventions. This study advances crash severity prediction through multimodal fusion, combining traffic flow dynamics with semantic information from crash narratives. Using 2,070 crashes on Autopista Central in Santiago, Chile, we integrate high-frequency traffic measurements with BERT-based narrative embeddings to predict Medical Assistance Required Crashes (MARC). An XGBoost model achieves 94.4% accuracy and a 96.6% F1 score.

■ WB-31

Wednesday, 10:30-12:00 - Room: JUR - Hörsaal 12 (Building: JUR)

Traveler-centric public transport optimization

Stream: Optimizing Transit
Invited session
Chair: *Paul Bouman*

1 - A Fixed-Point Analysis of User Route Choice and Operators Frequency Adjustment in Public Transport Networks
Valentina Gomez Zuniga, Andres Fielbaum, Julian Mestre

Passengers in public transport networks choose routes according to their preferences, often leading to unexpected distributions that deviate from the system optimum. When operators also respond strategically by adjusting frequencies and vehicle capacities, network design becomes a two-agent equilibrium problem. We propose a general framework based on abstract topologies and analyse multiple user and operator behaviours. For each scenario, we derive frequency bounds ensuring equilibrium existence, uniqueness, and convergence, with implications for efficiency and algorithmic validity.

2 - Simulation-Based Optimization for Multimodal BRT Integration: Coordinating Transfers and Reducing Travel Times with Real-World Data
Priscila Correa, Yasmin Rios Solis

This research develops a simulation-optimization framework to analyze operational dynamics at a Bus Rapid Transit (BRT) transfer station. We simulate two intersecting lines using real-world data, focusing on passenger transfer coordination between corridors. The study employs a discrete-event simulation, proposing strategies to facilitate seamless transfers. A mathematical programming model optimizes vehicle headways and bus holding times with the objective of minimizing total passenger travel time. Experimental results show that the BRT's dynamics can be optimized to improve service quality.

3 - Simulating Traveller Behavior with LLMs in Public Transport Optimization
Paul Bouman

Including passenger behavior in optimization models dealing with disruption management, demand responsive capacity planning, revenue management or service quality is difficult. We investigate the use of (local) large language models (LLMs) to simulate decisions in contexts with uncertainty from heterogeneous types of travellers, and discuss how to include these in optimization models for public transport that include passenger behavior. We aim to discuss some first experiments, challenges, concerns and future research directions related to this idea.

■ WB-32

Wednesday, 10:30-12:00 - Room: JUR - Hörsaal 14 (Building: JUR)

Cutting and packing II

Stream: Cutting and Packing
Invited session
Chair: *Tony Wauters*

1 - A Digital Twin Approach for Online Packing of Irregular Items with Stability Constraints
António Ramos, Pedro Rocha, Manuel Lopes, Fillipe Ribeiro

This work presents an online algorithm for real-time packing of irregular items, applied to cork plank palletization within a Digital Twin framework. Cork planks pose a challenging Container Loading Problem variant due to irregular contours and variable thickness, with items arriving sequentially. The algorithm combines maximal-space heuristics with a two-stage approach: bounding box approximations for rapid placement, followed by physics-based stability validation via the Bullet Physics Engine. Experiments with 64 real planks achieve 0.392s placement time and 71.2% utilization.

2 - A Column-Generation Approach for the Irregular Shape Bin Packing Problem
Filippo Ranza, Stefan Irnich, Christian Manz

We study the packing of 2D irregular shapes into rectangular containers, so that their number is minimized. Such an Irregular Shaped Bin Packing Problem is tackled with a column-generation approach. The master problem is a Gilmore-Gomory formulation. The pricer is a bounded knapsack problem with additional constraints. Feasibility is ensured by a Benders decomposition approach, validating patterns proposed by the pricer, and removing invalid ones with no-good cuts. An exact Benders subproblem guarantees global optimality. We present results using both heuristic and exact Benders subproblems.

3 - 3D Irregular Cutting and Packing Problem from Tokamak Reactor Decommissioning
Yifu Wei, Julia Bennell, Hamish Carr, Ipek Caliskanelli

The waste from Tokamak fusion reactor needs to be cut into legal pieces and packed into containers remotely by robotic arms, then, stored in disposal facilities. In this process, an optimised solution of cut and bin packing, considering practical constraints, has potential to reduce the overall cost by millions. In this research, we propose two patterns of cutting and bin packing algorithm, combining with GPU-empowered algorithm, advanced machine learning, heuristics and metaheuristics. These algorithms efficiently solve the problem and support the decision-making in real world applications.

■ WB-33

Wednesday, 10:30-12:00 - Room: JUR - Hörsaal 15 (Building: JUR)

Maintenance and Vulnerability

Stream: Passenger Railway Transportation
Invited session
Chair: *Tzu-Hao Yan*

1 - Exploring Subway Network Vulnerability and Uncertainty under Multiple Risks
Jinxiao Duan, Guanwen Zeng

Urban subway networks are exposed to various risks, e.g., demand disturbances, extreme weather, and malicious attacks. How to understand the vulnerability and uncertainty of subway systems under the above risks is the core question. We propose a percolation-based method to quantify subway vulnerability under random, degree-based, and betweenness-based disturbances. In addition, we applied XGBOOST model to analyze how network layout structures, local connectivity and bottlenecks quantitatively affect network vulnerability and uncertainty. This research may help design resilient subway networks.

2 - Optimal Daily Maintenance Rescheduling for Mass Rapid Transit Facilities
Tzu-Hao Yan, Chun-Yi Wang, Shangyao Yan

Daily maintenance rescheduling for MRT facilities must adapt to frequent changes in workforce availability and task demand. Planners need to account for committed tasks, resource constraints, contractor capacities, and both preventive and corrective maintenance. This study develops a time-space network-based model for daily maintenance rescheduling, enabling flexible task reassignment across subsections and work teams. A real-world case study is conducted to validate the model. The results demonstrate its effectiveness in supporting informed and efficient decision-making for MRT operators.

■ WB-34

Wednesday, 10:30-12:00 - Room: JUR - Hörsaal 16 (Building: JUR)

Robotic and hybrid mobile fulfillment systems 1

Stream: Warehousing
Invited session
Chair: *Martina Calzavara*
Chair: *Elena Tappia*
Chair: *An Caris*

1 - Deep Reinforcement Learning for Dynamic Charging of Warehouse Robots
Abhay Sobhanan, Taniya Shaji, Christof Defryn

In automated warehouses, mobile robots must manage stochastic order arrivals alongside finite battery capacities. When charging stations are limited, uncoordinated charging leads to severe operational congestion. Since traditional optimization methods often fail in these dynamic settings, we propose a Multi-Agent Deep Reinforcement Learning framework. Our approach enables robots to learn cooperative policies regarding charging timing, location, and duration. This decentralized model minimizes fulfillment times and queuing delays, offering a scalable solution for realistic environments.

2 - Simulation modelling for studying a robotic mobile fulfilment system: introducing reconfigurability features
Elena Tappia, Tea Castellucci, Ivo Adan, Marco Melacini

Reconfigurability features such as modularity, scalability, and convertibility are valuable traits for warehousing systems, allowing repeated and reversible changes in their design and operating logics in response to varying fulfilment needs. This work proposes an agent-based simulation model of a robotic mobile fulfilment system that, thanks to convertible (i.e., reversibly changing functionality in the system) and scalable human and robotic resources, interchangeably operates as picker-to-parts and parts-to-picker. Results show how performance varies with different mixes of the two logics.

3 - Simulation-driven efficient pick-and-place operations for Reconfigurable Manufacturing Systems
Pavlos Eirinakis, Konstantinos Giannakos, Dimitrios Tsakoumis, Stathis Plitsos, Gregory Koronakos, Giulio Vivo

Reconfigurable Manufacturing Systems require flexible logistics operations to handle changing demand. This work examines an industrial robotic pick-and-place setting where a robot transfers components from a Gravity Rack to modular Kit Holders. We propose a digital twin-based simulation-driven workflow that identifies efficient container-to-position assignments to reduce kitting time. The problem is formulated as a Bipartite Traveling Salesman Problem and solved via integer programming with iterative subtour elimination. Experiments demonstrate improvements over baseline sequencing policies.

■ WB-35

Wednesday, 10:30-12:00 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Sustainability in Retail

Stream: Operations Research and Sustainability
Invited session
Chair: *Sumanta Basu*

1 - Probabilistic Selling with Pity Time Mechanisms: Optimal Pricing and Consumer Welfare.
Yung-Hsun Chang, Chia-Wei Kuo, Kwei-Long Huang

Probabilistic selling raises consumer concerns over hidden odds and gambling. To mitigate this, sellers implement a "pity time" mechanism, guaranteeing the desired product after a set number of failed attempts. This study analyzes this mechanism across varying product qualities and consumer types. Results show that whether offering solely probabilistic or multiple products, implementing pity time consistently increases seller profits, consumer welfare, and overall social welfare. This achieves a win-win-win outcome for stakeholders, especially when quality differences are small to moderate.

2 - Sustainable Retail Refrigeration Under Disruptions: An Event-Driven ABM-SD Decision-Support Model
Tsung Yen Wang, Dong Shang Chang

Extreme heat and power outages threaten retail cold chains, yet studies rarely model managerial behavior during disruptions. We propose an event-driven hybrid agent-based and system-dynamics model linking cabinet heat-load dynamics to remaining shelf life, time-to-recovery, energy use and carbon emissions. Monte Carlo simulations under standardized heatwave and outage scenarios compare managerial archetypes and strategy portfolios (doors, curtains, PCM, IoT, SOPs). Findings reveal behavioral mechanisms behind resilience-sustainability trade-offs and inform retailer and policy decisions.

3 - AI-Informed Analytical Models for Sustainable Product Development
Raziyeh Reza-Gharehbagh

Sustainable product development requires firms to balance environmental performance with economic viability. This study develops analytical models to examine firms' decisions on product greenness, market competition, financing mechanisms, and policy incentives. Comparative analysis illustrates how key factors shape equilibrium outcomes and demonstrates implications for sustainable innovation, contributing to the broader United Nations Sustainable Development Goals. The work also highlights how emerging AI-enabled insights may complement analytical approaches in decision-making.

4 - Analytical Modeling of Channel Choice and Contract Design in Carbon-Regulated E-Commerce Supply Chains with 3PL
Sumanta Basu, Kirit Ghosh

Last-mile delivery is a major source of emissions in e-commerce supply chains. Using a game-theoretic analytical model, we examine channel choice (reseller vs. agency) in a green supply chain with a manufacturer, platform, and 3PL under a carbon tax. Reseller mode induces "double delivery" and higher emissions, while agency mode can mitigate tax exposure. We show how platform contracts coordinate channel choice and how 3PL greening investment affects equilibrium outcomes, revealing conditions under which agency mode improves sustainability and supply chain performance.

■ WB-36

Wednesday, 10:30-12:00 - Room: JUR - Seminar-Raum 42 (Building: JUR)

Resilient Systems

Stream: Building Resilient Systems
Invited session
Chair: *Stephan Helfrich*

1 - Maintaining Supply Network Resilience via Information Design
Qiao-Chu He, Peifeng Li, Jie Wang, Jiayi Zeng

Platform-based supply networks algorithmically match suppliers with upstream and downstream partners. We identify a critical matching threshold: above it networks remain stable, while below it collapse may occur. To mitigate fragility, we propose an information design approach in which platforms adjust matching algorithms to correct suppliers' underestimation of network benefits, strengthening participation and resilience. Our results highlight the strategic role of information in sustaining supply network stability.

2 - Balancing Grid Load and Emission Reductions: A Simulation Study of EV Electrification Strategies Across Indian City Tiers
Harish Rao

India's EV policy treats the country as a uniform whole, yet grid emission factors and vehicle mix vary sharply across city tiers. This study develops a discrete-event simulation model to examine how grid load and net GHG reductions shift across Tier-1, Tier-2, and Tier-3 cities by vehicle segment and charging regime. The model is designed to answer whether grid stress is disproportionately higher in smaller cities, whether 4W electrification delivers net climate benefits in coal-intensive states, and whether solar-coupled charging materially improves emission outcomes in Tier-2/3 cities.

3 - Urban Shading Optimization for Climate-Resilient Cities
Iris Forma

This research proposes a mixed-integer optimization model for urban shading planning under increasing heat wave conditions. The formulation considers natural and artificial shading interventions and integrates climatic, economic, and demographic parameters. An exact solution approach is used to identify optimal shading locations. The model is applied to a real-world metropolitan case study, and results demonstrate significant improvements in shaded area coverage compared to conventional planning methods, highlighting the relevance of operations research tools for urban heat mitigation.

4 - A Multiobjective Optimization Perspective On Resilience
Stephan Helfrich, Gabriela Ciolacu, Jan Boeckmann, Emilia Grass

Resilience is commonly understood as a system's capability to prepare, resist, absorb, and recover from adverse events. This implies that resilience must jointly capture multiple capabilities. However, existing optimization models often focus on single capabilities, leaving trade-offs among them unexplored.

In this talk, we translate resilience into multiple explicit decision objectives. This enables the identification and analysis of potential trade-offs among these and the assessment of their implications for decision-making, which we illustrate on a case study of healthcare systems.

■ WB-37

Wednesday, 10:30-12:00 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Optimization with structure

Stream: Nonlinear Optimization
Invited session
Chair: *Cong Sun*

1 - Monotone Reweighting of Assessment Scores: Linear and Nonlinear Rules with Debiasing
Thomas Weber

We study reweighting rules for assessment scores under the requirement that raising any one score increase the aggregate. The starting point is an endogenous adjustment of syllabus weights based on deviations from the weighted mean. The strongest admissible linear rule is unique, induces a variance bonus, and depends only on the smallest syllabus weight. We compare nonlinear rules to their linear approximations, quantify the loss from linearization, evaluate both against the infeasible maximum-score benchmark, and provide debiasing maps that restore a target mean without changing rankings.

2 - Intra-core Scheduling Optimization for General Neural Network Processors
Mengjun Ming, Yanru Cui, Tao Wang

SIMD-based neural network processors for edge computing suffer performance limits from node dependencies and cache constraints in large-scale computation graphs, with ineffective manual scheduling. This study proposes a greedy topological sorting scheduling algorithm that prioritizes nodes releasing large cache capacity without conflicts under topological and hardware constraints. Tests on six typical computation graphs validate the algorithm's effectiveness for large-scale graph optimization.

3 - A highly efficient second-order algorithm for solving group SLOPE-regularized least squares problems
Hang Zhao, Ziyan Luo

Least squares with group SLOPE regularization is effective for feature selection and grouping in high-dimensional regression. Existing first-order algorithms for solving the involved non-smooth optimization models suffer from low computational efficiency. To address this, we propose a semi-smooth Newton-based augmented Lagrangian method that appropriately leverages the sparse structure of generalized Jacobian matrices in subproblem iterations. Theoretical convergence guarantees are established, and numerical experiments on real datasets confirm the algorithm's effectiveness and efficiency.

■ WB-38

Wednesday, 10:30-12:00 - Room: JUR - Seminar-Raum 44 (Building: JUR)

Methodological Developments in Soft OR and PSMs

Stream: Soft OR and Problem Structuring Methods
Invited session
Chair: *Chris Smith*

1 - A Rose By Any Other Name? The change from 'industrial dynamics' to 'system dynamics' and its real significance for the field
David Lane

The SD field's name change is explored and revealed as secondary, lagging a more important development: a growing understanding of the field. As Forrester and his team put 'industrial dynamics' ideas to work they realised they had purchase beyond industrial applications. By 1968 there was greater understanding of the applicability of the ideas, as clearly stated in 'Principles of Systems'. When 'system dynamics' appeared (1970) it reflected the broader understanding. A conclusion is that the potential of Forrester's ideas was not initially appreciated; it took years to grasp their breadth.

2 - Strategic Diagnosis and Organizational Redesign in Product Development Organizations: An Integrated SODA-VSM Approach
Ricardo Simoni de Freitas, Mischel Carmen Neyra Belderrain

Product development organizations increasingly seek to better understand their environments and adopt dynamic strategies to remain competitive. In a context of strong competition and the emergence of technology startups, defining organizational structures and aligning strategic vision is challenging. This paper proposes a methodological approach to support problem structuring, cause-effect mapping, and the formulation of strategies for organizational redesign. It integrates Strategic Options Development and Analysis with Viable System Model to enhance competitiveness and sustainability.

3 - Methodological development of Rich Notes: An analysis of the structural features of Rich Notes
Chris Smith, Giles Hindle, Karthik Suresh

This paper develops our methodological understanding of the Rich Notes technique through an analysis of over 400 sets of Rich Notes from real use cases. The paper identifies 12 distinct elements that are used within a Rich Notes to capture information about the situation. These elements come together in a bottom-up rhizomatic structure that enables flexibility in note taking. The analysis of the builds a deeper methodological understanding of the approach and how it can be used in practice.

■ WB-45

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum 01 (Building: HG)

Data-driven optimization under uncertainty in rail transit systems

Stream: Data-driven Stochastic (Inverse) Optimization
Invited session
Chair: *Yahan Lu*

1 - Robust Optimization for Shared Utilization of Train Units in Urban Metro Networks
Housheng Zhou

Shared depots are widely adopted to reduce land and construction costs in expanding metro networks. However, sharing train units across lines couples operations, and demand uncertainty complicates frequency and capacity planning. This study develops a robust model that jointly optimizes timetables, train composition, and depot allocation. Three exact methods are proposed: an equivalent integer programming model, a column and constraint generation (C&CG) algorithm, and a progressive C&CG algorithm. Experiments on the Xi'an Metro Network demonstrate the effectiveness of the proposed method.

2 - Enhancing Efficiency and Fairness: Rolling Stock Scheduling with Virtual Coupling and Short-Turning Strategies
Hongyang Wang

We propose a novel urban rail transit mode combining short-turning and flexible train composition via virtual coupling to match capacity with passenger demand in time and space while ensuring service fairness. A MILP model is developed to optimize rolling stock schedules for operational cost, service quality, and fairness. To solve large-scale problems, we design three exact algorithms based on the model's structure. Experiments on Xi'an metro Line 3 show our algorithms outperform commercial solvers, and the proposed strategy surpasses the current scheme.

3 - Robust dynamic train regulation in urban rail networks under disturbance uncertainties
Zebin Chen

Urban rail networks with heavy passenger demand are highly vulnerable to frequent disturbances, and resulting delays can quickly spread across the network and reduce service quality. This study proposes a robust train regulation strategy based on information gap decision theory. The approach helps operators flexibly balance robustness and performance without requiring prior knowledge of disturbances. Experiments on the Beijing metro network demonstrate the robustness of the strategy and the effectiveness of the solution approach.

4 - Real-time train rescheduling for large-scale high-speed railway network
Huimin Zhang

Train rescheduling in large-scale high-speed railway networks is highly challenging, particularly when accounting for microscopic infrastructure details. Efficient algorithms are therefore essential to promptly generate real-time strategies that preserve stability under frequent perturbations. To this end, we propose a microscopic-level rescheduling strategy formulated as a mixed integer linear programming model within a rolling horizon framework to enhance robustness under dynamic changes, and develop an augmented Lagrangian-based decomposition algorithm to achieve real-time performance.

■ WB-46

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum 02 (Building: HG)

New challenges in scheduling 1

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Thomas Volling*

1 - Metaheuristics for Integrated Machine-Robot Scheduling
Bilgenur Erdogan, Quang Vinh Dang, Mehrdad Mohammadi, Ivo Adan

With the increasing automation of Industry 4.0 production systems, coordinating smart robots and manufacturing resources becomes critical. This study addresses the integrated scheduling of machines, AGVs, and AMRs in a production system. We develop a mixed-integer programming model and metaheuristics (GA and ILS) to solve larger instances. Results from an industry case study show that the proposed approaches significantly improves system performance while remaining computationally efficient.

2 - A Hybrid NSGA-II for the Human-aware Multi-mode Resource Investment and Project Scheduling Problem in Building Retrofitting
Jannis David, Thomas Volling

Building retrofit capacity is limited by low labor productivity and ergonomics-related absences. We introduce a human-aware multi-mode resource investment and project scheduling problem that optimizes duration, cost, and metabolic load via joint decisions on workforce and exoskeleton capacity sizing and scheduling. A hybrid NSGA-II with human-aware priority-list encoding and SSGS decoding, diversity-preserving niching, and GA seeding efficiently approximates the Pareto front, as shown by epsilon-constraint benchmarks.

3 - Minimizing Total Tardiness in Distributed Flow Shops Through Transportation and Speed-Ups: A Multi-Objective Approach
Lydia Hilarius, Udo Buscher, Tristan Becker

We extend the Distributed Flow Shop Scheduling Problem by incorporating (1) variable production speeds, and (2) the transportation of semi-finished products between factories. We consider three objective functions: total tardiness, the cost of production speed variation, and the cost of inter-factory transportation. We present a mathematical and constraint programming model, as well as an Iterated Greedy heuristic, aimed at identifying Pareto-efficient solutions. Results demonstrate that combining transportation and speed adjustments yields significant benefits in reducing total tardiness.

4 - Metaheuristics for a real-world enriched flexible job shop scheduling problem
Arsène Adam, Nicolas Zufferey, Philipp Baumann, Marc-Antoine Coindreau

We address a real-world production scheduling problem from a tube-drawing company. This problem extends the Flexible Job Shop Scheduling Problem by integrating machine availability, resumable jobs, family-dependent setup times, parallel batching, overlapping operations, and endogenous job splitting with task sizing. A unified MILP formulation and dedicated constructive heuristics and metaheuristics are proposed. Experiments on large-scale industrial instances demonstrate the effectiveness of our methods. Managerial insights are also derived from the computational study.

■ WB-47

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum 03 (Building: HG)

Robust optimization

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Hee Kyung Kim*

1 - A Rolling-Horizon Stochastic Optimization Model for Risk-Averse Spare Parts Management in Reverse Logistics Networks
Hossein Kianypor

This study proposes a rolling-horizon stochastic optimization model for managing spare parts in a multi-echelon reverse logistics network. The model incorporates Conditional Value-at-Risk to limit extreme costs and backorders. The framework jointly optimizes procurement, repair, and lateral transshipment decisions under uncertain demand and operational losses. Computational results demonstrate enhanced service stability, reduced risk exposure, and improved system resilience while preserving overall cost efficiency.

2 - From Response to Coordination: Distributionally Robust Optimization for Multi-Agency Hazmat Emergency Management
Ginger Y. Ke, Jiahong Zhao

Hazmat incident response requires coordinated multi-agency logistics under uncertainty. We model coordinated service via two metrics: mean response time and inter-team waiting time. With ambiguous demand severity, we formulate a distributionally robust facility location, activation, capacity expansion, and resource allocation problem. A Benders decomposition with in-out cuts solves large instances. Shenzhen case studies demonstrate effectiveness and provide managerial insights.

3 - Digitalization-Aware Wasserstein DRO for Inventory under Lead-Time Uncertainty
Hee Kyung Kim, Chang Won Lee

Digitalization affects lead-time tail risk in global inventory systems. We develop a Wasserstein distributionally robust base-stock model for lead-time demand where the ambiguity radius is mapped to DiGiX scores and tuned by cross-validation. A linear-program reformulation enables fast solution. Using open medical-supply and retail shipment data, we center on Korea and benchmark Germany, Austria, Canada, the United Kingdom, Japan, Singapore, and Vietnam, quantifying safety stock, worst-case service, and robustness premiums across eight representative national digital profiles.

■ WB-48

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum 04 (Building: HG)

Data-Driven OR for Machine Learning

Stream: Data-driven Operations Research
Invited session
Chair: *Yun Zhou*

1 - Determinants of dividend smoothing: An explainable artificial intelligence approach
Fatima Almaghrabi, Khadija Almaghrabi

This paper develops explainable artificial intelligence models to predict dividend smoothing using a large sample of firms. These models are implemented for interpretable feature selection based on numerous factors as potential determinants of dividend smoothing. Firm age, return volatility, and firm size emerge as the most influential predictors, while random forests achieve the highest accuracy The paper advances explainable machine learning in finance and provides policymakers with more reliable tools to predict dividend smoothing and support better financial policy design.

2 - Support Recovery in Sparse Regression with Quadratic Measurements via Weakly-Convex-Concave Regularization
Liqun Wang, Jun Fan, Jingyu Yang, Xinyu Zhang

Signal recovery from quadratic measurements finds extensive applications in many fields such as phase retrieval, power system state estimation, etc. We propose a weakly convex-concave regularized least squares method for high-dimensional quadratic measurements models and establish support recovery and L2 error bounds for the local minimizer. To solve the corresponding optimization problem, we adopt two proximal gradient strategies, where the proximal step is computed either in closed form or via a weighted L1 approximation. Numerical examples demonstrate the efficacy of the proposed method.

3 - Data-Driven and Value-Based Multiple Criteria Sorting via Quasi-Attitudinal Choquet Integral
Yangjingyu Zhang

This paper proposes the quasi-attitude Choquet integral(QACI) as an interpretable value function for data-driven multiple criteria sorting(MCS). It features a concise inner product under Möbius transformation that captures criterion interactions and risk attitude. We develop two interpretable linear programming QACI-MCS models, which ensures computational efficiency and attitudinal expressiveness. Experiments on 10 benchmark datasets indicate that our four MCS methods combining two sorting methods outperform traditional methods such as SVM, deep neural network, and standard Choquet integral.

4 - Conservative Dynamic Pricing with Demand Learning
Yun Zhou, Amin Shahmardan, Mahmut Parlar

Algorithms for dynamic pricing with learning may incur early revenue losses, leading managers to rely on baseline policies. We propose a pricing algorithm with safety guarantees that ensures, with high probability, revenue reaches a chosen fraction of a baseline policy. We study stage wise safety constraints requiring each period expected revenue to meet a benchmark and develop a UCB algorithm with near optimal learning. We also analyze cumulative safety constraints and extend the framework to checkpoint evaluation and joint price optimization.

■ WB-49

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management in Supply Chains and Manufacturing

Stream: Data-Driven Demand Management
Invited session
Chair: *Matthias Soppert*

1 - Assortment Optimization under Remanufacturing Considerations
Niloufar Sadeghi, Cornelia Schön-Peterson, Friederike Paetz

Remanufacturing is a strategy for enabling the transition to a circular economy, yet manufacturers face challenges like high investments and product cannibalization. We develop a choice-based assortment and pricing optimization model with remanufacturing that determines offerings, prices, buyback incentives, and production and remanufacturing quantities to maximize profitability under environmental constraints (e.g., CO emissions). The NP-hard problem is solved using a conic approach and evaluated through experiments based on a smartphone conjoint, capturing purchase and return decisions.

2 - An Integrated Approach to Sustainable Product Line and Supply Chain Design
Jan-Hendrik Büscher, Cornelia Schön-Peterson

We present an integrated optimization framework for green product and supply chain design that jointly determines facility openings and material flows on the supply chain side and product assortment and pricing on the market side. Supply chain CO emissions are allocated to individual units, while demand is driven by product attributes such as price and CO-label. Demand inputs are estimated via conjoint analyses for chocolate and smartwatches. Our study links supply chain optimization with consumer analytics and shows how CO accounting frameworks affect product and supply chain design.

3 - Decision-Focused Learning for Constrained Pricing in Manufacturing
Tom Nahrendorf, Stefan Minner

Automotive manufacturers increasingly control retail prices in direct-to-customer sales, creating a constrained multi-period pricing problem with operational coupling. We study pricing with commitment horizons, portfolio constraints, inventory dynamics, and CO regulations. Heterogeneous price elasticities are estimated using Double Machine Learning and embedded into a decision-focused learning framework. SHAP analysis identifies product life-cycle stage and product characteristics as key drivers of price sensitivity. We further analyze structural properties of the resulting optimal policy.

■ WB-50

Wednesday, 10:30-12:00 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Energy Systems Optimisation for Industrial Areas and Districts

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Daniela Guericke*

1 - Optimization-Based Topology Planning of District Heating Networks with Sector Coupling
Paul Luis Hahn, Guido Schryen

District heating networks are key infrastructures for low-carbon urban energy systems, where early-stage topology planning strongly affects costs, efficiency, and the ability to integrate flexible heat supply. This work develops an optimization-based framework for district heating layout design in urban districts. The approach explicitly represents sector-coupling options, such as power-to-heat technologies, enabling a planning model that integrates network topology decisions with power system operations.

2 - Realistic Synthetic Benchmark Instances for Multi-Objective MIPs in District Heating Networks
Annika Buchholz, Stephanie Riedmüller, Janina Zittel

This study analyzes the computational complexity of multi-objective mixed-integer programs arising from unit commitment problems in large-scale multi-energy networks. Using Berlin's district heating system as a reference, we develop a methodology for constructing synthetic instances that preserve realistic topological and temporal characteristics. The resulting benchmark instances highlight key structural and scaling effects. We investigate how densely connected networks, along with the tight coupling of unit commitment decisions and continuous flow variables, drive computational difficulty.

3 - Optimisation of industrial flexibility in energy hubs
Tobias Løvebakke Nielsen, Elise Huisman, Daniela Guericke, Kerstin Pfleger-Schopf, Devrim Murat Yazan

To utilize the increasing share of renewable energy (RE), flexible energy consumption is becoming more important, especially in energy-intensive industries. We present a modelling framework to integrate different types of flexibility into industrial systems. In our model, we optimise energy flows in production chains and not as aggregated demand to enable individual process-based flexibility. We present results from two cases (steel, paper) highlighting the potential for flexibility and high utilisation of RE. The model serves as basis for industrial networks sharing common RE assets.

4 - Optimising Energy Flows in Hubs for Circularity under Uncertainty
Daniela Guericke, Tobias Løvebakke Nielsen, Alessio Trivella, Devrim Murat Yazan

The EU's Clean Industrial Deal highlights clean energy and circular production as central to industrial competitiveness. Hubs for Circularity (H4C) enable industrial symbiosis (IS) through shared resources and energy flows. This study examines how energy management can support and enhance IS in H4C. We develop a stochastic, modular energy management model capturing uncertainties in renewable generation and prices while representing IS interactions. A case study illustrates how energy management under uncertainty shapes the operational potential of industrial symbiosis in H4C.

■ WB-51

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Causal ML & Decision making

Stream: Mathematical Optimization for Transparent and Fair Decision Making
Invited session
Chair: *Arno De Caigny*
Chair: *Sam Verboven*
Chair: *Sam Verboven*

1 - Optimising Athlete Readiness: A Dynamic Treatment Regime Approach to Individualised Training in Professional Football
Andreas Goethals

This study aims to develop a prescriptive analytics system for professional football that estimates individualised player Readiness to Train using Causal Machine Learning within a Dynamic Treatment Regime (DTR) framework. Treating daily training intensity as a time-varying treatment and match-day performance as the outcome, we will attempt to address time-varying confounding via G-methods. The system outputs a continuous [0,1] intensity score per player, aiming to optimise performance under biological constraints.

2 - Causal ML for customer retention
Arno De Caigny

Improving customer retention requires understanding not only which customers are at risk of churn, but also which interventions causally increase retention. This study investigates causal machine learning methods for estimating heterogeneous treatment effects in customer retention using a semi-synthetic dataset in a retail context.The study contributes evidence on the use of causal machine learning for targeted retention strategies and data-driven customer relationship management.

3 - Causal Modeling for Improved Organ Allocation
Sam Verboven, Alessandro Marchese

Organ transplantation is limited by donor scarcity and repeated offer refusals, which prolong cold ischemic time, worsen graft quality, and increase discard risk. We present two complementary methods: ClexNet, a causal acceptance model that leverages clinician refusal explanations, and DynamITE, a dynamic allocation framework that models acceptance, decision time, organ deterioration, and transplant benefit. Together, they enable more reliable counterfactual evaluation and improved organ allocation.

■ WB-52

Wednesday, 10:30-12:00 - Room: KOL - PC Raum 1 (Building: KOL)

Risk Modeling and Arbitrage Optimization in Energy Markets

Stream: Energy Markets & Systems
Invited session
Chair: *Christoph Graf*

1 - Trading Electrons: Predicting DART Spread Spikes in ISO Electricity Markets
Ronnie Sircar, Emma Hubert, Dimitrios Lolas

We study the problem of forecasting and optimally trading day-ahead versus real-time (DART) price spreads in U.S. wholesale electricity markets. To translate directional signals into economically meaningful positions, we develop a structural and market-consistent price impact model based on day-ahead bid stacks. This yields closed-form expressions for the optimal vector of zonal INC/DEC quantities. When applied to NYISO, the resulting strategy significantly improves the risk-return profile relative to unit-size trading and highlights substantial heterogeneity across markets and seasons.

2 - Virtual Power Contracts and Seller Default Risk
Felipe Verastegui

This paper investigates the buyer optimal structure of a bilaterally negotiated virtual power contract under uncertainty and limited liability in the case of seller default. Our framework rationalizes floating prices and adaptive discounts as part of the optimal contract, as well as other specialized instruments, such as buyer-originated long-term financial transmission rights. We focus on the special case of base load fixed price contracts as an incomplete contracting problem, and show that this form of incompleteness can introduce seller default risk even under efficient dispatch.

3 - Integrated Investment and Policy Planning for Power Systems via Differentiable Scenario Generation
Robert Mieth

This talk discusses a method to co-optimize power system capacity planning and policy investments that shape electricity load patterns. A gradient-based solution framework enables efficient operation-aware planning. The concept of "differentiable scenario generation" is introduced to compute consistent gradients with respect to daily demand conditions, and it is shown that established generative models meet the required mathematical properties. Numerical experiments combine a diffusion-based scenario generator with an exemplary capacity expansion model.

4 - Reachability in Power Systems with Energy-Limited Resources
Yury Dvorkin, Tomas Tapia

As battery storage adoption grows, balancing profit-seeking energy arbitrage and grid reliability is critical. System operators struggle to control energy-limited resources through regulation alone. We propose a reachability-based solution bridging asset-owner and system perspectives. Our method determines optimal charging and discharging thresholds under uncertainty while probabilistically ensuring batteries maintain sufficient state of charge for grid reliability.

■ WB-53

Wednesday, 10:30-12:00 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Multi-objective planning

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Erdi Dasdemir*
Chair: *Konur Dincer*

1 - A Composite Satisfaction Indicator for Employee-Centered Personnel Planning in Public Transport Environments
Nils Katzke, Irene Abi-Zeid, Natalia Kliewer

Personnel planning in public transport requires balancing operational needs with an increasingly heterogeneous workforce. This study presents a multi-objective optimization framework integrating a composite satisfaction indicator into crew rostering and rerostering. Through a multi-stage transdisciplinary process, we identify satisfaction dimensions used to define four robust utility functions by clustering employee preferences and backgrounds. An assignment application in a real-world organizational context demonstrates significant improvements in aggregate welfare and work-life balance.

2 - Feasibility of university course timetabling
Matthew Davison, Kent Andersen

Timetabling is central to strategic decision-making across many domains, requiring the balance of conflicting objectives. Current literature assumes decision-makers (DMs) can specify meaningful objective weights. In practice, this is difficult. We propose repeatedly solving satisfiability problems, hypothesising that highly constrained problems create opportunities for algorithms that quickly determine feasibility. This gives DMs full resource control and implicitly leverages tacit knowledge. Our research explores and develops algorithms for this new decision-making paradigm.

3 - The multi-objective multi-modal multi-period tourist trip design problem with time windows
Maria Truvolo, Annarita De Maio, Maryam Darvish, Roberto Musmanno

We study a multi-objective, multi-modal, and multi-period tourist trip design problem with time windows. The model identifies optimal itineraries balancing attractiveness of points of interest (POI) and environmental impact of transportation. The formulation accounts for multiple transport modes, time constraints, budget, and heterogeneity of POI categories. To address larger instances, we develop a Multi-Start ILS algorithm. Preliminary computational experiments highlight the effectiveness of the proposed approach in producing high-quality solutions within reasonable computational times.

4 - Multi-Objective Optimization of Intralogistics in Multi-Product Manufacturing Facilities
Erdi Dasdemir, Diclehan Tezcaner Öztürk, Murat Seçmen

We study a multi-objective intralogistics optimization problem arising in multi-product manufacturing facilities. The problem is to route transport vehicles so that parts are delivered between production stations in a timely and efficient manner, subject to vehicle capacity and route continuity constraints. The objectives are to minimize part delivery lead times and route durations simultaneously. We develop exact and heuristic solution approaches to address the problem and apply them to a real defense-industry case to identify efficient solutions.

■ WB-57

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum 07 (Building: HG)

BOR in climate change

Stream: Behavioural Operational Research
Invited session
Chair: *Oliver Behn*
Chair: *Silke Hüttel*
Chair: *Michael Leyer*

1 - Companies' Activities that Influence GHG Emissions: a Robust Explanatory and Causal Analysis
Bernhard Nietert

While the consequences of GHG emissions for companies and regulators are researched well, the analysis of companies' activities that reduce GHG emissions is under-researched. Thus, this paper aims, first, to discover companies' activities that explain GHG emissions using various statistical methods to obtain methodically robust results. Second, it conducts a causal analysis. It finds that over all statistical methods the same companies' activities possess explanatory power. Interestingly, these variables are not relevant in the causal analysis.

2 - Smart cities and the challenge of lived experience: Interpreting citizen-sensed data for inclusive urban futures
Katharina Burger

Urban climate interventions such as pedestrianisation create complex decision contexts marked by uncertainty and competing stakeholder perspectives. This paper examines how citizen-sensed environmental data and lived experience shape decision-making around such interventions. Drawing on a project in a UK city, we analyse how residents interpreted sensor data alongside survey responses when evaluating a pedestrianised street. We introduce the concept of experiential plurality and propose a process model for responsive smart city interventions to support participatory sensemaking.

3 - Climate Optimism in Agricultural Production: Implications for Farmer Welfare, Climate Shocks, and Policy Interventions
Jeongeun Sim, Hanvin Cho, Bosung Kim

Agricultural yields depend critically on climate conditions, yet farmers often hold optimistic climate beliefs. We develop a game-theoretic model of competing farmers with climate optimism. We show that, depending on belief heterogeneity and marginal costs, climate optimism can generate mutual profit gains but may also sustain economically nonviable production. Counter to conventional intuition, the expected profits of one or both farmers may increase as climate shocks intensify. We also discuss the effects of policy interventions intended to support farmers under climate risk.

4 - Learning from Experience: How Past Adaptation Outcomes Shape Farmers' Responses to Climate Extremes
Oliver Behn

Climate hazards threaten farm productivity, yet adaptation remains largely incremental. Existing research frames adaptation as a one-time, information-based decision, neglecting the cumulative role of lived experience and its cognitive processing. We argue adaptation is better understood as a dynamic, experience-driven process, where satisfaction

with past decisions shapes future choices. Using a farmer experiment with sequential adaptation decisions — ranging from incremental to transformative — in response to simulated climate extremes, we examine how prior out influence the adaptation.

■ WB-58

Wednesday, 10:30-12:00 - Room: HG - Seminar-Raum 08 (Building: HG)

Moments in the History (and Future) of OR - 3

Stream: Moments in the History of OR and IFORS
Invited session
Chair: *M. Grazia Speranza*

1 - Highlighting Some Historical Women Leaders in OR
Anna Nagurney

In this presentation I will highlight the contributions of females in OR to research and to service to the community.

2 - The Early History of a Pioneering UK OR Group in British Coal
John Ranyard

In 1948 the National Coal Board set up the Field Investigation (OR) Group to provide objective analyses of operational issues. Pat Rivett was Head in 1951 and oversaw a rapid expansion to 40 scientists. Projects were pragmatic until he visited Russ Ackoff in the USA and discovered OR techniques. Project work was then paused for 3 months while staff learned these techniques and trained new entrants, later setting up a part time external OR Masters course. Several LP studies were carried out. In the 1960s, the group doubled in size to meet the demand and reported at Board level.

3 - The History of Operations Research and Its Current Development in Czechia
Josef Jablonsky

The study traces the development, achievements, and current state of operations research (OR) in the Czech Republic. The Czech Operations Research Society, founded in 1993, is the leading organizer of events in the field of operations research in the Czech Republic. It successfully organized the EURO Conference in 2007, which was the first EURO Conference to attract more than 2,000 participants. In addition, it organizes its annual conferences Mathematical Methods in Economics, and facilitates cooperation with other societies, primarily those in Central Europe.

4 - Ackoff revisited: the future of OR is yet to come
Sally Brailsford

In healthcare OR, despite a vast academic literature, only a tiny fraction of published models are ever used in practice as part of business as usual. This is not unique to healthcare. One of my obsessions over my 38 years in OR has been how to overcome the barriers to sustainable use of models in practice. This problem is even more challenging today, given the rapidly increasing growth of AI and digital twins. How can we ensure that Russell Ackoff's gloomy statement back in 1979 that "the future of OR is past" does not become a reality?

■ WB-59

Wednesday, 10:30-12:00 - Room: KOL - Seminar-Raum 9 (Building: KOL)

Pairwise comparisons and preference relations 1

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Matteo Brunelli*
Chair: *Jiri Mazurek*
Chair: *Konrad Kułakowski*

1 - Fuzzy Heuristic Rating Estimation Method
Jiri Mazurek, Radomir Perzina, Konrad Kulakowski

This paper proposes a fuzzy extension of the Heuristic Rating Estimation (HRE) method. In the fuzzy HRE (FHRE) approach, the comparison matrix is composed of triangular fuzzy numbers, which leads to a fully fuzzy linear system of equations. Using the α-cut representation, the fuzzy system is transformed into a family of interval systems and subsequently embedded into an equivalent crisp formulation. Conditions guaranteeing existence and uniqueness of the fuzzy solution by exploiting the M-matrix structure of the HRE coefficient matrix are established as well.

2 - A Software Tool for the Fuzzy Heuristic Rating Estimation Method
Radomir Perzina, Jiri Mazurek, Konrad Kulakowski

This contribution presents a software tool for the fuzzy extension of the Heuristic Rating Estimation (HRE) method. In the Fuzzy HRE (FHRE) approach, the comparison matrix is composed of triangular fuzzy numbers, leading to a fully fuzzy linear system of equations. Using the α-cut representation, the fuzzy system is transformed into a family of interval systems and then embedded into an equivalent crisp formulation, enabling computation of the fuzzy solution and ranking. An illustrative example based on a real-life problem is also provided.

3 - On an application of optimal transport theory to the pairwise comparison method
Matteo Brunelli, Silvia Lorenzini

We study optimal transport with entropy regularization, which approximates the linear problem by a strictly convex one. We show that its solution offers a new perspective on pairwise comparison problems, including priority vector elicitation and consistency assessment. We present formal results and numerical experiments highlighting connections with well-known prioritization methods and inconsistency indices.

■ WB-60

Wednesday, 10:30-12:00 - Room: KOL - Seminar-Raum 10 (Building: KOL)

Fintech and DEFi

Stream: OR for Insurance, Banking and Financial Risk
Invited session
Chair: *David Neděla*

1 - Trend-risk vs trend-of-risk in portfolio optimization context
David Neděla

This paper examines two distinct perspectives on trend-based risk in portfolio decision-making: trend-risk, which incorporates trend information extracted from asset returns, and the newly proposed trend-of-risk (ToR), which focuses on the temporal trend of the risk measure itself. We study and propose portfolio optimization frameworks that explicitly differentiate between these approaches. Additionally, we demonstrate how they lead to fundamentally different allocation outcomes despite identical instantaneous risk levels.

2 - Portfolio Selection Framework Using Factor Investing and Reward-Risk Performance Measures
Noureddine Kouaissah

The effectiveness of factor investing is well recognized in portfolio construction but remains largely overlooked in portfolio preselection. To address this gap, this paper adopts an F-Score model and develops novel UTASTAR-based methods. Specifically, we evaluate kernel-, spline-, and polynomial-based UTASTAR ranking techniques, using factor investing as the primary set of criteria. The study aims to help investors align their portfolio choices and inform preselection decisions to enhance potential investment outcomes based on reward-risk performance measures.

3 - Cross Sectional Heterogeneity in Investor Sentiment Effects on Stock Market Characteristics
Bahate Maidiya

This study investigates the relationship between investor sentiment and stock characteristics using AAII weekly sentiment data and OLS regressions at the firm level across Russell 1000 and 2000 firms over 2000-2024. The results show that sentiment has limited predictive power for stock returns, but exhibits a strong and negative association with volatility and trading volume. The effects are more pronounced in big size stocks, and notable heterogeneity is observed across sectors. These findings highlight that sentiment effects are heterogeneous across both size and industry dimensions.

4 - Optimizing the Supply Chain Finance for Increasing the Efficiency
Xiaotong Sang

This study proposes a data-driven optimisation framework for supply chain finance, based on transaction and financial data from listed companies. Machine learning is used to predict demand, payment cycles and funding requirements at various points in the supply chain. Based on these forecasts, a multi-objective model is developed to balance financing costs, capital turnover and supplier stability. The results demonstrate improved capital allocation, reduced financial risk and better decision-making in uncertain conditions.

■ WB-62

Wednesday, 10:30-12:00 - Room: KOL - Seminar-Raum 19 (Building: KOL)

From Values to Cities: MCDA Approaches for Sustainable Urban Planning 2

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Francesca Abastante*
Chair: *Isabella Lami*
Chair: *Marta Bottero*

1 - Solving an urban space problem through multi-objective optimization
Caterina Caprioli, Marta Bottero, Elena De Angelis

In real-world urban problems, decision-makers need support to manage the multiple objectives and preferences of the stakeholders involved. Urban space problems in particular require the construction of alternative scenarios, designed according to a set of facilities (e.g. residential and commercial) and evaluated based on a set of criteria (e.g. economic, environmental and social), while respecting certain constraints. Within this context, this study proposes the application of a multi-objective optimization model to solve a design space problem in an underdeveloped area of Turin (Italy).

2 - Prioritizing Municipal Climate Action Measures: A Multi-Model Sorting Problem
Francis Marleau Donais, Abdel Mounim Echcharika, Jerome Cerutti

Climate action planning confronts municipalities with portfolios of 100+ adaptation and mitigation measures addressing various climate risks. We developed a sorting tool based on ELECTRE Tri-C that integrates three distinct models (adaptation, mitigation and support for transition) for aiding municipalities in Quebec, Canada. The process involved seven municipalities and included: (1) problem structuring, (2) defining weight and reference profiles, (3) implementing the models in a user-friendly tool, and (4) application and validation. The tool is adaptable to diverse municipal contexts.

3 - Green and blue strategies in historic centres. The Heuristic Planning Support System (HPSS)
Maria Rosa Trovato

To reduce emissions by 55% by 2030 and achieve climate neutrality by 2050, the 2030 Agenda, the Green Deal and Directive (EU) 2024/1275 (EPBD) have set a target to significantly reduce the energy consumption of buildings and greenhouse gas emissions. These objectives are much more difficult to achieve for existing buildings, particularly those in historic centres. This study proposes the Heuristic Planning Support System (HPSS), an integrated tool aimed at exploring green and blue strategies to support the ecological transition of Borgata di Santa Lucia, a historic district in Syracuse.

4 - Extraction and Ranking of Criteria for Spatial Multi-Criteria Decisions
Abdellah Mebrek, Abdelkader Mendas, Zohra Mekranfar, Yasmine Zohra Oulhaci

Sustainable planning of small water infrastructures requires integrating environmental, hydrological, geological, and socio-economic criteria derived from planning documents. However, identifying and structuring these criteria is often time-consuming and subjective. This study proposes a decision-support approach combining Natural Language Processing and Geographic Information Systems to automatically extract and organize criteria. The validated criteria are then integrated into spatial Multi-Criteria Decision-Making methods to support site suitability analysis for water impoundment planning.

■ WB-65

Wednesday, 10:30-12:00 - Room: HG - Hörsaal 27 (Building: HG)

Responsible Business Analytics: Transparent Models and Accountable Decisions

Stream: Analytics
Invited session
Chair: *Sureyya Ozogur-Akyuz*

1 - When Confident Predictions Rely on Unstable Explanations: Measuring Explanation Instability in Event Sequence Models
Qi Lyu, Shaomin Wu

AI decision support systems often provide both predictions and explanations, yet confident recommendations may rely on unstable rationales. We propose a framework to measure explanation instability in event sequence models, defined as variation in event-level attributions under minor perturbations. Using educational early-warning data, we find that such instability can persist even when predictive confidence is high, with temporal patterns partly driven by model architecture. Our results highlight when AI-supported decisions warrant additional caution.

2 - A strategic and adoption-oriented Framework for Business Analytics implementation
Nádilla Tsuruda, Renata Pelissari

Despite the growing adoption of Business Analytics (BA), the literature reports persistent limitations in its implementation and in the results achieved. A key challenge lies in recognizing that analytics frameworks should be understood as dynamic decision processes rather than as sequences of steps, while also ensuring alignment with organizational strategy. This paper proposes a new framework for BA implementation that integrates elements from established analytics life cycles, theories of data science trajectories, technology adoption models, and strategy-support methodologies.

3 - Trustworthy or Not? Authentication as a Credible Signal in Second-Hand Online Platforms
Masoud Fazlavi, Eirini Spiliotopoulou

How can uncertainty about the product's condition be mitigated in second-hand online platforms? We investigate the role of an authentication service offered at a cost. Developing a signaling game, we show that trustworthy sellers can differentiate themselves and signal their credibility to consumers, either through buying the service (when the authentication fee is moderate) or through lower prices (when the fee is low). Offering the authentication as an optional service, compared to mandatory, benefits trustworthy sellers as well as consumers.

■ WB-66

Wednesday, 10:30-12:00 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Optimal Control Theory and Applications

Stream: Continuous and Global Optimization
Invited session
Chair: *Gustav Feichtinger*

1 - Corporate investment portfolio with time-risk
Haejun Jeon, Michi Nishihara

We study a risk-averse firm's optimal portfolio choice among investment projects with time-risks. Time-risk arises not only at an individual project level but also across projects. A firm with a quadratic utility function inherently seeks time-risk from three perspectives: 1) uncertainty in the order in which projects are completed, 2) uncertainty in the timing of earlier revenue generation within a portfolio, and 3) uncertainty in the timing of revenue generation for each individual project. We demonstrate the diversification effect of time-risk always exists and derive the optimal portfolio.

2 - Dynamic Corporate Governance with Observable Financial Policies: The Principal-Agent Tradeoff
Fouad El Ouardighi

This paper develops a continuous-time model in which corporate governance operates through observable managerial decisions-dividend payments and debt issuance—embedded in a simple capital accumulation process with a Tobin's q valuation mechanism. A principal designs a dynamic contract that adjusts the manager's remuneration and mandate duration in response to these financial policies, which influence investment capacity, leverage, and firm value. The framework highlights the central tradeoff between managerial discretion and financial discipline generated by payout and debt decisions.

3 - Democracy between anarchy and dictatorship: A fragile balance
Reinhard Neck, Dieter Grass, Stefan Wrzaczek, Gustav Feichtinger

Starting from Acemoglu and Robinson on the "narrow corridor", we investigate the situation of liberal democracies using a dynamic model, the Holling type III functional response, with negative external effects, between the elite and civil society. We analyze the dynamics of an uncontrolled system, a system with control by the elite, and a game model with strategic interactions between the two groups using dynamic systems theory, bifurcation theory, optimal control theory, and dynamic game theory. A low inequality of initial endowments and a low discount rate are helpful for liberal democracy.

4 - Corridors as Another Feature of Complexity
Gustav Feichtinger, Jonathan Caulkins, Gian Maria Campedelli, Dieter Grass, Rafael Prieto-Curiel, Gernot Tragler, Stefan Wrzaczek

The occurence of narrow corridors admits interesting insights into the economic behavior of pertinent processes. We analyze an optimal control problem related to Mexican cartels. By using bifurcation analyses, we obtain up to ten equilibria, some separated by Skiba curves. We identify parameter regions with narrow corridors. Further examples of models exhibiting corridors as optimal solutions are presented and open questions in corridor research are discussed. Among them are a full-fledged definition of corridors and the study of socio-economic mechanisms generating them.

■ WB-67

Wednesday, 10:30-12:00 - Room: KOL - PC Raum 3 (Building: KOL)

Capacity Expansion Planning II

Stream: Energy Markets & Systems
Invited session
Chair: *Jan Wiegner*

1 - Low-Regret Pathways for the Energy Transition under Uncertainty
Gabriel Wiest, André Bardow, Stefano Moret

We introduce a decision-support framework that translates the complex outputs from energy systems optimization under uncertainty into actionable insights, where traditional approaches overwhelm planners with options. For this purpose, we reduce the solution space of possible transition pathways for the Swiss energy system through k-means clustering into a few representative strategies. Calculating the regret for these strategies under uncertainty as the cost difference to an optimal strategy allows us to identify transparent, low-regret pathways to support decision-making.

2 - Analyzing trade-offs in integrated residential energy systems by Pareto navigation
Amit Roy, *Jonas Finke*, *Valentin Bertsch*

Households face different conditions when decarbonizing their energy use, so a single "best" solution rarely fits everyone. Existing studies often report one optimum per archetype and offer limited support for preference-based choice among alternatives. We build an open-data, household-level, sector-coupled energy model and compute Pareto-optimal solutions using multi-objective optimization. We then use Modeling to generate alternatives to map near-optimal designs in selected Pareto regions. Finally, Pareto navigation supports trade-off exploration and selection of a preferred solution.

3 - Empirically based assumptions for wind power - Consequences for modeling low-carbon energy futures
Carin Lundqvist

Large-scale energy system models (ESMs) for long-term planning assume onshore wind power deployment densities and siting patterns that lack empirical justification. We incorporated historical deployment patterns for wind power into an ESM for 166 countries. Compared to typical literature assumptions, empirically based assumptions lead to a median increase in system cost of 3-10% and decrease global onshore wind generation by 40-70%. The findings show that applying empirically inconsistent assumptions can introduce a significant bias in assessments of system cost and wind power competitiveness.

4 - Understanding parametric uncertainty in energy systems
Jan Wiegner, *Matteo Gazzani*, *Madeleine Gibescu*

The optimal technology mix in energy system models strongly depends on techno-economic parameters, and identifying relations between these parameters and the optimal technology choice is often non-intuitive. We use decision trees to reveal structural drivers for technology selection and produce explicit, policy friendly decision tools. The method is demonstrated on a stylized energy system with an onshore and an offshore node, relying on wind and solar energy. 2,000 parametrized instances of this system are optimized and used to fit the decision trees.

Thursday, 8:15-9:00

■ HA-01

Thursday, 8:15-9:00 - Room: HG - Audimax

EURO EJOR Best Paper Award and IFORS Fellows

Stream: Special Sessions
Award Competition session
Chair: *Janny Leung*

1 - EURO EJOR Best Paper Award and IFORS Fellows
Janny Leung

Two sets of awards will be presented in this session. Firstly, the EURO Awards for the Best EJOR Papers will be announced and presented. Next, the IFORS Fellows for 2024, 2025 and 2026 will be presented.

Thursday, 9:00-10:00

■ HB-01

Thursday, 9:00-10:00 - Room: HG - Audimax

Plenary Katya Scheinberg

Stream: Plenaries
Plenary session
Chair: *Ulrich Pferschy*

1 - A study of stochastic and noisy oracles in unconstrained continuous optimization
Katya Scheinberg

Classical unconstrained continuous optimization algorithms, such as gradient descent rely on the ability to compute the gradient and the, sometimes, value of the objective at the iterates. Many practical algorithms today relax the requirement of access to the exact derivatives or function values and work with their approximations. We call these inexact computations - zeroth- and first-order oracles. They appear in stochastic optimization, where the true quantities are expectations over a distribution, and thus cannot be computed exactly, but can be approximated by sample averages. Inexact oracles also appear in derivative-free optimization where first order derivatives are approximated using function values. There are many other examples arising from extensions of these settings as well as from using randomization. We will give examples of such oracles, provide classification of different types of inexactness that arise in different settings and show the different effects they have on algorithmic behavior.

Thursday, 10:30-12:00

■ HC-01

Thursday, 10:30-12:00 - Room: HG - Audimax

Tutorial Katsuki Fujisawa

Stream: Tutorials
Tutorial session
Chair: *Sophie Parragh*

1 - Digital Twin: From Algorithms to Industrial Applications
Katsuki Fujisawa, Xun Shen, Takashi Tanaka

The concept of Digital Twin has evolved from a theoretical framework into a key technology driving digital transformation across industries. This session will explore the fundamentals of Digital Twin, transformative algorithms, data-driven modeling techniques, and practical applications across various industrial domains, focusing on the role of Operations Research (OR) in Digital Twin systems.

We will discuss how mathematical optimization, machine learning, deep learning, graph analytics, quantum computing, high-performance computing, and simulation models are integrated into Digital Twin systems to enable real-time decision-making, predictive analytics, and operational optimization. Through case studies on smart infrastructure, including factories and industrial facilities, we will showcase how Digital Twin technology transforms operations, enhances efficiency, and drives innovation.

■ HC-02

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 10 (Building: JUR)

Urban Logistics Network Design and Service Systems II

Stream: City Logistics
Invited session
Chair: *Praveen Muthukrishnan*

1 - Logistics of Urban Monitoring with Moving Sensors
Amir Ahmadian, Matthew J. Roorda, Mehdi Nourinejad

Moving sensing offers a scalable approach to monitoring transient events over large urban areas. This study develops an analytical framework to quantify how fleet size, sensing range, and routing policy jointly determine detection coverage for events that occur at locations unknown a priori and persist for finite durations, such as illegal parking violations. It derives asymptotic upper and lower bounds on achievable coverage under multiple routing policies and uses the results to identify cost-optimal fleet designs in terms of fleet size and sensing range, that meet prescribed coverage goals.

2 - Multi-Commodity IRP with Pickup and Delivery in Hospitality Services
Lukas Seeholzer, Kris Braekers, Johan Joubert, Pieter Vansteenwegen

Service providers in the hospitality sector often share a limited number of suppliers. The service providers are competitors, and their suppliers often don't know about each other, leading to little cooperation, currently. Allowing cooperation leads to the multi-commodity inventory routing problem with pickup and delivery. To solve this problem, interdependent decisions in multiple dimensions have to be taken at the same time. A large neighborhood search is proposed to solve realistic instances, based on an industrial case study. Results show a considerable potential for collaboration.

3 - The Non-overlapping Convex Region Partitioning Problem
Xuan Ren, Chenhao Zhou, Li Xue, Yuansong Jin

We study a non-overlapping convex region partitioning problem motivated by last-mile logistics, where customers are partitioned into a minimum number of territories subject to capacity and geometric constraints. Territories are defined as the convex hull of assigned customers and are mutually non-overlapping. We propose a mixed-integer linear programming formulation based on the separating hyperplane theorem and develop a column generation-based heuristic. On a set of real-world instances, our heuristic yields all optimal solutions and outperforms a K-means approach in quality and efficiency.

■ HC-04

Thursday, 10:30-12:00 - Room: HG - BIG-Hörsaal (Building: HG)

Appointment planning and patient admission

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Antoine Sauré*

1 - An Online Algorithm for Scheduling Appointments in the Presence of Endogenous No-Show Uncertainty
Maxim Frankish, Broos Maenhout

Patient no-shows increase idle time and reduce care provision. While no-show history and age have an effect on no-show behaviour, schedule-dependent factors like access and waiting times also impact this behaviour. We present an optimisation framework for (multi-)appointment scheduling considering both patient and schedule factors. Using machine learning to predict no-show risks, our online rules proactively assign patients to slots to minimise no-shows, idle time, and overtime. We demonstrate that integrating no-show risk is a realistic alternative to traditional overbooking.

2 - Improving MRI Scheduling with Data-Driven Templates: A Constraint Programming Perspective
Katrin Kopfer, Karl Doerner, Pamela C. Nolz

Magnetic resonance imaging is an important diagnostic tool, often requiring tactical planning of scheduling templates for patient groups to enable efficient online patient scheduling under limited resources. We propose a data-driven Constraint Programming model to generate templates under varying demand scenarios and constraints, supporting flexible decision-making. Performance is evaluated via simulation using historical data from an MRI imaging center near Vienna, Austria, demonstrating improvements in patient waiting times.

3 - A problem-based scenario reduction approach for stochastic chemotherapy planning
Serhat Gül, Gunsu Dagistanli Calli, Melih Celik

We study the problem of assigning multiple treatments of each patient to days and chairs over a fixed planning horizon under uncertain treatment durations. The problem is formulated as a two-stage stochastic mixed-integer program. The objective penalizes earliness, tardiness, within-window delays, deferrals to the next period, and overtime. We develop problem-based scenario reduction algorithms extending a recent stochastic programming method and evaluate them using real data from an outpatient chemotherapy center.

4 - Dynamic Advance Patient Scheduling with Uncertain Number of Follow-Up Appointments
Antoine Sauré, Vusal Babashov, Sara Mesgari, Jonathan Patrick

This study addresses advance outpatient scheduling for patients requiring an initial consultation followed by a stochastic number of follow-up visits. Using an infinite-horizon Markov decision process and approximate dynamic programming techniques, we derive an approximate optimal policy and a practical heuristic. Validated with data from an endocrinology clinic, our results show these policies significantly outperform current practice and a set of benchmark policies. They enhance capacity utilization while increasing service levels, offering a scalable solution for real-world settings.

■ HC-05

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 18 (Building: JUR)

Ridepooling, Ridesharing, and Carpooling Algorithms

Stream: Shared Mobility
Invited session
Chair: *Luca Quadrifoglio*

1 - Traveling Salesman Problems with Stochastic Demand: Optimizing Arrival Time Commitments in Ridepooling Services
Lina Schmidt, Julian Golak, Arne Schulz, Malte Fliedner

In ridepooling, the arrival time a provider commits to strongly shapes customer choice. Ambitious commitments attract more customers but can yield demand levels that exceed capacity, while conservative ones reduce acceptance and leave capacity underutilized, causing revenue loss. We study this trade-off in a simplified Traveling Salesman setting, modeling customer acceptance probabilistically as a function of the offered arrival time. We formulate a two-stage stochastic optimization model and propose exact and heuristic methods to derive near-optimal arrival time commitments.

2 - A Generalized Framework for Peer-to-Peer Group-Stable Ridesharing with Flexible Role Choice
Luca Quadrifoglio, Min-Ci Sun

We formulate the stable ridesharing problem in a multi-user, one-sided matching context, with dual-role participants and a proportional cost-sharing mechanism fairly including detour costs. A Peer-to-Peer Group-Stable procedure quickly computes stable solutions regardless of problem size. The feasible matches pool is identified by a clique-based algorithm with a pruning mechanism and the stability model is then solved via an exact algorithm. Results prove the efficiency of the proposed algorithms and certify the limited added cost (below 10%) of the stable solution compared to system optimal.

3 - Toward Realistic Modeling of CO2 Emissions in Carpooling Optimization Problem
Anna Joliot, Philippe Canalda, Hakim Mabed

Attractive carpooling service relies on the optimization of the traveler experience and the ecological impact. Most works ignore the environmental dimension of the problem or involve simplified expression of the Carbon footprint. We propose a realistic and accurate Mixed Integer Linear model of the avoided CO2 that accounts for the vehicles' powertrain type. Experiments conducted on a representative vehicle fleet show an average reduction of 17.66% in CO2 emissions compared to a scenario where all users drive alone, and 11.22% compared to a model that minimizes the number of cars.

■ HC-06

Thursday, 10:30-12:00 - Room: HG - Hörsaal 07 (Building: HG)

Management of Restaurants & Online Food Delivery

Stream: Retail Operations
Invited session
Chair: *Winfried Steiner*

1 - Securing Service Capacity for Online Orders: How OFD Platforms Negotiate with Restaurants?
Arvind Shroff, Bhavinkumar Shah

Establishing and managing a restaurant network is a long-term strategic decision for Online Food Delivery (OFD) platforms. To secure dedicated service capacity for online orders, platforms often provide incentive-based contracts such as Minimum Business Guarantees (MBG) in return for capacity reservation by restaurants. To capture this iterative contracting and negotiation process, we adopt a Stackelberg game framework. It contributes fresh insights into platform-restaurant relationship management in the OFD ecosystem.

2 - The Restaurant-Platform Conundrum in the Sharing Economy: Restaurant's Capacity, Pricing and Channel Decisions in the Presence of Online Food Delivery Platforms
Ashutosh Sarkar, Soumyadeep Kundu

This study investigates how the presence of food platforms affects restaurant's doorstep channel choice and investments in kitchen capacity. We find that partnering with platforms is beneficial for consumers and help restaurants increase dine-in business. Further, we find that a restaurant's kitchen capacity decisions greatly influence prices. However, the decision to engage with a platform depends on the restaurant's ability to differentiate its dine-in and delivery services.

3 - Integrating Machine Learning and Econometrics for Advancing Subscription Services in E-Commerce Food Logistics
Pei-Ju Wu, Bo-Yu Lai

Consumer dissatisfaction with subscription services in e-commerce food logistics remains a critical challenge. To address this, we first apply machine learning to identify successful business models for managing service prioritisation. Building upon these algorithmic insights, we subsequently develop integrated choice and latent variable behaviour models to elucidate subscription adoption. The analytical findings offer a profound comprehension of consumer behaviour, providing actionable frameworks to design highly efficacious subscription models.

4 - Survival Analysis to Identify Key Drivers Causing Rider Churn in On-Demand Food Delivery
Anand Gurumurthy, Praveen Puram, Soumya Roy

This study investigates operational-level drivers of rider churn in the On-Demand Food Delivery (ODFD) sector using survival analysis integrated with interpretable machine learning (IML) techniques. A right-censored dataset from a leading ODFD platform comprising delivery records, weather, traffic conditions, and rider activity is analyzed. The findings highlight that factors such as temperature, distance, engagement time, humidity, visibility, localized delivery, and order delay are the most important, and managers should focus on these to improve rider retention and reduce inefficiencies.

■ HC-08

Thursday, 10:30-12:00 - Room: HG - Hörsaal 41 (Building: HG)

Diagnostic Analytics, Model and Feature Engineering

Stream: Descriptive, Diagnostic and Predictive Analytics
Invited session
Chair: *Thanh Phan*
Chair: *Kai Hoberg*

1 - Cycle-Level Feature Extraction for Predictive Quality Analytics in Molding
Eyyüb Batuhan Ünal, Alara Baysal, Ahmet Eralp Avunduk, Cevdet Utku Şafak, Erinc Albey

This work presents a descriptive and predictive analytics pipeline for industrial sensor data from a molding machine. Raw binary pressure and temperature recordings are organized by production cycle, segmented to isolate the active process phase via threshold-crossing detection, and trimmed of idle periods. Scalar features such as statistical, morphological, energy-based, and complexity metrics are extracted per sensor to better understand process behavior, enable cycle grouping, and ultimately predict quality defects before they propagate.

2 - The role of YRNA-derived small RNAs in atherosclerosis development and progression - modeled and analyzed using Petri nets
Agnieszka Rybarczyk

Non-coding RNAs regulate development, homeostasis, and diseases. Among them, YRNA-derived fragments are clinically relevant as potential biomarkers due to their abundance in cells, body fluids, and tumors. This study examines their role in atherosclerosis progression using a Petri net-based model. Using t-invariant analysis, in silico knockouts, and dynamic simulations, we found that dual-target strategies as suppression of oxidative stress combined with inhibition of either TLR7, s-RNYs, or the pro-inflammatory cytokine IL-6, attenuate lesion progression, supporting multi-pathway therapy.

3 - Schema-Agnostic Interactive Detection of Data Quality Anomalies in Mixed-Type Data
Leon Weihrauch, Leif Meier

Ensuring data quality in heterogeneous datasets remains challenging, as anomalies often go unnoticed without adequate analytical support. We present an interactive framework that integrates visual analytics with automated cell-level anomaly detection to enable rapid identification and exploration of data quality issues. The system operates without prior knowledge of dataset structure and dynamically adapts to heterogeneous column types, applying tailored statistical and machine learning methods to improve detection accuracy while reducing cognitive effort.

4 - The Contingent Value of Case-Level Data in Online Lead-Time Prediction
Thanh Phan, Kai Hoberg

Online prediction of when an order or shipment will complete is critical for planning and intervention. Models can rely on the aggregate state of the system (queueing models, time series) or case-level trajectories using event logs. Prior work overlooks how process characteristics affect the incremental accuracy gain of case-based over state-based predictions. Using discrete event simulation, we find this gain is smallest in processes with low path entropy and low between-path time variance. We propose a contingency view that links the value of case-level data to quantified process structure.

■ HC-09

Thursday, 10:30-12:00 - Room: HG - Hörsaal 50 (Building: HG)

(Deep) Reinforcement Learning for Combinatorial Optimization II

Stream: Data Science meets Optimization
Invited session
Chair: *Yingqian Zhang*
Chair: *Kevin Tierney*

1 - Using Reinforcement Learning to create end-to-end predict+optimise models
Timothy Cargan, Dario Landa-Silva, Isaac Triguero
Recent advancements in reinforcement learning-based methods for constructing solutions to combinatorial optimization problems are rapidly approaching the performance of human-designed algorithms. As they are fully differentiable by construction, these learned neural optimizers present an opportunity to create full end-to-end solutions for decision-focused-learning. We shed light onto how to learn unknown hard constraints through RL cost functions. We will present methods for integrating both the prediction and optimisation into a single model for solving CVRP problems with unknown features.

2 - Configuring LLM-Generated Heuristics via Instance-Specific Deep Reinforcement Learning
Xiaowei Liu, Kevin Tierney
Designing effective optimization algorithms requires both quality heuristics and well-configured parameters. While large language models (LLMs) have shown promise in automated heuristic discovery, configuring parameters of generated heuristics remains challenging. We propose an instance-specific deep reinforcement learning approach to configure LLM-generated heuristic operators. Our method integrates LLM-based heuristic refinement with local search to minimize parameter changes and is evaluated on vehicle routing problems.

3 - Fair Resource Allocation via Count-Proportion-Based Deep Reinforcement Learning
Yossiri Adulyasak, Xiaohui Tu, Erick Delage
We tackle fair resource allocation in combinatorial optimization problems modeled as major-minor weakly coupled Markov decision processes (MDPs) where fairness is enforced via the generalized Gini function (GGF) over long-run returns. By exploiting symmetry in the weakly coupled MDPs, we prove the fair objective can be optimized through utilitarian methods over permutation-invariant policies. This allows us to solve the problem using a count-proportion-based deep reinforcement learning (CP-DRL) approach. We demonstrate its effectiveness on machine replacement and taxi dispatching applications.

4 - On the DSO working group discussing the methodological impact of AI related ideas for optimization
Patrick De Causmaecker
In 2016, the EURO/WG Data Science meets Optimization was created to bridge between two large domains of research essential in operations research. The subject of the group is not restricted to specific application domains nor to specific algorithmic techniques or approaches to analyze large data sets. It is on the use of AI techniques to improve optimization algorithms or on how optimization algorithms can improve AI techniques.

■ HC-10

Thursday, 10:30-12:00 - Room: HG - Hörsaal 31 (Building: HG)

Location problems with user preferences

Stream: Combinatorial Optimization
Invited session
Chair: *Herminia I. Calvete*

1 - A Location-Routing Problem with Delivery Preferences
José-Fernando Camacho-Vallejo, Elena Fernandez, José Emmanuel Gómez-Rocha

In this talk, we introduce the Location-Routing Problem with Delivery Preferences. A company decides which collection points to activate, which customers may receive home delivery, and the service route that visits activated points and selected customers. Customers may reject home delivery if the proposed delivery time is less preferred than picking up the parcel at an activated collection point. In such cases, they select their most preferred point and receive compensation. Preliminary results show the importance of having an integrated approach, while considering customers preferences.

2 - On the complexity of location problems with user preferences
Sophia Wrede, Christina Büsing, Timo Gersing

Classic facility location problems (FLPs) often disregard the customers' perspective. Preference constraints aim to prevent this by ensuring that each customer is served at one of their most preferred open facilities. In this talk, we discuss the effect of preference constraints on the theoretical complexity of FLPs. We show that these constraints increase the complexity of locating facilities but also simplify the assignment of customers for capacitated FLPs. Furthermore, we analyse the impact of different types of preferences on the complexity.

3 - Capacity constraints in location models with user preferences
Herminia I. Calvete, Carmen Galé, Aitor Hernández, Jose A. Iranzo

This research addresses facility location problems with capacity constraints and explores the use of bilevel optimization models to account for users' preferences. The proposed models provide insights into solution strategies and their implications. Despite the inherent nonconvexity of bilevel models and challenges such as the existence of multiple lower-level optima or multiple followers, the models presented here can be reformulated as single-level problems. Computational experiments assess the performance of exact solution approaches using off-the-shelf optimization software.

4 - Strategic Sizing of Collection and Delivery Point Networks for Urban Parcel Distribution
Homero Larrain, Benjamín Rojas, Mathias Klapp

Collection and delivery points (CDPs) reduce last-mile costs by consolidating deliveries, but depend on customer adoption. We propose a simple model to choose the number of CDPs and customer incentives. Using continuous approximation, we estimate infrastructure, routing, and incentive costs while capturing how distance and incentives affect choices. Results show CDPs work best in high-density areas, while incentives matter more in low-density settings. A Santiago case study confirms the model provides accurate, practical guidance for CDP network design.

■ HC-11

Thursday, 10:30-12:00 - Room: HG - Hörsaal 32 (Building: HG)

OR in Natural Resources

Stream: OR in Natural Resources
Invited session
Chair: *Victor M. Albornoz*

1 - New Convex Relaxations for Global Optimization Problems in Water Networks
Burak Kocuk, Ahmet Emir Sener

Water scarcity is a global issue, which threatens many countries across the world. Developing OR-based strategies to efficiently use limited water resources, economically reorganize aging water network infrastructure and reduce negative environmental impacts can help mitigate water scarcity. However, the presence of nonlinear and nonconvex hydraulic equations and discrete variables makes the optimization problems very challenging. In this talk, we present global optimization methods and convex relaxations for mixed-integer nonlinear programming problems that arise in water networks.

2 - From area targets to efficiency frontiers: a multi-objective framework for conservation planning
José Salgado-Rojas, Matías Moreno-Faguett, Eduardo Álvarez-Miranda, Virgilio Hermoso

We propose an exact multi-objective mixed-integer optimisation framework for spatial conservation planning under the 30×30 target. The model jointly minimises cost and maximises ecological representation and spatial cohesion. Pareto-optimal solutions are generated with AUGMECON, enabling systematic analysis of trade-offs across policy scenarios. We further define a frontier-consistent irreplaceability metric to quantify the contribution of individual planning units to Pareto efficiency. An application to Chile's territorial sea reveals inefficiencies in current networks

3 - On fuzzy logic-based tools for assessing the value of information in ecological management
Svetlana Asmuss

We develop fuzzy modelling of uncertainties, focused on assessing the value of information for ecological management (e.g., renewable resource control and extraction, pollution control). This includes analysis of the value of information for related optimal control problems and development of decision-making tools for assessing the need of acquiring new information. One of the advantages of the proposed fuzzy logic-based approach is the ability to consider information systems that include expert-based knowledge. The research is funded by the Latvian Council of Science, project lzp-2024/1-0188.

■ HC-12

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 11 (Building: JUR)

Transfusion and Transplant

Stream: Health Care Logistics
Invited session
Chair: *John Blake*

1 - The Value of Future-Aware Matching in Dynamic Kidney Exchange: Stochastic and Learning-Based Methods
Roby Cremers

Kidney exchange programs match patient-donor pairs through cycles and chains in a dynamic setting where current decisions affect future transplant opportunities. Yet matching is typically performed statically, ignoring future uncertainty. We study stochastic scenario-based methods, including scenario-scoring and Sample Average Approximation models. Using simulation, we show that stochastic optimization increases transplants and particularly benefits hard-to-match patients. We further examine whether these gains can be approximated by learned scoring rules embedded in static optimization.

2 - Blood Supply Chain Design: an integrated strategic-tactical mathematical model
Joao Almeida, Jose Paulo da Silva Neto, Lasara Rodrigues, Fabricio Oliveira

This study proposes a generic mathematical model for Blood Supply Chains that integrates strategic-level decisions, including facility location, allocation, and capacity, with tactical-level decisions defining collection, production, inventory, and distribution policies. The model's practical applicability and computational performance are demonstrated through a case study of a Brazilian blood supply system. The results show its ability to support strategic planning decisions and confirm its potential for replication and adaptation across different regions and healthcare systems.

3 - Optimising single nurse schedules for home-based chemotherapy and infusion services
Vishmi Fernando, Melih Ozlen, Sona Taheri

We study a single nurse routing and scheduling problem for home-based chemotherapy and infusion services, where patients need multiple cyclic visits. We show that a one-time rescheduling of existing patients enables the system to accommodate more new patients compared to the problem which maintains the existing patients' scheduled days. A pattern-based Mixed Integer Linear Program and a novel two-phase matheuristic, combined with commercial solvers, minimise travel by spatial-temporal grouping, optimise scheduling and computation time, achieving high-quality solutions in a short timeframe.

4 - Genetics by Genetic Algorithm
John Blake

Immune factors drive 20% of platelet transfusion refractoriness (PTR), mitigated by HLA-A/B-matched platelets. Using simulations of 10,000 patients, we tested donor-pool size and ethnic mix. More typed donors improved matches, but disparities persisted: AFA patients needed far larger pools. Single-group recruitment helped targets but hurt others. Optimized, diversity-focused strategies improved equity, showing universal expansion alone cannot close gaps.

■ HC-13

Thursday, 10:30-12:00 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Explainability & LLMs

Stream: Software for Operations Research
Invited session
Chair: *Christine Tawfik*

1 - Explainability in optimization — ensuring results are transparent, interpretable, and defensible
Christine Tawfik

This talk presents practical strategies for embedding explainability into optimization workflows — from clarifying model assumptions and constraint logic to effectively communicating objective trade offs, sensitivities, and scenario impacts in ways stakeholders can readily understand. Additionally, we highlight several lesser known Gurobi features that can help practitioners and decision makers build trust in optimization outcomes, enhance adoption, and ensure that resulting decisions remain accountable and aligned with both business KPIs and application specific objectives.

2 - Sensitivity analysis for linear changes of the constraint matrix of a (mixed-integer) linear program
Quentin Louveaux, Guillaume Derval, Damien Ernst, Bardhyl Miftari

We investigate the computation of optimal values of linear (mixed-integer) optimization problems in which the constraint matrix is subject to linear perturbations controlled by a scalar parameter. This is a largely unresolved question with the additional burden that the resulting value function may be largely irregular. We propose several bounding techniques that provide formal guarantees on the behaviour of the objective value across the entire parameter range. Experimental results show that the proposed bounding techniques deliver strong guarantees and good precision.

3 - Hexaly Assistant: LLM-driven modeling for Hexaly
Fred Gardi

Large language models (LLMs) enable the generation of optimization models from natural language. Prior work focuses on linear integer programs (NL4OPT benchmark), but Hexaly uses a non-linear set-based formalism well-suited to compactly model combinatorial problems such as vehicle routing, scheduling, and packing. We assess the capabilities of foundational LLMs in this context and show how results can be improved via prompt engineering and automatic syntax validation and correction in a closed-loop process integrated in Hexaly Studio.

■ HC-15

Thursday, 10:30-12:00 - Room: HG - Hörsaal 34 (Building: HG)

Learning in Games I

Stream: Algorithmic Game Theory
Invited session
Chair: *Julius Durmann*

1 - Equilibrium Computation in Finite-Horizon Dynamic Oligopoly with Endogenous Exit: Predatory Pricing and Exclusionary Incentives
Fabian Raoul Pieroth, Martin Bichler

Dynamic oligopoly models are often analyzed using infinite-horizon stochastic games and Markov Perfect Equilibrium for tractability. Yet finite horizons matter when incentives depend on remaining time to recoup losses or induce rival exit, making continuation values non-stationary and terminal conditions important. We study a finite-horizon oligopoly with continuous pricing and endogenous exit. Using multi-agent reinforcement learning with ex-post deviation bounds, we compute approximate equilibria and identify regimes where equilibrium pricing induces competitor exit.

2 - Deep Reinforcement Learning Finds Bayes-Nash Equilibrium in Competitive Newsvendor Problems
Kassian Köck, Martin Bichler, Fabian Raoul Pieroth

We investigate learning dynamics in competitive newsvendor games. We analyze structural properties under complete and incomplete information, deriving closed-form equilibria for a benchmark with perfect substitution. We show strict monotonicity in both complete-information and Bayesian models, ensuring equilibrium uniqueness and guaranteed convergence for VI-based algorithms. Numerical experiments using deep RL agents with PPO empirically demonstrate convergence to (Bayes)-Nash equilibria. These results establish a foundation for applying deep RL in competitive inventory management.

3 - Convergence of Stochastic First-Order Algorithms in Bertrand Competition Under Incomplete Information
Jan-Sebastian Hoehener, Martin Bichler

We analyze the stochastic learning dynamics of Regularized Robbins-Monro (RRM) algorithms in Bayesian Bertrand competition with symmetric private costs. Although this setting violates the Minty variational inequality, we prove Euclidean RRM converges almost surely to the unique Bayes-Nash equilibrium within a finite-dimensional strategy space approximation, by constructing a global Lyapunov function for symmetric piecewise-linear strategies. These rigorous convergence guarantees provide a principled counterpoint to algorithmic collusion.

4 - Online Optimization Algorithms in Repeated Price Competition
Julius Durmann, Matthias Oberlechner, Martin Bichler

We study how online learning algorithms converge in repeated pricing games. This has implications for sellers optimizing revenue, buyers influenced by pricing strategies, and policymakers concerned about algorithmic collusion.

We show that mean-based algorithms, a type of online learning algorithm, converge to the set of correlated rationalizable actions. In pricing, this often means the algorithms price at or near the Nash equilibrium. We support this result with numerical experiments showing that most multi-armed bandit (MAB) algorithms also achieve competitive prices.

■ HC-19

Thursday, 10:30-12:00 - Room: HG - Hörsaal 05 (Building: HG)

New Trends in Stochastic Optimization Applied to Energy Systems

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Adrián Esteban Perez*

1 - Inferring Behind-the-Meter Demand Components from Net Load via Inverse Optimization
Adrián Esteban Perez

This work addresses electricity demand forecasting under growing consumer flexibility from assets like solar-plus-storage and electric vehicles. Since system operators observe only net demand at grid connection points, key behind-the-meter behaviors remain hidden. The paper proposes a data-driven inverse optimization framework that infers latent consumption and flexibility patterns using net demand and price signals. By estimating parameters of an underlying optimization model, it improves both point and probabilistic forecasts, outperforming standard time-series and machine-learning methods.

2 - The Impacts of Spatial Representations of Dunkelflaute Events on European Electricity System Planning
Giovanni Martini

Prolonged periods of low wind and solar output (Dunkelflaute) challenge highly renewable power systems. We develop a stochastic capacity-expansion framework that represents such events at multiple spatial scales (European, weather zones, and national levels). System designs are evaluated through dispatch simulations across historical weather years. Results show that typical-year planning underestimates risks, while explicitly modeling extreme events improves reliability. Wind deployment remains robust, though the optimal mix of firm capacity depends strongly on transmission availability.

3 - Contextual Robust State Estimation with Limited Measurement Data
Jose Gomez de la Varga, Juan Miguel Morales, Salvador Pineda Morente

Distribution system state estimation faces a double information shortage: real-time measurements are too sparse to guarantee observability, while historical data quickly becomes outdated. To address them, we develop a Contextual Robust State Estimator that formulates state estimation as a weighted least squares problem over K-nearest neighbor pseudo-measurement scenarios, and hedges against their inherent statistical uncertainty by optimizing over an adversarial reweighting of the neighbors, subject to contextual proximity and monotonicity constraints.

4 - An Iterative Approach to Maximize Self-Consumption in Medium Voltage Energy Communities
Baptiste Ferrato, Frédéric Messine, Sandra Ulrich Ngueveu

We address self-consumption maximization in medium voltage energy communities combining companies and PV generation. Using an incentive-based demand response framework, we propose an iterative negotiation process. This method dynamically adjusts flexibility bounds to align consumption with production, minimizing grid imports via linear programming. Simulations demonstrate that this strategy significantly reduces imports and approaches the theoretical optimum, ensuring efficient energy management while respecting consumer privacy.

■ HC-20

Thursday, 10:30-12:00 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Vehicle routing problems: novel applications

Stream: Vehicle Routing and related problems
Invited session
Chair: *Yanlu Zhao*
Chair: *Ivana Ljubic*

1 - Fairness in routing through the lenses of bilevel optimisation
Ivana Ljubic

We provide a generic MIP approach to model diverse fairness objectives and solve them within a common optimization framework. For facility location problems, we show how the discrete ordered objective can be efficiently handled using Benders decomposition, significantly improving the performance of state-of-the-art MIP approaches. For routing problems, we leverage connections to bilevel optimization to incorporate fairness directly into route planning.

2 - The traveling salesman problem with release dates and drone resupply
Claudia Archetti, Maurizio Boccia, Adriano Masone, Claudio Sterle

we tackle the Traveling Salesman Problem with Release Dates and Drone Resupply (TSP-RD-DR), which consists of determining the truck route and the drone resupply schedule to serve all customers in accordance with their release dates while minimizing the delivery completion time. We propose a novel formulation for the TSP-RD-DR and a matheuristic approach that exploits this formulation. The proposed methods are tested on benchmark instances and compared with the state of the art for the TSP-RD-DR. The results demonstrate that our approaches beat the ones proposed in the literature.

3 - The context-aware Traveling Salesman Problem
M. Grazia Speranza, Davide Angioni

In the Traveling Salesman Problem (TSP) a Hamiltonian cycle, that is a closed path that visits every vertex of a weighted graph exactly once, has to be found at minimum total cost. Several variants of the TSP have been studied in the literature. In this talk a new variant, called context-aware TSP, is presented where the cost of an edge (in a non-oriented graph) or an arc (in an oriented graph) depends on features, such as weather and time of the day. The problem is solved with a machine learning approach. The results are compared with classical exact and heuristic algorithms.

4 - Vaccination Allocation and Routing with Adaptive Intervention Timing
Dung Tran, Fang Liu, Yanlu Zhao

Epidemic response requires jointly deciding which areas to vaccinate, in what sequence, how to distribute a limited supply, and when to begin vaccination. We propose a Vaccination Allocation and Routing Problem in which each location evolves under a SIR model, with allocation, routing, and intervention delay decisions. The resulting formulation is a mixed-integer program coupled with a nonlinear ODE system, for which we develop an exact Logic-Based Benders Decomposition algorithm. Sensitivity analyses reveal how supply constraints, vaccine efficacy and travel times shape the optimal strategy.

■ HC-21

Thursday, 10:30-12:00 - Room: JUR - U 22 (Building: JUR)

Explainable Optimization and AI

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Ilker Birbil*

1 - Counterfactual Explanations for Linear Optimization
Ilker Birbil, Jannis Kurtz, Dick den Hertog

We study counterfactual explanations (CEs) in linear optimization and define three types: strong, weak, and relative. While strong and weak CEs are intractable to compute, we show that relative CEs can be efficiently derived by exploiting hidden convex structures. Our method computes them in time comparable to solving the original problem. Experiments on the NETLIB library confirm our findings.

2 - Counterfactual Explanations for Integer Optimization Problems
Felix Engelhardt, Jannis Kurtz, Ilker Birbil, Ted Ralphs

Counterfactual explanations (CEs) are of changes to the input parameters of a model that would lead to a desired change in outcomes. So far, little research has been done on CEs for integer optimization. We show that constructing a CE is S2P-complete even for binary integer programs with a single mutable constraint. We then propose algorithms for several (tractable) cases: mutable objective parameters, a single mutable constraint, mutable right-hand-side, and problems where all input parameters are mutable. We evaluate our approach on knapsack and resource constrained shortest path problems.

3 - Generating Input Distributions for Explaining Portfolio Optimization Pipelines
Nursen Aydin, Batuhan Atas, Mehmet Kıral, Ilker Birbil

We present a predict-optimize-explain framework using gradient-based sample generation to interpret portfolio models by identifying macroeconomic conditions tied to specific outcomes. Unlike standard feature-importance methods, it directly probes decision pipelines with meaningful what-if questions. We explore three cases involving return targets, diversification, and model comparisons. This flexible approach reveals behavioral differences across models, enhancing transparency and robustness in portfolio strategies.

4 - Smart Campus Digital Twin for Traffic and Mobility
Jayendran Venkateswaran, Sayantan Maiti

This work presents the development of a Smart Campus Digital Twin architecture for university campus to analyze intra-campus mobility and traffic dynamics. The framework integrates GIS and 3D spatial data with hybrid agent-based discrete-event simulation model in AnyLogic. The model replicates real-world vehicular movement and temporal demand variations across the campus road network based on sensor data. DT provides an interactive dashboard and end-user interface for stakeholders to monitor traffic conditions, gain insights, and perform what-if scenario analysis.

■ HC-22

Thursday, 10:30-12:00 - Room: KOL - Seminar-Raum 5 (Building: KOL)

OR Dynamics, Games and Optimization in Health

Stream: OR Dynamics and Games in Finance
Invited session
Chair: *Alberto Pinto*
Chair: *José Martins*

1 - Threshold Optimization for Clinical Risk Assessment
Kimia Ghobadi

Clinical risk scores are typically point-based and thresholded into ordinal categories, yet standard learning struggles when misclassification costs are asymmetric and distance-dependent. This work presents a MIP framework that jointly optimizes integer scoring weights and category thresholds, augmented by a smooth convex relaxation that warm-starts the MIP. In a case study on inpatient fall risk, our results indicate that the joint optimization increased high-risk recall from 29% to 48% and AUPRC from 0.51 to 0.67 while retaining the existing three-tier thresholds.

2 - A dynamic programming model for outpatient clinics overbooking considering queueing time
Wei-Ting Chen, Kuancheng Huang, Liang-Yi Wu, Jou-Wei Lin, Yi-Chung Chen

Outpatient clinic overbooking has long been a prominent research topic, with the aim of mitigating resource waste caused by patient cancellations and no-shows. This study integrates a dynamic programming model to optimize appointment utilization, accounting for stochastic consultation durations and patients' queue times. The numerical experiments show that the proposed model performs robustly across multiple scenarios. The analytical solution derived from dynamic programming achieves an appointment-slot utilization rate of 124%, whereas simulation results yield 118%.

3 - Evolutionary Dynamics of Vaccination-Infection Risk: Hopf-Bifurcation and Cycles of Vaccination
José Martins, Alberto Pinto

When vaccination is not mandatory, individuals decide whether to be vaccinated by weighing the perceived risks of the infection against the risks of the vaccine itself. We analyze evolutionary vaccination dynamics within a homogeneous population to determine the optimal strategy based on relative morbidity risks. The study reveals that, rather than reaching a stable equilibrium, certain epidemiological parameters trigger a Hopf bifurcation. This mathematical shift results in limit cycles, where vaccination coverage oscillates in a repetitive loop instead of settling at a fixed percentage.

■ HC-23

Thursday, 10:30-12:00 - Room: HG - Hörsaal 02 (Building: HG)

Exact and Heuristic Methods for MDP and Reinforcement Learning

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Francesca Maggioni*

1 - ESSAM: A Novel Competitive Evolution Strategies Approach to Reinforcement Learning for Memory Efficient LLMs Fine-Tuning
Haishan Ye

Reinforcement learning (RL) has become a key training step for improving mathematical reasoning in large language models (LLMs), but it often has high GPU memory usage, which makes it hard to use in settings with limited resources. To reduce these issues, we propose Evolution Strategies with Sharpness-Aware Maximization (ESSAM), a full parameter fine-tuning framework that tightly combines the zero-order search in parameter space from Evolution Strategies (ES) with the Sharpness-Aware Maximization (SAM) to improve generalization. We conduct fine-tuning experiments on the mainstream mathematica

2 - Adaptive Decomposition with Q-Learning for Risk-Aware Energy System Planning
Patrizia Beraldi, Nazmi Sener

Design problems combining long-term investments with operational uncertainty present significant computational challenges. In this talk we focus on multigeneration system design, presenting a risk-aware stochastic programming formulation. We propose a scenario-based decomposition where a Q-learning agent dynamically calibrates penalty parameters to accelerate convergence. Experiments show significant computational speedups and demonstrate that risk-conscious designs improve energy autonomy and profitability.

3 - Towards the Integration of Strategic and Operational Decision Making
Luke Fairley, Rob Shone, Peter Jacko, Jefferson Huang

Deterministic optimisation considers problems with a single strategic decision, often using mixed-integer programs. In contrast, stochastic dynamic optimisation considers sequential operational decisions under uncertainty, modelled as Markov decision processes. Emerging frameworks integrate strategic and operational decisions into MDP Design frameworks, and the literature on this is limited to three studies with their own approaches. We cover these prior studies, introduce our own frameworks and solutions, and highlight the potential for further research and applications across many fields.

■ HC-24

Thursday, 10:30-12:00 - Room: HG - Hörsaal 03 (Building: HG)

Applications of Knowledge and Technology 2

Stream: Knowledge, Technology, and Innovation Decisions
Invited session
Chair: *A. D. Amar*
Chair: *Medha Nag Kommaghatta Girish*

1 - Analyzing Carbon Removal Technology Hype Cycles Through Large Language Models
Medha Nag Kommaghatta Girish, Reinhard Madlener

Existing analysis of technological hype cycles rely on manual literature reviews and Natural Language Processing (NLP). This study presents a Large Language Model (LLM) driven approach to extract sentiment in English language news coverage of carbon removal technologies (CRTs) over the period 2009-2024. The sentiments are mapped over time to identify media-driven hype dynamics. The key finding of the study is that media sentiment tracking can complement other innovation indicators in mapping a hype cycle, revealing that the CRT domain as a whole is heading towards a productivity plateau.

2 - The impact of digital platform capability and organizational resilience on firms' ambidextrous green innovation
Juanru Wang

Drawing on information processing theory and dynamic capabilities theory, this study explores the impact of digital platform capability on firms' ambidextrous green innovation, and analyzes the mediating role of organizational resilience and the moderating role of top managements' environmental awareness. The results indicated that digital platform capability and organizational resilience have inverted U-shaped impact on exploitative and exploratory green innovations, organizational resilience plays a full mediating role, and top managements' environmental awareness plays moderating role.

■ HC-25

Thursday, 10:30-12:00 - Room: HG - Hörsaal 16 (Building: HG)

Sustainable Supply Chain Analytics, and Decarbonization in Oil and Gas Systems

Stream: OR for Sustainability
Invited session
Chair: *Z. Pelin Bayindir*
Chair: *Ozgen Karaer*

1 - When Buyers Build Supplier Capabilities: Value Appropriation In The Case of Walmart's Project Gigaton
Carolin Betz

Project Gigaton, launched by Walmart in 2017, provides suppliers with tools and training to reduce supply chain emissions. Such buyer-led capability development challenges the traditional view that powerful buyers extract value from suppliers because it enables suppliers to transfer capabilities beyond the focal relationship. I argue suppliers capture part of the value-surplus due to their intermediary position in the value chain, and that capture is stronger when suppliers possess credible outside options through similar buyers. First empirical tests support these hypoetheses.

2 - Structure alone appears to be sufficient to indicate part similarity: Phylogenetic BoM Comparison for Product Emission Reporting
Renske Prins, Jan van Dalen, Rob Zuidwijk

Companies face increasing pressure to report product emissions in scalable ways. This study applies phylogenetic comparison of Bill-of-Materials (BoM) graphs to identify similar parts that can serve as alternatives or additional emission data sources. We evaluate 17 graph comparison methods based on BoM properties and test the six best on a generated BoM dataset, ensuring sufficient size and varying complexity in the data. Results show structural information alone can indicate alternatives, with the Nye distance performing best in speed and similarity quality.

3 - Decarbonization in Oil and Gas System: The Carbon Capture, Utilization and Storage (CCUS) Scheme under Capacity Constraints
Xiaoyan Xu

Carbon capture, utilization, and storage (CCUS) is a critical decarbonization technology for the oil and gas (O&G) industry. However, CCUS investment presents challenges, primarily due to the mismatch between carbon capture capacity and demand. This paper introduces a two-period model for an O&G system, where we analyze how CCUS capacity affects optimal operational decisions and investment strategies in the system. Our results highlight the optimal CCUS strategies under varying product cost conditions that balances environmental and economic objectives.

■ HC-26

Thursday, 10:30-12:00 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis VII

Stream: Data Envelopment Analysis
Invited session
Chair: *Paulo Nocera Alves Junior*
Chair: *Anjali Naik*

1 - Assessing Workforce Relations Stability under Modern Slavery Risk: An Inverted SBM-VRS Approach
Isotilia Costa Melo, Morteza Alaeddini, Paulo Nocera Alves Junior

This study assesses performance related to workforce relations stability under modern slavery risk pressure in 1,990 European Union firms through a two-stage framework combining multivariate analysis and inverted Data Envelopment Analysis under variable returns to scale. Firms closer to the inverted frontier are identified as the most critical profiles, characterized by higher institutional and innovation risk and lower workforce stability. The approach provides a practical benchmarking tool to support due diligence, supplier monitoring, and risk mitigation in supply chains.

2 - Inverse Range Directional Measure DEA Models for Non-Homogeneous Decision-Making Units
Anjali Naik, Aparna Mehra

This study develops an inverse Data Envelopment Analysis framework for evaluating non-homogeneous decision-making units with negative input and output data. The proposed Range Directional Measure approach estimates the input adjustments required to achieve specified output targets while maintaining a fixed efficiency level. The model accommodates units that share common inputs but produce different output sets. An application to commercial vehicle manufacturers illustrates how the approach supports resource planning and production expansion while preserving existing efficiency performance.

3 - A Multi-Technology Hybrid Returns-to-Scale Approach to Assessing Power Plant Environmental Performance
Majid Azadi

Efficiency measurement plays a strategic role in enhancing organizational performance and strengthening competitive advantage. However, evaluating efficiency in environments characterized by multicomponent production technologies remains a significant challenge for existing approaches in the literature. This paper addresses this gap by proposing a novel nonparametric framework for efficiency assessment that overcomes several theoretical limitations in multi-output contexts.

4 - Window-Based Chance-Constrained DEA for Assessing Total Cost Efficiency of Inventory Control Systems with Safety Stock
Paulo Nocera Alves Junior, Isotilia Costa Melo

This study proposes a window-based chance-constrained DEA model to assess total cost efficiency in multi-period inventory control systems under uncertainty. The model includes costs related to inventory, safety stock, demand, and production or ordering decisions across periods. Uncertainty is handled through deterministic equivalents of chance constraints. Window analysis captures variation in stochastic moments and efficiency scores. An application to 15 public companies shows that uncertainty can affect efficiency assessment and frontier classification.

■ HC-27

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 13 (Building: JUR)

AI and Emerging Technologies for Disaster Logistics

Stream: Humanitarian Logistics
Invited session
Chair: *Andréa Cynthia Santos*

1 - Generation of extreme scenarios for the wildfire domain
Pedro Nuno de Souza Moura, Andréa Cynthia Santos

Climate change is a major problem, leading to extreme events and natural disasters, with severe human, environmental, and economic consequences. Given their rarity and limited data, modeling these events is challenging. Recent advances in Generative Artificial Intelligence, especially Generative Adversarial Networks (GANs), have made it possible to model extreme scenarios across various domains. This work explores the use of GANs to generate extreme scenarios for the wildfire domain, still underexplored in the literature. Results from computational experiments are presented and discussed.

2 - Robust firebreak placement under wildfire spread uncertainty
Yanis Srairi, Andréa Cynthia Santos, Lucas Assuncao

Wildfires pose a growing threat in forested regions, making the optimal placement of firebreaks a key preventive measure. We propose an approach to set firebreak placements to attenuate fire propagation. The terrain is represented as a digraph, where arcs are potential fire propagation between areas, with associated weights representing rates of spread, driven by uncertain environmental factors. We model these situations through maximum flow formulations under different robust optimization criteria, analyzing their performance, to get the min-cut for identifying firebreaks.

3 - A Dynamic Hypercube Model Approach for Helitack Crew Location in Wildfire Management Considering Fire Behavior
Florentina Hager, Valérie Bélanger, Jonathan Boucher

Wildfires pose an increasing threat, creating an urgent need for effective suppression strategies. The placement of helitack crews in high-risk areas is one such strategy, yet its effectiveness depends critically on crew location. We therefore introduce a framework for optimizing helitack crew locations while incorporating fire behavior dynamics and dynamic crew availability. The approach is evaluated in a case study in Québec, Canada, and benchmarked against the currently used decision logic.

4 - Online Allocation with Diffusion: Managing Humanitarian Logistics Under Victim Migration
Hao Wang, Yu Fan

This paper studies an online emergency resource allocation problem in humanitarian logistics, incorporating uncertain supply and dynamic demand from victim migration. Methodology/Results: We propose an online allocation with diffusion (OAD) model. As migration creates high-dimensional and state-dependent constraints challenging standard online linear programming (OLP), we develop a reduction framework and a dynamic learning algorithm, achieving near-optimal competitive ratios and sublinear regret. We also provide numerical results demonstrating the algorithm's effectiveness in practice.

■ HC-28

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 17 (Building: JUR)

Vessel operations

Stream: Maritime Logistics
Invited session
Chair: *Michell Queiroz*

1 - Multi-Period Pricing for RoRo Short Sea Shipping in Competition with Road Transport: A Stochastic Approach
Michell Queiroz, Seyed Parsa Parvasi, Dario Pacino

We study a multi-period pricing for RoRo Short Sea Shipping competing with road transport using a Stackelberg game under uncertainty. Operators commit to long-term decisions facing uncertain demand and costs. We apply Sample Average Approximation across scenarios with distinct customer profiles and cost trajectories. Shippers respond via logit models where low-margin industries show high price sensitivity while high-margin industries prioritise reliability. Experiments evaluate stochastic versus deterministic pricing and assess how customer heterogeneity affects modal shift to sea transport.

2 - Integrating Worker Autonomy in Ro-Ro Stevedoring: A Behavioral Simulation Study
Teresa Marquardt, Catherine Cleophas

Efficient unloading and loading of roll-on roll-off vessels can reduce emissions within the terminal and at sea. Existing research focuses on algorithms that reduce the process's makespan. In our work, we incorporate human tug drivers who can choose their next job from a set of available jobs. This approach introduces more decision autonomy and a better fit, increasing job satisfaction. We cluster workers into personas by their choice characteristics. Based on the results, we conduct a simulation study to assess potential effects on productivity and well-being.

3 - AI2STOW: End-to-End Deep Reinforcement Learning to Construct Master Stowage Plans under Demand Uncertainty
Jaike van Twiller, Yossiri Adulyasak, Erick Delage, Djordje Grbic, Rune Jensen

Container stowage planning is inherently uncertain, yet it is often modeled deterministically in literature. We propose a deep reinforcement learning model for master stowage planning under demand uncertainty, which integrates instance, solution, and uncertainty information. Constraints are enforced through differentiable projection layers, enabling feasible learning with tight computational budgets. Computational experiments show superior performance over constrained RL and stochastic programming baselines, along with robustness to distribution shifts and scaling to longer voyages.

4 - Benchmarking the Empty Container Repositioning Problem in Global Shipping Networks
Celia Jiménez-Piqueras, Dario Pacino

The empty container repositioning problem seeks to redistribute empty containers across a shipping network to meet future demand while minimizing operational costs. However, the instances commonly used in the scientific literature are notably smaller than those encountered by large shipping companies. To support the development of efficient and practical solution methods, we provide a benchmark dataset comprising instances at multiple scales: small and medium-sized instances for model development and testing, and large-scale instances that reflect the complexity of global shipping networks.

■ HC-29

Thursday, 10:30-12:00 - Room: HG - Hörsaal 30 (Building: HG)

Metaheuristic algorithms

Stream: Combinatorial Optimization
Invited session
Chair: *Yannis Marinakis*
Chair: *Magdalene Marinaki*

1 - Reinforcement Learning for Scheduling in Reconfigurable Parallel Machines with Maintenance and Worker Assignment
Demiray Demir, Milad Elyasi, Simon Thevenin

Scheduling decisions in reconfigurable manufacturing systems are complex due to uncertain ma- chine conditions, unknown processing times, and the coordination of human and machine resources.Machine degradation and worker heterogeneity further complicate scheduling, limiting traditional deterministic methods. This study models the problem as a Markov Decision Process and proposes a reinforcement learning framework within a simulation environment to learn adaptive scheduling policies for Hybrid Flexible Job Shop machine environment. A MILP model is also developed to benchmark small instances.

2 - Using Simulated Annealing for Solving Reentrant Permutation Flow Shop Problems
Itamar Segal, Tal Grinshpoun, Elad Shufan, Hagai Ilani

Reentrant flow shop problems arise when jobs revisit machines multiple times during processing. When a common job sequence is imposed across machines, the problem becomes a reentrant permutation flow shop (RPFS). We previously defined four RPFS permutation types based on job passing and level passing constraints. Classical heuristics such as NEH and Palmer are less effective for some permutation types. We propose a simulated annealing approach that improves solution quality across all RPFS permutation types and yields near-optimal makespan and total completion time solutions for small sets.

3 - Hyper-heuristics for the capacitated p-median problem
Ida Gjergji, Lucas Kletzander, Nysret Musliu

In this work, we focus on the capacitated p-median problem (CPMP) that has a wide range of application areas. We provide an in-depth study of hyper-heuristics for the CPMP, which are high-level problem independent solution methods. Additionally, we propose new low-level heuristics to be employed in hyper-heuristics. The hyper-heuristics are tested on benchmark instances for the CPMP and experimental analysis demonstrates their good performance. Moreover, the usage of low-level heuristics by different hyper-heuristics as well as their influence on distinct instances is investigated.

4 - Addressing the Single and Multi-objective Energy-Aware Flowshop Scheduling Problem Through Diverse Variations of the PSO Algorithm
Yannis Marinakis, Maria Tsiftsoglou, Magdalene Marinaki

This study examines three single-objective variants of the Flowshop Scheduling Problem, optimizing makespan, total flow time, and total energy consumption. A hierarchical approach evaluates combinations of these criteria, while a multi-objective formulation jointly optimizes makespan and total flow time. We have employed a bio-inspired methodology, specifically a Hybrid Particle Swarm Optimization Algorithm, along with several adaptations for addressing these challenges. For evaluating the algorithm, benchmark instances are used and comparisons are made with existing methods.

■ HC-30

Thursday, 10:30-12:00 - Room: HG - Seminar-Raum 06 (Building: HG)

Machine Learning meets Optimization

Stream: Machine Learning and Optimization
Invited session
Chair: *Yasmin Rios Solis*

1 - A survey of optimization modeling meets LLMs
Yuan Wang

Optimization modeling is widely used for decision-making in many sectors but typically requires significant expertise in operations research. The emergence of large language models (LLMs) creates new opportunities to automate mathematical modeling. This survey reviews recent advances across the full technical stack, including data synthesis and fine-tuning, inference frameworks, benchmark datasets, and evaluation methods. We analyze existing benchmarks and identify high error rates, then clean the datasets and construct a fair leaderboard.

2 - Decision-Focused Learning via Pessimistic Decision Diagrams
Henri Dehaybe

Decision-Focused Learning (DFL) trains ML models to minimize decision regret, requiring a pessimistic bilevel formulation to handle ties robustly. We propose a Decision Diagram (DD) approach for combinatorial DFL where leader decisions influence follower objective coefficients. By reformulating the follower via DDs, our method bypasses the numerical instability of Big-M constraints and the complexity of column generation common in current pessimistic solvers. This yields a more stable, direct training framework. Initial experiments demonstrate improved efficiency and regret minimization.

3 - Generative Adversarial Networks for Synthetic Instance Generation in the Capacitated Family Traveling Salesman Problem
Felipe Arguelles Hernández, Yasmin Rios Solis

As e-commerce grows, mega-warehouses have become essential for fast order fulfillment, where reducing picking time is critical and may exceed half of operational costs. The Capacitated Family Traveling Salesman Problem models picker routes to collect items from different product families under capacity constraints. Yet existing benchmark instances do not reflect realistic inventory scales or demand levels. Using Generative Adversarial Network with enhanced features, we generate synthetic instances that capture warehouse structure while enabling data sharing without exposing private information

■ HC-31

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 12 (Building: JUR)

Digital platforms for freight transport

Stream: Smart Logistics
Invited session
Chair: *Stefano Fazi*

1 - Netwerk Effect on B2B Digital Matching Platforms
Rob Zuidwijk

On B2B digital matching platforms, as compared to some other digital platforms, the network effect is more likely to be informed by the extent to which users of the platform are willing to engage with each other. This paper elaborates on a quantitative assessment of the network effect moderated by the relationships among users. We will also elaborate on some drivers of user behaviour on logistics matching platforms, that were unveiled by a careful analysis of a real transactional dataset.

2 - The Multi-Period Multi-Resource Stochastic Generalized Assignment Problem: model and exact approach
Duarte Medeiros, Stefano Fazi, Jafar Rezaei

Generalized Assignment Problems (GAPs) assign jobs to agents in optimization contexts. Classical GAPs assume all jobs are available, but in real-world applications, some may fail to materialize, causing underutilized resources and potential loss of revenue. We extend a Stochastic Generalized Assignment Problem to a multi-period setting with integer resource requests, propose a Nested Logic-Based Benders Decomposition algorithm, and present computational experiments demonstrating its performance.

3 - Incentive-based Coordinated Approach for Decentralized Multimodal Freight Platforms
Xueying Ou, Bilge Atasoy, Wouter van Heeswijk, Neil Yorke-Smith

Digital freight platforms coordinate multimodal transport by subcontracting shipments to independent operators, yet decentralized decision making often undermines efficient relay planning. This study proposes an incentive-based coordination approach that uses compensation payments to align operators' operational choices with platform-level objectives. We formulate the problem as a bilevel optimization model and develop a logic-based Benders decomposition algorithm. The approach enables otherwise infeasible multimodal connections and improves on-time delivery, and system profitability.

■ HC-32

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 14 (Building: JUR)

Cutting and Packing III

Stream: Cutting and Packing
Invited session
Chair: *Tetyana Romanova*

1 - Latest developments in the PackingSolver library
Florian Fontan

PackingSolver is an open-source solver for geometrical packing problems. It addresses one-, two-, and three-dimensional variants and supports the classical objectives "knapsack", "open dimension", "bin packing", and "variable-sized bin packing". The solver achieves state-of-the-art performance on several of these variants. In this presentation, we provide an overview of the library architecture and the implemented algorithms, and discuss how the different components interact. We also present several industrial applications and discuss how the library can support research.

2 - A row and column generation approach for a discretized version of the drainage area maximization problem
Javier Marenco

The drainage area maximization problem asks to maximize the area of a polygon covered with axis-parallel rectangles of prespecified sizes, while avoiding polygonal obstacles. This problem arises in the operation of unconventional hydrocarbon fields. A previous work presented an integer programming approach based on discretizing the field which, although effective in practice, suffers from performance issues if the discretization step is small. We propose a row and column generation approach for this problem, allowing to tackle instances in a fraction of the solving time previously required.

3 - Optimized Packing Lp- bodies
Tetyana Romanova, Julia Bennell, Igor Litvinchev, Andreas Fischer, Petro Stetsyuk, Sergiy Shekhovtsov

We propose a composite Lp-norm modelling approach that enables accurate representation of geometric object configurations (Lp-bodies), providing a flexible alternative to polygonal or mesh-based approximations. The approach is well suited for industrial cutting and packing problems involving curved or organic shapes. A model-based heuristic is developed that efficiently handles non-overlap and containment constraints. Computational experiments on diverse benchmarks show that norm-based modelling balances geometric accuracy and computational tractability.

■ HC-33

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 15 (Building: JUR)

Planning in the Station Area

Stream: Passenger Railway Transportation
Invited session
Chair: *Han Hoogeveen*

1 - The Schouw must go on: Planning and optimization of the Video Schouw Trein on large real-world instances with temporal unavailabilities
Thomas Heerdink

Scheduling the Dutch railway inspection train requires covering all tracks on a network with dense traffic. The problem is formulated as a Chinese Postman variant with predetermined train paths and time dependent track blockages. We propose a two level approach combining spatial decomposition and constraint programming: local CP models generate feasible routes for subareas, while a global CP selects and combines these routes into a consistent plan. To our knowledge, this is the first study at real world scale. Experiments on real railway data show the method reliably produces feasible plans.

2 - Integration of Rolling Stock Rescheduling and Shunting Operations
Jia Hui Zhu, Twan Dollevoet, Dennis Huisman

We consider the integration of railway infrastructure availability, shunting movements, and shunting driver rescheduling within real-time rolling stock rescheduling. In practice, these interdependent problems are solved iteratively, which can be time-consuming and can lead to unnecessary delays, cancelled trips or conservative decisions. We propose an integrated approach that simultaneously considers these aspects and has the ability to slightly retime passenger trains and shunting movements, thereby providing additional flexibility to create high-quality schedules.

3 - Planning trains in the station area: Distribute and Route
Han Hoogeveen, Rens de Heer

At night trains are sent to shunting yards. We developed an algorithm HIP to make a shunting plan for a single yard, but at bigger stations there are multiple yards. Hence, we must find feasible routes from station to the yards and vice-versa, where the distribution is such that the resulting shunting problems are feasible. Checking feasibility using HIP is much too slow. We circumvent this by determining through Logistic Regression a linear function to estimate the probability that a shunting problem is feasible; we use this function as objective in a CP formulation to find good routes.

■ HC-34

Thursday, 10:30-12:00 - Room: JUR - Hörsaal 16 (Building: JUR)

Robotic and hybrid mobile fulfillment systems 2

Stream: Warehousing
Invited session
Chair: *An Caris*
Chair: *Elena Tappia*
Chair: *Martina Calzavara*

1 - Learning to Select Task Allocation Heuristics in Robotic Mobile Fulfillment Systems
Lin Xie

Robotic Mobile Fulfillment Systems require efficient multi-agent task allocation under dynamic conditions. We propose an adaptive heuristic orchestration framework where a high-level controller selects among task allocation heuristics based on abstracted system state information. Inspired by hyper-heuristic and algorithm selection approaches, heuristic selection is learned via reinforcement learning. A Large Language Model provides interpretable reasoning for heuristic choice. Experiments in RAWSim-O demonstrate competitive performance across diverse instances.

2 - Omni-scale Learning-based Sequential Decision Framework for Order Fulfillment of Tote-handling Robotic Systems
Jiaxin Liu, Peng Yang, Xinyue Xie, Yuping Li, René de Koster, Yeming Gong

Driven by the rapid growth of e-commerce, totes are replacing pallets as the primary handling units in automated order fulfillment systems. Despite different system architectures, tote-handling robotic systems share a common sequential decision structure involving orders, totes, and robots. This paper proposes an omni-scale learning-based sequential decision framework integrating neural combinatorial optimization and multi-agent reinforcement learning. Experiments show near-optimal performance on small systems and 8-12% fewer tote movements than heuristic methods in large-scale scenarios.

3 - Human-Centric Digital Twin for Warehouse Optimization: Concept and Industrial Motivation
Yueyi Li, Quang Vinh Dang, Giovanni Lugaresi, Bhoomica Nataraja, Jelle Adan, Ivo Adan

While most Digital Twins (DTs) focus on highly automated, sensor-rich environments, this paper proposes a Human-Centric Process-Aware DT for labor-intensive, low-IoT warehouses. The framework centers on an automated simulation engine that converts SOP/BPMN workflows into Petri-net models for rapid modeling of heterogeneous warehouse processes. Combined with semantically rich scan events, it synchronizes physical workflows, detects congestion, and triggers automated what-if analysis. A cobot-assisted high-density picking case shows its potential to improve hybrid mobile fulfillment efficiency.

■ HC-35

Thursday, 10:30-12:00 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Contributing to a Circular Economy

Stream: Operations Research and Sustainability
Invited session
Chair: *Miles Weaver*
Chair: *Maximilian Eisenmenger*

1 - Routing and collection planning for second-hand goods in circular economy systems
Beatriz Brito Oliveira, Miguel Costa, Soraia Taipa

The transition toward circular economy systems requires efficient collection of reusable goods. This work addresses a real planning problem faced by a metropolitan waste management operator that collects second-hand items from ecocenters and scheduled household pick-ups. Fixed routes are avoided because predictable patterns increase the risk of theft and vandalism. We study a multi-period collection planning problem with uncertain arrivals and highly variable item volumes, addressed through a robust optimization approach.

2 - Toward Adaptive Circular Factories: Reconfiguration of Modular Production Cells
Alexander Ernst, Pietro Schumacher, Jan Baumgärtner

Remanufacturing involves highly variable products and process requirements, demanding production systems that can be reconfigured quickly and efficiently. We investigate the transformer cell, a modular manufacturing concept in which autonomous mobile robots relocate mobile process modules to create task-specific layouts. We model this reconfiguration task as a novel location-routing problem that jointly optimizes module placements and robot pickup-delivery routes, minimizing setup time, thereby supporting flexible, resource-efficient, and demand-responsive circular production.

3 - Design of EPR Regulations Based on Carbon Tax: From the Perspective of Manufacturing-Remanufacturing Competition
Jian Cao

According to the three different forms of extended producer responsibility (EPR) system in practice, aiming at the manufacturing-remanufacturing competition system composed of an original equipment manufacturer (OEM) and an independent remanufacturer (IR), three kinds of mixed regulations with EPR characteristics combined with the carbon tax are designed by constructing a dynamic game model, and the effect of introducing the connotation of the EPR system on improving the efficiency of carbon tax policy is discussed.

4 - Systems Thinking for Sustainability in a Circular Economy
Miles Weaver, Kamila Pokorna

Systems thinking for sustainability is vital to addressing the complexity of the climate and nature crises and to enable meaningful action. To do so, we suggest that integrating a systems approach and exploring an environmental/social systemic perspective can help to bridge the gap between values and action when practising circular design. We view circularity as a systems concept and use the Systemic Sustainability Framework as an upfront boundary critique to support community learning, appreciate diverse purposes and values, and balance a business model's viability with its legitimacy.

■ HC-36

Thursday, 10:30-12:00 - Room: JUR - Seminar-Raum 42 (Building: JUR)

Resilient Supply Chains I

Stream: Building Resilient Systems
Invited session
Chair: *Reza Alikhani*

1 - Stress Testing Supply Chains: Integrating Anomaly Detection and Scenario Analysis for Early Risk Identification
Leif Meier, Andreas Kneissler

This study presents a stress test methodology for supply chain analysis, inspired by financial industry practices. By integrating economic conditions, local market structures, and company-specific data, combined with anomaly detection and scenario analyses, it enables rapid identification of risks and emerging issues. This scalable approach supports decision-makers in uncovering new insights and enhancing supply chain resilience.

2 - Reverse stress testing for supply chains
Busra Gultekin, Frans de Ruiter, Meike Reusken, Sander De Leeuw

This study introduces reverse stress testing to identify minimal deviations from normal operations driving supply chain failure. We present a six-step framework: selecting risk variables, defining baselines, formalizing policy, formalizing KPIs, setting thresholds, and identifying the critical scenario. We propose an optimization model to find the smallest risk deviations stressing the chain beyond KPI thresholds. The model is computationally tractable and guarantees policy robustness. Numerical examples demonstrate that the framework effectively uncovers where disruptions become most harmful.

3 - A Knowledge Graph Approach to Disruption Propagation Analysis in Semiconductor Supply Chains
Hyeonji Hwang, Kangbae Lee

Global semiconductor supply chains are vulnerable to disruptions such as geopolitical conflicts, trade restrictions, and natural disasters. This study proposes a knowledge graph approach to analyze disruption propagation in semiconductor supply chains. Risk events are extracted from news and open data using large language models and linked to a supply chain knowledge graph. The approach identifies affected elements, traces disruption propagation paths, and explores alternative suppliers to support risk management and resilience.

4 - Evaluating the Joint Performance of Supply Chain Resilience Strategies
Reza Alikhani

Research on supply chain resilience often evaluates strategies in isolation, overlooking how they interact when implemented together. We develop an extended super-efficiency DEA model to assess the joint performance of concurrent resilience strategies, considering implementation cost, residual disruption cost, service level impact, and recovery time. A decision framework ranks strategy portfolios across disruption scenarios. A real case illustrates managerial implications under budget and network constraints.

■ HC-37

Thursday, 10:30-12:00 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Recent development of optimization methods

Stream: Nonlinear Optimization
Invited session
Chair: *Jiaojiao Zhang*

1 - SQP without QP
Titus Pinta

Sequential Quadratic Programming is the standard Newton-type approach to solving a constraind optimization problem. In order to avoid the cost of solving a quadratic program, we propose an alternative formulation, based on replacing quadratic programs with a simple iterative linear equation solver. The proposed algorithm is based on a splitting scheme, which first produces an affine approximation of the constraints, and then uses an unconstrained Newton method to optimize the objective over this lower dimensional space.

2 - Non-Euclidean High-Order Smooth Convex Optimization
Juan Pablo Contreras

We develop algorithms for convex optimization with higher-order smoothness using access to derivative information. The methods work under general norms and allow inexact optimization in non-Euclidean settings via an accelerated proximal approach. We also prove a lower bound showing near-optimality in high dimensions, even with randomness and parallel computation, resolving an open question in parallel convex optimization.

3 - Analyzing changes in optimal variables in linear programming with uncertain parameters
Baptiste Istace, Guillaume Derval, Bardhyl Miftari, Quentin Louveaux

Linear problems often include many parameters that may be uncertain. Sensitivity analysis studies how these parameters impact optimal values. Instead of analyzing the objective function, we shift the focus to the optimal values of the variables. We consider three types of linear modifications: on the cost vector, the RHS, and on the constraint matrix. We show theorems discussing properties of these modifications, including conditions for continuity of variable values, as well as local convexity and concavity properties.

■ HC-38

Thursday, 10:30-12:00 - Room: JUR - Seminar-Raum 44 (Building: JUR)

OR in Practice: Models and Impact

Stream: The Practice of OR: Stories of Solutions, Setbacks, and Successes
Invited session
Chair: *Yannick Becker*
Chair: *John Ranyard*

1 - Development and implementation of a MILP-based vacation planning tool
Teemu Kinnunen, Alvar Wilhelmsson, Antti Punkka

To optimize vacation allocations, we develop a MILP model that accounts for varying workforce demand, skill availability requirements, employees' wishes or rotational vacation patterns and other factors affecting vacation scheduling. We demonstrate the model with an in-house built scheduling tool, including required input data, parameters, user interface and visualization of vacation plans. The tool has been used in 750 outlets at S Group, a major retail and service sector operator in Finland, providing more balanced summer resourcing and savings in planning time.

2 - Mathematical Optimization with Generative AI for Cross-Project Team Allocation and Scheduling
Agata Banaszewska, Felix Götzinger, Alexander Hipolito

Cross-project team allocation and scheduling is a complex allocation problem faced by services-based industries with complicated rules for staffing project teams (e.g., management/technology consulting, utilities and aircraft maintenance, among others). Such firms must assemble multi-role teams, align skills to demand, manage overlapping phases, and respect availability, leave, preferences, and development priorities. This session presents Bain & Company's automated staffing engine built on multi-objective mixed-integer optimization.

3 - Accelerating Practical Portfolio Rebalancing via Integer Programming and Machine Learning
Qian Hu, Ke Li, Xingyu Lu, Caihua Chen, Zhixing Luo, Zhibo Zhu

We present a practical application of operations research in portfolio rebalancing at a leading Chinese fintech company. Existing formulations fail to support near-real-time computation, which is essential for its application serving over one billion users. To overcome this challenge, we improve the formulation via integer programming techniques and narrow the potential solution space using machine learning based predictions. Our predict-then-optimize algorithm successfully produces optimal or near-optimal solutions within 500 milliseconds, enabling practical deployment at scale.

4 - When Portfolio Optimization Meets Reality: Building a Decision Support System for Strategic Asset Allocation
Yannick Becker, Pascal Halffmann, Jörg Wenzel, Florian Schirra

We present the development of a decision support system for strategic asset allocation at a large German insurance company. The system combines multiobjective portfolio optimization with practical requirements such as regulatory metrics and organizational constraints. Developed in close collaboration with stakeholders, the tool evolved alongside the decision process. We highlight the recent integration of sensitivity analysis, which helped address parameter uncertainty and strengthen confidence in the results. This illustrates how long-term collaborations between OR and practice can grow.

■ HC-43

Thursday, 10:30-12:00 - Room: JUR - Seminar-Raum 63 (Building: JUR)

Matheuristics

Stream: Metaheuristics
Invited session
Chair: *Vittorio Maniezzo*
Chair: *Günther Raidl*

1 - Matheuristic algorithm for the Robust Capacitated p-Median Problem
Sergio Salazar, J. Manuel Colmenar, Abraham Duarte

The Robust Capacitated p-Median Problem (RCPMP) extends the classical CPMP by considering demand uncertainty. It aims to select facility locations and assign customer demand while minimizing distances and respecting facility capacities. Our matheuristic proposal combines a mathematical model, a GRASP constructive phase, and an Iterated Greedy improvement step. The method exploits geometric properties of instances to reduce computational time and improve solution quality. Computational experiments show competitive performance compared with state-of-the-art approaches.

2 - Timing of Queries in Interactive Job Scheduling
Johannes Varga, Günther Raidl, Tobias Rodemann

Traditionally, it is assumed that for solving scheduling problems the information about the availability of users is readily available. However, this often implies a burdensome process of collecting the information upfront or to operate on incomplete information. In interactive scheduling, the scheduler actively involves users by asking them a small number of targeted questions to create an effective schedule. We present a heuristic interactive scheduling framework that utilizes integer linear programming as optimization core, and in particular investigate the timing when to query which users.

3 - A Novel MIP Heuristics: Iterative Decomposed Partial Convexification
Seoyeo Choi, Chungmok Lee

This talk introduces a new MIP heuristic algorithm called iterative decomposed partial convexification. We decompose the given MIP into two problems: the first is a pure IP, and the second is an LP. The first pure IP problem is reformulated by expressing the projected polyhedron as a convex combination of feasible solutions from the second LP. We develop an iterative procedure by leveraging modern computing resources, such as multi-core CPUs and GPUs. The computational study shows that our algorithm outperforms the existing algorithms.

4 - A Beam Search for Linearly Covering all Subsets of a Finite Set
Enrico Iurlano, Günther Raidl, Alexander Weissenfels

For the problem of calculating a minimum-length string accommodating each subset of a finite alphabet as contiguous substring we propose and investigate a Beam Search. The latter adopts initial symmetry breaking assumptions and carries out a tailored equivalency pruning to thin out the search tree. It works for any subsystem of the power set as well, therefore, on the system of size-k subsets of the finite alphabet, we can compare it to a previously developed metaheuristic approach relying on the Generalized Traveling Salesperson Problem and demonstrate its efficiency.

■ HC-45

Thursday, 10:30-12:00 - Room: HG - Seminar-Raum 01 (Building: HG)

Stochastic Optimization for Transportation

Stream: Data-driven Stochastic (Inverse) Optimization
Invited session
Chair: *Kadir Erdem Sahin*
Chair: *Lin Xie*

1 - Optimization Models for Disaster Response Operations
Stefan Voss, Liping Ge, Lin Xie

Disaster relief operations have become a major issue in OR including emergency transportation. Reviews of stochastic VRPs show that a wealth of related literature is available, but that some areas are almost completely neglected. Especially issues regarding an uncertain number of vehicles and related right-hand-side uncertainty (as well as chance constraints) need to be explored further. This research area comes along with a proposal of some readily available research avenues as well as related data-driven approaches even based on the classical Solomon VRP instances.

2 - Choice-Based Periodic Vehicle Routing and Pricing for Urban Last-Mile Deliveries
Chenghua Yang, Jie Gao, Bilge Atasoy

This paper proposes a choice-based periodic vehicle routing and pricing problem (CB-PVRP) that integrates stochastic customer choices into the joint optimization of service offering, pricing, and routing for periodic deliveries. We formulate CB-PVRP as a two-stage stochastic programming. The first stage determines service offerings and prices to maximize the expected profit. The second stage embeds a bilevel optimization structure to capture customer responses and decides on the daily routing. We develop a logic-based Benders decomposition algorithm with provable solution quality guarantees.

3 - Data Collection in Stochastic Optimzation
Xin Li, Xuan Vinh Doan, Juergen Branke

Data-driven optimization requires estimating uncertain parameters, often through costly data collection. We study when to stop sampling via an optimal stopping framework under parameter uncertainty. Using Bayesian updates, we evaluate the expected marginal benefit of additional data against sampling cost. We develop benefit-driven stopping policies and test them on a newsvendor problem. Results show these policies reduce data collection while achieving near-optimal performance, highlighting the value of adaptive stopping.

4 - Dynamic Stochastic Task and Resource Assignment Problem with Underqualified Assignments, Failure and Retry
Kadir Erdem Sahin, Gudrun Kiesmuller

We study a stochastic, dynamic skilled workforce assignment problem with service failures and retries. In a multi-skill, multi-level setting, assignments are allowed without skill match, and all assignment outcomes follow a probabilistic success model. We propose a hybrid post-decision state value function approximation that combines heuristic solution exploration with a Heterogeneous Graph Transformer for evaluation. A comprehensive numerical study demonstrates effectiveness of our approach, and we identify conditions under which underqualified assignments arise and their operational impact.

■ HC-46

Thursday, 10:30-12:00 - Room: HG - Seminar-Raum 02 (Building: HG)

New challenges in scheduling 2

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Jan-Erik Justkowiak*

1 - Well-Being-Aware Dual-Resource Flexible Job Shop Scheduling
Peyman Yasari, Dieter Claeys, El-Houssaine Aghezzaf

This research addresses the Well-Being-Aware Dual-Resource Flexible Job Shop Scheduling Problem, balancing efficiency with strict well-being constraints. We present a mathematical model that minimizes the makespan while actively managing operator cognitive loads and physical ergonomics. To tackle large-scale industrial scenarios, we developed a specialized algorithm that efficiently navigates complex search spaces.

2 - A Relax-Optimize-and-Fix Matheuristic for Resource-Constrained Project Scheduling
Loris Trotter

While continuous-time models for the RCPSP excel in scenarios with scarce resources, solving large-scale instances to optimality often requires prohibitive computation times. We present a matheuristic based on a relax-optimize-and-fix strategy that decomposes the problem by iteratively reimposing binary constraints for subsets of activities. By combining the strengths of mathematical programming with a structured heuristic framework, our approach yields efficient schedules for large-scale instances while requiring significantly less computational effort than exact methods.

3 - Coordinated Vehicle-Drone Delivery with Distributed Order Fulfillment and Mid-Route Item Transfers
Busra Yagmur Celiker, Sharan Srinivas

This study introduces a coordinated vehicle-drone delivery problem for distributed order fulfillment. Drones transport missing items from supporting stores to designated hand-off locations to complete customer orders during ground delivery. The problem jointly determines vehicle routing, drone dispatching, item-level fulfillment, and synchronization decisions to minimize total system cost. A mixed-integer programming (MIP) model and a simulated annealing (SA) algorithm are developed. Results show that MIP solves instances with up to 15 customers to optimality, while SA scales effectively.

4 - Solving the parallel machine scheduling problem with sequence-dependent setup times
Silvio Hamacher, *Raphael Bittencourt*, *Fabricio Oliveira*

This study focuses on the parallel machine scheduling problem with sequence-dependent setup times. It aims to compare the main mathematical programming models developed in the literature (continuous, arc time index, time index, bucket) using a large, robust set of instances, considering not only the number of jobs and machines, but also variations in job and setup durations. The results showed that no single model solves all instances more efficiently. Therefore, this paper can serve as a guideline for selecting the most suitable model based on the characteristics of the problem being studied.

■ HC-47

Thursday, 10:30-12:00 - Room: HG - Seminar-Raum 03 (Building: HG)

Routing 1

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Simon Voorberg*

1 - The Robust Two-Echelon Vehicle Routing Problem with Multiple Deliverymen and endogenous Costumer Clustering
Enzo Geraldini, *Pedro Munari*, *Reinaldo Morabito*

We address a two-level vehicle routing problem under uncertainty, considering time windows, endogenous clustering and multiple deliverymen. The uncertainty arises from demand increases, travel delays, and service-time variability, which are typical in last-mile operations. Relying on robust optimization, we propose and compare four exact solution strategies, including a compact formulation, column-and-constraint generation, and cutting-plane methods. Experiments with benchmark instances evaluate computational performance, Risk and Price of Robustness.

2 - Sustainable Daily Drone Inspection via Public Transit: Routing and Charging Optimization
Na Li, *Feifeng Zheng*

Daily daylight drone inspections in cities are constrained by battery range and costly charging infrastructure. Required checkpoints vary by day due to new work orders, incident reports, weather, and shifting priorities. We study a multimodal system where a drone may fly or optionally ride scheduled buses, transferring at designated pickup and drop-off points, to reach the next checkpoint or a charging station. A two-stage stochastic model chooses charging sites and then adapts daily routes to the realized checkpoints, minimizing cost, time, and energy while ensuring full coverage.

3 - Optimizing Fuel Delivery Routes Under Operational Constraints: A Comparative Evaluation of Exact and Heuristic Models
Simon Voorberg

Optimizing delivery routes is a critical challenge in petrochemical distribution, where transportation costs account for a significant share of operational expenses and customer expectations impose strict delivery requirements. Identifying a suitable optimization approach for complex vehicle routing problems remains an important question, one that must balance solution quality, scalability, and computational effort. The model incorporates realistic operational constraints, including heterogeneous vehicle capacities, stock limitations, customer priorities, and the option for split deliveries.

■ HC-49

Thursday, 10:30-12:00 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management in Stochastic Service Systems

Stream: Data-Driven Demand Management
Invited session
Chair: *Demet Batur*

1 - From Daily Schedules to Smart Replenishment: Optimal Policies for Real-World Industrial Vending Operations
Karina Sindermann, *Esma Gel*, *Nesim Erkip*

Industrial vending machines (IVMs) automate supply dispensing at customer sites as part of vendor-managed inventory programs. We study how distributors should manage replenishments for IVMs serving hundreds of items with stochastic demand. We analyze policies that use real-time inventory levels across all items to determine when to replenish. We prove monotonicity of the optimal policy and develop a scalable approximate online control capable of handling hundreds of items. Using transaction data, we find substantial cost reductions over current daily replenishment practice.

2 - Managing Savings Plans in Cloud Resource Provisioning using Reinforcement Learning
Melis Boran, *Secil Savasaneril*, *Demet Batur*

Cloud users face a trade-off between flexible but expensive on-demand resources and lower-cost long-term commitments such as savings plans, especially under uncertain computational demand. To address this trade-off, we study a dynamic decision problem modeled as a Markov decision process for savings plan commitment and machine allocation under stochastic demand. Due to large state and action spaces, we adopt a deep reinforcement learning approach based on Proximal Policy Optimization (PPO) which performs competitively and provides a promising approach for dynamic cloud provisioning.

3 - Prioritization in Heterogeneous Populations: Efficiency and Equity under Imperfect Information
Dilay Ozkan, *Nilay Argon*, *Serhan Ziya*

We study a single-server priority queue motivated by emergency departments, where decisions are made under imperfect information and may affect certain demographics differently. Customers belong to one of two subpopulations and to one of two unobserved types that differ in service needs and waiting costs. The service provider infers the type from biased signals that vary by subpopulation. We analyze priority policies based on these signals, their impact on overall delay cost and subpopulation outcomes, and investigate these policies in terms of system efficiency and fairness.

4 - Joint Spectrum Leasing and Admission Control for 5G Spectrum Sharing Networks Using Reinforcement Learni
Demet Batur, Romina Raafat, Jennifer Ryan, Mehmet C Vuran

We study real-time spectrum management for a licensed primary user that serves its own customers' demand while opportunistically leasing idle channels to unlicensed secondary users. The primary user must decide whether to admit service requests and when to lease unused spectrum, balancing revenue against slowdown costs and service quality. We model this problem as a continuous-time Markov decision process and develop a reinforcement learning approach to handle the large state space and enable scalable online decision making to manage demand in the network.

■ HC-50

Thursday, 10:30-12:00 - Room: KOL - Seminar-Raum 7 (Building: KOL)

Data-Driven Methods in Energy Systems

Stream: Optimal Decision Making in Energy
Invited session
Chair: *Eda KoÇak*

1 - Multi-agent reinforcement learning for wind farm optimization
Ana Busic

Maximizing wind farm energy production requires considering wake effects, where turbines disrupt downstream airflow. Multi-agent reinforcement learning has shown strong empirical results. However, this approach lacks convergence guarantees due to non-stationarity. We model the problem as a transition-independent decentralized partially observable Markov decision process with a directed acyclic graph agent dependence structure, and show that a multi-scale approach can ensure convergence. Joint work with C. Bizon Monroc, J. Zhu, D. Dubuc.

2 - Optimizing Pairs Trading Strategies through AI-Driven Market State Prediction
Jingchuan Ma, Yu-wang Chen, Fanlin Meng

Electricity markets exhibit high volatility and frequent regime shifts, intensified by recent energy crises, which challenge traditional pairs trading strategies. This study proposes an AI-driven framework combining Hidden Markov Models and XGBoost to predict stressed market states from electricity price dynamics. The predicted stress probabilities guide a regime-aware trading strategy that adjusts trading exposure. Using German electricity spot and futures data, the framework improves stress prediction accuracy and enhances risk-adjusted trading performance.

3 - Techno-Economic and Life Cycle Assessment of Renewable Hydrogen Production : A Belgian Case Study
Justin Barras, Bardhyl Miftari, Guillaume Derval, Damien Ernst, Angélique Léonard

Hydrogen is expected to play a key role in decarbonizing hard-to-abate sectors. This study optimizes hydrogen production in 2030, considering different electrolyzer technologies, demand profiles, and grid/off-grid configurations in Belgium. Economic (LCOH) and environmental (LCA) indicators are evaluated under RFNBO hourly constraints, a European regulatory framework for renewable hydrogen production. Results show that grid coupling significantly reduces costs, with a minimum LCOH of 3.02 EUR /kg H, while electricity supply dominates most environmental impacts.

4 - A Hybrid Decision Support Framework for Sustainable Energy Transition in Türkiye: Integrating NARDL and Machine Learning
Eda KoÇak

This study examines the effects of renewable energy consumption and carbon emissions on economic growth in Türkiye within a sustainability framework. A hybrid NARDL-machine learning model captures asymmetric dynamics. Results indicate that increases in renewable energy consumption support growth, while emissions sustain a carbon-intensive path. The framework offers a data-driven decision support tool for effective policy design.

■ HC-51

Thursday, 10:30-12:00 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Hub Network Design

Stream: Hub Location and Network Design
Invited session
Chair: *Sibel A. Alumur*

1 - Hub Network Design for Truck Platooning under Uncertain Cost Savings
Elif Zeynep Serper, Sibel A. Alumur

Truck platooning can improve freight transportation efficiency, but its economic benefits are uncertain because they depend on operating conditions. This study addresses tactical hub network design for truck platooning under uncertain cost savings. We develop deterministic and two-stage stochastic optimization models for hub location and routing and solve the stochastic model using Sample Average Approximation. Results based on real-world data show that platooning reduces costs and improves delivery performance, while accounting for uncertainty supports more robust freight planning decisions.

2 - Demand-driven hub and service network design under uncertainty
Sibel A. Alumur, Hao Li, Gita Taherkhani, Mike Hewitt

We study a planning problem for freight carriers that aims to profitably match supply and demand under uncertain shipment volumes. On the supply side, decisions on hub locations and vehicle dispatches are made over a planning horizon. On the demand side, the carrier can expand service by selectively accepting additional long-term and transactional customers. The problem is formulated as a two-stage stochastic program and solved using an enhanced Benders Decomposition. Computational results demonstrate clear improvements over benchmark methods and the benefits of solving the integrated model.

3 - A Multistage Stochastic Framework for Hub and Service Network Design
Hao Li, Gita Taherkhani, Sibel A. Alumur, Mike Hewitt

This study proposes a multistage stochastic framework for hub and service network design in freight transportation under demand uncertainty. It integrates strategic hub location, tactical seasonal vehicle planning, and operational routing/outsourcing. Modeled on a time-expanded network with commodities and seasonal distributions, the three-stage program minimizes hub, transportation, and outsourcing costs, enforcing capacity and path constraints. This work contains novel model integration, solution methods for large instances, and managerial insights from an LTL carrier.

4 - On the complexity of Price-collecting Hub Location Problems
Nele Pommerening, Christoph Buchheim

We study the complexity of price-collecting variants of the well-known hub-location problem, in part with vehicle based costs. Due to the complexity of classical hub location problems, most of the variants are also NP-hard. So we also investigate variants when the hubs and the allocations are given in advance. It is interesting to see, that here the complexity differs depending on how the costs for the transport arise. The problem with linear costs lies in P, while some variants with vehicle based costs are NP-hard in the strong sense.

■ HC-52

Thursday, 10:30-12:00 - Room: KOL - PC Raum 1 (Building: KOL)

Electricity Demand Supply Prices and Markets

Stream: Energy Markets & Systems
Invited session
Chair: *Ronnie Sircar*

1 - Iberian Peninsula Blackout: A Trade-Off Between Operational Risk and Consumer Cost
Christoph Graf, Daniel Davi Arderius

Under the European short-term wholesale market design, system operators must reactively adjust (redispatch) market schedules originating from an assumed unconstrained (copper plate) network. This sequential market-clearing approach can complicate real-time operations and may increase operational risk. We perform an event study analysis using hourly market and system data from 2019-2025. We find that after the 2025 Iberian Peninsula Blackout the Spanish system operator responded by prioritizing reliability, procuring greater volumes of gas-fired generation and curtailing more wind and solar.

2 - Dantzig-Wolfe Decomposition for Co-Optimisation and Pricing of Energy and Ancillary Services
Andreas Makrides, Pierre Pinson, Fei Teng

This presentation applies Dantzig-Wolfe decomposition to the co-optimisation of energy and ancillary services, enabling efficient pricing in large-scale systems. The framework captures the ability of generation resources to provide multiple services. Prices are derived from the master problem to reflect marginal values. Results are compared with other approaches commonly used in the literature (e.g., dispatchable, restricted, and traditional convex-hull pricing), analysing impacts on uplift and efficiency. The framework highlights trade-offs between pricing accuracy and market feasibility.

3 - Prosumer investments as risk-mitigation strategy in highly distributed electricity systems - a soft-linked model coupling approach
Tom Krause, Silke Johanndeiter, Valentin Bertsch

As Europe advances towards climate neutrality, decentralised structures are increasingly reshaping electricity systems, while their implications for wholesale and retail market participants remain insufficiently understood. We examine these uncertainties as physical and transition risks for consumers and producers in France and Germany, using a soft-coupled wholesale market-consumer model to identify consumer risk-mitigation strategies through investments in prosumer technologies under different retail tariff designs and assess their feedback effects on the wholesale market.

4 - Modelling start-up decisions for thermal power plants and their impact on electricity prices as a Hamiltonian control problem
Christoph Weber, Mihail Birsan, Philipp Castro

The increasing short-term price fluctuations in electricity markets are related to the growing infeed from renewable energies. Yet they are exacerbated by the inflexibility of conventional thermal generation, notably the existence of a minimum stable operation level and start-up costs. We analyze the start-up and shut-down decisions as a control problem, enabling the derivation of novel analytical insights at both the individual plant and the aggregated market level. These insights may be used to formulate enhanced parsimonious fundamental models with improved performance in price modelling.

■ HC-53

Thursday, 10:30-12:00 - Room: KOL - Seminar-Raum 16 (Building: KOL)

Dynamic and Learning-based Approaches to Multiobjective Optimization

Stream: Multiobjective Optimization (MOO/MOP)
Invited session
Chair: *Charis Ntakolia*

1 - Interactive Multiobjective Optimization for Mobile Clinic Planning: An Enhanced E-NAUTILUS Approach with Explainability and Dynamic Constraints
Giovanni Misitano

Mobile clinic planning involves locating clinics and allocating personnel to meet service demands. These decisions involve conflicting objectives, making them well-suited for multiobjective optimization. We employ E-NAUTILUS, an interactive method where decision makers iteratively navigate toward a preferred solution without making trade-offs during the search. We extend E-NAUTILUS with what-if explainability and dynamic constraint handling, allowing decision makers to update location preferences throughout the process. Validated on a real-world case study using DESDEO.

2 - A Novel Hybrid Adaptive Bee-Swarm Optimization (HABSO) With Discrete Event Simulation for Multi Objective Optimization of Assembly Line Balancing Problem
Tamrat Yifter Meles, Chao-Lung Yang, Atinkut Atinafu Yilma, Melkamu Mengistnew Teshome

Assembly Line Balancing Problems (ALBP) remain a major challenge in labor-intensive manufacturing, where poor task allocation causes bottlenecks and inefficient resource use. This study proposes a simulation-optimization framework for multi-objective ALBP in garment manufacturing, integrating Discrete Event Simulation, OptQuest, and a novel Hybrid Adaptive Bee-Swarm Optimization (HABSO) algorithm. The results show reductions in workstations, cycle time, and waiting time, confirming the framework as a practical decision-support tool improving productivity and efficiency.

3 - Real-Time Dynamic Constrained Multiobjective Optimization via a Fully Tensorized GPU-Accelerated Evolutionary Algorithm
Rui Wang, WeiXiong Huang, Guopeng Song

Real-world dynamic constrained multi-objective optimization must handle changing objectives and constraints with high computational

efficiency, especially under fast environmental changes. Existing studies usually schedule environmental changes by iteration count, ignoring real time and the different iteration costs of algorithms. We propose TensorizedDCEA, a fully tensorized GPU-Accelerated based algorithm and response framework. Tests on dynamic benchmarks and a vehicle routing problem show large gains in speed and solution quality over existing methods.

4 - Fuzzy Deep Q-Learning for Energy-Efficient Path Planning in Unmanned Surface Vehicles
Charis Ntakolia, Giannis Mpartsiokas, Georgios Avdikos, Dimitrios Lyridis

Unmanned Surface Vehicles require autonomous navigation that balances safety, efficiency, and obstacle avoidance. This study proposes a Fuzzy Deep Q-Learning (F-DQN) framework integrating fuzzy reasoning into reinforcement learning to support multi-objective maritime path planning. The model optimizes path deviation, trajectory smoothness, and fuel consumption. Simulation results show that F-DQN improves trajectory optimality and convergence stability, reducing path length and fuel use compared to baseline DQN while maintaining comparable navigation success rates.

■ HC-57

Thursday, 10:30-12:00 - Room: HG - Seminar-Raum 07 (Building: HG)

AI and Experiments in Behavioral OR

Stream: Behavioural Operational Research
Invited session
Chair: *Wieland Müller*
Chair: *Ayşegül Engin*
Chair: *Lea Trampitsch-Vink*

1 - The Value of AI Cheap Talk: A Field Experiment in Online B2B Procurement
Jingying Ding

Price bargaining is a core challenge in B2B procurement. Prior research shows that the initial price quote acts as an anchor that strongly influences the final transaction price. Using a field experiment in online B2B procurement, we study how retailers employ cheap talk with different confidence levels to obtain lower initial quotes and examine the role of AI in this process. Cheap talk effectively reduces initial quotes, particularly when inquiries are initiated by AI rather than human managers. AI achieves the strongest effect with high-confidence messages.

2 - How Feedback Aggregation Improves Algorithm Use
Chantale Köster, Cedric Lehmann, Andreas Fügener, Ulrich Thonemann

Algorithmic advice is increasingly used in managerial decisions, where people must decide how much to rely on it. Feedback on such decisions can be misleading under uncertainty when superior advice appears inferior and vice versa. Aggregating feedback can help people to form more accurate beliefs about advice quality and improves human-algorithm collaboration. We examine how feedback granularity affects reliance on algorithmic advice using two lab experiments. Participants used superior algorithms 14% more and inferior algorithms 19% less, increasing decision accuracy by at least 12%.

3 - Personalizing gamification at work: Freedom to choose or freedom to fail
Mounir Derboghossian, Ayşegül Engin, Rudolf Vetschera

Current implementations of gamification in organizational contexts follow a one-size-fits-all principle and ignores individual differences. We address this limitation by examining user-directed adaptive gamification. Using a 3x1 between-subjects designed laboratory experiment, we compare user directed adaptive gamification to static gamification (uniform affordances for all users) and tailored gamification (affordances assigned according to theoretical user types). Results contribute to gamification theory to create effective and autonomy-supportive work environments.

■ HC-58

Thursday, 10:30-12:00 - Room: HG - Seminar-Raum 08 (Building: HG)

Data-Driven Decision Making

Stream: Healthcare OR in developing countries
Invited session
Chair: *Susana Mondschein*

1 - Data-Driven Prescriptions in Long-Term Care: Integrated Learning-Optimization for Capacity Expansion and Placement of Patients Under Uncertainty
Mostafa Mostafavi Sani, Davod Hosseini, Majid Taghavi, Michael Zhang

Long-term care (LTC) systems face a persistent mismatch between uncertain admissions and fixed bed capacity, producing costly waitlists and suboptimal placements. We propose a prescriptive planning framework that integrates multi-period capacity expansion with patient-to-facility assignment. To capture the interacting incentives of upstream and downstream providers, we develop a bilevel optimization model that jointly considers hospitals and LTCs, with each level minimizing its respective costs while coordinating admissions, expansions, and placements.

2 - Machine Learning-Enabled Overbooking for Outpatient Appointments: Lessons from Three Case Studies in Colombia
David Barrera Ferro

Missed outpatient appointments harm patients and providers, leading to delayed diagnoses, postponed treatment, higher costs and idle capacity. Overbooking policies can mitigate these effects, yet inaccurate no-show estimates may increase waiting times and clinician workload. This study examines the use of individual-level non-attendance predictions derived from machine learning to inform overbooking decisions, drawing on three case studies in Colombia. Results assess predictive performance, system efficiency and service quality, and evaluate how data bias affects equitable resource allocation.

3 - From hype to hope? Integrated predictive and prescriptive analytics in healthcare systems
Elena Valentina Gutierrez-Gutierrez, Jennifer Benavides Castillo, David Barrera Ferro

This study develops a conceptual framework to support the integration of predictive and prescriptive analytics in healthcare decision-making. Drawing on a structured review of the analytics and operational research literature, the framework organizes analytical approaches according to their level of integration and their role in healthcare decision processes. The study synthesises how analytical methods are combined in healthcare applications and discusses implications for operational and managerial decision-making in health systems while highlighting directions for future research.

4 - From Compliance Gaps to AI-Driven Policies: Rethinking Breast Cancer Screening in Chile
Susana Mondschein, Natalia Yankovic

Using 500,000+ mammograms from Chile's public health system, this work delivers two contributions. First, the first national-scale characterization of mammographic follow-up compliance, uncovering critical delays in high-risk assessments and stark regional inequities. Second, a simulation framework evaluating AI-based personalized screening policies using the Mirai deep learning model, benchmarked against current practice via an expected diagnostic delay metric. Together, these provide a rigorous diagnosis of screening failures and a data-driven tool for designing more equitable, effective pol

■ HC-59

Thursday, 10:30-12:00 - Room: KOL - Seminar-Raum 9 (Building: KOL)

Pairwise comparisons and preference relations 2

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Matteo Brunelli*
Chair: *Jiri Mazurek*
Chair: *Konrad Kulakowski*

1 - A statistical look at the geometric mean-based pairwise comparison method with the reference values
Konrad Kułakowski

Methods based on pairwise comparisons have long been widely used in expert-supported decision-making. In this presentation, we propose a method that incorporates reference values and uses the geometric mean to determine alternative priorities. The method is described within a statistical framework that allows simultaneous analysis of phenomena related to the inconsistency of the pairwise comparison matrix and the preference distance between alternatives. Additionally, we introduce indicators for evaluating the quality of the resulting weight vector.

2 - Agent-based preference disaggregation protocol for autonomous consensual group decision-making
Andrej Bregar

This research incorporates agents into collaborative multi-criteria decision processes to accelerate automation, reduce cognitive load, and enhance the utilization of preferential information. It proposes an autonomous multi-agent consensus-seeking protocol based on integrative negotiation, aggregation-disaggregation analysis, agent coalition building, dynamic constraints, and convergence measures. The approach is validated through use cases addressing cross-organizational cyberattack mitigation and a sustainable energy community that negotiates supply. An agent system implements the protocol.

3 - Efficient ranking vectors for pairwise comparison matrices
Susana Furtado, Charles Johnson

We give two descriptions of the set of efficient vectors for a pairwise comparison matrix: an inductive one and another as a union of a finite number of convex sets. As a consequence of the latter, we give precise matrix intervals for the consistent matrices obtained from the efficient vectors. Related with the often used right Perron eigenvector and geometric mean of the columns of a pairwise comparison matrix, we provide new formulaic ranking vectors that are universally efficient.

■ HC-60

Thursday, 10:30-12:00 - Room: KOL - Seminar-Raum 10 (Building: KOL)

Risk Management in Bond Markets

Stream: OR for Insurance, Banking and Financial Risk
Invited session
Chair: *Qian Gao*

1 - Probabilistic Crisis Early Warning for Sovereign Credit Risk: Evidence from a Bayesian Markov-Switching GARCH Framework
Shikai Gao

This paper develops a probabilistic early warning framework for sovereign credit risk in emerging markets. A Bayesian Markov-switching GARCH model incorporates commodity market shocks and macro-financial predictors to capture transitions from stable to stress and crisis states. Posterior probabilities of entering high-volatility regimes are used as warning signals. A rolling pseudo-real-time evaluation examines lead time and the trade-off between false alarms and missed crises, providing an interpretable tool for financial stability monitoring.

2 - Market state aware graph attention networks for pre-clustering and second-order stochastic dominance portfolio optimization
Qian Gao

This study proposes a market state-aware graph attention network for portfolio optimization using multi-layer financial networks and differentiable clustering. Market states modulate cross-layer attention, while asset embeddings and portfolio weights are jointly learned. The model maximizes a differentiable Calmar ratio under a quadratic utility and second-order stochastic dominance framework. Rolling window tests show more stable clustering and improved out-of-sample risk-adjusted performance.

3 - Barrier Option, Daily Price Limit, and Repeated Richardson Extrapolation
Jia-Hau Guo, Tsung-Han Yeh

This study proposes a modified efficient approximation scheme of the static hedge portfolio approach for exotic barrier options in markets with daily price limits. Building on the intraday model of Ban et al. (2000) and Guo and Chang (2020a), we present a new data-driven estimation model for the Richardson extrapolation parameter p with a Poisson distribution to improve the convergence and accuracy of the repeated Richardson extrapolation.

4 - Turning Investor Attention into Portfolio Views with Google Trends and the Black-Litterman Framework
Jialei Xiong

Traditional portfolio optimization largely overlooks behavioral factors such as investor attention. This thesis addresses the gap by constructing an attention change indicator from Google Trends and embedding it into the Black-Litterman framework. Using Hang Seng Index constituents from 2016 to 2025 at weekly frequency, the study validates ΔGSV as a predictor of short-term returns and translates it into BL investor views. Backtests show the strategy improves both return and risk control, offering a replicable approach for integrating attention signals into portfolio allocation.

■ HC-62

Thursday, 10:30-12:00 - Room: KOL - Seminar-Raum 19 (Building: KOL)

Applications of MCDM 1

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Gwo-Hshiung Tzeng*
Chair: *James Liou*
Chair: *Sun-Weng Huang*

1 - Integrating Demand Forecasting and MODM-Based Procurement Planning for Multi-Product Electronics Manufacturing
Yi-Xuan Liu, Huai-Wei Lo, Ching-Yun Chi

This paper presents a two-stage fuzzy MCDM approach for multi-product demand forecasting and procurement planning in electronics manufacturing. Seasonal indices, centered moving averages, and fuzzy regression estimate uncertain demand. These forecasts feed a fuzzy multi-objective procurement model balancing cost, delivery reliability, quality, supplier sustainability, and disruption risk. A real industrial case shows more resilient procurement and better service performance.

2 - Exploring Failure Analysis of Smart Robotic Arms Using Modified FMEA and MCDM models
James Liou, Bruce H.T. Guo, Chao-Che Hsu, Chun-Nen Huang, Chao Rong Chen

With the growing adoption of intelligent robotic arms in smart manufacturing, systematic fault diagnosis has become essential for ensuring operational reliability. This study proposes a hybrid FMEA-based reliability evaluation model. Interval Type-2 Fuzzy Sets are employed to capture uncertainty in expert judgments. IT2F-DEMATEL is applied to identify causal relationships among risk factors, and PROMETHEE II is utilized to rank failure modes by risk level. The findings demonstrate that integrating MCDM methods within FMEA can substantially improve the reliability of intelligent robotic arms.

3 - A Multi-Criteria Decision-Support Framework for International Partnership Selection in Higher Education: Navigating Geopolitics and Digital Transformation
Paichou Huang, Shui-lien Chen, Gwo-Hshiung Tzeng

Global partnerships pose governance challenges for HEIs due to geopolitical tensions, de-risking, and compliance. This study proposes a decision-support framework with five dimensions: geopolitical alignment, compliance, strategic fit, academic complementarity, and operational feasibility. A two-stage expert elicitation, combining content validity refinement with the Best-Worst Method, derives consistent group weights with reduced cognitive burden. Sensitivity analysis and consensus indicators confirm robustness. The results rubric supports transparent, transferable partnership decisions.

4 - Customer-Oriented Strategic Prioritization of IoT Platforms Using an Integrated MCDM Architecture
Hung-Yi Wu, Tai-Ching Chen, Hung-Shu Wu

This study constructs a customer-oriented hybrid Multicriteria Decision Making (MCDM) framework to enhance IoT platform performance. The proposed three-stage methodology integrates the Kano model for requirement classification, the Fuzzy Delphi Method (FDM) for expert consensus, and Quality Function Deployment (QFD) synthesized with Grey Relational Analysis (GRA) for strategic prioritization. Findings identify customization, data analytics, and heterogeneous connectivity as primary satisfaction drivers, while technical relevance and market feasibility emerge as critical strategic imperatives.

■ HC-65

Thursday, 10:30-12:00 - Room: HG - Hörsaal 27 (Building: HG)

Analytics in Industrial Applications

Stream: Analytics
Invited session
Chair: *Jeanine Vonkeman*

1 - Distribution Alignment for Transfer Learning in Injection Molding Sensor Data
Ahmet Eralp Avunduk, Cevdet Utku Şafak, Eyyüb Batuhan Ünal, Alara Baysal, Erinc Albey

This study presents a preprocessing pipeline that leverages kernel density estimation (KDE) to standardize pressure and temperature sensor data from injection molding machines across heterogeneous manufacturing sources. The method aligns statistical distributions using class-specific percentiles for labeled datasets and global density fitting for unlabeled data. By reducing cross-domain shifts, the pipeline prepares datasets for transfer learning, enabling machine learning models to generalize across facilities and support defect classification in data-scarce manufacturing settings.

2 - End-to-End Predictive Optimization for Production Planning
M. Harshvardhan

Production planning separates forecasting from optimization: predict demand, then decide quantities. This assumes better predictions yield better decisions. We challenge that assumption. Prediction error and decision cost correlate weakly because symmetric losses ignore asymmetric penalties. Underproducing is costlier than overproducing, yet standard models treat both errors identically. We embed a differentiable optimization layer in the prediction pipeline, training on decision regret. The model biases forecasts toward safer cost regions. Experiments on semiconductor data show major savings.

3 - Adaptive RL scheduling for soil flow logistics in a dike construction project
Jeanine Vonkeman, Kamal Mokhtar

Adaptive reinforcement learning scheduling is applied within a discrete-event simulation to plan soil flow logistics for a large dike construction project. Excavated soils of different types become progressively available as layered floodplain materials are uncovered, enabling reuse or sale depending on the timing and soil quality. The learned policy maximizes revenue and minimizes transport distances to rapidly recompute feasible schedules under changing field conditions, demonstrating the suitability of RL for time-dependent resource flow logistics.

4 - New fault diagnosis framework for railway switch machines based on machine learning with heterogeneous model fusion
Haoxiang Wang, Yuliang Shen, Qinming Liu

As critical electromechanical components in railway systems, switch machines require accurate fault diagnosis to ensure safety and efficiency. Existing methods face limited generalization, scarce fault samples, and low accuracy in multi-fault scenarios. An electro-dynamic parameter arithmetic fusion (EPAF) method is proposed to integrate multi-source signals, which are encoded via Gramian Angular Fields (GAF). An improved VQ-VAE generates synthetic samples, combined with transfer learning. A hybrid fusion strategy improves multi-fault diagnosis, achieving 95.24% accuracy across 15 states.

■ HC-66

Thursday, 10:30-12:00 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Emerging Applications of Continuous Optimization

Stream: Continuous and Global Optimization
Invited session
Chair: *Andrea Seidl*

1 - A Feasibility-Guaranteed Method for UAV Path Planning with Positioning Error Correction
Jie Chun, Xiaolu Liu, Weiyi Yang, Jun Wen

We study UAV path planning with positioning error correction, where vertical and horizontal drifts grow with distance and can only be reset at specified correction nodes. Locally feasible paths may lead to dead ends under global feasibility constraints. We propose a deep reinforcement learning-based framework that considers error accumulation and correction. It integrates feasibility judgment and dead-end avoidance to ensure globally executable paths. Experiments show our method improves planning success rate and path quality over traditional methods under positioning error limits.

2 - Superlinearity and Monotonicity in Electrical Resistance Tomography
Teresa Scarinci

The talk describes a mathematical method for solving the Calderón problem, i.e., determining the interior of a material from boundary data consisting of the Dirichlet-to-Neumann (DtN) map in electrical resistance tomography (elliptic PDE). After introducing the DtN operator, we investigate its properties, including superlinearity and monotonicity. These properties are then used to create a fast imaging method formulated as a proper constrained optimisation problem.

3 - Optimal Control of Resource Extraction under Endogenous Risk and Scarcity
Alessandra Buratto, Luca Grosset, Maddalena Muttoni

We study resource extraction when depletion affects not only future availability but also the risk of rising costs. We develop an optimal control framework in which extraction influences both remaining reserves and the probability of switching to a high-cost regime. When depletion intensifies and the resource constraint binds, a state-dependent tradeoff emerges between scarcity and risk. The model may include a state constraint on the resource stock, highlighting how the interaction between depletion and endogenous risk shapes optimal policies and extraction timing.

4 - Sustainable Production in Fragile Environments
Andrea Seidl, Gustav Feichtinger, Dieter Grass, Richard Hartl, Peter Kort, Stefan Wrzaczek

Production activities are often essential to ensure economic wealth; however, in many cases they cannot be performed without causing harm to the environment. History-dependent production strategies are a typical outcome of optimal control problems that capture this tradeoff. The present talk investigates how different model and parameter assumptions affect the long-run outcome in such a setting. In particular, we discuss the impact of environmental and financial constraints on the system behavior and the according implications for firms and policy makers.

■ HC-67

Thursday, 10:30-12:00 - Room: KOL - PC Raum 3 (Building: KOL)

Modelling practices for large-scale capacity expansion planning with policy targets

Stream: Energy Markets & Systems
Invited session
Chair: *Anthony Papavasiliou*
Chair: *Marilena Zampara*

1 - Double interior-point regularization for large-scale capacity expansion
Leonard Göke, Giovanni Sansavini

To tackle large linear problems, we introduces the double interior-point regularization for Benders Decomposition, combining the advantages of traversing the interior of the solution space while remaining close to a reference solution. We benchmark the method on a power-sector problem and an energy-system problem, varying problem size and the level of foresight during operations. Results demonstrate that DIP-set outperforms competing regularizations in all test cases. The speed-up increases with size, reaching 30-50% for the largest problems.

2 - Capacity Expansion Modelling in ENTSO-E's European Resource Adequacy Assessment
Oscar Miralles Perez

Assessing the long-term evolution of the European power system under climate and energy policy targets requires large-scale optimization models for capacity expansion planning. This presentation discusses modelling practices applied in the Economic Viability Assessment (EVA), part of ENTSO-E's Energy Resource Adequacy Assessment (ERAA). The model, looking ten years ahead, explores cost-optimal evolutions of generation and flexibility capacities across Europe, capturing investment, retirement, mothballing, and lifetime extension decisions under energy-only market assumptions.

3 - Column Generation Methods for Large-Scale Capacity Expansion Planning under Multiscale Uncertainty
Angela Flores, Byron Castro, Ignacio Ñancupil

Power systems are increasingly influenced by climate change. Rising temperatures, changing precipitation patterns, and extreme weather events introduce uncertainty across multiple temporal scales, affecting both long-term resource availability and short-term operations. In this work, power system planning is modeled as a multi-horizon stochastic programming problem capturing multiscale uncertainty. Then, column generation schemes are studied to solve the resulting large-scale optimization problem. Performance is evaluated through computational experiments on the Chilean power system.

Thursday, 13:00-14:00

■ HD-01

Thursday, 13:00-14:00 - Room: HG - Audimax

Keynote Gabriele Eichfelder

Stream: Keynotes
Keynote session
Chair: *Pamela C. Nolz*

1 - Compromising objectives-more information thanks to multiobjective optimization
Gabriele Eichfelder

Almost all decisions involve more than one objective, and this is even more relevant today: In addition to financial gains, companies are now expected to consider environmental aspects. The United Nation member states have formulated the 17 goals for sustainable development. However, in general, such objectives are competing, and one has to find a "good" tradeoff between them. Multiobjective optimization delivers important ingredients for finding such a good solution, and, at the same time, helps to understand the dependencies between the objectives.

In this talk, we give an introduction to multiobjective optimization. Next to presenting basic solution approaches, we emphasize aspects which illustrate that solving such problems poses significantly new challenges compared to focusing on just one objective function, but we also provide strategies for overcoming those.

■ HD-02

Thursday, 13:00-14:00 - Room: JUR - Hörsaal 10 (Building: JUR)

Keynote Ming Xu

Stream: Keynotes
Keynote session
Chair: *Margaretha Gansterer*

1 - AI for Sustainability Research and Education
Ming Xu

Artificial intelligence is reshaping how we understand, measure, and advance sustainability. This talk explores the development and application of TianGong AI, a large language model (LLM) application suite specifically designed to accelerate research and education in sustainability science. It encompasses a large-scale knowledge base, model fine-tuning, and agentic workflows as its key components. TianGong AI integrates domain knowledge in environment and sustainability with advanced AI architectures for reasoning, data governance, and generative intelligence. Agentic tools developed based on TianGong AI enable researchers to automate data extraction, knowledge synthesis, and cross-scale modeling. Beyond research, TianGong AI has been deployed as an educational co-pilot—supporting interactive teaching and student-driven inquiry. By combining the power of domain knowledge and AI, TianGong aims to build an open, intelligent infrastructure that bridges data, models, and human expertise—laying the groundwork for a new era of AI-empowered sustainability research and education.

Thursday, 14:15-15:45

■ HE-01

Thursday, 14:15-15:45 - Room: HG - Audimax

Tutorial Rafael Martinelli

Stream: Tutorials
Tutorial session
Chair: *Günther Raidl*

1 - Decomposition Methods for Discrete Optimization Problems
Rafael Martinelli

This tutorial presents two key decomposition methods for discrete optimization: Benders Decomposition and Dantzig-Wolfe Decomposition with Column Generation. These techniques are used to solve large and structured problems by separating them into smaller parts that can be solved more efficiently. We will explain how each method works, and how to apply them in practice. Special focus will be given to the algorithmic elements required for high performance: stabilization methods to improve dual convergence, primal and dual heuristics to speed up solution time, and ways to handle degeneracy. The goal is to provide a practical guide to implementing these methods effectively, with insights on what needs to be coded to build strong and efficient algorithms.

■ HE-02

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 10 (Building: JUR)

IFORS Prize 1

Stream: Special Sessions
Invited session
Chair: *Margaretha Gansterer*

1 - Prosecutor HeredIA - Analytics meets Artificial Intelligence to efficiently combat Organized Crime
Richard Weber, Sebastian Maldonado, Fredy Troncoso, Carla Vairetti

Organized crime poses a persistent and complex challenge to public security, particularly in developing countries, where law enforcement agencies often operate under severe technological and analytical constraints. This work presents an integrated decision-support ecosystem for crime investigation that combines advanced tools from Operations Research and Artificial Intelligence. The results achieved at the Chilean National Prosecutor's office demonstrate substantial improvements in efficiency, detection outcomes, and the timeliness of investigative decisions.

2 - NIRSE-CL: Design, Monitoring, and Impact Evaluation of Chile's Universal Immunization Strategy against RSV
Leonardo J. Basso

Chile implemented the first universal RSV immunization strategy for infants using nirsevimab. The Nirse CL project generated evidence for adoption and evaluated the policy. The program reached over 95% of 150,000 infants in 2024 and 2025. Using survival models, optimization-based matching, and augmented synthetic control methods substantial reductions in RSV-related hospitalizations, ICU admissions, outpatient visits, and medical leaves, alongside a net economic benefit of USD 20 MM per year were found. No infant died in 2024-2025. The project offers a scalable model for other countries.

3 - Optimised Planning for Food Banks with the Incorporation of Poverty Metrics
Rhyan Rampazo, Dylan Jones, Mariana Oliveira Iamamoto, Daniela Cantane

Global food insecurity affected >2B people in 2024, while nearly US$1T in edible food is wasted annually. Researchers from São Paulo State University (UNESP, BR) and the University of Portsmouth (UK), with the São Paulo Municipal Food Bank, developed an advanced methodological approach, Extended Goal Programming with Poverty Incorporation, to optimise food-allocation planning in food banks. Applied in a 12M city redistributing 1.5M kg (2024), it improved equity up to 350% and coverage of vulnerable populations by >40%. Results inform policy; implementation is underway and transferable.

■ HE-04

Thursday, 14:15-15:45 - Room: HG - BIG-Hörsaal (Building: HG)

Decision support in healthcare

Stream: OR in Healthcare (ORAHS)
Invited session
Chair: *Piyal Sarkar*

1 - Simultaneously Expiring Organ Offers: The Benefits of Variable Batch Sizes
S. Raghavan, Zhenyu Yue, Michael Fu

To reduce organ discards, without a significant increase in disappointment (when a patient agrees to accept the organ but does not receive it) or redundant work (unnecessary evaluations) we develop two variable batch sizing policies (Greedy and Dynamic Programming), where the batch size can be dynamically adjusted during the organ offer process. Relative to the current sequential policy (25% discard rate), variable batch-size policies can reduce the discard rate to approximately 18.6%—indicating the potential to increase the number of kidney transplants in the US by 1920 annually.

2 - From Preferences to Healthy Choices: A Goal Programming Model for Palatable Menu Design
Laura Delgado Antequera, Jose García-Cuenca, Francisco Martos-Barrachina, Monica Hernandez

Palatability is an essential factor in menu design, as it largely determines consumer acceptance and satisfaction. This study structures daily food intake according to typical consumption patterns in Spain, considering a large database of ingredients and traditional recipes. Users are asked to define a menu, which serves as a reference point to capture their preferences. Palatability is defined relative to the initial menu through a goal programming approach. The problem is formulated as a decision-making process pursuing to maximize palatability.

3 - Problem-Specific Genetic Operators for Multiobjective Beam Angle Optimisation
Nicolle Ojeda Ortega, Mauricio Moyano, Rubén Saborido, Guillermo Cabrera-Guerrero

Multiobjective beam angle optimisation (MO-BAO) is a discrete and highly constrained combinatorial problem in which conflicting dosimetric objectives must be optimised simultaneously. This work investigates genetic operators tailored to the structure of MO-BAO within an NSGA-II framework. The impacts of problem-specific crossover and mutation operators on feasibility preservation, population diversity, and search behaviour are evaluated and compared. Overall, the study provides computational evidence of the importance of operator design in evolutionary approaches for MO-BAO.

4 - Impact of Health Information Technology on Hospital Performance: A Longitudinal Study Using Advanced Analytics
Piyal Sarkar

The purpose of this study is to clarify the impact of Health Information Technology (HIT), including Electronic Health Records (EHRs) and Health Information Exchange (HIE), on hospital performance. It addresses the mixed and often unclear evidence in existing literature regarding the direct benefits of HIT. We used advanced statistical models and flexible machine learning algorithms to analyze 936 annual records from acute care hospitals in USA over a nine-year period. Our approach was grounded in the Technology-Organization-Environment (TOE) framework and the Resource-Based View.

■ HE-05

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 18 (Building: JUR)

Automation and System-Level Effects in Shared Mobility

Stream: Shared Mobility
Invited session
Chair: *Michal Hochman*

1 - When Does It Pay to Adopt? Equilibrium Strategies for Autonomous Vehicle Introduction under Platform Competition
Xiang Zhu

Autonomous vehicles (AVs) are expected to transform ride-hailing markets. We study the strategic introduction of AVs by competing platforms operating mixed fleets of autonomous and human-driven vehicles. Using a game-theoretic model, we analyze platforms' entry decisions and equilibrium outcomes as functions of market size and adoption costs. Results show strong first-mover incentives when AVs are absent. However, once a rival adopts AVs, the follower's optimal response depends on market conditions and investment costs.

2 - Evolving Patterns of Ride-Hailing Use and Socioeconomic Inequality
Raul Pezoa

Ride-hailing has become central to urban mobility, raising questions about equity and long-term adoption. Prior research shows use concentrates among younger, educated, and high-income groups, but most studies rely on short observation periods. Using 4.4 million rides from Santiago, Chile (2017-2023), we apply trajectory clustering, inequality indices, and convergence models to study whether adoption varies by neighborhood and whether low-adoption areas catch up. We find ride-hailing spread from wealthier to lower-income districts; disparities have nevertheless slowed equalization.

3 - Pedestrian Decision-Making in the Presence of Multiple Autonomous Vehicles
Michal Hochman, Tal Oron-Gilad, Yisrael Parmet

External human-machine interfaces (eHMIs) may improve communication between fully autonomous vehicles (FAVs) and pedestrians. We examined crossing decisions on two-lane roads with one/two FAVs showing consistent/inconsistent eHMI messages. 30 participants observed 76 fixed urban scenes and decided if it was safe to cross. Eye tracking and response times were recorded. Results showed compliance was similar, but conflicts increased hesitation, especially with two FAVs (slower for far 'Stop' and more for close 'Cross'). Therefore, eHMI designs should aid conflicts and ensure message consistency.

■ HE-06

Thursday, 14:15-15:45 - Room: HG - Hörsaal 07 (Building: HG)

Game Theory in Retail I

Stream: Retail Operations
Invited session
Chair: *Winfried Steiner*
Chair: *Xiyue Xiong*

1 - Supply-side Transshipment or Demand-side Stock-out Substitution? Retailer Operations under Overconfidence
Xuan Zhao

In the retail industry, there is a strategic choice between arranging supply-side transshipment and relying on demand-side stock-out substitution. The common belief suggests that competing retailers can benefit from transshipment with a high transfer price. To capitalize on this opportunity, retailers must arrange bi-lateral transshipment in advance. However, recent research shows that overconfidence significantly influences decision-making in these contexts. This paper delves into the economic conditions under which overconfident competing retailers should engage in transshipment.

2 - A Right to Spare Part
Junxia He, *Benny Mantin*, *Jasper Veldman*

How should manufacturers price their products and spare parts when consumers are forward-looking? We develop a game-theoretic model where demand for spare parts stems from the failure (modeled as a Binomial distribution) of purchased products. We show that the manufacturer may leverage the demand for spare parts as an instrument to price differentiate among consumers, whereby only consumers with high valuations are able to repair their failed products. This gives rise to potential social welfare-improving regulatory intervention such that constraints on pricing of repair parts are mandated.

3 - Seller Entry and Pricing Decisions under Competition in a Customer-to-Customer Second-Hand Platform
Hamidreza Abedsoltan, *Yann Bouchery*, *Vincent Hovelaque*

Our research focuses on second-hand product sales in a Customer-to-Customer marketplace. We study the interactions between buyers, sellers, and platform decisions under sellers' competition. We develop an operations research model of seller entry and pricing decisions where the probability of sale follows a logit model (depending on total price and product condition level), and we characterize participation conditions and optimal pricing. We further study the platform's impact on the second-hand channel efficiency.

■ HE-08

Thursday, 14:15-15:45 - Room: HG - Hörsaal 41 (Building: HG)

Explainable AI and Interpretable Machine Learning

Stream: Descriptive, Diagnostic and Predictive Analytics
Invited session
Chair: *Mahnaz Hosseinzadeh*
Chair: *Ahmet Eralp Avunduk*

1 - Unmasking Deceptive Recruitment in Labour Supply Chains: A Signalling Theory and Explainable AI Approach
Mahnaz Hosseinzadeh, *Sajid Siraj*, *Amin Vafadarnikjoo*, *Shuyang Li*

This study examines how deceptive online job ads enable forced labor by exploiting information asymmetries in recruitment. Grounded in signaling theory, it applies an AI-driven multimodal approach to a unique dataset of verified job ads linked to real forced labor cases collected by anti-slavery charities. By integrating textual, visual, and structural features, an explainable model identifies low-cost deceptive cues like poor visual quality, informal communication patterns, and misleading claims. The study delivers an interpretable decision-support tool for early detection in supply chains.

2 - Enhancing operational data interpretation through context capture
Naomi Hulst

We explored whether recording crew communication during offshore installation operations can enhance the interpretability of log data to support post-operation analysis. During a simulated monopile installation with four operators, we captured and transcribed audio and processed the resulting transcripts. The results show that voice-derived context can clarify and explain observations seen in operational log data.

3 - Frequency-Selective Learning for Contamination-Robust Vibration Anomaly Detection
Wonhwa Choi, *Jun-Geol Baek*

Industrial vibration anomaly detection models are typically trained using normal-only data. However, real-world datasets may contain undetected faults or mislabeled samples, leading to contamination that degrades model reliability. This study proposes a frequency-selective learning strategy that selectively controls the influence of spectral components during training rather than filtering entire samples. By suppressing contaminated frequency bins while preserving normal patterns, the approach improves robustness to contaminated training data.

4 - Cross-Machine Quality Classification in Plastic Injection Processes via Unified Feature Space Mapping
Ahmet Eralp Avunduk, *Cevdet Utku Şafak*, *Eyyüb Batuhan Ünal*, *Alara Baysal*, *Erinc Albey*

This study presents a data-driven quality classification framework for industrial plastic injection processes using transfer learning across multiple machines. Sensor signals are represented through mathematically interpretable features derived from domain knowledge and time-series analysis. Data from different machines are mapped into a unified feature space via a linear transformation based on a reference machine. This mapping enables transferring learned knowledge to new machines and mold types, improving the robustness and scalability of quality prediction models.

■ HE-09

Thursday, 14:15-15:45 - Room: HG - Hörsaal 50 (Building: HG)

Data science meets Optimization problems with complex structure

Stream: Data Science meets Optimization
Invited session
Chair: *Dimitri Papadimitriou*

1 - Effective Sparsity: A Unified Framework via Normalized Entropy and the Effective Number of Nonzeros
Hao Wang

Classical sparsity models based on the 0 norm treat all nonzero components equally, often overestimating complexity in practical inverse problems. We introduce the effective number of nonzeros (ENZ), a normalized entropy-based measure that captures energy concentration and provides a stable, continuous notion of sparsity. Under RIP conditions, we establish uniqueness and stability guarantees for ENZ-based recovery. Numerical results show improved robustness and accuracy compared with cardinality-based methods.

2 - Learning NG-Sets in Branch-and-Cut-and-Price for the Capacitated Vehicle Routing Problem with Time Windows
Juan Pablo Cantillana, Christian Tilk

Branch-and-cut-and-price solves vehicle routing variants exactly via a shortest path subproblem generating routes. Elementarity constraints make this hard in practice, so tools such as ng-path relaxations define per-node neighborhoods to control this trade-off. These sets are fixed or grown through augmentation until elementarity is reached. We investigate whether the latter can be learned and if this reduces solution time. ML methods achieve accuracies between 79-95%, and learned sets outperform traditional fixed approaches in 23-30% of cases with negligible bound degradation.

3 - Forecast-Driven Two-Stage Stochastic Programming for Multi-Ward Nurse Rostering in Mental Healthcare
Mustafa Aslan, Bahman Rostami-Tabar

Mental healthcare rostering is challenged by volatile, regime-switching patient occupancy. We introduce a Multi-Ward Nurse Rostering framework integrating an Autoregressive Markov-Switching Regression model with two-stage stochastic programming. We systematically evaluate how alternative probabilistic forecasts impact downstream operational utility. In our experiments, this approach reduces average understaffing by 58.7% and total costs by 13.6% compared to deterministic baselines, ensuring cost-efficient and robust staffing decisions.

4 - Researching Cargo Bike Operations: Towards VRP Benchmarks Grounded in Dispatcher Reality
Mina Akbarpour, Maria Astefanoaei, Nicolas Collignon, Renaud Sarrazin, Soonmyeong Yoon, Esben Sørig

Standard VRP benchmarks assume homogeneous fleets in featureless environments. Real mixed-fleet urban logistics involves context-dependent vehicle performance, heavy-tailed service times, and multi-hub operations absent from existing instances. We have access to operations data from light EV and van operators across European cities, including GPS traces and delivery logs. Building upon this data, we present new problem instances with evaluation metrics grounded in how dispatchers assess route quality, using H3 spatial indexing and OpenStreetMap features to encode location-dependent behaviour.

■ HE-10

Thursday, 14:15-15:45 - Room: HG - Hörsaal 31 (Building: HG)

Logistics

Stream: Combinatorial Optimization
Invited session
Chair: *Alan Osorio-Mora*

1 - SOAR Metaheuristic for the Clustered-Generalized Median Tour Problem
Giovanni Campuzano

This paper introduces the Clustered-Generalized Median Tour Problem (CGMTP), a novel hierarchical routing problem that explicitly separates customers into clusters and subclusters, capturing geopolitical distribution structures observed in service networks. To solve the CGMTP, we propose Strategic Oscillation with Adaptive Relinking (SOAR), combining strategic oscillation, adaptive iterated local search, and path relinking. Computational results show that SOAR outperforms the MILP formulation in runtime and solution quality for small instances and surpasses state-of-the-art metaheuristics.

2 - A Unified Decomposition Framework for Location-or-Routing Problems
Juan C. Pina-Pardo, Alonso Peña, Alan Osorio-Mora

Location-or-routing problems (LoRPs) involve selecting depots to serve customers either via vehicle routes or by direct assignment within the coverage areas of open depots. The objective is to minimize total cost, defined as the sum of transportation costs and the fixed costs of opening depots and operating vehicles. This presentation introduces a unified decomposition-based solution framework for solving several LoRP variants. Extensive computational experiments show the effectiveness of the proposed approach.

3 - Integrated and Sequential Approaches for Electric Bus Timetabling and Vehicle Scheduling
Alex Barrales-Araneda, Valentina Cacchiani, Emanuele Tresoldi

This work addresses the optimization of timetabling and vehicle scheduling in a public transport system with a mixed fleet of electric and conventional buses, under operational and electric-specific constraints. Two heuristic approaches are developed: a sequential scheme and an integrated scheme. Timetabling is formulated as an Integer Linear Programming model, while vehicle scheduling is modeled as a set partitioning problem solved by column generation. Computational results on MINOA benchmark instances highlight the trade-off between the two schemes.

4 - An exact algorithm for the cumulative capacitated vehicle routing problem with time windows
Alan Osorio-Mora, Timo Gschwind

The cumulative capacitated vehicle routing problem with time windows (CCVRTTW) is a variant of the well-known vehicle routing problem with time windows (VRPTW) where the objective is to minimize the sum of the service start times at the customers. A branch-price-cut (BPC) algorithm for solving the CCVRPTW is presented. BPC is able to solve to proven optimality within a time limit of two hours 84% of the Salomon instances. Moreover, the structural differences between CCVRPTW and VRPTW are analyzed using a bi-objective model. Finally, several managerial insights are presented for CCVRPTW.

■ HE-11

Thursday, 14:15-15:45 - Room: HG - Hörsaal 32 (Building: HG)

OR in Agriculture I

Stream: OR in Agriculture
Invited session
Chair: *Alejandro Mac Cawley*

1 - Assessing the efficiency of European Agricultural systems under the prism of a parallel hierarchical network structure
Marios Kremantzis, Leonidas Sotirios Kyrgiakos, Siwei Xiao, Georgios Kleftodimos, Marios Vasileiou, George Vlontzos

Improving resource efficiency in agriculture is key to sustainable output under CAP 2023-2027. Yet common operational research models treat farms as "black boxes," ignoring internal structures. We apply a parallel hierarchical network approach to crops, livestock, and mixed systems with multiple subunits, using FADN data on sector inputs/outputs. Results show major differences from the traditional BCC model and provide efficiency scores for systems, units, and subunits. This multi-level assessment can inform researchers and policymakers toward a more sustainable EU agriculture sector.

2 - A stochastic optimization model for planning resilient fresh fruit supply chains
Victor M. Albornoz, Alejandro Contreras-Roa

The paper considers a mixed-integer two-stage stochastic optimization model to propose a resilient planning framework for fresh fruit supply chains by applying two quantitative risk management formulations: one based on the Conditional Value-at-Risk (CVaR) measure and another aimed at minimizing the absolute negative deviations with respect to the distribution average (MOTAD). TResults show that increasing risk aversion stabilizes the supply chain's performance by reducing exposure to the most adverse combinations of port disruptions and low prices.

3 - Optimal Scheduling Problems with Non-time Indexed Formulation using Conflict Constraints: The Wine Fermentation Tank Assignment Case
Sergio Maturana, Alejandro Mac Cawley, Susan Cholette, Carlos Monardes, Ricardo Luna, Jorge Vera, Arturo Wenzel, Guilherme Tortorella

Production planning and scheduling (PPS) problems are critical for efficient resource utilization but often become computationally intractable. This paper proposes a non-time-indexed integer programming formulation for batch scheduling with release windows. Feasibility is enforced through disjunctive conflict constraints within a branch-and-cut framework. We applied the model to the Fermentation Tanks Planning Problem to minimize blending and ullage. Results show that the proposed model was much smaller and could yield optimal solutions more quickly than time-indexed formulations.

4 - Robust Scheduling Algorithm using Conflict Constraints: The Grape Harvest to Wine Fermentation Tank Assignment Problem
Alejandro Mac Cawley, Stefano Sbarbaro, Susan Cholette, Sergio Maturana, Jorge Vera, Ricardo Luna

Scheduling problems rely on integer programming, which can be computationally demanding. One way to address this challenge is to replace the time-indexed formulation with a conflict-constraint representation. However, this approach introduces a new question: how can uncertainty in the time dimension be integrated into the model? We propose a set of algorithms designed to enhance robustness within the conflict-constraint framework. We then compare the results against a robust time-indexed formulation and assess the robustness of each solution through a Montecarlo simulation.

■ HE-12

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 11 (Building: JUR)

Health Care Supply chain

Stream: Health Care Logistics
Invited session
Chair: *Ming-Hua Lin*

1 - From breakage to breakthrough: Contract mechanisms and public incentives for vaccine supply chain
Milad Asadpour, Guven Demirel, Brigitte Granville

We discuss the role of funding in fostering innovation in the vaccine supply chain (VSC). We first examine the upstream side of the VSC and evaluate contract mechanisms aimed at improving the quality of vials to reduce breakage. Using a game-theoretical framework, we model the interaction between a vial supplier(S) and a vaccine manufacturer(M), in which M provides funding to S to improve vial quality. We then turn to the downstream side, where public funding is allocated to early-stage research projects, to determine the extent to which the development of new vaccines relies on such support.

2 - Understanding and Mitigating Midstream Vaccine Supply Chain Disruptions Through Agent-Based Modelling
Farshid Babaei, Erly Sintya, David Robins, Solomon Brown

Geographically fragmented health systems and uneven infrastructure create persistent vulnerabilities in midstream vaccine distribution. Motivated by recurring stockouts and inequitable access, this study examines how transport disruptions propagate through vaccine supply chains and undermine coverage. Using an agent based model integrated with GIS data, it simulates flows from national warehouses to local clinics and evaluates a forward buying strategy to buffer disruptions. Results show how delays generate backlogs and stockouts, and how strategic pre-positioning can strengthen resilience.

3 - The Choice of Public Health Distribution Networks for Essential Medicines: Insights from the Select Indian States
Debadyuti Das, Rahul Kumar

Different Indian States use different types of Public health distribution networks (PHDNs) for essential medicines, which fall into six models. We are unaware of whether the States select the most suitable PHDNs based on service level, cost, and carbon emissions. The present work attempts to develop a mixed integer goal programming model by considering three goals, maximizing service level, minimizing costs, and minimizing carbon emissions concerning PHDNs. The findings reveal that one model may perform very well on one metric in one State but not on another. The study provides rich insights.

4 - A Study of Optimal Vaccine Distribution Strategy by Mathematical Programming Techniques
Ming-Hua Lin, Jung-Fa Tsai

Vaccination remains one of the most effective ways to control the outbreak of infectious diseases. However, the available doses of vaccines are often insufficient, especially during sudden outbreaks. This study investigates the minimum number of distributed vaccines using mathematical programming techniques to effectively control an emerging outbreak. Based on COVID-19 data, a sensitivity analysis is conducted on critical epidemic parameters, including vaccine efficacy and the quarantine proportion of infected individuals, to provide actionable recommendations for public health authorities.

■ HE-13

Thursday, 14:15-15:45 - Room: JUR - Seminar-Saal 20 (Building: JUR)

Platforms & Frameworks

Stream: Software for Operations Research
Invited session
Chair: *Jens Schulz*

1 - A Parallel Data-Oriented Framework for Mixed-Integer Programming
Mohammed Ghannam, Gioni Mexi, Sebastian Pokutta, Ambros Gleixner

Managing complex, interdependent processes, manipulating large volumes of data, and orchestrating parallel computation are challenges shared across many domains. While parallelization has not traditionally been a primary focus in mixed-integer programming (MIP), the game development community has long embraced data-oriented and parallel design patterns as a foundation for scalable software. Inspired by these advances, we present a novel solver framework for MIP based on the Entity-Component-System (ECS) paradigm, a cornerstone of modern game engines.

2 - Autonomous UI-Level System Learning for Process Automation in Enterprise Systems
Florian Eris Estfeller, Gerald Reiner

The automation of enterprise software is often limited by incomplete process knowledge and reliance on tacit user expertise. This study proposes a user-independent approach to autonomously explore and reconstruct UI-level task spaces as a foundation for automation. A constraint-guided GUI explorer is evaluated in a controlled sandbox environment with variable UI structures and flows. Results assess coverage and robustness, demonstrating reduced reliance on tacit process knowledge and enabling business process reengineering through the detection of alternative execution pathways.

■ HE-14

Thursday, 14:15-15:45 - Room: HG - Hörsaal 01 (Building: HG)

Ethics and OR, Public Service, Societal Complexity, and the Common Good

Stream: OR and Ethics, and Societal Perspectives
Invited session
Chair: *Dorien DeTombe*
Chair: *Ulrike Reisach*

1 - Measuring Sustainability Disclosure Quality with AI-Assisted Semantic Analysis: A Study of Taiwanese Technology Firms
Qiyao Hong

This study asks whether sustainability reports are written in a clear and verifiable way. It uses a large language model to read reports from Taiwanese semiconductor firms and score each paragraph for vagueness. A paragraph is considered vague when it lacks numbers, deadlines, scope, responsible parties, or evidence. The paragraph scores are combined into a firm-level index. Firms with higher vagueness scores have lower TESG scores, even after considering report length and firm size. DJSI firms are less vague. This shows that LLMs can help detect unclear ESG disclosure.

2 - Discovering specific customers using Machine Learning for Marketing Strategies.
Ioannis Tsiligkaridis

Our business model is based on Machine Learning (ML) techniques that can attract more customers to buy bank products. We focus on how much each feature of a dataset contributes to the model predicting customer behavior. An ensemble model consisting of Random Forest and XGBoost classifiers is used to identify potential customers. The XGBoost is strongly reliant on a certain variable. The feature importance of both ensembles uses socioeconomic indicator variables from a bank's demographic attributes dataset, and it serves as a global explainability method for business decision making.

3 - Simulating the emergence, rise and restriction of a language innovation: The case of the genitive apostrophe in German
Markus Günther, Tanja Ackermann, Marius Bartsch, Herbert Dawid, Theresa Elbracht, Christian Stummer, Frederik Tolkmitt

When studying the historical development of languages, challenges such as limited and unevenly available data, uncertainty in reconstruction, and uncertainty in the effects of sociopolitical factors are encountered. Simulations offer a way to overcome some of these obstacles. Therefore, we present a corpus-informed agent-based simulation of the German genitive apostrophe, which enables us to contribute to theoretical discussions on influencing factors (e.g., stigmatization or contact with English) by generating and validating observed diffusion patterns over time.

4 - Using Analytics and Colour to Slow the Aging Process towards Dementia, Alzheimer's Disease
Cathal MacSwiney Brugha

Dementia currently affects 50 million people globally. We present a non-medical Analytics method, including a 'Decision Map' and 'Mind Map', to help predict if one is vulnerable to developing Dementia / Alzheimer's disease. The colours you see in yourself can reveal if you have begun an aging process. Is your soul becoming disinterested in giving to community? Is your spirit disengaging from making a contribution? Is your mind becoming distracted, from bringing your capability to others, as in Dementia? Or is your body's Alzheimer's Disease taking down your functioning capacity?

■ HE-15

Thursday, 14:15-15:45 - Room: HG - Hörsaal 34 (Building: HG)

Learning in Games II

Stream: Algorithmic Game Theory
Invited session
Chair: *Abheek Ghosh*

1 - Estimation of Private Value Distributions in Markets from Field Data
Markus Ewert, Martin Bichler

Digital marketplaces generate rich data on strategic behavior in auctions and contests, creating new opportunities for market design. We propose a learning-based framework that infers latent type distributions from observed actions. In contrast to classical structural estimation, our approach does not rely on mechanism-specific analytical inversion and can therefore be applied across different market settings. This makes it useful for behavioral analysis, model comparison, and the evaluation of alternative platform designs using observed data.

2 - The Complexity of Sparse Win-Lose Bimatrix Games
Abheek Ghosh, John Fearnley, Rahul Savani, Eleni Batziou

Nash equilibrium is a central solution concept in economics and operations research, so understanding when it can be computed efficiently is a fundamental question. We study sparse win-lose bimatrix games, among the simplest natural classes of games whose complexity had remained open. We prove that computing an approximate Nash equilibrium is PPAD-hard even for 3-sparse win-lose games, for inverse-polynomial approximation; this is tight, since 2-sparse games admit a polynomial-time algorithm.

3 - LLM Pricing Agents in Oligopoly Competition
Philip Hierhager, Martin Bichler, Fabian Raoul Pieroth, Kassian Köck

This paper studies whether large language models (LLMs) outperform standard learning algorithms in repeated pricing environments. We compare LLM agents with deep reinforcement learning, Exp3-style bandits, and contextual bandits in oligopoly markets with homogeneous and heterogeneous goods. LLMs show little advantage in homogeneous-goods Bertrand competition but perform better in heterogeneous-goods settings where product descriptions contain transferable demand information. Performance is evaluated using profits, regret, welfare, collusion, convergence, and out-of-sample transfer.

4 - Gradient-based Learning in Signaling Games
Rilind Sahitaj, Artem Tsikiridis, Martin Bichler

Understanding when simple learning dynamics converge to Nash equilibrium is central in learning in games. We study a simple, finite signaling game, one of the simplest extensive-form settings where beliefs, sequential rationality, and off-path reasoning all matter. Online learning converges computationally to pure separating and pooling equilibria, but not to semi-separating mixed equilibria. We identify, when structural properties as Monotonicity and global Minty conditions fail or succeed in proving convergence results. We also give a positive result regarding Lyapunov stability.

■ HE-16

Thursday, 14:15-15:45 - Room: HG - Hörsaal 42 (Building: HG)

Emerging Concepts in Last-Mile Logistics and Delivery

Stream: Emerging Delivery Ideas and Alternative Modes
Invited session
Chair: *Iman Dayarian*

1 - Fast Approaches for Interactive Time Slotting
Lucas Veelenturf, Gustavo Hurovich, Niels Agatz

Attended home delivery requires customers to select a delivery time slot, after which routes are planned. Between cut-off and delivery, there is a window to interact with customers and request alternative slots to improve routing. We study the Time Slot Adjustment Problem from two perspectives: incremental adjustment strategies, analyzing how individual changes interact, and starting from promising routes to identify required slot changes. This work explores heuristics to identify effective offer strategies leveraging interaction patterns.

2 - Parcel locker routing in a two-echelon delivery and pickup system with heterogenous drones
Qiruo Zhang, Emrah Demir, Cheng Chen

This study proposes a two-echelon parcel locker(PL) network served by drones for both delivery and pickup services, in which a set of motherships and subships jointly serve hub and satellite PLs. The problem is formulated as a two-echelon VRP that determines the selection of PLs and the associated routing decisions. To solve larger instances, we propose a two-stage hybrid algorithm that combines a capacitated clustering algorithm with an adaptive large neighbourhood search algorithm. The study also provides several insights into the design and operation of PL logistics served by drones.

3 - Crowdshipping under a Joint Delivery Policy with Variable Transfer Points
Michel Jahns, Margaretha Gansterer, Christian Bierwirth

We study collaborative deliveries in a crowdshipping system where parcels can be transferred between occasional drivers at variable locations. A mathematical framework generates an efficient delivery plan for a given planning period, with the Transfer Point Determination Problem (TPDP) at its core. To address computational complexity of the TPDP, we introduce crowdshipper corridors enabling multi-stage filtering and heuristic generation of feasible delivery options. Computational experiments show substantial improvements in crowdshipping performance.

4 - Crowdkeeping for last-mile delivery with stochastic demand
Iman Dayarian

This study proposes a crowd-based last-mile delivery system where individuals act as crowd-keepers (CKs), temporarily holding parcels for customer pickup. The retailer selects CKs and assigns service regions under uncertain demand, balancing fixed hiring costs, routing costs, and potential revenue. The problem is formulated as a two-stage stochastic program that integrates CK selection, region assignment, and vehicle replenishment routing, and is solved using a branch-cut-and-price algorithm.

■ HE-17

Thursday, 14:15-15:45 - Room: JUR - Dach-Geschoss (Building: JUR)

OR Journal Editors Panel

Stream: Special Sessions
Invited session
Chair: *Martin Kunc*

1 - FT50s, a reflection to PUBLISH OR PERISH, and the oldest OR journal in the world - JORS
Konstantinos Nikolopoulos

We do reflect on the ongoing pressure to 'Publish or Perish', especially for early-career scholars, in 'elite' FT50s journals, versus the quest to see your research in more natural outlets, including the oldest OR/MS journal in the world, the Journal of the Operational Research Society, where the more romantic quest of chasing ideas that aim to change the world as we know it, rather than diminishing returns in complex mathematical explorations without impact, is a more intuitively appealing offering.

2 - The Journal of Simulation (JOS): Editorial Vision, Initiatives, and Opportunities for Authors
Navonil Mustafee, Claudia Szabo, Charles Macal, Enlu Zhou

Journal of Simulation publishes articles and technical notes that advance both the theory and practice of simulation, including methodological developments and applications of discrete-event simulation, agent-based modelling, system dynamics, and hybrid approaches. This session will present the journal's scope, editorial vision, and current priorities. It will also introduce key initiatives such as the Africa Focus initiative and the JOS Model Reproducibility Initiative (MRI), while providing guidance to researchers on positioning their work for publication.

■ HE-19

Thursday, 14:15-15:45 - Room: HG - Hörsaal 05 (Building: HG)

Sustainable Stochastic Operations

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Yanlu Zhao*

1 - Charging an electric vehicle on fast-lanes and stations: accessibility, availability and uncertainty
Yanlu Zhao, Kai Pan, Fang Liu

The rapid increase in electric vehicle (EV) use has profoundly transformed urban transportation and placed significant demands on the energy system, primarily due to the increased need for battery charging. Stationa charging limits vehicle availability, particularly for

heavy goods vehicles (HGVs) that require substantial energy for long-haul trips with heavy loads. This requirement adds to the vehicle weight, perpetuating a problematic cycle. In response, some pioneering countries like Sweden and innovative companies are exploring road-charging technologies that charge EVs while they are mov

2 - Towards a More Sustainable Future through Flexible Architectures
Xiaolong Li

Carbon regulations and cap-and-trade mechanisms are reshaping how firms design and operate flexible supply networks. This study examines how firms should upgrade selected network links with green technology while allocating capacity under demand uncertainty and carbon caps. We propose a target-based optimization framework that separates long-run planning from operational decisions and adopts a robust approach and online allocation. The results show that flow targeting achieves near-optimal performance while balancing service level, operating cost, and carbon compliance.

3 - A bilevel approach for compensation and routing decisions in last-mile delivery
Martina Cerulli, Claudia Archetti, Elena Fernandez, Ivana Ljubic

In last-mile delivery, peer-to-peer logistics platforms connect senders, customers and independent carriers to perform deliveries. Since carriers are not controlled by the platform, their reactions must be anticipated when allocating orders. We model this interaction with bilevel programming: the platform assigns orders at the upper level, while carriers solve a profitable tour problem at the lower level to decide which requests to accept. Two settings are considered, with fixed compensations or compensation decisions, and solved through a branch-and-cut algorithm.

4 - Behavioral Implications of Costly Information Acquisition in Newsvendor Problems: An Experimental Study
Jiayi Lin, Wanshan Zhu, Xiaobo Zhao, Jinxing Xie

With information abundance, decision-makers navigate diverse channels for acquiring demand signals, each offering varying levels of accuracy at different costs. Our study investigates how such costs influence decision-makers' choices of signal accuracy and their subsequent order quantity decisions. Human decision-makers' behavior in acquiring demand signals will significantly affects business performance, but its mechanism has not been explored. We develop a stylized model in newsvendor framework and conduct laboratory experiments to examine human biases in information acquisition.

■ HE-20

Thursday, 14:15-15:45 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Routing problems in waste collection

Stream: Vehicle Routing and related problems
Invited session
Chair: *Christopher Kirkbride*

1 - Visually Attractive and Equitable Arc Routing Problem for Residential Waste Collection
Seungyeop Lee, Byung-In Kim

Residential waste collection can be modeled as an arc routing problem on a mixed graph where a heterogeneous fleet must service required arcs and edges under operational constraints. Vehicles may need multiple trips to disposal facilities due to capacity limits, and routes must satisfy working-time limits. Minimizing only total cost can cause overlapping routes and unbalanced driver workloads. We propose a hierarchical graph-partitioning matheuristic that creates visually attractive and balanced clusters, decomposes routes under capacity limits, and solves single trips with turn penalties.

2 - Sensor-Driven Periodic Waste Collection with Intermediate Facilities
Christina Hess, Alina-Gabriela Dragomir, Karl Doerner

We study a real-world waste collection problem with sensor-based, non-constant demands, periodic visit patterns and intermediate facilities where vehicles unload waste. The problem is considered over a two-week rolling horizon with service level constraints such as overflow avoidance and minimum visit frequencies. We propose a mixed-integer programming (MIP) model and an Adaptive Large Neighborhood Search (ALNS) tailored to the problem proposed. Results with real-world data show that flexible, sensor-informed planning reduces costs compared to fixed cyclic schedules.

3 - Balancing Cost and Workload Equity in Municipal Waste Collection: A Hybrid Arc-Node Routing Model with a Heterogeneous Fleet
Sonia Trifa, Taicir Loukil

Municipal waste collection combines door-to-door and mechanized container pickup modes, creating a complex routing problem. This paper formulates it as a hybrid arc-node routing model with a heterogeneous fleet, minimizing operational cost under a workload equity constraint among crews. The constraint captures the social sustainability dimension by bounding working time disparity. The model is solved using CPLEX and a hybrid NSGA-II-VND metaheuristic. Experiments based on data from Sfax, Tunisia, highlight cost-equity trade-offs and provide decision-making support for municipal planning.

4 - Index policies for recycling collections with dynamic rosters and routes
Christopher Kirkbride, Diego Ruiz-Hernandez

We develop a heuristic index policy for a problem in which a recycling depot services a network of collection points. Each period, a capacitated truck is allocated to a route visiting a subset of collection centres, emptying each en route. The aim is to minimise the long-run costs of scheduling visits to collection points while meeting service level constraints. As opposed to fixed rosters, we allow for dynamic schedules in response to estimated inventory levels in the first instance. We extend the problem, in the case of correlated inventories, to allow for in-period dynamic route updates.

■ HE-21

Thursday, 14:15-15:45 - Room: JUR - U 22 (Building: JUR)

Integrating deep learning and combinatorial optimization

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Calvin Tsay*
Chair: *Lavinia Ghilardi*

1 - Neural networks for multi-horizon stochastic programming
Hongyu Zhang, Gabriele Sormani, Enza Messina, Alan King, Francesca Maggioni

This paper proposes a machine-learning-based approach for solving multi-horizon stochastic programs by embedding a deep neural network to approximate the recourse operational objective. The method is demonstrated on a UK power system planning problem with uncertainty at investment and operational timescales. Results show good surrogate performance across architectures, up to 34.7× speed-up over the deterministic equivalent, and comparable in-sample stability with improved out-of-sample performance. A computational study highlights trade-offs between accuracy, efficiency, and robustness.

2 - Deterministic Global Optimization of Trained Neural Networks: Integrating Tightening based on Subgradients into the Envelope of a Single Neuron
Clara Witte, Alexander Mitsos, Dominik Bongartz

Optimization problems involving trained neural networks are challenging due to their nonconvexity, motivating deterministic global optimization (DGO). A recent method computes the envelope of an entire neuron. We recently demonstrated that using this envelope in DGO can be slower than propagating relaxations through pre-activation and activation function. To improve computational performance, we present a method that uses a subgradient-based heuristic to obtain tighter bounds for the input of the activation function and integrates them into the computation of the envelope of a neuron.

3 - Stochastic Optimisation of Green Hydrogen Systems Using Quantile Neural Networks
Lavinia Ghilardi, Gabriel Patron, Antonio Alcántara, Calvin Tsay

This study addresses a two-stage stochastic program for green hydrogen production, where uncertainty in electricity prices plays a key role. We employ Quantile Neural Networks (QNNs) to approximate the second-stage, accelerating decision-making while enabling risk-averse formulations through Conditional Value at Risk. The QNN-based stochastic program provides an effective framework to jointly optimize the design and operation of green hydrogen systems. Compared with scenario-based approaches, QNNs facilitate fast what-if analyses on first-stage investment decisions and risk parameters.

4 - Nanotomography Tailored to Homogeneous Materials
Jan Rolfes, Andrea Gilch, Frauke Liers

In nanotomography, one often faces the challenge of the proper acquisition of projection data, e.g. because of ill-described imaging physics, beam sensitivity of the sample material or specific restrictions on the sample geometry, which may prevent the acquisition an artefact-free 3D reconstruction. In this talk, we aim to reduce the amount of projection data required by complementing a compressed sensing approach with expert knowledge and learned properties of the sample material in case the sample contains only a small number of piecewise constant material phases.

■ HE-22

Thursday, 14:15-15:45 - Room: KOL - Seminar-Raum 5 (Building: KOL)

OR Dynamics, Games and Optimization in Energy

Stream: OR Dynamics and Games in Finance
Invited session
Chair: *Alberto Pinto*

1 - Optimizing Long-Haul Electric Truck Charging in Europe
Stella Steidl, Alicia Lerbinger, Siobhan Powell

The heavy-duty transport sector is rapidly electrifying in Europe. Large-scale electric truck charging demand will affect electricity systems, yet system-wide impacts and flexibility potentials remain unclear. We develop a modelling framework where long-haul truck charging schedules are optimized to minimize wholesale electricity costs and peak load impacts to the electricity system under regulatory and operational constraints. We further present our ongoing work on how different electricity tariffs, policy, and subsides influence charging patterns and their locations.

2 - Game-Theoretic Bilevel Optimization of Investment and Operations for Green Hydrogen Supply Chains with Salt Cavern Storage
Shiyu Guo, Maria Beranek, Udo Buscher

Renewables call for flexibility to absorb surplus power and reduce curtailment. We develop a multi-period game-theoretic bilevel model for a decentralized green hydrogen supply chain with salt cavern storage. The leader (power plant) invests in electrolyzers and sets daily power allocation, H2 price, and total storage/transport flows. The follower (storage operator) allocates injections/withdrawals across caverns and sets storage prices. A one-year case study shows that H2 can reduce curtailment, caverns can provide seasonal flexibility, and costs are key drivers of H2 competitiveness.

3 - Multi-Market Bidding Strategy Selection for Power Plants Using Value Function Approximation
Raik Becker

Multi-market bidding across capacity, day-ahead, and energy activation markets is challenging due to sequential decisions under uncertainty. Multi-stage stochastic optimization is often impractical. A practical alternative is proposed: a classification algorithm identifies the best bidding strategy from observable features. A value function approximation generates the training data. The model captures nonlinearities and relies less on forecasts than deterministic optimization. Backtesting on Finnish market data demonstrates viability.

4 - Optimal Fine Mechanisms for Industrial Pollution Control
Alberto Pinto, Alberto A. Álvarez-López, Filipe Martins

Industrial pollution control is a key policy issue. We study a polluting industry and a government that supervises emissions, modelling their interaction as an evolutionary game. By setting appropriate fines, the government can induce all firms to reach the same pollution-reduction target (the green level) chosen in advance. The mechanism requires supervision proportional to each firm's abatement cost. We present two fine designs: piecewise affine, which is easier to implement, and piecewise quadratic, which leads to faster convergence for more polluting firms.

■ HE-23

Thursday, 14:15-15:45 - Room: HG - Hörsaal 02 (Building: HG)

Exact and Heuristic Methods in Robust Optimization

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Francesca Maggioni*

1 - Robust Optimization Using the Bernstein Approximation: Application to Topology Design
Miguel Carrasco, Alfredo Canelas, Julio López

We propose a robust formulation for the topology optimization of structures. The objective is to determine the optimal distribution of a linear elastic material within a reference domain subjected to both stochastic and deterministic external loads. A key feature of this formulation is the incorporation of a failure-probability constraint defined in terms of compliance (a quadratic functional of the stochastic variable). The Bernstein approximation is used to derive an upper bound on the failure probability, yielding a more tractable formulation. Numerical experiments are presented.

2 - Dynamic Programming using Average-Value-at-Risk Criteria
Kerem Ugurlu

We investigate dynamic programming equations on Average-Value-at-Risk (AVaR) using machine learning techniques and demonstrate several simulations. The dynamic programming equation on AVaR is specifically using a so called "state aggregation technique" that makes use of the sufficient statistic of the optimization problem. Via state aggregation, we present the "Markovian" framework and demonstrate several implementations using ML techniques. The risk averseness level alpha on the model is also investigated via several simulations.

3 - A novel approach to solving Mixed Integer Two-Stage Distributionally Robust Optimization Problems
Gerben Ouwersloot

We present a novel methodology for solving two-stage distributionally robust optimization problems with mixed-integer first-stage decisions. Our approach involves integrating the column-and-constraint (CCG) algorithm within the branch-and-bound framework. Whereas the classic CCG algorithm involves repeatedly solving an increasingly harder MILP, our method requires solving a single MILP with intermediate column-and-constraint generation as optimality cuts. Computational experiments on a multi commodity network design problem demonstrate significant improvements in performance.

4 - On the separation subproblem in decomposition algorithms for two-stage linear robust optimization problems
Patxi Flambard, Ayse Nur Arslan, Boris Detienne

We study two-stage linear robust optimization problems with continuous and fixed recourse. Exact solution approaches include constraint, constraint-and-column, and semi-infinite constraint generation. These approaches are decomposition methods that require solving a bilinear separation subproblem at each iteration, which is often the computational bottleneck. We review and compare how the separation subproblem can be handled using mixed-integer linear programs, depending on the nature of the separation problem (feasibility or optimality) and the structure of the uncertainty set.

■ HE-24

Thursday, 14:15-15:45 - Room: HG - Hörsaal 03 (Building: HG)

Knowledge in Organizations

Stream: Knowledge, Technology, and Innovation Decisions
Invited session
Chair: *A. D. Amar*
Chair: *Rajhans Mishra*

1 - A Reproducible Classification Model for Corporate R&D Themes: Integrating Semantic and Rule-Based Approaches
Kazuki Shimasaki, Hiroshi Morita

This study proposes a reproducible classification model for corporate R&D themes by integrating a semantic interpretation approach with a rule-based textual mapping method. While innovation typologies are widely discussed, publicly disclosed R&D portfolios lack systematic operationalization. We construct a three-category framework covering process, product, and business innovation, and apply it to longitudinal R&D data from a manufacturing firm. The results demonstrate classification consistency, methodological transparency, and applicability to innovation portfolio analysis.

2 - Decentralized Collaborative Decision Systems shaping Supply Chain Resilience-A Design Science Research
Rajhans Mishra, Shantanu Dey

Supply chain disruptions are a critical problem for global businesses. The literature highlights the role of visibility and agility in improving resilience, visibility challenges in multi-tiered supply chains, and technology systems such as big data and cloud catering to visibility needs. This study focuses on decentralized technology systems for improving resilience that can cater to information processing needs in a resource-agnostic manner. We conduct design science research following the DSRM framework using organizational information processing theory and sensemaking as lenses.

3 - Designing Flexible Supply Chain using System Dynamics: A case of Indian Soap Manufacturing firm
Rohit Kumar Singh, Sachin Modgil

Being competitive and challenging environment of the industry, domestic personal care firms are stressed for their supply chain performance. The state of affairs is predominantly critical in the soap manufacturing firm, which have simple, but yet long supply chain with ample amount of uncertainty, and thereby increase the challenges for firms such as "how much to produce" and "how much should be the production lead time". Using expert views along with academicians and literature support, this paper investigates the flexibilities associated with soap manufacturing supply chain.

4 - Hype as a Lever: NFT Market Competition Under Bandwagon Effect and Decentralized Secondary Market
Negin Karimani, Hubert Pun, Salar Ghamat, Hamid Elahi

This study analyzes the NFT market's unique competitive landscape, defined by low entry barriers, smart contract royalties and social bandwagon effects. Using a two-period game-theoretic model, we examine interactions between incumbents, entrants, and heterogeneous consumers (tech savvys, investors, late adopters). Results show that a weaker bandwagon effect can counterintuitively benefit all parties. Furthermore, consumers may gain from higher entry costs or limited competition. While investors provide liquidity, they risk eroding community value. Notably, secondary royalties favor consumers.

■ HE-25

Thursday, 14:15-15:45 - Room: HG - Hörsaal 16 (Building: HG)

OR in Sustainability: Logistics, Emissions and Resilience

Stream: OR for Sustainability
Invited session
Chair: *Sarfaraz Hashemkhani Zolfani*

1 - Designing Greener Last-Mile Delivery Strategies: Home Delivery versus Self Collection
Valentina Bonomi

We propose a Green Two-Echelon Location-Routing Problem aimed at evaluating different service strategies under multiple optimization objectives, accounting for heterogeneous emissions generated by both delivery vehicles and clients traveling for self-collection. Two service strategies are analyzed: full home delivery and a hybrid option enabling satellite self-collection for failed attended deliveries. An ALNS is developed to solve real-world instances and evaluate operational and environmental trade-offs.

2 - Non-linearity of aviation CO2 emissions in Europe: scenario-based modelling of short- and long-haul flights
Fabricio Andres Niebles Atencio, Lucia Rivera Charun

This study analyses the non-linear distribution of aviation CO2 emissions in Europe by comparing short-haul and long-haul flights using a scenario-based modelling framework calibrated to publicly available aviation statistics. Statistical and exploratory analyses are used to characterise the concentration of emissions and evaluate potential reduction levers. The results suggest that long-haul flights represent a small share of flights but contribute a disproportionate share of total emissions, supporting targeted mitigation strategies for aviation decarbonisation.

3 - A Multi-Method Analysis of Circular Economy Principles in Enhancing Flexibility of Public Sector Pharmaceutical Supply Chains
Lokesh Vijayvargy, Saumyaranjan Sahoo

Digital transformation is essential for fostering sustainability and resilience in public-sector pharmaceutical supply chains by offering improved traceability, resource efficiency, and circular economy practices. In this paper, a mixed-methods approach is used to investigate Indian public-sector pharmaceutical supply chains. By integrating the TOE framework with a Delphi study, the prime enablers of digital transformation and circular economy adoption have been identified. The Best-Worst Method is utilized for ranking these enablers, and then a Bayesian Network has been used.

4 - Navigating Uncertainty in Agricultural Adaptation: A Multi-Valued Neutrosophic Decision Support Framework for Climate-Resilient Farming
Sarfaraz Hashemkhani Zolfani, Fernando Montenegro

Sustainable agriculture needs strong approaches for managing uncertainties and conflicting decisions. This paper proposes MVN-ARAS, which combines Multi-Valued Neutrosophic Numbers and ARAS for decision-making in ambiguous situations. In the context of climate change resilience for smallholder farmers in water-scarce areas, MVN-ARAS identifies drought-tolerant crops and efficient irrigation techniques as critical strategies for decision-makers to address sustainability challenges.

■ HE-26

Thursday, 14:15-15:45 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis VIII: Environmental and Sustainability

Stream: Data Envelopment Analysis
Invited session
Chair: *Sanjeet Singh*

1 - Understanding Food Waste Through Economic, Social and Environmental Values: A Multidimensional Efficiency Analysis of OECD Countries
Eda Helin Yıldız, Fusun Ulengin, Umut Aydın, Melis Almula Karadayı

This study examines the waste performance of 26 OECD countries using economic, social and environmental values. Principal component analysis was used to combine variables into composite components under three categories. These components were then incorporated into a two-stage data envelopment analysis to capture the effect of social and economic factors reducing food waste and eventually having a positive effect on environmental performance. The results show that countries with coordinated systems perform better and resource availability alone does not guarantee lower food waste levels.

2 - Dynamic Network DEA for Green Port Transition: Measuring Regulation-Driven Efficiency Under Environmental Constraints
Mozhgan Mansouri Kaleibar, Evelin Krmac

Ports face increasing pressure to balance operational efficiency and environmental sustainability under regulatory requirements. Existing studies primarily use black-box DEA models that do not capture the dynamic nature of green transition processes. This study proposes a dynamic DEA framework with undesirable outputs to evaluate the transition efficiency of ports over time. Ports are modeled as a three-stage dynamic system encompassing operations, emissions generation, and environmental compliance, enabling identification of stage-specific inefficiencies and intertemporal adjustment paths.

3 - Environmental Performance-Driven Emission Permit Allocation: A Dynamic DEA Framework
Sanjeet Singh, Utsav Pandey, Sunil Tiwari

Globalization has made it essential to balance economic growth with environmental protection. This study proposes a performance-based approach to allocating emission permits that considers both production scale and environmental performance. Using multi-year data on CO emissions and waste, firms maximize revenue while regulators allocate permits based on economic and environmental efficiency. Applied to China's transport sector, the approach achieves 76% of total profit with only 25% of emissions, balancing both profit-only and emission-only strategies.

■ HE-27

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 13 (Building: JUR)

OR Models for Humanitarian Logistics

Stream: Humanitarian Logistics
Invited session
Chair: *Vittorio Nicoletta*

1 - Optimization Models for Humanitarian Logistics: The Location-Routing Problem in Earthquake Response
Jingtong Ma, Antonio Martinez Sykora, Carlos Lamas-Fernandez

To address urgent medical evacuation needs during the post-earthquake "golden hour," this study develops a Mixed-Integer Linear Programming (MILP) model to jointly optimize facility location and vehicle routing. The model determines optimal sites and functional types of shelter facilities while scheduling a heterogeneous fleet. By incorporating patient priorities and specific time-window constraints, the framework ensures efficient casualty transfer. Simulation results identify the maximum problem size solvable with high efficiency, providing practical decision support for real-world response.

2 - Integrated Two-Echelon Humanitarian Logistics with Demand Prioritization under Supply Scarcity: A MILP Approach for Pandemic Response
Glaydston Ribeiro, Filipe Mendes, Marcus Camara

The study proposes a Mixed-Integer Linear Programming (MILP) model to support decision-making in humanitarian logistics during pandemics. The model integrates two levels of the supply chain: from suppliers to distribution centers and from these centers to hospitals. It considers supply scarcity, different hospital priority levels, and vehicle routing with time windows. Applied to the Metropolitan Region of Rio de Janeiro during COVID-19, the model showed good results in operational cost and delivery time.

3 - A non-myopic policy for online fair decision making in food bank resource allocation
Pauline Beaupuits, David Rey, Roel Leus

We study an online fair resource allocation problem motivated by food bank operations, where supply and demand arrive over time and allocation decisions must be made without knowledge of future events. Fairness is enforced through a minimum fill rate across agents while maximizing efficiency. We propose an offline MILP formulation and develop a non-myopic online policy combining lookahead and surrogate objectives. Computational results show an improved trade-off between efficiency and the deviation from the minimum utility target compared with myopic benchmarks.

4 - An Interactive Network Optimization Tool for Evacuation Planning and Visualization
Vittorio Nicoletta, Valérie Bélanger, Jonathan Boucher

We present an interactive tool for analyzing vehicle evacuation strategies using network optimization and traffic assignment models. Built on OpenStreetMap and demographic data, it combines shortest-path routing with BPR congestion functions to simulate clearance times and congestion dynamics under alternative scenarios. The tool supports comparative policy evaluation and illustrates how operations research methods enhance emergency planning and decision-making.

■ HE-28

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 17 (Building: JUR)

Yard management and Seaside Planning

Stream: Maritime Logistics
Invited session
Chair: *Jana Ries*
Chair: *Rosa G. González-Ramírez*

1 - Towards a classification of Yard Management Problems - the case of container space allocation
Jana Ries, Rosa G. González-Ramírez

The container space allocation problem - closely related to container stacking - focuses on efficiently assigning containers to yard locations. While a number of solution approaches to the problem exist, the impact of instance specific features on algorithmic performance is not well understood. We propose a classification template for the problem to enable the characterisation of existing problem variants. By integrating port specific contextual information, the work further aims to guide the development of a benchmark that helps identify advances in solution design for yard management.

2 - Planning Empty Container Yards with Value-Added Services: Layout Design and Template Optimization
Sebastian Muñoz-Herrera

Empty container depots (ECDs) offering value-added services remain underexplored in literature. We present a novel yard template problem considering container segregation and service operations with precedence constraints and resource interdependencies. Based on a maritime terminal in Chile, we describe the optimization journey from layout evaluation using a discrete-event simulation framework to yard template optimization for the new configuration using mixed-integer programming. This work advances a replicable methodological framework for ECD design and planning under service complexity.

3 - Predicting Container Dwell Time Using Historical Pre-Entrance Data: An ML-Based Approach
Nazin Shokravi, Dongping Song, Yuanjun Feng

Container dwell time (CDT) prediction has gained attention, yet most models rely on post-arrival operational data. This study addresses whether pre-entrance information can enable early prediction for proactive container yard management, focusing on medium-sized ports where early visibility is critical. A machine learning model using only historical pre-entrance data was developed and achieved an R' of 0.75. The results show that use of pre-entrance information achieve the reasonable accuracy of CDT prediction.

4 - Berth allocation for a multipurpose port terminal
Rosa G. González-Ramírez, Giovanni Campuzano, Amina Balha, Eduardo Lalla-Ruiz

The Berth Allocation Problem aims to ensure efficient vessel service by determining an optimal schedule for ships within a planning horizon. It has been widely studied considering different operational characteristics. In this study, we address the problem at a multipurpose port terminal handling multiple cargo and vessel types. Because some berths are shared, setup times between consecutive operations must be considered. A mathematical model and a metaheuristic approach are proposed, and computational experiments are conducted to evaluate their performance.

■ HE-29

Thursday, 14:15-15:45 - Room: HG - Hörsaal 30 (Building: HG)

Polynomially solvable combinatorial optimization problems

Stream: Combinatorial Optimization
Invited session
Chair: *Federico Della Croce*

1 - On the Complexity of the Paper Selection Problem for the Italian Research Quality Evaluation (VQR)
Francesco Carrabs, Martina Cerulli, Carmine Sorgente

This work studies the paper selection problem faced by Italian departments in the 2020-2024 VQR. Given a set of researchers and their publications, the task is to select a fixed number of ⟨researcher, paper⟩ pairs, subject to lower and upper bounds on the number of papers per researcher, while ensuring that each paper is selected at most once. Each pair is associated with a score, and the goal of the problem is to select the pairs so as to maximize the total score. We analyze the computational complexity of the problem.

2 - An improved primal algorithm for the assignment problem
Rosario Scatamacchia, Roberto Bargetto, Federico Della Croce

We consider the assignment problem, one of the most well-known graph optimization problems in mathematical programming and operations research. In this work, we propose an exact primal algorithm based on an efficient iterative search for improving solutions through the detection of negative-length cycles in a graph with a limited number of arcs, using a suitable application of the Bellman-Ford shortest path algorithm. The proposed algorithm is competitive with the best available solution approaches for the problem. Computational results will be presented at the conference.

3 - Revisiting Johnson's rule for minimizing makespan in the two-machine flow shop scheduling problem
Federico Della Croce

We consider Johnson's rule for minimizing the makespan in the two-machine flow shop problem.Although its worst-case time complexity is O(n logn), we show that it is possible to detect in linear time whether a full sorting of jobs can be avoided and an optimal solution can be computed in O(n) time. A probabilistic analysis indicates that linear-time

complexity holds with high probability under uniformly distributed processing times, a result also supported by extensive computational experimentation.

■ HE-30

Thursday, 14:15-15:45 - Room: HG - Seminar-Raum 06 (Building: HG)

Machine Learning and Optimization in Mobility

Stream: Machine Learning and Optimization
Invited session
Chair: *Kris Braekers*

1 - Leveraging Social Media Content for Preference Learning in Automated Travel Bundle Generation
Omar Aitoulghazi, Jan Fabian Ehmke, Rudolf Vetschera

The increase of travel-related content on social media platforms has created unprecedented opportunities for understanding user preferences over travel services through their digital interactions. This paper presents a semantic ontology-based travel recommendation framework that functions within a simulated social media environment, enabling multi-modal analysis of user behavior to generate personalized destination and activities suggestions.

2 - Reinforcement Learning Based Air Traffic Management: A Use Case on Certification Challenges
Fynn Oppermann, Marta Ribeiro

Reinforcement Learning (RL) shows potential for Conflict Detection & Resolution (CD&R), aiding Air Traffic Controllers (ATCOs) as a decision support tool. However, certification challenges (e.g., explainability, robustness, reproducibility) currently block real-world deployment. We develop an open-source CD&R use case that follows a development framework considering future certification. This ATCO advisory agent is used to show the potential of RL and the training and safety-assurance challenges that must be overcome before RL can reach operational use.

3 - Using Machine Learning to Enhance Hybrid Transit System Optimization
Seyedehsima Madani, Kris Braekers, Imre Keseru

Designing integrated fixed-route and demand-responsive transit systems requires solving a computationally expensive bi-level optimization problem. We propose a learning-enhanced metaheuristic framework where surrogate models replace explicit demand-responsive routing optimization. Classical machine learning models and graph neural networks are evaluated and embedded within a particle swarm optimization algorithm to estimate fleet size and rapidly assess network configurations. Experiments show comparable solution quality while substantially reducing computational runtime.

■ HE-31

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 12 (Building: JUR)

Integrated Transport Problems

Stream: Smart Logistics
Invited session
Chair: *Tom van Woensel*

1 - Environmental Impact of Long-Combination Vehicles in Full-Truckload Transport Planning
Casper Bazelmans, Albert Schrotenboer, Gilbert Laporte, Tom van Woensel

Heavy-duty vehicles in full-truckload (FTL) transport contribute significantly to greenhouse gas emissions. Long combination vehicles (LCVs) can reduce costs and emissions but require complex configuration planning. We introduce the FTL Pickup and Delivery Problem with Configurations and propose a large neighborhood search heuristic. Computational results show improved solution quality compared to a benchmark. A real-world case study at our industry partner, Van der Wal, demonstrates emission reductions of 13% compared to current operations and further gains from equipment standardization.

2 - Enhancing Last-Mile Delivery Through Coordinated Truck and Automated Robot with Battery-Swapping Capability
Mahdi Bashiri, Zahra Sadat Hosseini, Tom van Woensel

City logistics is vital for urban mobility but contributes to emissions. While robots support sustainable last-mile delivery, their integration with trucks creates energy challenge. This study develops a model to minimize operational cost, focusing on charging decision and reducing truck idle time. The model evaluates whether truck should wait for robot to charge or use battery swapping. The model also balances robots across robot depots. To reduce waiting time, increasing robot numbers, fast charging, and battery swapping are evaluated with results confirming the effectiveness of last option.

3 - Integrated Hub Location and Electric Pusher Routing for Multimodal Freight Transport on Inland Waterways
Mir Mohammad Musavi, Layla Martin, Nevin Mutlu, Tom van Woensel

Urban freight heavily contributes to emissions and congestion. Shifting this transport to inland waterways requires effective transshipment infrastructure. This research jointly optimizes water-hub locations, electric pusher routing, and flow assignments for full-load exchanges between hinterland and waterside nodes. Given the problem's complexity, we propose a phased Adaptive Large Neighborhood Search utilizing standard and novel full-route operators. Dutch construction data shows a few hubs drive a major modal shift, cutting emissions at minimal cost.

4 - An Iterative Column Generation Framework for Integrated Trunk Relay Transportation and EV Pickup and Delivery
Akane Seto, Takafumi Chida, Stephen Maher, Yuji Shinano

Recent logistics require relay-based trunk transportation with driver and container exchanges to improve working conditions, and EV-based local pickup-and-delivery for decarbonization. To integrate transportation and pickup-and-delivery for wide area service, we propose an iterative framework that ensures both efficiency and consistency of arrival and departure times at relay hubs. Subproblems are solved using column generation with labeling algorithms that incorporate the characteristic of each problem. This approach efficiently solves large scale instances within practical computation times.

■ HE-32

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 14 (Building: JUR)

Cutting and packing IV

Stream: Cutting and Packing
Invited session
Chair: *Arthur Leonard*
Chair: *François Clautiaux*

1 - A Unified Exact Algorithm for Multiple Variants of Heterogeneous 2D Bin Packing
Roberto Baldacci, Sunkanghong Wang, Lijun Wei, Qiang Liu, Fabio Furini, Zhou Xu

We study the two-dimensional heterogeneous bin packing problem, packing rectangular items into bins of varying sizes and costs to minimize total cost. Extensions include guillotine constraints and limits on the number of bins per type, reflecting practical cutting and resource constraints. We propose three mathematical formulations with strengthening techniques, derive tight lower bounds, and develop a unified exact solution framework. Computational experiments show the effectiveness of the proposed solution approach.

2 - Arc-flow formulation for a two-stage two-dimensional dual bin packing problem to optimize wood reuse
Pauline Bessemans, Célia Paquay, Morgane Dumont

We aim to manage wood waste more efficiently through optimization techniques to recycle it into Cross-Laminated Timber (CLT) panels of variable dimensions. The inputs are slats with heterogeneous lengths. In the literature, our problem is a two-stage two-dimensional multiple bin size dual bin packing problem that we apply to wood reuse optimization. We propose a description of the problem and an arc-flow formulation that maximizes the wood reused, and present the results of numerical experiments based on realistic instances from the wood industry.

3 - Mixed-Integer and Constraint Programming Solutions to the Two-Dimensional First-Order Non-Guillotine Cutting Problem
Adam McGregor, Sergey Polyakovskiy, Rym M'Hallah

We consider the two-dimensional first-order non-guillotine cutting of a single plate. We propose a constraint programming (CP) model and its mixed-integer programming (MIP) variant. Both are assignment-based models that build a tree of non-guillotine cuts using a constant number of rectangular regions, with some regions allocated to items. Given a plate as the parent region, they decide on cuts required to split the regions recursively till they produce space for the items. Both models are strengthened with a variety of symmetry-breaking constraints. They outperform the state-of-the-art MIPs.

4 - An Efficient Solver for Integral Flows in Decision Hypergraphs with Applications to Orthogonal Knapsack Problems
Arthur Leonard, François Clautiaux

We study guillotine knapsack problems using decision hypergraphs. We design an efficient algorithm using bounds from linear programming techniques and an improved labeling algorithm. Our implementation beats the state of the art for the 2-dimensional any-stage problem, solving more than 63/80 instances (compared to the 22/80 previously achieved on the Velasco & Uchoa instances) using new valid inequalities that allows us to reduce the LP upper bounds, and their efficient usage in a refined labeling algorithm that reduces the total memory footprint significantly.

■ HE-33

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 15 (Building: JUR)

Train Scheduling Optimization

Stream: Passenger Railway Transportation
Invited session
Chair: *Yuan Gao*

1 - Integrated bus bridging service design and vehicle scheduling considering passenger flow control strategy in an oversaturated metro network
Chuntian Zhang, Jiawei Geng, Lixing Yang, Ziyou Gao

We propose an integrated optimization approach for bus transit planning and metro passenger flow control to recommend efficient travel routes. The framework jointly considers bus timetable design with uneven headways, multi-depot vehicle scheduling with multi-route operations, and passenger assignment in a multimodal system with coordinated bus bridging services and train operations. The problem is formulated as an ILP on a space-time-mode network and solved using a Lagrangian relaxation and column generation heuristic with dynamic programming.

2 - Learning-based Model Predictive Control for Train Timetabling and Rolling Stock Circulation Planning with Flexible Train Composition on Y-type Metro Lines
Kun Ji, Yihui Wang, Andrea D.Ariano, Zhengwen Liao, Jiateng Yin

To address uneven passenger demand on Y-type metro lines, this paper proposes an integrated MINLP model that jointly optimizes timetables, rolling stock circulation, and train composition within an MPC framework. To enable real-time operation, a learning-based approach is proposed that uses offline-trained LSTM models to selectively predict key binary decisions, thereby reducing computational complexity. Experiments based on Guangzhou Metro Line 14 show that the proposed approach achieves real-time timetabling with only marginal feasibility loss.

3 - Integrated timetable and rolling stock circulation rescheduling on high-speed railways
Shuguang Zhan, Jianhao Zhang

We investigate integrated timetable and rolling stock circulation rescheduling. To jointly minimize the cost of train delays and rolling stock circulation, a mixed-integer linear programming model is constructed based on an extended time-space network incorporating depot nodes and rolling stock circulation arcs. A column generation-based framework is proposed to solve the model. Train path variables are generated conventionally, whereas a lazy generation strategy is applied to rolling stock variables. A diving heuristic is integrated to rapidly yield high-quality integer solutions.

4 - A two-stage robust optimization approach for train service planning under reservation-based passenger demand
Yuan Gao, Lin Yang, Valentina Cacchiani

Driven by ICT advances, this study explores a two-stage robust optimization model for demand-responsive railway planning. It categorizes passengers into long-term (early flexible booking) and short-term (uncertain demand). Stage one defines stop patterns, train compositions, and seat assignments; stage two reallocates seats once demand is realized. An enhanced inexact column-and-constraint generation (Ei-C&CG) algorithm is developed to solve the model. Results using real-world data show Ei-C&CG is more efficient than classic methods and highlights the value of robust planning.

■ HE-34

Thursday, 14:15-15:45 - Room: JUR - Hörsaal 16 (Building: JUR)

Air Traffic Management

Stream: Passenger air transportation: airlines and airports
Invited session
Chair: *Marjan van den Akker*

1 - Scheduling Flights with Reduced Runway Capacity
Philip de Bruin, Marjan van den Akker

The availability and capacity of runways has a big impact on an airline's operations, especially on the hub airport of an airline. To deal with runway capacity reductions, one needs to determine which flights to cancel and which to delay. We look at scheduling flights where the duration of the capacity reduction is uncertain. We present an optimization algorithm where we determine which flights to cancel and minimize future expected delay costs. This work is done in collaboration with KLM Royal Dutch Airlines.

2 - Dynamic Arrival Routes in a Terminal Maneuvering Area with Integrated Operational Factors
Roghayeh Hajizadeh, Tatiana Polishchuk, Elina Rönnberg, Christiane Schmidt

We consider the computation of dynamic arrival routes: routes from all entry points of a terminal maneuvering area that merge traffic arriving within a given time interval toward the runway while guaranteeing separation and enabling optimal descent profiles. We propose a new model based on a Dantzig-Wolfe reformulation of a previous approach. Computational experiments for Stockholm Arlanda Airport show that the new model consistently outperforms the previous one and can incorporate practical aspects such as atmospheric conditions and aircraft remaining in the TMA from a previous period.

3 - A Time-Space Network Model and Branch-and-Price Algorithm for eVTOL Scheduling in Urban Air Mobility
Wenjing Liu, Shuai Jia

This paper addresses the deterministic scheduling problem for eVTOL aircraft in Urban Air Mobility. A time-space network integer programming model is developed to plan eVTOL flight paths, incorporating vertiport capacity, multi-route selection, and safety separation enforced via departure time intervals, with the objective of minimizing operational and delay costs. The problem is solved by a branch-and-price algorithm, where the pricing subproblem is a resource-constrained shortest path problem. Acceleration techniques include heuristic algorithms and parallel computing.

4 - Cross-organisational coordination for planning airport turnaround operations.
Silvia Padron, Maurizio Tomasella, Elisa Guardo, Daniel Guimarans, Cemalettin Ozturk

Planning turnaround operations on the apron requires coordination between airlines, airport operators, and third-party ground handlers. Conflicting objectives and power imbalances often hinder collaboration and reduce operational performance. This paper proposes and models alternative coordination settings with varying levels of ground handler participation in decision-making. Results suggest that granting handlers autonomy to manage resource constraints, combined with feedback from a coordinating organisation, improves the efficiency of resource plans and the overall robustness of the apron.

■ HE-35

Thursday, 14:15-15:45 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Energy Management toward a Sustainable Future

Stream: Operations Research and Sustainability
Invited session

1 - Optimism, Pessimism, And Chaos Worldwide: A Comparative Study of Energy Management Performance with Robust Benchmarking Methods
Filipe Farinhas, Diogo Cunha Ferreira, Guilherme Vara, Paulo Caldas

Assessing national Energy Management Performance (EMP) faces challenges like weighting subjectivity and outlier sensitivity. This study evaluates EMP across 174 countries (c. 2022) using 13 indicators, Benefit of the Doubt (BoD) modeling, and order-m analyses accounting for 9 environmental variables. Results reveal a negative correlation between optimistic and pessimistic ranks, indicating specialization. Crucially, rankings remained highly stable when adjusting for context, meaning environmental influence proved minimal due to high baseline BoD performance.

2 - Robustness of Benefit of the Doubt in Energy Management Performance Assessment: A Hit-and-Run Randomized Weights Approach Across 174 Countries
Diogo Cunha Ferreira, Filipe Farinhas, Guilherme Vara, Paulo Caldas

Benefit-of-the-Doubt (BoD) models flexibly assess national energy management performance but may overestimate results due to optimization bias. This study proposes a hybrid BoD-Hit-and-Run (H&R) sampling approach to improve robustness. Using 13 indicators for 174 countries (2022), 100,000 simulations per country explored the feasible weight space. Conventional BoD scores showed a significant upward bias (+0.2381). Although rank correlation remained high (ρ0.934), some countries shifted up to 111 places, revealing sensitivity to weighting and enabling more reliable energy benchmarking.

3 - Multi-period multi-objective green hydrogen import route utility optimization
Louis Vincent Sroka, Frank Meisel

We propose a multi-period, multi-objective optimization model for green hydrogen import route selection. The model evaluates single- and multi-source import networks across a planning horizon, integrating criteria such as cost, emissions, social progress, resilience, and technology readiness into a weighted utility function. Benchmark-based normalization ensures cross-criteria comparability. Results identify robust import strategies under varying stakeholder preferences and reveal dynamic trade-offs between cost efficiency, network complexity, and sustainability.

■ HE-36

Thursday, 14:15-15:45 - Room: JUR - Seminar-Raum 42 (Building: JUR)

Resilient Infrastructure Systems

Stream: Building Resilient Systems
Invited session
Chair: *Jian Zhou*

1 - Optimal Renewal Planning for Sewage Treatment Facilities in Japan
Taichi Sakamoto, Taira Ozaki, Hiroshige Dan

In Japan, efficient maintenance and management of sewerage infrastructure has become a serious challenge due to aging facilities and population decline. To address this issue, we propose a method for constructing a renewal plan that minimizes the total cost over the next 45 years. For each sewage treatment facility, one of three renewal options must be selected: maintaining the status quo, consolidation, or decentralization. The proposed method determines the optimal renewal options and their timing by solving two optimization problems: a shortest path problem and a set partitioning problem.

2 - Optimal Maintenance Planning for Road Tunnels in Japan Based on Deterioration Prediction
Hiromu Saito, Masakazu Sako, Naoki Sato, Hiroshige Dan

Developing an effective maintenance plan for road tunnels is essential for preventive maintenance. For this purpose, accurate deterioration prediction is crucial. In Japan, the condition of road tunnels is evaluated using a five-category rating system based on guidelines issued by the supervisory authority. In this study, we predict the deterioration of road tunnels in Japan and develop an optimal maintenance plan based on the predicted deterioration. To estimate the expected duration of each assessment category, we employ a mixed Markov hazard model.

3 - Challenges in Distributed Grid Restoration for a Resilient Energy Infrastructure
Sarnavi Mahesh, Hatice Calik, Georg Jung, Dirk Van Hertem

Distributed grid restoration enables power systems to recover from widespread outages by concurrently energizing production, network segments, and loads without central control. Decentralized restoration is enabled by increasing distributed generation. It introduces new challenges including optimal placement of synchronizing switches, optimal asset activation sequences, state estimation, and resilient dynamic control under disrupted communications. We investigate mixed-integer and stochastic optimization, graph-based planning, topology-aware state estimation, and decentralized control methods.

4 - Resilient interconnected-microgrid expansion planning with combined cooling, heating, and power: considering power trading and pricing
Jian Zhou, Yifan Zhang, Xiangxiang Li, Xiaoting Nie

To enhance power system resilience, this paper presents an expansion planning framework for Interconnected Microgrids (IMGs) with CCHP. We propose a decentralized trading mechanism with adaptive pricing for dynamic operation modes. The problem is formulated as a Markov Decision Process and solved via Deep Reinforcement Learning to optimize strategies for cost and reliability. Results confirm the model improves resilience, reduces emissions, and validates the pricing mechanism's effectiveness in resource allocation.

■ HE-37

Thursday, 14:15-15:45 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Dynamics of the Firm 1

Stream: Dynamics of the Firm
Invited session
Chair: *Konstantin Kogan*

1 - Investment, capital structure, strategic debt service, and financing constraints
Takashi Shibata, Michi Nishihara

We develop a dynamic real options model to examine how debt financing constraints influence a firm's investment, financing (capital structure), and debt renegotiation (strategic debt service) decisions.Our findings show that these constraints do not always delay investment, although they always reduce debt issuance, resulting in lower credit spreads and lower leverage. These results are consistent with existing empirical evidence.

2 - Optimal Capacity Investment under Uncertain Technological Innovation
Carlos Oliveira, Peter Kort, Maria Lavrutich, Afonso Moreira, Cláudia Nunes

This paper studies how firms should optimally time and size their investments when facing sequential technological innovations. Building on Grenadier and Weiss (1997), we incorporate endogenous capacity choices into a real-options framework where a superior technology arrives at an uncertain time. We characterize the optimal investment thresholds, the interaction between early investment in an established technology and future upgrade decisions, and how drift and volatility in technological progress shape firms' incentives to wait.

3 - A class of linear-quadratic stochastic problems: The effect of state unobservability
Konstantin Kogan, Matan Shnaiderman, Ahiad Miness

Stochastic linear-quadratic problems are common in optimal control and differential games. Standard solutions rely on feedback control and implicitly assume observable state dynamics, an assumption often violated in practice. We derive an optimal open-loop control and compare it with the optimal feedback solution to assess the impact of state unobservability. Interpreting the state as a resource, we show that when both approaches converge to a steady state, the open-loop control and the expected steady-state resource level may be higher or lower than under feedback control.

■ HE-38

Thursday, 14:15-15:45 - Room: JUR - Seminar-Raum 44 (Building: JUR)

Supporting Planning and Sustainability

Stream: Soft OR and Problem Structuring Methods
Invited session
Chair: *Isabella Lami*

1 - From Global Goals to Local Choices: A Participatory Path to Urban Sustainability Indicators
Francesca Abastante, Beatrice Mecca

This research aims to return a participatory process to select urban sustainability indicators aligned with the SDGs, addressing the challenge of localizing global targets at the city level. Through the engagement of multiple stakeholders, official and innovative indicators were reviewed, discussed and contextualized. The process led to a shared set of 27 indicators supporting urban planning, project evaluation and more informed, sustainability-oriented decision-making. The research result constitutes one of the outcomes of GLOSSA, a Project of Relevant Interest (PRIN).

2 - Building and Defending Urban Strategies: Argumentation as a Key Competence
Beatrice Mecca, Marta Bottero, Isabella Lami, Alexis Tsoukias

This paper proposes argumentation theory as a pedagogical tool in PhD training in urban studies to strengthen students' ability to design planning strategies and defend them in conflictual decision-making contexts. Through a simulated urban project, students develop and justify a project option, respond to peer critiques, and debate before a professor acting as judge. The study describes the methodological design of the exercise, the strategies adopted, and the argumentation schemes that emerged, highlighting its value for developing critical and decision-making skills in urban planning.

3 - Sheerwater as an evolving community
Jose-Rodrigo Cordoba-Pachon, Alberto Paucar-Caceres

This paper proposes and reflects on an approach that combines historical research about the housing estate of Sheerwater in the UK with the use of soft operational research (Soft OR) methods. Through a practical project in which we involved Sheerwater residents in 2025, we

have learned of the importance of considering communities as evolving system in two ways: a). Notions or visions of community can shift through time, and b) so the identities of researchers. Both of these insights could have have important implications for the practice of community operational research (COR).

4 - When Generative AI enters the workshop: evidence from two AI-supported sessions in problem structuring
Isabella Lami, Elena Todella, Leroy White

What happens when Generative Artificial Intelligence (GenAI) enters the workshop? In this study, we address a gap in Soft OR by examining how GenAI interacts with humans during decision-making. Across two AI-supported workshops, we analyse post-workshops reports via an iterative coding process. Findings show how AI shapes discussions, roles, trust and efficiency, but also when bounded, generic or unreliable outputs can limit value. Accordingly, facilitation becomes the hidden battleground on which Soft OR theory must focus to keep it contestable, preserve ownership, and sustain legitimacy.

■ HE-43

Thursday, 14:15-15:45 - Room: JUR - Seminar-Raum 63 (Building: JUR)

Metaheuristics and applications

Stream: Metaheuristics
Invited session
Chair: *Nysret Musliu*

1 - Heuristic Strategies for finding Feasible Virtual Network Embeddings
Jorge Sánchez, Sergio Cavero, Eduardo G. Pardo

We tackle the online virtual network embedding problem that maps multiple virtual networks onto a single physical substrate while satisfying capacity constraints. The difficulty lies in finding feasible mappings as new embedding requests arrive. In this research we propose heuristics to establish minimal feasibility criteria based on the problem constraints to determine whether a request can be satisfied. If it can be satisfied, we use a greedy constructive to embed the network. These strategies have been theoretically and experimentally validated across a variety of topology instances.

2 - Automating Peptide Marker Discovery to Enhance Taxonomic identification in Paleoproteomics
Valentin Hottlet, Hélène Touzet, Julie Jacques

Paleoproteomics identifies species using collagen peptides from mass spectrometry. Its limitation is that it uses manually defined peptide markers, preventing the identification of closely related taxa. So, we propose a robust automated approach to discover diagnostic peptides. The problem is formulated as a feature selection task solved with Local Search and Genetic Algorithms. Their objective is to find the subset of peptides that maximises the hierarchical F1 score by embedding the PAMPA tool to evaluate on real spectra, discriminating simultaneously between different taxonomic groups.

3 - Solving Parallel Machine Scheduling With Precedences and Cumulative Resource Constraints With Calendars
Felix Winter, Lukas Frühwirth, Matthias Horn, Marie-Louise Lackner, Patrick Malik, Matthias Moik, Christoph Mrkvicka, Nysret Musliu

Recently, in the manufacturing industry, unique precedence and calendar resource constraints have arisen that cannot be efficiently solved by existing methods, creating the need for innovative automated scheduling techniques.

We introduce a novel machine scheduling variant with job precedences and calendar-based resource constraints. A constraint modeling approach is proposed as an exact method, and we develop a local search metaheuristic to tackle large-scale problems.

Experiments show that the investigated methods can provide high-quality results on realistic, large-scale problems.

■ HE-45

Thursday, 14:15-15:45 - Room: HG - Seminar-Raum 01 (Building: HG)

Advances in inverse optimization

Stream: Data-driven Stochastic (Inverse) Optimization
Invited session
Chair: *Kimia Ghobadi*
Chair: *Houra Mahmoudzadeh*

1 - Inverse Markov decision processes with noisy data
Archis Ghate

Inverse optimization in Markov decision processes (MDPs) involves finding reward and transition probability parameters that would render a given policy optimal. We will present a noisy version of this problem, where multiple policies are given. We will illustrate that this problem is nonconvex bilinear and discuss tailored solution methods.

2 - Uncertainty Quantification in Inverse Optimization
Nasrin Yousefi, Timothy Chan, Nathan Sandholtz

In applied optimization, observed decisions often deviate from true optima due to noise from measurement, modeling, or human error. This complicates inverse optimization (IO), which aims to recover unknown model parameters from data. We propose a fully Bayesian framework that jointly estimates model and noise parameters. Using MCMC methods, we approximate the posterior distribution and construct credible regions to quantify uncertainty. Numerical results show reliable coverage and decreasing uncertainty as sample size grows.

3 - Statistical Inverse Optimization with Noisy Decisions
Kimia Ghobadi, Farzin Ahmadi, Fardin Ganjkhanloo

Inverse optimization can be reframed to jointly estimate unknown parameters and a latent optimal solution from noisy data. We explore asymptotic statistical guarantees through maximum likelihood estimation as well as finite sample guarantees through concentration inequalities. We discuss how these extensions form a unified toolkit for rich data and guaranteed performance when observations are scarce. Numerical results and real-world case studies illustrate the trade-offs and benefits of inverse learning with expert constraints.

4 - Inverse Learning of Clinical Trade-offs in Radiation Therapy
Houra Mahmoudzadeh, Rana Shiravi, Bradley Hallett, Johnson Darko, Ernest Osei

Radiation therapy treatment planning involves complex trade-offs between tumor coverage and healthy tissue sparing. In this paper, we use inverse optimization (IO) to learn from past treatments and identify clinically relevant pair-wise trade-offs. Through clustering, similar constraints are grouped, and a data-driven goodness-of-fit metric selects meaningful, representative trade-offs that reflect observed planning behaviour. Using prostate cancer data, we demonstrate how these trade-offs connect historical planning with clinical guidelines, making data-driven IO models more practical.

■ HE-46

Thursday, 14:15-15:45 - Room: HG - Seminar-Raum 02 (Building: HG)

New challenges in scheduling 3

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Stanislaw Gawiejnowicz*

1 - A Mixed-Integer Programming Model for Cooperative Scheduling and Subcontracting under Yield Decay
Selin Özpeynirci, Burak Gokgur, Ipek Tanil Can

This study introduces a mixed-integer programming framework to analyze cooperative scheduling and outsourcing decisions for perishable products affected by yield decay. We study two manufacturers that share a subcontractor, operate under sequence-dependent setup times, and aim to schedule their operations to maximize profit. No subcontracting, non-cooperative subcontracting, and cooperative scheduling strategies are assessed. Our illustrative example and extensive numerical experiments across different scenarios demonstrate notable efficiency gains with cooperative subcontracting.

2 - New results in scheduling in time-dependent shops
Stanislaw Gawiejnowicz

We consider several open problems of scheduling proportional jobs in time-dependent shops with the criterion of minimizing the schedule length. First, we summarize the previous research, focusing on the applied proof methods. Next, we indicate some relations between the open problems and their classical counterparts. Finally, based on these relations and their consequences, we show how to solve the considered time-dependent scheduling problems.

3 - Flexible Multitier Scheduling for Dynamic Operational Demands
Julio Lopez, Santiago Reinal Giménez, Ángel M. González-Rueda

This study applies scheduling methods to work shift allocation in a fashion retailer using a divide-and-conquer strategy. The complexity of the scheduling problem is reduced by decomposing it into manageable subproblems. The methodology optimizes shift distribution and ensures compliance with labor regulations and employee satisfaction. One of the key challenges is the non-fixation of shifts and the high flexibility that exponentially expands the solution space. Results show that a multi-level strategy is a powerful tool for solving complex scheduling problems in flexible work environments.

4 - Dynamic Programming for Fixed-Order Parallel Machine Scheduling with Sequence-Dependent Setups and a Single Server
Andrzej Gnatowski

This work proposes an exact dynamic programming (DP) algorithm for the job-to-machine assignment problem on unrelated parallel machines with fixed technological order, sequence-dependent setups, single-server constraint and makespan minimization. The problem occurs in cells where machines share one server (human or robotic), forcing strictly sequential, non-overlapping execution of jobs and setups. For any fixed number of machines, the asymptotic time complexity of the proposed DP is polynomial. Benchmarks DP vs. Gurobi MILP show DP is faster on instances with realistic sizes.

■ HE-47

Thursday, 14:15-15:45 - Room: HG - Seminar-Raum 03 (Building: HG)

Last mile delivery

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Benxuan Miao*

1 - When Small Parcels Matter: Trade Facilitation and Firms' Trademark Strategies
Mohsen Kermani, Jan van Dalen

This paper studies how trade facilitation policies influence firms' intellectual property strategies. Exploiting the 2016 increase in the U.S. de minimis import threshold from $200 to $800, we examine how changes in border enforcement affect trademark filings. Using a novel dataset linking U.S. Customs and Border Protection counterfeit seizures with trademark registrations, we implement a difference-in-differences design to show that firms more exposed to counterfeiting increase both the number and scope of trademark filings when enforcement weakens.

2 - Robust Optimization of Drone Delivery Locker Locations Based on Queuing Theory under Demand Uncertainty
Yiyi Xiao

This paper firstly proposes the network design for drone delivery locker locations in low-altitude delivery scenarios, balancing consumer accessibility and service provider costs. The two-stage framework addresses short-term uncertainties via queueing-based stochastic programming with second-order cone reformulation, and long-term uncertainties via robust optimization. The resulting model is efficiently solved using a nested column-and-constraint generation algorithm. Numerical experiments validate the effectiveness of the approach and offer practical managerial insights.

3 - Strategic Multi-Sourcing Under Supply Disruptions: A Game-Theoretic Analysis of Supplier Competition and Buyer Resilience
Benxuan Miao

Although multi-sourcing under supply disruptions has been widely studied, the challenge of designing contracts that incentivize supplier reliability investment remains unresolved. This paper develops a game-theoretic framework analyzing one buyer and two suppliers with heterogeneous disruption risks in a three-stage Stackelberg game. We show decentralized decisions lead to underinvestment in reliability, and quantity-discount contracts can coordinate the supply chain. Under asymmetric information, we characterize the separating equilibrium and quantify efficiency loss.

■ HE-49

Thursday, 14:15-15:45 - Room: HG - Seminar-Raum 05 (Building: HG)

Data-Driven Demand Management with Learning-Based Approaches

Stream: Data-Driven Demand Management
Invited session
Chair: *Niloufar Sadeghi*

1 - Machine Learning Applications in Bundle Pricing Problem
Ezgi Karabulut, Burak Gokgur

We study a pricing problem in a multi-segment market with multiple products and their bundle combinations. A customer arrives from a random, unknown segment, and only the observed purchase decision is available. Using these purchase observations, we learn the segment probabilities and product valuations in order to determine revenue-maximizing prices. We propose algorithms that address this joint learning and pricing problem under different market structures.

2 - Reinforcement Learning for Choice-Based Dynamic Models in Revenue Management: A Comprehensive Benchmark
Fabian Lange, Cornelia Schön-Peterson

Reinforcement Learning (RL) has emerged as a class of algorithms for optimizing sequential decisions under uncertainty, yet its performance relative to established dynamic programming (DP) approaches remains unclear. We benchmark six discrete-action RL algorithms on the choice-based dynamic model of Talluri and van Ryzin under multiple demand specifications. Our results show substantial differences across RL algorithms. Under demand misspecification, RL exhibits robustness; however, DP solutions remain unexpectedly competitive in both solution quality and efficiency.

3 - Dynamic Guardrails in Reinforcement Learning for Pricing Problems
Adam Page, Anna-Lena Sachs, Christopher Kirkbride, James A. Grant

Reinforcement learning is used by vendors to dynamically price perishable products to maximise their revenue. These methods allow the pricing problem to be solved without knowledge of demand. When choosing exploration schemes, one usually focuses on learning fast and correctly, regardless of actions taken in the process. Unrestricted exploration in pricing has clear issues: setting extreme prices leads to financial or reputational damage. Safe exploration is addressed through the introduction of guardrails that dynamically adapt the action space by following a two-stage truncated-beta policy.

■ HE-51

Thursday, 14:15-15:45 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Hub and Service Network Design

Stream: Hub Location and Network Design
Invited session
Chair: *Borzou Rostami*

1 - Optimizing Multi-Stakeholder Freight Transportation Systems: Resource Allocation Strategies and the Economic Value of Reliability
Mojtaba Hosseini, Gita Taherkhani, Ali Hassanzadeh

This study examines capacity planning and service network design in less-than-truckload freight systems coordinated through a M1M platform matching shippers with carriers. We incorporate heterogeneous resource types and integrate strategic capacity allocation with tactical service network design. We develop a stochastic, risk-aware model using CVaR to produce resilient transportation plans that balance profitability, reliability, and operational stability. We present an several exact and approximate solution methods based on Benders decomposition to tackle large instances.

2 - Multi-period p-hub center problem with nesting property
Nader Ghaffarinasab

We introduce the multiple allocation nested p-hub center problem, a variant of multi-period hub location problems. Over a planning horizon with a given set of origin-destination flows, hubs must be selected for each period with non-decreasing cardinality and nesting property, i.e., the hubs in period t must be a subset of hubs in period t+1. The goal is to minimize the sum of maximum transportation costs across all periods. A mixed-integer programming model and an accelerated Benders decomposition algorithm are proposed to efficiently solve large-scale instances.

3 - Fleet Sizing under Demand Uncertainty with Contextual Information
Borzou Rostami

We study fleet sizing in transportation networks under demand uncertainty through a contextual stochastic optimization framework. The approach incorporates observable contextual factors, such as seasonality and market conditions, to improve demand estimation, while imposing loss-ratio constraints to control expected shortages relative to available capacity. We develop a data-driven solution method combining nonparametric learning and integer programming, establish its asymptotic optimality, and demonstrate its computational tractability in practical settings.

■ HE-52

Thursday, 14:15-15:45 - Room: KOL - PC Raum 1 (Building: KOL)

Game Theory & Strategic Behavior in Energy

Stream: Energy Markets & Systems
Invited session
Chair: *Afzal Siddiqui*

1 - Assessing optimal capacity mix models in competitive electricity markets
Irena Milstein, Asher Tishler, C.k. Woo

This paper examines two issues in modelling optimal capacity mix in competitive electricity markets. First, we assess the impact of demand uncertainty by comparing models with stochastic and deterministic demand. Second, we analyze the impact of the variability of solar PV generation, whose hourly output (HO) depends on solar radiation and varies over the day and across seasons. We show that deterministic demand and only two daily, non-seasonal, HO values provide adequate estimates of optimal capacity. Our framework is general and applicable to regions such as California, Texas, and Australia.

2 - Reliability of Cooperative Multi-state System with Performance Sharing and Maintenance Cost Allocation
Guanhua Huang

We study a stochastic multi-state performance-sharing model in which interconnected components reallocate surplus capacity through a common bus to cover shortages. In the divisible-sharing formulation, coalition cost is the expected optimal recourse cost. We show that the induced cooperative cost game is balanced, so the core is nonempty and full cooperation is sustainable. The dual also yields an explicit price-based stable allocation. Computational tests show that complementary risk profiles increase cooperation gains, while tighter shortages raise scarcity rents and settlement differences.

3 - Strategic Behavior under Production Quotas: The Case of OPEC
Jakub Illík

This paper analyzes strategic interactions among OPEC member states under production quotas using a static Cournot-Nash framework with heterogeneous producers. The model examines how cost convexity, fiscal dependence on oil revenues and imperfect quota enforcement shape incentives to exceed quotas and affect organizational stability. Initial results indicate that stronger fiscal pressure increases incentives for quota deviations. Ongoing research extends the framework to dynamic interactions and fuzzy set methods capturing uncertainty from imperfect data.

4 - Heat and Power: Sector Coupling and Strategic Incentives in Sweden's Electrification Pathway
Afzal Siddiqui, Kirstine Roberts, Juuso Seuri

Sweden's aim for carbon neutrality by 2045 requires widespread electrification, expansion of low-emission technologies, and increased sector coupling. Combined heat and power plants and heat pumps (HPs) are both flexible, low-emission generation assets that better integrate district-heating (DH) and power sectors. However, increased HP capacity could bolster firms' ability to exert market power with ensuing welfare and emissions impacts. We develop a Nash-Cournot model of Swedish DH and power sectors to examine how economic and environmental outcomes are affected by HP adoption.

■ HE-57

Thursday, 14:15-15:45 - Room: HG - Seminar-Raum 07 (Building: HG)

AI in Behavioral OR 2

Stream: Behavioural Operational Research
Invited session
Chair: *Wieland Müller*

1 - Demonstration of a Meta-Model which integrates between a method of MCDM and designing of AI-embedded DSS.
Gil Greenstein

The current research tries to illuminate how to integrate the principles of MCDM (Multi Criteria Decision Making) into a comprehensive method for analysis of an analytical model which instructs how to design a DSS properly in the AI era. The purpose of this research is to develop and show a Meta-Model for processes of Analysis and Design of DSS. This Meta-Model should integrate between DSS, Usage of Generative AI tools and decision-making. The implementation of this Meta-model should help to bridge the Gap that prevents us from making automatic (structured) decisions.

2 - AI, Corporate Governance, and Service Quality in Antioquia's Credit Unions
Yony Fernando Ceballos, Maria Fernanda Piedrahita, Jenny Moscoso, Luis Horacio Botero

This quantitative study analyzes the relationship between AI adoption, corporate governance, and service quality in credit unions in Antioquia (Colombia). Using a descriptive-correlational design, data from executives, employees, and customers were analyzed. Results show a positive correlation between AI integration and strengthened governance, enhancing service quality and operational efficiency. Findings suggest that AI contributes to financial inclusion and institutional trust. In conclusion, AI strategic integration, backed by solid governance, is vital for the sector's sustainability.

3 - From Algorithmic Aversion to Appreciation: Conversational AI in Health Risk Communication
Md Rifayat Islam Rushan, K.Nadia Papamichail, Kenneth R. Muir, Artitaya Lophatananon

Despite growing interest in conversational generative AI (GenAI) applications in healthcare, individuals often remain reluctant to follow algorithmic advice. This experimental study examines how interactions with conversational GenAI tools such as ChatGPT (compared with human providers) affect behavioural responses to health risk communications. Drawing on algorithmic folk and signaling theory, we illustrate how human-AI interaction shapes decision behaviour in AI-supported decision contexts and identify the conditions under which it enhances AI appreciation and improves risk communication.

■ HE-58

Thursday, 14:15-15:45 - Room: HG - Seminar-Raum 08 (Building: HG)

Scheduling and Resource Allocation

Stream: Healthcare OR in developing countries
Invited session
Chair: *Raha Akhavan-Tabatabaei*

1 - Balancing Efficiency and Preferences in Medical Doctor Scheduling: An Optimization Approach for Imaging Services in Uruguay
Gastón Notte, Alfonso Calandra, Juan Pedro Tornoni, Julieta Viera, Pedro Piñeyro

Healthcare scheduling is crucial for efficiency. Excessive shifts can cause staff burnout, compromising service quality and patient care. This study addresses medical doctor scheduling in imaging services in Uruguay, minimizing overtime to reduce institutional costs while incorporating preferences through staff-requested shifts. A multi-objective model was implemented for the problem, based on the Goal Programming approach and considering real-world instances. Results show these models reflect operational reality, highlighting trade-offs between efficiency and the medical doctors' well-being.

2 - Improving Rehabilitation Scheduling through Multi-Criteria Decision Support Approach for Patient Prioritisation in Rehabilitation Services
Keiny Meza-Vasquez, Raxá Aguilar, Mauricio Moyano, Guillermo Cabrera-Guerrero

Access to rehabilitation services is frequently constrained by limited specialist resources and the growing waiting list. Many healthcare centres still allocate appointments on a First In, First Out, which overlook clinical urgency. This study proposes a decision support system for patient prioritisation in rehabilitation based on multi-criteria decision-making. The approach integrates clinical, functional, and social criteria to produce transparent priority rankings. A real-world case study demonstrates its potential to support fairer and more consistent allocation of rehabilitation services.

3 - Surgery Scheduling Using Optimization, AI and Machine Learning in a public hospital in Chile
Jorge Vera, Alexander Böhm, Jorge Jacque

Chile presents long waiting in its complex healthcare system. One important area is surgery scheduling and OR tools for this problem can be complemented with Artificial Intelligence and Machine Learning. We present an optimization approach for scheduling surgeries in a public hospital, which considers various uncertainties. Patients are prioritized based on their DRG groups, which are predicted with AI analysis of patient records. We also discuss extensions using Decision Focused Learning to address the whole large-scale model. We show preliminary results with real, as well as synthetic data.

4 - Dynamic Multi-Priority Resource Allocation in Breast Cancer Diagnostic Care
Raha Akhavan-Tabatabaei, Mahour AbbaspourKhiabani, Sina Ansari

Timeliness is key for the best possible prognosis in breast cancer care, yet many systems face delays due to rising demand and limited resources, especially in developing countries. These delays particularly affect diagnostic mammography, where urgency and service times differ from routine screening. We develop a dynamic resource allocation model for stochastic demands of multi-priority patients that adapts OR methods from prior "advance scheduling" studies to the specific operational challenges of breast cancer diagnostics, aiming to improve efficiency, equity, and wait-time performance.

■ HE-59

Thursday, 14:15-15:45 - Room: KOL - Seminar-Raum 9 (Building: KOL)

Pairwise comparisons and preference relations 3

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Matteo Brunelli*
Chair: *Jiri Mazurek*
Chair: *Konrad Kulakowski*

1 - Structural Equivalence and Quasi-Consistency of Pairwise Comparison Matrices in AHP
Tsuneshi Obata, Shunsuke Shiraishi

Pairwise comparison matrices may look different when item order changes, even if based on the same judgments. They share the same comparison structure and thus the same consistency; we call them structurally equivalent. In the Analytic Hierarchy Process (AHP), consistency requires exact weight ratios, but real judgments rarely meet this. Such inconsistencies range from cyclic judgments to milder cases that follow an overall ranking. This study demonstrates that structural equivalence provides a useful basis for distinguishing severe inconsistency from milder, quasi-consistent situations.

2 - On a Maximization Problem Arising from Low-Dimensional Positive Reciprocal Matrices in AHP: Uniqueness of the Solution
Shunsuke Shiraishi, Tsuneshi Obata

When a pairwise comparison matrix contains missing values, various methods have been proposed. We focus on the third coefficient of its characteristic polynomial and adopt maximizing it toward zero as a consistency criterion. The resulting problem can be formulated as a convex minimization problem. We show that, for low-dimensional cases, uniqueness of the solution is equivalent to connectedness of the graph generated by the incomplete matrix.

3 - Comprehensive Decision Analysis via Interval Priority Estimation from a Crisp Pairwise Comparison Matrix
Masahiro Inuiguchi, Yeyang Hong, Shigeaki Innan

The good performances of interval priority weight (IPW) estimation methods have been shown by numerical experiments assuming the DM's vague evaluation. We investigate a decision analysis via the IPW estimation from a crisp pairwise comparison matrix for multiple criteria decision problems. The IPW estimation problem has a nonunique solution, which is obtained as a line segment in the IPW vector space. We propose a decision analysis with the solution set using the Hurwicz rule. The proposed method provides an explainable and detailed analysis with the comprehension of DM's hesitation.

■ HE-60

Thursday, 14:15-15:45 - Room: KOL - Seminar-Raum 10 (Building: KOL)

Risk management with digital securities

Stream: OR for Insurance, Banking and Financial Risk
Invited session
Chair: *Roy Cerqueti*

1 - Liquidity Dynamics and Price Discovery in Cryptocurrency Perpetual Futures: An Agent-Based Modeling Approach
Sascha Hägele

This study uses an agent-based model to investigate price discovery and liquidity in cryptocurrency perpetual futures. By simulating exchanges such as Binance and Bybit, the model isolates the effects of funding mechanisms and market maker behavior on basis convergence. The results show that, while the designs ensure price efficiency under normal conditions, wider spreads and reduced participation can lead to substantial peg deviations and non-random clustering. These findings underscore the importance of liquidity in maintaining price stability and offer valuable insights for exchange design.

2 - Volatility and Risk Analysis of the Cryptocurrency Market through GARCH Models (2017-2025)
Marta Tolentino, María del Valle Fernández Moreno, Irene Villalba

This study analyses the volatility and risk of the cryptocurrency market between 2017 and 2025 using GARCH models. It examines Bitcoin, Ethereum, Ripple, Dogecoin, and a general Index, assessing their behaviour through volatility estimates and forecasts, as well as the calculation of Value at Risk (VaR). The results reveal significant differences between assets, highlighting Doge Coin as the most volatile and the selected index as the most stable. The study demonstrates the usefulness of GARCH models for estimating volatility and risk, as well as for short-term forecasting.

3 - Macro-Financial Determinants of ESG vs. Conventional Equity Returns: A Multicountry Analysis
Francisco Jareño, María de la O González

This study analyses how ESG equity indices in Germany, Spain, France and Italy react to nominal and real interest rates and inflation expectations, compared to conventional indices. Using weekly data from 2017 to 2025 and quantile regressions, the results demonstrate the strong dominance of European market effects and the weaker, asymmetric influence of monetary policy. ESG indices demonstrate lower and steadier sensitivity, indicating greater resilience to monetary policy shocks.

4 - Artificial intelligence role in innovation ambidexterity
Sebastian Ion Ceptureanu, Eduard Gabriel Ceptureanu

Although the management literature on the overall potential of AI to enhance effectiveness and efficiency has proliferated in recent years, the impact of building innovation capability on innovation ambidexterity remains ambiguous. We propose that AI enhances innovation ambidexterity by amplifying synergistic effects through improved information flow and expedited transitions between exploration and exploitation.Our research establishes an empirical basis for subsequent investigations into the interplay between AI and innovative ambidexterity.

■ HE-62

Thursday, 14:15-15:45 - Room: KOL - Seminar-Raum 19 (Building: KOL)

Applications of MCDM 2

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Gwo-Hshiung Tzeng*
Chair: *James Liou*
Chair: *Sun-Weng Huang*

1 - Using MCDM model to explore corporate intangible asset value
James Liou, Shiao Tzu Kuo, Chi Fu Wang

In the knowledge economy, intangible assets drive corporate value yet remain inadequately captured in traditional financial statements, particularly as the industry shifts toward R&D, data governance, and organizational learning under industry 4.0. This study develops an intangible asset evaluation framework through systematic literature review and Multi-Criteria Decision-Making, employing the Best-Worst Methodto derive consistent expert weights. Findings identify R&D investment, digital capabilities, and human capital as core drivers of long-term competitiveness.

2 - Performance Measurement for Bank-Led Digital Credential Wallets in Cross-Border Corporate Banking
Yu-Cheng Kao, Nien-Ping Chen

Self-sovereign identity (SSI) and verifiable credentials are changing how banks perform cross-border KYC and serve multinational firms, but banks still lack a disciplined framework to evaluate digital credential wallet (DCW) initiatives. We use the Fuzzy Delphi Method to aggregate cross-functional expert judgments and develop a multidimensional indicator system spanning operational efficiency, business value, risk, and ecosystem adoption. The resulting index provides a tractable basis for benchmarking, governance, and subsequent decision models.

3 - Impact of Asset-Trading Loopholes on Corporate Sustainability Reporting Authenticity
Yu-Cheng Kao, Mao-Wei Hung, Shu-Ying Chen

"Pollution shuffling"—selling high-emission assets to inflate ESG scores—threatens carbon reporting credibility. Using the Fuzzy Delphi Method (FDM), we identify 18 consensus indicators across five dimensions: Emission Performance, Transaction Integrity, Tech Capacity, Corporate Governance, and Market Transparency. "Transaction Integrity" emerges as the key filter separating genuine decarbonization from opportunistic asset-trading, providing investors and regulators a tool to direct capital toward substantive emissions reduction.

4 - Automated Testing Coverage in Bancassurance Mobile Apps: A Decision Framework for Sustainable Digital Operations
Ju-Ping Huang, Yu-Cheng Kao, Shu-Ying Chen

Insurtech has shifted bancassurance toward mobile, platform-based distribution, yet evidence remains limited on how banks should allocate automated testing effort across complex digital journeys. We develop an expert-validated indicator framework using the Fuzzy Delphi Method. Based on 13 experts from banking IT, insurance, risk, and digital marketing, we find Risk and Compliance receives the strongest consensus. The resulting five-dimension, fifteen-indicator structure offers an operational governance tool for reliable bancassurance delivery.

■ HE-65

Thursday, 14:15-15:45 - Room: HG - Hörsaal 27 (Building: HG)

Analytics Applications

Stream: Analytics
Invited session
Chair: *Dell'Olmo Paolo*

1 - Predicting Drop-out from Academic Trajectories: A Longitudinal Study at the University of Porto
Fernando Osório, Flávia Barbosa, Giovanna D'Inverno, Ana Camanho

This paper analyses academic trajectories and drop-out risk at the Faculty of Engineering of the University of Porto using longitudinal student records from 2021/22-2025/26. The data link individual students across years and track semester-level enrolment and outcomes in curricular units (grades, approvals, credits) together with demographic, admission, and progression indicators. This structure enables predictive modelling to identify signals of academic risk and distinguish institutional drop-out from internal degree transfers, informing more targeted academic interventions.

2 - Beyond Quadrant Inertia: A Dynamic Priority Framework for Cross-Generational Product Upgrades
Bingqian Zhou, Liangxing Shi

Capturing user feedback is vital for product upgrades. Yet, traditional Importance-Performance Analysis (IPA) ignores dynamic evolution and asymmetric utility, causing "quadrant inertia." We propose an end-to-end framework to solve this. Deep learning jointly extracts attributes and sentiments, while interpretable machine learning quantifies non-linear importance. We introduce a Dynamic Priority Index (DPI) integrating performance momentum with penalty multipliers. Tested on smartphone data, DPI flags hidden degradation and prevents resource overkill.

3 - Process Mining and Path Similarity Analysis
Dell'Olmo Paolo, Lavinia Amorosi, Rita D'Ecclesia, Alina Dynnikova

We propose a method to leverage process mining techniques to analyze real-life event logs and give insights to managers to improve process performance. For this purpose, we adopt the Levenshtein distance and kmedoids clustering, to identify representative prototype traces for process variants. Then, we introduce a novel Composite Similarity Score, integrating graph-based and attribute-based measures, to assess trace conformance to prototypes. Thus, anomalous traces can be identified by means of outlier detection, revealing significant deviations in duration and process complexity.

4 - After the Breach: Modelling Repeat Victimisation in Organisational Cyber Risk
Mark Sallos, M. Harshvardhan

Repeat cyber victimisation at the macro level remains poorly understood, constraining organisational resilience planning. We apply survival analysis to the CISSM Cyber Events Database, modelling organisational time-to-next-incident across sectors, actor types, and geopolitical contexts. Cox proportional hazards, discrete-time logit, and survival forest models identify factors associated with recurrence risk, including post-incident time windows, attribution characteristics, and sectoral exposure. Findings provide empirical benchmarks for post-incident defence allocation across sectors.

■ HE-66

Thursday, 14:15-15:45 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Conic and Convex Relaxations

Stream: Continuous and Global Optimization
Invited session
Chair: *Mirjam Duer*

1 - A Comparison of Convex Relaxations of Optimization Problems with Hard Cardinality Constraints
E. Alper Yildirim, Merve Bodur, Buket Ozen
Due to the interpretability, robustness, and ease of implementation of sparse solutions, optimization problems with cardinality constraints arise in a plethora of applications such as interpretable machine learning, portfolio optimization, and principal component analysis . In this talk, we consider alternative formulations of this NP-hard class of optimization problems. We introduce various polyhedral and convex conic relaxations of such formulations. We compare the resulting convex relaxations in terms of their strength and computational cost. We present preliminary computational results.

2 - On pseudo-polynomial sized linear programs for a class of continuous minimization problems over the hypercube
Rick Willemsen, Karthik Natarajan
We consider the problem of minimizing the sum of univariate and bivariate submodular functions over the unit hypercube where the functions are Lipschitz continuous. We show that for any approximation tolerance, there exists a pseudo-polynomial sized linear program that provides an additive approximation for this continuous optimization problem. We develop optimization algorithms to solve the linear programs to optimality. In a computational study, we compare their performance with other solutions methods in the literature.

3 - The role of 0/1 completely positive matrices in conic optimization
Mirjam Duer, Ulf Friedrich, Ralf Werner
A completely positive matrix A is called 0/1 completely positive if it can be written as a sum of rank-one matrices generated by 0/1-vectors. In this talk, we discuss properties of such matrices and their role in conic optimization.

■ HE-67

Thursday, 14:15-15:45 - Room: KOL - PC Raum 3 (Building: KOL)

Energy System Modeling for Decarbonization

Stream: Energy Markets & Systems
Invited session
Chair: *Ayush Sharma*

1 - Strategic Decarbonization of District Energy Systems: a tool to design decarbonization pathways
Caterina Tamburini, Luca Ferrari, Stefano Morgione
We present an optimization framework for the long-term decarbonization roadmap in urban multi-energy systems. To manage computational complexity while capturing seasonal variability, a clustering algorithm identifies representative days. Then we solve a MILP to optimize investment timing and technology selection, balancing installation costs, fluctuating energy prices, and a strictly decreasing annual CO2 emission cap. A dedicated web application enables final users to perform scenario analysis, supporting the assessment of system evolution under different policy and technology assumptions.

2 - Assessing the role of data centres in decarbonisation scenarios for the Italian energy system.
Silvia Laera, Fabio Sala

As digital services are gaining momentum, the demand for electricity of data centres soars at an unprecedented pace, thus posing significant challenges for energy systems planning.

Looking forward to 2050, when the electricity production is expected to cope with a deep electrification of end-uses, it is crucial to include the deployment of this critical infrastructure within energy scenarios.

Therefore, this work exploits the national model TIMES-RSE to explore different pathways for data centres infrastructure in an increasingly electrified and carbon-neutral system for Italy.

3 - Development and testing of new load control schemes for an electrical load cabinet for small health posts
Ayush Sharma, Rebecca Alcock, Mauricio Restrepo, Rafael De Jesus Castillo Sierra, Elizabeth Tilley, Gabriela Hug

Reliable energy access remains a big challenge for small remote health facilities. Solar-battery systems can power off-grid facilities, but limited and intermittent energy makes reliable operation of critical services difficult. This work proposes a finite-state-machine based load control algorithm that dynamically prioritizes medical loads based on solar irradiance, battery state, and emergency cases. Simulation and hardware testing show improved battery utilization and uninterrupted power for critical healthcare services during low-solar conditions, supporting resilient off-grid healthcare.

4 - Optimization for Rural Electrification Planning: A Branch-and-Cut Approach
Gözde Yazıcı, Ayse Selin Kocaman, Oya Ekin-Karasan

About 9% of the world lacks electricity, mostly in rural areas, highlighting the need for rural electrification. We propose a series of mixed-integer linear programming models that minimize costs by simultaneously allocating settlements to off-grid, grid, or mini-grid options and designing the corresponding networks. We also introduce multistage extensions of these models. We propose a branch-and-cut algorithm for the efficient solution of the problem. Computational experiments on real-life and synthetic instances demonstrate the computational advantages of the proposed approach.

Thursday, 16:15-17:45

■ HF-02

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 10 (Building: JUR)

IFORS Prize 2

Stream: Special Sessions
Invited session
Chair: *Margaretha Gansterer*

1 - Practical Application of Operational Research for Sustainable Agricultural Production and Waste Management in Vietnam
Trung Hieu Tran, Thi Thu Ba Nguyen

In this project, we develop mathematical programming models and math-heuristic algorithms for mitigating the impact of climate change (e.g., flooding) on agricultural waste collection, transport and treatment network. This project aims to stop burning agricultural waste at fields and to promote utilizing the agricultural waste for producing bio-organic fertilizer and biomass energy. The innovative solutions have improved the environmental quality and enhanced the economic and social development in Quang Tri (Central Vietnam), An Giang (Southern Vietnam), and the Vietnam Mekong Delta.

2 - Enhance: Balancing Multiple Solutions Through Enhanced Diet Optimization for Food Security
Marleen Balvert, Melissa Koenen, Hein Fleuren, Claudia Damu, Saskia De Pee, Cassidy Gasteiger, Marijn Markus, René Flohil, Brent Kim

Billions of people cannot afford healthy diets. Diet optimization can help assess interventions like school meals, though current tools fail to include various goals, limiting effective policy design. Enhance offers advanced methods to generate nutritionally adequate diets while mapping trade-offs between cost, cultural acceptability and sustainability. In standard use by WFP, Enhance is used in 26+ countries, boosting vulnerable populations' access to healthy diets. Its mathematical rigor and practical usability makes it a scalable tool for shaping food and nutrition policies worldwide.

3 - Anna-Chakra: Transforming India's Public Distribution System (PDS) through Operational Research
Shallu Bhasin, Ankit Sood, Shivam Sharma, Anita Karn, Mateshwari Mishra, Priya Jacob, Nomesh Bolia

India's PDS, the world's largest public food supply chain spanning 31 elected governments, legally guarantees food access to 810+ million people through a vast network of warehouses and delivery outlets. Anna Chakra, an OR-driven optimization framework developed by a partnership of government, multilateral, and academia, has transformed the PDS by efficient, accountable, data-driven governance, savings of 2.5 billion annually, and 35% carbon emission reduction, thus harbingering OR in public systems at scale—domestically and globally.

■ HF-05

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 18 (Building: JUR)

Shared Autonomous Vehicles 2

Stream: Shared Mobility
Invited session
Chair: *Yue Su*

1 - The Bi-objective Electric Autonomous Dial-a-Ride Problem
Yue Su, Sophie Parragh, Nicolas Dupin, Jakob Puchinger

The electric autonomous dial-a-ride problem extends the classical DARP by considering fleets of electric autonomous vehicles. Instead of the commonly used weighted-sum objective, we model routing cost and user excess ride time as two separate objectives. We propose an exact fragment-based framework with a "select-and-check" algorithm that iteratively builds feasible solutions from fragments. Computational experiments benchmark our approach against literature methods. Results show competitive performance, solving 21/38 instances optimally and producing high-quality Pareto approximations.

2 - Event-based formulations for a stochastic electric autonomous dial-a-ride problem
Niloofar Nadimkabiri, Gerhard Hiermann, Sophie Parragh

On-demand transport can support traditional public transit, especially in low-density areas and for mobility-impaired users. The electric autonomous dial-a-ride problem combines ride sharing and the eco-friendly benefits of electric autonomous vehicles. This study proposes a stochastic extension of the problem considering uncertainties in travel conditions, battery consumption, and passenger ride times. A two-stage stochastic mixed-integer programming formulation relying on an event-based graph is developed, where vehicle capacity, pairing, and precedence constraints are implicitly embedded.

3 - The electric autonomous dial-a-ride problem with non-linear charging function
Gerhard Hiermann, Sophie Parragh

We study the effect of a non-linear charging function in the context of the electric autonomous dial-a-ride problem, comparing it to the usual linear charging assumption. We develop several mathematical models based on an event graph reformulation. We further propose a branch-and-cut scheme to handle charging operations. In extensive computational studies, we compare the performance of these approaches on an extended set of instances derived from the literature, and highlight cases in which a linear approximation yields infeasible solutions when a non-linear charging function is considered.

■ HF-06

Thursday, 16:15-17:45 - Room: HG - Hörsaal 07 (Building: HG)

Game Theory in Retail II

Stream: Retail Operations
Invited session
Chair: *Hamidreza Abedsoltan*

1 - To Invest or To Abstain? The Role of Direct Selling Cost Reduction in Dual-Channel Supply Chains
Ayush Gupta

A direct channel's feasibility is restricted by a higher direct selling cost. While a supplier can invest to lower this cost, such investments intensify retail channel conflict. Therefore, should the supplier invest in reducing the direct selling cost? We find that the supplier should invest only when the initial direct selling cost is sufficiently low or moderately high; otherwise, if it is moderately low or sufficiently high, the supplier should abstain from investing. Further, we find that the investment benefits not only the supplier but may also benefit the retailer and consumers.

2 - Justifying membership fees with product quality: A perspective from the sunk cost effect
Xiaoyu Jin, Shandong Mou

Membership retail stores confront a core dilemma in new product launches: balancing affordability against quality expectations. Applying Stackelberg game theory to model strategic equilibrium under sunk cost effects, we identify four scenarios where optimal pricing and quality shift with sunk costs. Findings deliver a strategic roadmap for managers to calibrate pricing and quality based on the competitive landscape and firm maturity.

3 - The interaction between platform traffic allocation and consumer search
Xiyue Xiong, Mao Yuan, Haijun Wang

Digital platforms strategically allocate traffic in recommendation systems to shape consumer search and competition. We develop a sequential search model with vertically and horizontally differentiated retailers, where the platform chooses the visibility of quality tiers. The optimal policy depends on consumer heterogeneity and search costs, yielding two distinct strategies: a search-deterrence strategy that limits high-quality exposure to soften competition and sustain markups, and a search-accommodation strategy that promotes high-quality products to enhance profits.

■ HF-08

Thursday, 16:15-17:45 - Room: HG - Hörsaal 41 (Building: HG)

Concordance index

Stream: Descriptive, Diagnostic and Predictive Analytics
Invited session
Chair: *Bart Smeulders*
Chair: *Joel Joris Van de Klundert*

1 - Maximizing the C-Index with Linear Scoring Functions
Bart Smeulders, Luis Olivares-Álvarez, Francisco Pérez-Galarce, Joel Joris Van de Klundert

In many settings, linear functions on patient attributes are used to quantify risk. The weighting of components is usually not done with discrimination as the primary objective. However, the resulting rankings are then often used in, for example, donor allocation decisions. We therefore investigate the problem of finding the optimal linear scoring function, which maximizes discrimination. The resulting problem, a special case of the maximum feasible subsystem problem, is shown to still be NP-Hard and computationally challenging in practice. We discuss algorithmic ideas to speed up computation.

2 - Unveiling the mystery of the low C Index - Upperbounds and Performance Measures for Equitable Discrimination
Joel Joris Van de Klundert, Francisco Pérez-Galarce, Felipe Simon, Luis Olivares-Alvarez

The C-Index measures the discrimination performance of survival prediction models. In many applications it is found that performance is closer to the random prediction lowerbound of 0.5 than to the perfect prediction bound of 1. We proof upper bounds that maximize expected C Indexes attainable and show that for well-known analytical and empirical models one should not expect a performance above 0.75. The results are extended to subpopulation C Indices and we show that discrimination - relative to the upperbounds - is not equitable for kidney transplant survival in the USA.

3 - Improving survival prediction for kidney allocation - a state of the art framework and results
Joel Joris Van de Klundert, Valentina Peralta Clarke, Francisco Pérez-Galarce, Felipe Simon

Predicted survival after transplantation is an important determinant of deceased donor kidney allocation policies and co-determines who receives a life-saving transplantation. The prediction performance of prediction models is modest, with C Indices < 0.65. We present a new prediction framework to optimize transplant survival prediction for kidney allocate policies that incorporates state-of-the-art methods for predictor selection, imputation, validation, and period analysis. We present results for graft survival using censoring and competing risk, with modest but significant improvements.

■ HF-09

Thursday, 16:15-17:45 - Room: HG - Hörsaal 50 (Building: HG)

Industrial Optimization

Stream: Data Science meets Optimization
Invited session
Chair: *Grzegorz Pawlak*

1 - Adapting stochastic optimization workflow to an unreliable HPC platform
Maciej Drozdowski, Jakub Wawrzyniak, Jakub Marszałkowski

This study originated as optimization of partitioning a maritime container terminal quay into berths. Evaluation of a quay partition was conducted in parallel on a Slurm cluster. Performance results revealed limitations of the platform reliability. This experience lead to the analysis of the performance and solvability limits on unreliable platforms. A method to trade the optimization quality for the survival probability is proposed. The analysis is pertinent to stochastic optimization applications run on unreliable platforms.

2 - Forecast-driven inventory replenishment with demand-based product clustering for e-commerce warehouse networks
Mutlu Soruklu, Betül Ahat, Ahmet Çınar

We study inventory replenishment in an e-commerce network with multiple warehouses where stock transfers operate under capacity and lead-time limits. The objective is to maximize product availability while minimizing excess inventory. We propose a three-stage framework combining SKU-level demand forecasting via a hybrid machine learning pipeline, product segmentation through clustering of sales patterns to prioritize high-potential SKUs, and a constrained allocation model that determines transfer quantities. Historical simulations demonstrate improvements in realization rate and unit coverage.

3 - Learning-Informed Rolling Horizon Optimization for Aircraft Maintenance Tasks Scheduling
Javier Isaac Torres Vergara, Rodrigo A. Carrasco, Nouri (Nourhan) Sakr

This study addresses aircraft maintenance task scheduling across multiple checks to ensure fleet airworthiness under operational uncertainty. We propose an uncertainty-aware optimization model that accounts for variability in task durations and non-routine work. Uncertainty bounds are estimated using machine learning from operational data and embedded within a Rolling-Horizon (RH) framework. The model is validated using data from an airline partner and compared with buffered and quantile-based approaches. Our best RH policy yields makespans within 4% of the perfect information benchmark.

4 - Learning Geometry Aware Surrogate Models for Transient Heat Transfer
Onur Tanil Doganay, Hanno Gottschalk

Partial differential equation (PDE) simulations are essential in engineering but often too expensive for iterative design and optimization. In this talk, we present a geometry-aware world model that learns the temporal evolution of flow and temperature fields from simulation data. Using geometric representations of the domain, the model captures transient convective heat transfer across varying geometries. Trained on 2D transient CFD data, it provides fast surrogate predictions while preserving key statistical properties of the flow and generalizes to unseen geometries.

■ HF-10

Thursday, 16:15-17:45 - Room: HG - Hörsaal 31 (Building: HG)

Exact and heuristic algorithms

Stream: Combinatorial Optimization
Invited session
Chair: *Jan van Vuuren*

1 - A Multi-Agent System for Robust Park-and-Ride Hub Location
Algirdas Lančinskas

This research addresses the location of Park-and-Ride (P&R) hubs under uncertainty in traveler behavior. The problem is formulated as a discrete facility location problem with predefined candidate sites. A Multi-Agent System is proposed in which agents represent different traveler choice models and identify promising locations for new hubs using a reinforcement learning-based ranking mechanism. The system negotiates candidate solutions to identify robust solutions. The approach is validated using a real geographical dataset.

2 - Accelerating column generation procedures for the GAP
Basile Blayac, Andrew J Mason, Andrea Raith

The Generalized Assignment Problem (GAP) is a classic combinatorial optimisation problem. The best heuristic applies a diving procedure on an extended formulation (EF) solved via column generation, which often converges slowly. We propose two methods to accelerate column generation: Neighbourhood Pricing, restricting new columns to those near the current primal solution, and estimating EF optimal dual values using relaxations of EF. These relaxations also reveal GAP structural insights, leading to a new challenging instance class and helping explain the strong performance of diving on EF.

3 - Fair Course Allocation with Social Preferences
Yosef Sokolov, Tal Grinshpoun, Lihi Dery

We study course allocation under capacity limits when students care not only about courses but also about being assigned with friends. We propose a friendship-aware extension of an iterative allocation mechanism, followed by a local-improvement stage with swaps and drop-add moves. The resulting allocations are evaluated using total utility, inequality, and additional performance measures, showing how social preferences and post-allocation improvements affect allocation quality.

4 - A new school bus location routing model with mixed loads and bus stop selection
Willem Meiring, Jan van Vuuren

We propose a unified bus service in which students from multiple schools share stops and buses in a school bus location-routing problem (SBLRP). A new mixed-integer linear programming (MILP) model is derived that simultaneously addresses bus stop location and student allocation, bus routing, and bus scheduling within a single integrated formulation. Two objectives are pursued: Minimising the maximum student walking distance and minimising operational cost. It is demonstrated that operational cost savings of up to 35% are achievable relative to independent single-school routing.

■ HF-11

Thursday, 16:15-17:45 - Room: HG - Hörsaal 32 (Building: HG)

OR in Agriculture III

Stream: OR in Agriculture
Invited session
Chair: *Victor M. Albornoz*

1 - Assessment of the economic impact of twin calving and impact on optimal replacement of cows
LluisM Pla-Aragones, Osvaldo Palma, Alejandro Mac Cawley, Victor M. Albornoz

This study presents a discrete event stochastic simulation model designed to represent the productive and reproductive dynamics of a dairy herd. The model is applied to examine the economic consequences of different management decisions, particularly those related to twin calvings and the impact on replacement policies of cows. The results indicate that, under the most profitable voluntary culling strategy, herds without twin births achieve a monthly net profit of $170.81 per cow, while those with twin calvings reach $154.02 per cow, which represents an annual loss of $83.04 per animal.

2 - Integrated Resource and Task Scheduling in Agricultural Production
Leon Hintermeier, Alexander Hübner, Fabian Schäfer

This work develops a reactive optimization framework for integrated task and resource scheduling in agricultural production under short-term disruptions. It generates daily operational plans and supports the coordinated allocation of workers and machinery across agricultural tasks. Using a rolling-horizon approach, consecutive planning iterations are explicitly linked to preserve plan continuity. The framework thus bridges the gap between tactical planning and day-to-day operational decision-making under uncertainty.

3 - Multi-year optimal allocation of land and water to an orchard and annual crops
Raphael Linker, Isaya Kisekka

In a previous work we developed a model-based optimization framework for multi-year allocation of land and water among several annual crops. A key element of this framework is that it takes into account the agronomic requirement to rotate crops. In the present work we extended the framework to include an orchard on some of the land, and optimized simultaneously the orchard characteristics (its size and the volume of the trees canopy, which determines the amount of water required), the choice of the annual crops for each year and the amount of water allocated to each annual crop on each year.

4 - A Multi-Objective Optimization Model for Platform-Based Collaborative Logistics in Food Grain Supply Chains
Abhay Singh, Aalok Kumar

This study proposes a platform-enabled collaborative logistics framework for designing sustainable food grain supply chains in developing economies like India. A multi-objective mixed integer linear programming (MOMILP) model is developed to optimize facility locations, capacity expansion, and product flows across a four-echelon network such as farmers, collection centres, logistics centres, and processing units. The model simultaneously minimizes logistics costs and carbon emissions while maximizing employment generation.

■ HF-12

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 11 (Building: JUR)

Emergency Medical Services

Stream: Health Care Logistics
Invited session
Chair: *Vera Tilson*

1 - Digital Emergency Care Routing at Scale: Operational Performance, Healthcare Utilization, and Equity Implications of a Patient-Initiated mHealth Platform
Osnat Bashkin, Tamar Shalom, Limor Adler, Ilan Yehoshua

We analyzed 94,795 patient-initiated emergency requests via a smartphone routing platform over four years in Israel's second-largest health organization. The system matches requests to nearby community physicians in real time. Of requests, 51.6% were approved; 76.9% of approved patients attended. Attendance was associated with 41% lower odds of emergency center visits and 16% lower primary care visits within 7 days, with no rise in ED visits. Disparities in approval and attendance across geographic and socioeconomic groups raise considerations for routing optimization and decision support.

2 - Dynamic Heterogeneous Pickup-and-Delivery with AMRs in Hospitals
Dominik Stampa, Anna Hess

Medicar4.0 is a research project aiming to reduce the workload of human couriers and cut delays in hospital logistics for goods such as blood, medicine, or samples, by introducing a fleet of AMRs to handle some transport tasks. Still, human couriers remain essential for emergency or specialized transports that an AMR cannot handle. Planning the overall transportation activities results in a dynamic pickup-and-delivery problem with heterogeneous fleets. We present a heuristic algorithm to solve this problem and evaluate it through simulation using real-world data from a German hospital.

3 - Streamlining Emergency Department Workflow: Reducing Length of Stay with Congestion-Triggered Standing Orders
Vera Tilson, Saied Samiedaluie, Armann Ingolfsson

Standing orders, or advanced triage protocols, allow triage providers to initiate tests or treatments based on predefined criteria, reducing ED LOS. While beneficial for low-acuity patients by offloading diagnostic testing and optimizing process flow, concerns about overtesting and resource strain limit adoption. This study proposes a dynamic policy based on operational conditions, using queueing models to analyze standing orders' impact. A heuristic threshold policy, derived from system parameters, performs near-optimally, balancing reduced LOS and unintended consequences.

■ HF-14

Thursday, 16:15-17:45 - Room: HG - Hörsaal 01 (Building: HG)

OR conjectures for AI

Stream: OR and Ethics, and Societal Perspectives
Invited session
Chair: *Leonidas Sakalauskas*

1 - Strategic Interplay and Fairness Concerns: Optimizing Commission Schemes in an App Ecosystem
Nelly Bart, Tatyana Chernonog, Tal Avinadav

This research uses a Stackelberg game to analyze a mobile app supply chain where a platform chooses between proportional and fixed commissions. By incorporating a utility function for fairness (addressing inequality), the study finds that fixed commissions, though less common, often yield higher platform profits and better coordination. While fairness concerns act as a "price" that reduces absolute profit, they enhance collaboration with diverse developers. Under fairness considerations, fixed fees can benefit both parties but may result in cheaper, lower-quality apps for consumers.

2 - A Model of AI Supply Chain Governance for Social Media Addiction
James Siderius, Laurens Debo

Social media platforms use compute to improve recommendations by learning about content and users. While compute can surface valuable content, it can also enable platforms to target vulnerable users with addictive material. We develop a model where a platform chooses its interface design and allocates compute between learning about content or users, while regulators intervene through compute caps, algorithmic constraints, or litigation. We show that compute caps can have non-monotonic welfare effects, with the effectiveness of different policies depending on the degree of behavioral targeting.

3 - Machine Learning Meets SDGs: A Framework for Sustainable Development in Higher Education Using Bibliometric Data
Violeta Cvetkoska, Bojan Kitanovikj, Ljupcho Eftimov

This study examines how higher education institutions (HEIs) use machine learning (ML) to advance UN's Sustainable Development Goals (SDGs). Using a PRISMA-based bibliometric analysis of Web of Science publications, it maps key themes, collaboration patterns, and research trends through co-occurrence, bibliographic coupling, and co-authorship analyses. Five thematic clusters emerged: sustainability pedagogy and SDG integration, learning analytics, smart and green campus operations, digital inclusion, and ethics. The study offers guidance for future research and university decision-making.

4 - Efficient online algorithms for Artificial Intelligence
Leonidas Sakalauskas

The technological revolution of inexpensive chips is a decisive factor in the modern economic and social development (Leiserson et al, 2020). The mathematical foundation for the most widespread AI neural network technology is laid by the Kolmogorov-Vitushkin theorems. The paper highlights the conjecture of efficient training online training and discusses its partial solution when solving control problems of stochastic dynamic systems. Other relevant aspects of applied mathematical modeling are discussed as well.

■ HF-15

Thursday, 16:15-17:45 - Room: HG - Hörsaal 34 (Building: HG)

Resource Allocation and Traffic

Stream: Algorithmic Game Theory
Invited session
Chair: *Tobias Harks*

1 - A Link-based Traffic Assignment and Equilibrium in Multi-modal Networks
Weizhao Su, Selin Ahipasaoglu, Edilson Arruda

We present a multimodal, link-based traffic equilibrium model that integrates congestion and en-route travel mode changes. The multimodal system is represented as the union of mode-specific network layers connected by transfer links. We assume that travelers make sequential, history-independent link and mode choices at each node. We model travel costs including congestion effects with a modified BPR travel-time function. A case study in Southampton (UK) illustrates how the model can inform planning, operations, and pricing decisions by quantifying equilibrium travel behavior.

2 - Are System Optimal Dynamic Flows Implementable by Tolls?
Tobias Harks

We discuss whether or not system optimal flows are implementable using tolls for dynamic flow networks. We give several characterizations and also some counterexamples.

3 - Carbon Pricing in Traffic Networks
Svenja M. Griesbach, Tobias Harks, Max Klimm, Michael Markl, Philipp Warode

Traffic is a major source of carbon emissions. We study how pricing externalities such as emissions or regulated-area entry can steer multicommodity traffic flows to Wardrop equilibria that satisfy given budgets. We characterize all flows implementable by such prices and show that every feasible externality budget can be achieved at equilibrium. For convex-potential settings, prices arise as Lagrange multipliers; for a single externality, we prove monotonicity and give an efficient algorithm for computing budget-respecting prices.

4 - The Value of Early Testing Under Quality Uncertainty in Biomanufacturing Projects
Yasemin Limon

We study early testing in biomanufacturing projects with upstream fermentation and downstream purification under batch-quality uncertainty. A scouting run provides an imperfect signal of intermediate quality before purification is done. We develop a game-theoretical model in which upstream effort affects batch quality, downstream may conduct scouting, and purification intensity is selected from validated protocols. We characterize the integrated benchmark and show how decentralized decision-making distorts operational decisions. We also examine how contract design can better align incentives.

■ HF-16

Thursday, 16:15-17:45 - Room: HG - Hörsaal 42 (Building: HG)

Electric Vehicle and Drone Charging Models

Stream: Emerging Delivery Ideas and Alternative Modes
Invited session
Chair: *Bruce Golden*

1 - Challenges in collaborative truck-robot deliveries: A focus on non-linear charging models
Jakob Puchinger, Shaohua Yu

Collaborative truck-robot deliveries have recently attracted increasing attention from scientific research and industry. We first review and analyze the challenges, models, and methods associated with collaborative truck-robot deliveries. We give an overview of existing research and present novel results on the effects of considering a non-linear charging function. Our results indicate that partial charging strategies consistently outperform full charging, and that ignoring non-linear charging characteristics may yield infeasible or misleading solutions in practice.

2 - Hierarchical Reinforcement Learning for Dynamic Electric Vehicle Routing with Stochastic Requests and Time Windows
Junyu Jiang, Jian Zhang, Jakob Puchinger

We study a dynamic electric vehicle routing problem with stochastic requests and time windows (DEVRPSR) arising in urban instant logistics services. In response to randomly arriving requests, the service provider should jointly optimize demand management, vehicle routing, and battery charging decisions in real time. Aiming to serve as many requests as possible under time and fleet constraints, we formulate a route-based Markov decision process, and propose a hierarchical reinforcement learning solution approach integrating value and cost function approximations with large neighborhood search.

3 - Managing Shared Mobility Systems with Electric Vehicles Under Correlated Demand Uncertainties
Kai Pan, Ziliang Jin, Bin Tian, Yun Fong Lim

We study shared mobility with EVs and V2G, where charging/discharging affects vehicle availability. We propose a two-stage distributionally robust optimization model with ambiguously correlated trip-demand uncertainty across regions and time. The operator selects initial EV allocation, then operational actions to minimize worst-case expected cost over a moment-based ambiguity set. We prove monotonicity in covariance, prioritize key demand pairs, and accelerate computation via PCA and temporal decomposition. Real-data tests show sizable savings from modeling correlation.

■ HF-19

Thursday, 16:15-17:45 - Room: HG - Hörsaal 05 (Building: HG)

Sustainable Operations Management

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Guoqing Zhang*

1 - A Stochastic Optimization Model for Waste Reduction in Retail Grocery
Guoqing Zhang, Fatemeh Keshavarz Ghorbani

A significant portion of retail food waste arises from overstocking caused by demand uncertainty and short product shelf life. This study proposes an integrated inventory-sharing policy for retailers participating in donation initiatives and third-party online platforms. We develop a multi-stage stochastic-robust programming framework that captures stochastic demand in the primary retail channel and robust demand for imperfect products in the third-party channel. An accelerated two-phase Benders decomposition algorithm is used to solve the resulting scenario-based MILP efficiently.

2 - Waste management service platform: a stochastic single-leader-multi-follower framework
Shi Zong, Johan Joubert

This study proposes a waste management platform as a two-sided market intermediating heterogeneous generators and recyclers, unifying material trading and waste disposal across multiple waste streams. A stochastic single-leader-multi-follower framework with queueing-based network effects is developed to capture market strategic interactions and uncertain waste generation. The resulting bilevel problem is reformulated via strong duality into an MPEC and solved as a mixed-integer nonlinear program with a scalable fixed-point heuristic. A case study of Leuven, Belgium demonstrates applicability.

3 - A Distributionally Robust Optimization Framework for AI Cooling Redundancy under Transient Demand Uncertainty
Yuanming Song, Yan-Fu Li

Liquid-cooled AI computing centers require CDU redundancy designs that remain effective under transient thermal loads and demand ambiguity. We study a mixed-redundancy allocation problem with load-sharing active CDUs and imperfect cold-standby switching. A transient CTMC and a two-stage distributionally robust model are integrated to choose active and standby units, minimizing cost and worst-case CVaR of PUE under thermal-availability constraints. Numerical results show lower tail-risk PUE loss than steady-state and pure-active N+1 designs.

4 - Dynamic Control and Operations of Industrial Symbiosis Networks
Jiayun Wang, Alessio Trivella, Daniela Guericke, Devrim Murat Yazan

Rising disposal costs make waste management a core business risk, encouraging firms to engage in industrial symbiosis networks (ISNs), where waste is processed and reused as resources by other firms. We analytically study an ISN to examine how system behavior changes under varying operational conditions and uncertainty. Multi-plant ISNs are modeled as a Markov decision process to jointly optimize production, inventory, and logistics. To address exponential growth of state and action spaces, we use approximate dynamic programming to derive scalable policies validated on a real ISN.

■ HF-20

Thursday, 16:15-17:45 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Customer and user-oriented routing problems

Stream: Vehicle Routing and related problems
Invited session
Chair: *Tamara Ertl*

1 - A Route Pooling Framework for the Mixed-Fleet Vehicle Routing Problem with Customer Preferences
Justin Wittig, Christian Bierwirth

This research extends the mixed-fleet vehicle routing problem with customer preferences (MFVRP-CP) by generalizing two-customer tours to multi-customer routes. A preprocessing framework generates candidate routes using large neighborhood search and constructs a diverse route pool via quality filtering and a Jaccard-distance criterion. The pool is embedded in a set-partitioning model to optimize customer satisfaction. Experiments on Solomon instances with up to 300 customers evaluate impacts on costs, emissions, satisfaction, and computational effort.

2 - Modeling Complex Customer Preferences in Routing and Scheduling Problems
Tom Bormann, Jan Fabian Ehmke, Alexander Kleff

Effective routing and scheduling in logistics requires decision models that reflect customer preferences, often simplified as a single time window. In this study, customer information is stepwise integrated into linear piecewise penalty functions. Preferences are captured through a four-level survey that lets customers express time-related preferences in natural language. The problem is formulated as a Traveling Salesman Problem with General Time Windows and solved using dynamic programming. Experiments show that greater customer information granularity affects routing and scheduling.

3 - An Anticipatory Order Management Approach for Multi-Period Vehicle Routing Problem with Simultaneous Pickup and Delivery
Joonhwa Jeong, Chang Seong Ko, Ilkyeong Moon

In e-commerce logistics, vehicles handle deliveries and return pickups while managing orders with varying urgency across multiple periods. We consider a multi-period VRPSPD where orders arrive in batches and must be accepted or postponed before the deadline. We propose an anticipatory approach combining offline TSP-based preprocessing with online optimization to evaluate these decisions simultaneously. Future insertion costs estimated offline guide an online cost-comparison model each period. Results show that anticipatory postponement reduces routing costs compared to benchmark policies.

4 - Human-Centric Vehicle Routing: A Multi-Objective Mixed-Integer-Linear Programming Model with Physical and Mental Driver Fatigue
Tamara Ertl, Sophie Parragh, Gerhard Hiermann, Francesco Pilati

This work proposes a multi-objective Mixed-Integer-Linear Programming model for the Capacitated Vehicle Routing Problem incorporating economic and social aspects of driver workload. The model is strengthened with valid inequalities and solved using Branch-and-Cut embedded into a multi-objective solution framework. Considering driver fatigue is essential for safe and sustainable logistics. The model distinguishes physical fatigue from lifting tasks at customer nodes and mental fatigue accumulated along driving arcs.

■ HF-21

Thursday, 16:15-17:45 - Room: JUR - U 22 (Building: JUR)

AI Inside the Loop: Embedding Intelligence in Decision-Making

Stream: From Models to Smarter Decisions: Harnessing OR + AI
Invited session
Chair: *Antonio Alcántara*

1 - Leveraging neural networks to optimize heliostat field aiming strategies in Concentrating Solar Power Tower plants
Antonio Alcántara, Pablo Diaz-Cachinero, Alberto Sanchez-Gonzalez, Carlos Ruiz

CSPT plants use heliostat fields to focus sunlight onto a central receiver. Simple aiming maximizes energy collection but causes uneven flux, hotspots, thermal stress, and reduced receiver lifetimes. This session presents a data-driven method combining constraint learning, neural network surrogates, and mathematical optimization. Trained on simulation data, the surrogate is embedded in a framework balancing energy capture and flux uniformity, refined via a trust region strategy. On a real case study, it outperforms heuristics, cutting peak flux by 10% and unsafe concentration deviations by 50%

2 - Automating the Development of Complex Railway Rescheduling Models with raiLPminer 2.0
Jörn Maurischat, Nikola Bešinović, Michael Färber

Disruptions in Railway demand highly customized rescheduling models. Developing those models is a time-consuming task demanding specific expertise. We develop the LLM framework raiLPminer 2.0, which features a multi-step feedback loop to tailor a Mixed Integer Linear Program to a rescheduling problem. Thus, we aim to reduce expertise and time requirements. To reliably generate quality models, it integrates validation layers for the graph-based structure, the code execution and the solution into the process. We validate it against existing MILPs acting in the same problem environment.

3 - A Hierarchical Control Framework for Dynamic Steel-Slitting Planning with Reinforcement Learning
Yang Deng, Yuxin Qiu, Chengshuo Ying

This study addresses a weekly rolling steel-slitting problem with dynamically arriving orders, where the manufacturer seeks to maximize profit while balancing order fulfillment and material waste. A hierarchical framework is proposed: at the upper level, a learning agent decides whether to release the current order pool or temporarily buffer it; at the lower level, fixed heuristics generate feasible cutting plans with different operational priorities, from which the upper level selects one for execution. The approach improves profitability, order completion, and waste reduction in practice.

4 - LLM-Driven Auditing of Optimization Models
Ahmad Tayachi, Quentin Louveaux, Guillaume Derval, Bardhyl Miftari, Damien Ernst

Optimization models support high-stakes decisions, yet solvers guarantee optimality only for the implemented formulation, not for its alignment with the intended real-world problem. We propose a novel approach that uses LLMs to assess the correctness of optimization models. It focuses on two analyses: one at the mathematical formulation-level and one on the solution. It outputs an evidence-based report proposing ways to improve the model and assess its correctness. Computational results detect 77.5% of faulty models and confirm 95.7% of correct ones.

■ HF-23

Thursday, 16:15-17:45 - Room: HG - Hörsaal 02 (Building: HG)

Stochastic Programming in Transportation

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Paolo Beatrici*
Chair: *Francesca Maggioni*

1 - Redesigning Transportation and Evacuation Networks to Increase Minimum Saturated Flow
Ivan Eryganov, Jakub Kašný

We study network redesign under limited flow controllability using the minimum saturated flow (MSF) concept. We formulate a bilevel model in which the planner adjusts capacities or topology, while users follow MSF-based behavior rather than optimal routing. Structural graph properties are exploited to derive tractable reformulations. Computational experiments show how targeted redesign increases guaranteed throughput and mitigates inefficiencies caused by uncontrolled responses.

2 - Alleviating interchange crowding via early alighting: An evolutionary game approach
Henry KF Cheung

Severe congestion at public transit interchanges degrades efficiency. To alleviate crowding, operators increasingly offer financial incentives to passengers who voluntarily alight early. Designing such mechanisms is complex due to bounded rationality and social influence. We formulate a Stackelberg game coupled with an evolutionary game theory model, uniquely embedding socially induced pride into the passengers' payoff matrix. Analytically solving the operator's pricing problem, we uncover a counterintuitive "majority penalty" and rebound effect in the extended multi-period dynamic game.

3 - Cost-Emission Trade-offs in Green Dry Port Network Planning: A Stochastic Bi-objective Optimization Approach
Gaicong Guo, Chandra Irawan, Hing Kai Chan, Zhen Tan

Jointly optimizing dry port lifecycle decisions and multimodal flows under demand uncertainty—balancing cost and carbon emissions—remains underexplored. This paper addresses this gap with a multi-period stochastic bi-objective program covering facility activation, green upgrades, and decommissioning. An exact ϵ-constraint method and a hybrid genetic algorithm are developed and compared. A Shenzhen Port hinterland case study confirms stochastic robustness gains and shows the hybrid GA yields solutions consistent with the exact frontier at substantially lower computation time.

4 - The Value of Advance Demand Information for Shipment Consolidation under Customer Behavioral Responses
Haiwei Lu, Gudrun Kiesmuller

This paper studies how warehouses should price advance demand information in shipment consolidation systems. We model customer ordering behavior influenced by discount rates and lead times, while incorporating order cancellation. We develop three shipment policies, which achieve near-optimal performance. Optimal discounts exhibit an inverted-U relationship with demand lead time. Price sensitivity amplifies optimal discounts, while high cancellation costs and late-delivery penalties constrain them. These findings provide guidance for pricing advance demand information under various conditions.

■ HF-24

Thursday, 16:15-17:45 - Room: HG - Hörsaal 03 (Building: HG)

Operations Technology and Analytics

Stream: Knowledge, Technology, and Innovation Decisions
Invited session
Chair: *A. D. Amar*
Chair: *Santanu Roy*

1 - Research on the Hierarchical Diffusion and Spatiotemporal Evolution of Low-Altitude Economy Policies
Chen Gong, Gengyan Luo, Jing Peng

As a key practical arena for fostering new quality productive forces, the policy system of the low-altitude economy not only provides strategic guidance for industrial development but also establishes institutional safeguards for the formation and enhancement of such productive forces. This study innovatively constructs a three-dimensional "data-representation-diffusion" framework to conduct in-depth mining of low-altitude economy policy texts, systematically elucidating the overall deployment and evolutionary trajectory of China's low-altitude economy policies.

2 - Innovating with digital health systems in resource constrained environment
Sachin Modgil, Rohit Kumar Singh

In this study, we examine the how resource constraints can shape the digital innovation in healthcare. Our findings reveal that scarcity of resources do not only limit the innovation, instead it shapes the innovation trails by meaningful adoption, modular system design and improvised digital practices in public hospital requirements. In this study we identified capability bricolage, frugal design principles, modular Health information systems architecture elements those are critical for digital innovation in constrained environment.

3 - Shelf Positioning and Category Portfolio Optimization in Multi-Brand Retail Outlets: A Case Study
Santanu Roy, Krishna Priya

The study on retail productivity was carried out for a multi-brand retail chain primarily based in the UAE. The data of the entire stock keeping units inventoried in the retail chain across five selected outlets were considered, identifying the top-selling five master categories in terms of their gross profit margins. In-store shelf positioning location optimization for these selected categories using the space productivity index of each category-shelf combination and the specific zone locations was then carried out, indicating increased profits for the optimized locations validating our work.

4 - Sustainable Feasibility Modeling for Data Center Siting in the United States
Emily Zhu

This study evaluates U.S. data center siting feasibility through integrated analysis of water availability, energy grid capacity, and cooling technologies. Using geospatial mapping, regression, and simulation modeling, it quantifies energy-water trade-offs to identify regions supporting sustainable data center expansion while addressing environmental and infrastructural constraints.

■ HF-25

Thursday, 16:15-17:45 - Room: HG - Hörsaal 16 (Building: HG)

Graph-based approaches for disassembly operations modeling and optimization

Stream: OR for Sustainability
Invited session
Chair: *M.-Lounes Bentaha*
Chair: *Taha Arbaoui*
Chair: *Karim Tamssaouet*

1 - Dimensioning and Time Limit Decisions for Reusable Containers
Mahyar Taheri

This paper studies reusable container systems for takeaway restaurants partnering with third-party platforms. We develop a queuing-based game-theoretic model in which the platform sets a time limit for container returns and the restaurant decides the number of containers to stock. Customers experience disutility from both short return times and container unavailability. We characterize when restaurants adopt reusable containers, the minimum container capacity required, and how optimal time limits affect demand and profitability for both the platform and the restaurant.

2 - Flexible Scheduling for Multi-Actor Demanufacturing
Sander Teck

To enable a circular economy, this research addresses the multi-actor demanufacturing scheduling problem through a proactive-reactive framework. This approach manages end-of-life product stochasticity via real-time diagnostic feedback and dynamic disassembly depth. By optimizing task sequences and resource allocation among robots and humans, the system navigates "hidden" product states and buffer constraints. Case studies on electronic waste show the framework significantly outperforms standard rules, especially in high-congestion systems, offering a scalable path for resource recovery.

3 - Structural Properties of And/Or Disassembly Graphs
M.-Lounes Bentaha

Disassembly operations modeling is fundamental for disassembly systems design and operation. And/Or graphs are established models for representing all disassembly alternatives of End-of-Life products. However, structural properties of these graphs have never been studied. This study presents first combinatorics properties of And/Or graphs. Results provide decision-makers with quantitative insights on the complexity of disassembly processes. They also set the foundation of And/Or graph generator that allows researchers and practitioners evaluate performance of used decision-aiding tools.

4 - Stochastic Programming Framework for Disassembly System Design
M.-Lounes Bentaha

Multiple sources of uncertainty affect disassembly system performance. They concern End-of-Life product demand, their quality states, variability in task processing times, presence of hazardous material (e.g., in batteries). Addressing these uncertainties across strategic, tactical, and operational decision levels contribute to efficient disassembly system design and operation. The work demonstrates effectiveness of stochastic programming as a decision-aiding tool to tackle uncertainty in disassembly systems.

■ HF-26

Thursday, 16:15-17:45 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis IX: Models, Methods, and Applications

Stream: Data Envelopment Analysis
Invited session
Chair: *Adel Hatami-Marbini*
Chair: *Aliasghar Arabmaldar*

1 - Classifier DEA Models for Flexible Factors: An Energy Efficiency Case Study
Aliasghar Arabmaldar, Mehdi Toloo, Adel Hatami-Marbini

This study develops envelopment-based classifier DEA models for evaluating homogeneous units when some performance factors can act as either inputs or outputs. The models determine factor roles endogenously under generalized returns to scale, provide both DMU-specific and common classifications, and include aggregated formulations. An application to energy efficiency shows how the framework improves the interpretation of flexible factors, supports more reliable benchmarking, and clarifies the practical implications of classification choices.

2 - Sustainability Performance Analysis in Nigerian Government Service Agencies
Amaka Amadi, Adel Hatami-Marbini, Alexandros Nikitas

The current state of socio-economic development in Nigeria reflects the poor performance and service quality of the public sector. Despite several government reforms aimed at improving performance and service delivery, there has been little improvement. Nigeria's civil service therefore requires efficient performance management tools. This study explores a sustainability performance management framework for Nigerian service-based government agencies by integrating the Balanced Scorecard (BSC) with Data Envelopment Analysis (DEA) to evaluate performance and efficiency.

3 - Does Economic Complexity Foster Carbon Efficiency? A Non-Parametric Framework.
Ghazal Shahpari, Maria Chiara D Errico

The study aims to provide a comprehensive picture of how Multidimensional Economic Complexity (MEC) affects Total Factor Carbon Productivity (TFCP) in 47 countries from 2000 to 2019. A two-stage approach is used. First, TFCP is computed within a DEA framework, considering desirable and undesirable outputs. Then, TFCP is explained by MEC using GMM estimators. A set of diagnostic tests including separability tests is applied to ensure the robustness. The findings show that higher MEC has a positive correlation with TFCP, suggesting that more sophisticated economies contribute to improving TFCP.

4 - Fuzzy Group DEA for Risk Prioritisation in Oil Supply Chain
Adel Hatami-Marbini, Pegah Khoshnevis, Aliasghar Arabmaldar

This study develops a fuzzy group data envelopment analysis (DEA) framework for risk prioritisation under multiple-expert judgments. The method introduces an ϵ-selection procedure to reduce sensitivity in efficiency measurement and extends the group DEA model to fuzzy environments. Applied to the Nigerian oil supply chain, the proposed framework evaluates risks across the supply, production, and distribution stages and identifies the most critical threats under varying levels of uncertainty, thereby supporting more robust and transparent risk mitigation decisions.

■ HF-27

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 13 (Building: JUR)

Optimization Models for Disaster Response

Stream: Humanitarian Logistics
Invited session
Chair: *Jiyin Liu*

1 - Optimizing Post-Disaster Last-Mile Distribution: A Two-Echelon Vehicle Routing Problem with Crowdsourcing and Deprivation Costs
Yen-Cheng Wu, Vincent F. Yu

Infrastructure damage often disrupts last-mile relief distribution after disasters. This study proposes a Two-Echelon Vehicle Routing Problem for humanitarian logistics using heterogeneous transport, where motorcycles operate in the first echelon and volunteer walkers serve inaccessible areas in the second. Crowdsourcing and deprivation costs are incorporated into a Mixed-Integer Linear Programming model for the problem. Computational results show an 82.5% load rate within 53 minutes for small instances. For larger instances, an Adaptive Large Neighborhood Search algorithm is developed.

2 - Distributionally Robust Approach to Integrated Post-Earthquake Relief Logistics under Uncertainty: The Hualien Case
Abhijit Bera, Vincent F. Yu, Soumen Kumar Das, Hsiu-I Ting

Effective post-earthquake response requires an integrated aid distribution and evacuation system, but uncertain and limited data hinder planning. This study proposes a distributionally robust optimization model to minimize the operational time of the integrated response system. The framework uses an ambiguity set to capture uncertainties in road conditions, relief demand, and evacuee numbers. Using duality theory, the model is reformulated for tractability and solved with CPLEX. A case study of the 2024 Hualien earthquake shows that the model yields reliable and time-optimal response networks.

3 - The Truck-Drone Hurdle Relay Problem in a Euclidean Space
Christin Münch, Alf Kimms, Fabian Wilschewski

In this talk, we present the Truck-Drone Hurdle Relay Problem in a Euclidean Space, in which a drone is tasked with the delivery of relief supplies in a disaster-stricken area while being supported by ground vehicles along its way with transportation and battery exchanges. We develop a MILP for the problem, where we apply a geometric approach that includes trajectory planning for the drone. Further, we develop an exact row-generation solution method with six different strategies on adding rows, and we perform an extensive computational study.

4 - Dynamic resource planning under information uncertainty for post-disaster relief operations
Jiyin Liu, Eko Setiawan, Alan French

We study the problem of locating relief supplies and medical facilities, and deploying transport vehicles, in response to natural disasters. Information on resource availability is initially incomplete and keeping updated over time. We formulate a mixed integer linear programming model to minimize victim sufferings and run it with a rolling horizon approach. Experiments are conducted to investigate different ways of considering future information. The results show that it is worthwhile to incorporate even imperfect future information, provided it is reasonably reliable.

■ HF-28

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 17 (Building: JUR)

Smart tools for (just-in-time) port call optimization

Stream: Maritime Logistics
Invited session
Chair: *Julia Pahl*

1 - Ship scheduling at the Panama Canal: Evaluating the Impact of Just-in-Time Arrivals on Emissions
Torstein Takvam, Gabriel Fuentes, Stein W. Wallace

The Panama Canal schedules most ships to arrive hours before transit to avoid idle time, creating queues. Just-in-Time (JIT) arrivals allow vessels to slow steam, reducing emissions and costs for ship operators. This study applies a mixed integer linear programming model to assess how JIT and scheduling policy changes affect emissions and canal throughput. Using AIS data, preliminary results indicate significant emission reduction potential, with limited impact on throughput and revenue, though further analysis is ongoing.

2 - Defining and Detecting Waiting in Maritime Traffic: A Sensor-First Approach for Just-in-Time Port Call Optimization
Jonas Hedegaard, Julia Pahl

Reducing vessel waiting near ports can cut fuel use and emissions, but measuring waiting from AIS alone is difficult without port readiness signals. We compare two AIS-only methods to detect waiting at Port of Valencia: an IMO-aligned speed-mode classifier and a Spatio-Temporal Waiting Behavior (STWB) model using low speed, compact tracks, low directional progress, and proximity before entry. The proposed STWB method offers a promising alternative for accurately capturing waiting behaviour in AIS-only scenarios, supporting more effective Just-in-time Port call optimisation implementations.

3 - Port Call Learning and Optimization Challenges
Frederik Schulte

Port call processes of visiting ships may involve 30 parties and 200 interactions. Moreover, the anticipated sharp surge in demand for electricity and renewable fuels introduces new uncertainties. This poses an urgent need for new methods to support coordinated decision-making. Existing methods often lack integrated planning capabilities, are often limited by data sharing, and do not sufficiently account for uncertainties introduced by shore power and new fuels. In this work, we review related challenges and solution approaches for (federated) machine learning and optimization in port calls.

4 - From Shortest Paths to Reinforcement Learning: A Graph-Based Formulation of the Berth Allocation Problem
Fabricio Andres Niebles Atencio, Stefan Voss

In this paper, we propose a graph-based framework for the Berth Allocation Problem (BAP), modeling scheduling as a sequential decision process over a state-space graph. Introducing Learning Shortest-Path Scheduling (LSPS), we show the deterministic BAP theoretically reduces to a minimum-cost path problem. Because exponential state-space growth renders classical exact algorithms intractable, this formulation acts as a rigorous theoretical bridge. It unifies combinatorial optimization and learning-based methods, enabling reinforcement learning to solve large-scale, stochastic port operations.

■ HF-29

Thursday, 16:15-17:45 - Room: HG - Hörsaal 30 (Building: HG)

Topics in Combinatorial Optimization

Stream: Combinatorial Optimization
Invited session
Chair: *Tatiana Tchemisova*

1 - Finding New Bounds for Quadratic Binary Integer Programming using Quadratic Pseudo-Boolean Optimization
Chulin Likasiri

We establish new bounds for quadratic binary integer programming by converting it into a Quadratic Unconstrained Binary Optimization (QUBO) problem. This involves creating a network and using a max-flow technique to find the upper bound. Using Lagrange multipliers allows us to define the necessary conditions for establishing flows. We derive the upper bound from a feasible flow and provide examples of networks with and without flows, demonstrating lower and upper bound solutions. Our algorithm is tested on well-known problems, including the capacitated vehicle routing and N-Queens problems.

2 - Characterization of Knapsack Polytopes using Minimal Cover Inequalities
Sachin Jayaswal, Shreyas Bhowmik, Guneshwar Anand

We compare the strength of alternate formulations (polyhedra) of the binary knapsack set. We introduce a specific class of knapsack sets for which we prove that the polyhedra based on their minimal cover inequalities (together with the bounds on the variables) are strictly contained inside the polyhedra defined by their continuous knapsack relaxations. Furthermore, we answer an open question in the literature by establishing that for the knapsack sets belonging to this class, the formulations based on minimal covers provide their complete convex hull.

3 - Container Loading Problem with Stability, Load-Bearing, and Robotic Handling
José L. Sainz-Pardo Auñón, Carlos Hernández Barrueco, Ana Meca

This work tackles the stability-constrained three-dimensional container loading problem, incorporating cargo stability and load-bearing requirements. We propose exact and heuristic methods that outperform existing approaches in the literature. Additionally, we extend our framework to autonomous robotic loading environments.

4 - From minimal zeros to maximal cliques: a graph-theoretic view of copositive matrices
Tatiana Tchemisova, Olga Kostyukova

We study the relationship between copositive matrices and graph theory through the structure of normalized zeros. It is shown that the set of normalized zeros of a copositive matrix can be represented as a union of convex hulls generated by subsets of minimal zeros. These subsets are characterized as maximal cliques of a graph associated with the minimal zeros of the matrix. An algorithmic procedure for constructing both the normalized minimal zeros and the full set of normalized zeros is also presented.

■ HF-30

Thursday, 16:15-17:45 - Room: HG - Seminar-Raum 06 (Building: HG)

Machine Learning in Optimization

Stream: Machine Learning and Optimization
Invited session
Chair: *Borzou Rostami*

1 - Graph Neural Network Enhanced Column Generation
Albert Brincker Olson

Solving many large scale combinatorial optimization problems to optimality remains beyond the reach of existing column generation algorithms. Using graph neural networks, we build a framework to accelerate exact column generation by reducing the size of the problem while ensuring that the algorithm still converges to an optimal solution of the full problem. In addition, a study of the ability of these methods to generalize to structurally different instances is conducted. For experiments, a suite of different types of electric vehicle scheduling problems is used.

2 - Imitation Learning of Backdoor-Based Branching for Faster Solving of Mixed Integer Linear Programs
Changlin Li, Hongbo Ye, Chin-shin Edward Chung

Branch-and-bound is a key method for mixed integer linear programming but its efficiency depends on branching decisions. Existing imitation learning work mimics strong branching, trading smaller node time for larger trees. This paper introduces a new IL paradigm using better experts from MILP backdoors to generate smaller B&B trees. Using weak-optimality and optimality-proof backdoors, we construct smaller trees and train graph-neural-network policies. On set covering, generalized independent set and maximum clique problem, our approach reduce nodes by up to 81% compared with strong branching.

3 - Efficient Usage of Machine Learning-Based Approaches to Improve the Solvability of Mixed Integer Programming
Ronit Neogy, Jitamitra Desai

Recognizing that the computational time required to solve a mixed-integer programming problem can be heavily influenced by the choice of a primal bound (incumbent), we use historical data and several well-known classification techniques, which are based on a detailed feature set, to determine a starting incumbent which has a negligible inference cost. Furthermore, we use machine learning-based prediction models to ensure the validity of the generated starting primal bound and demonstrate the efficiency of these methods through detailed computation results of mixed integer programming.

4 - Learning-Augmented Benders Cut Generation for Large-Scale Optimization
Borzou Rostami, Erfan Rafieikia

In this talk, we present a learning-augmented approach to address the computational challenges of solving large-scale mixed-integer optimization problems using Benders decomposition. The classical multi-cut BD method requires solving the full set of subproblems to generate exact Benders cuts, which becomes expensive at scale. We integrate machine learning into the decomposition process to generate valid approximate Benders cuts, derive bounds on the resulting optimality gap, and demonstrate effectiveness through computational experiments on large-scale stochastic optimization problems.

■ HF-31

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 12 (Building: JUR)

Strategic Logistics Networks & Digital Transformation

Stream: Smart Logistics
Invited session
Chair: *Tho Le*

1 - Exploring Digital Transformation Strategies for logistics operation: An MCDM approach
Sheng Teng Huang

Digital transformation is crucial for improving efficiency and competitiveness in logistics operations. This study empirically examines digital transformation strategies using MCDM framework. Data from experiential logistics experts identify the most critical strategies for enhancing operational performance and supporting digital logistics adoption. The findings offer practical guidance for implementing digital transformation in logistics industry in Taiwan.

2 - Multi-Modal Fleet Assignment in Overnight Tactical Freight Planning
Elham Heydarigharaei, Matthew J. Roorda

This study develops a rolling-horizon optimization framework for overnight planning in last-mile parcel delivery for a Canadian freight courier. The approach jointly determines shipment-mode assignments and delivery routes across a heterogeneous fleet, including vans, e-bikes, low-speed vehicles, and walking couriers. The model accounts for incomplete shipment information and service requirements. By integrating mode assignment with routing decisions, the framework improves delivery efficiency and enables scalable multi-modal urban logistics.

3 - Stochastic optimization of personalized UAM transport networks considering demand uncertainty and relocation strategies
Hyeonbin Jeong, ByungDuk Song

Urban Air Mobility (UAM) is an emerging urban transport mode with inherent stochasticity. This study integrates relocations to preemptively balance vehicle supply with stochastic demand. A stochastic MILP optimizing schedules, task assignments, energy management, airspace congestion, and relocation strategy is developed. Model variants were developed for a comparative analysis on key model components. Results demonstrate that relocation under demand uncertainty can enhance the throughput by 142%, providing a quantitative basis for designing efficient operational strategies for UAM networks.

4 - Tactical planning in cooperative two-tier city logistics systems with fairness constraints
Pirmin Fontaine, Johannes Gückel, Teodor Gabriel Crainic

Cooperative two-tier city logistics systems improve urban freight efficiency but require coordinated planning among multiple logistics service providers. To address fairness, we introduce a multi-day tactical service network design problem with shared demand and resources, incorporating workload, cost, and service regularity considerations and formulate it as a mixed-integer linear program. Results show that cooperation significantly reduces costs and emissions, but may lead to imbalances without fairness constraints, while overly strict constraints reduce efficiency.

■ HF-32

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 14 (Building: JUR)

Cutting and packing V

Stream: Cutting and Packing
Invited session
Chair: *Emeline Leloup*

1 - Order Batching Problem with Packing Constraints
Iván Valero Pedrón, Francisco Parreño, Miguel Reula Martín, Consuelo Parreño-Torres, Maria Teresa Alonso Martínez

The Order Batching Problem (OBP) groups customer orders into batches collected on a single picking route. Traditional models usually consider only one capacity constraint, such as total volume or weight, which may produce geometrically infeasible batches requiring rehandling or splitting. We study the Order Batching Problem with Packing Constraints (OBPPC), where batching must respect feasible three-dimensional placement of items. We propose a mixed-integer linear programming model integrating batching, routing, and packing, and an exact algorithm separating batching and routing from packing.

2 - Solving a 2D Cutting and Planning Problem with Reusable Leftovers
Leo Gilbert, Maria I. Restrepo, Nadjib Brahimi

In the two-dimensional cutting industry, about 30% of raw material is discarded, generating significant ecological and financial costs. We address this issue through an Integrated Cutting Stock and Lot Sizing Problem with Reusable Leftovers. To solve it, we propose a column generation approach in which a machine learning model embedded in an optimization algorithm efficiently generates solutions to subproblems. The resulting method is already deployed in a real-world industrial application.

3 - A model-based heuristic for a three-dimensional loading vehicle routing problem with split pickups and time windows
Emeline Leloup, Célia Paquay, Thierry Pironet

Developing efficient logistics is crucial with the rise of e-commerce. Logistics service providers handle the first-mile collection problem, a key part of reverse logistics. They must design cost-minimizing routes to collect customers' boxes in urban areas and return them to a depot. To the best of our knowledge, the insert-and-fix matheuristic, which sequentially solves smaller MILP problems, has never been applied for problems combining routing and 3D packing. We perform computational experiments to analyze parameter impacts and identify this method's performance.

■ HF-33

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 15 (Building: JUR)

Advanced Optimization Approaches for Railway Operations Planning

Stream: Passenger Railway Transportation
Invited session
Chair: *Fatih Kocatürk*

1 - Intercontinental service network design problem in rail freight transportation with uncertainties
Martin Scheffler, Jing Chan, Udo Buscher

Efficient intercontinental rail freight transport is crucial for global supply chains but is hampered by unpredictable border-crossing delays caused by customs clearance, inspections, and logistical inefficiencies. We enhance the Intercontinental Scheduled Service Network Design problem by incorporating uncertain holding times at border-crossing terminals. Using robust and stochastic optimization methods, the model enables realistic decision-making, mitigates delays, improves resource utilization, and provides insights for managing border crossing rail freight complexities.

2 - A Decomposition Approach for Large-Scale Rolling Stock Scheduling with Heterogeneous Fleets
Janis Sebastian Neufeld, Paul Päprer, Martin Scheffler, Udo Buscher

Railway companies typically operate heterogeneous fleets of locomotives. The resulting rolling stock scheduling problem is highly complex and strongly interdependent with subsequent crew scheduling due to differences in driver qualifications. Based on a time-space network formulation, we propose a decomposition approach that first determines an optimized assignment of locomotive combinations to trips and then constructs circulation plans for each locomotive type. We analyze the impact of different objective functions on planning outcomes for large-scale real-world instances.

3 - Handling delays for a real-world locomotive scheduling problem
Kanchan Joshi, *Jan Fabian Ehmke*

Railways offer an environmental efficient way of transport. But amid infrastructure and resource constraints, ad hoc adjustments to locomotive schedules are inevitable. In this work, to generate reliable schedules, we design and include buffers considering stochastic travel times in our time-space network formulation designed to minimize the number of locomotives and empty-run distances. Using Austrian rail data, we analyze the trade-off between reliability and resource utilisation, offering valuable insights to planners seeking to address disruptions.

4 - A Sim-heuristic Approach for Green Locomotive Assignment Problem
Fatih Kocatürk, *Jan Fabian Ehmke*

After train timetables are created in railway planning, locomotives must be assigned to trains, known as the locomotive assignment problem (LAP). While existing studies mainly minimize costs, fleet size, or empty runs, this study addresses the Green LAP by minimizing total energy consumption. A Variable Neighborhood Search (VNS) metaheuristic is proposed and extended with Monte Carlo simulation to incorporate operational uncertainties. The resulting VNS-Simheuristic framework improves solution robustness significantly with only a small increase in energy consumption.

■ HF-34

Thursday, 16:15-17:45 - Room: JUR - Hörsaal 16 (Building: JUR)

Crew Scheduling and Rostering

Stream: Passenger air transportation: airlines and airports
Invited session
Chair: *Rainer Kolisch*

1 - Workforce Planning for Airline Pilots under Seniority Rules and Fairness Conditions
Guangrui Yang, *Rainer Kolisch*, *Thomas Hagspihl*

We consider the long-term workforce planning problem for airline pilots over a 36-month period, taking into account two qualification levels (copilots and captains) and up to 23 salary levels. It has to be decided on the number of new copilot hires, the number of copilots to be promoted to captain, and the amount of overtime for all groups of pilots, defined by qualification and salary level, to meet demand and minimize total labor costs. We model the problem as a MILP and present the results of a computational study based on real-world instances.

2 - Modelling Pilot Line Training in Airline Crew Rostering Problem
Andriy Svynaryov, *Emily Curry*, *Henrik Wallenius*

Pilot Line Training is a special case of a rostering problem which plans a transition training for a crew position or a fleet type which involves three stages: ground training, simulators and line flying under supervision. In this presentation we will focus on modelling pilot training requirements in a rostering problem. After implementing the model in Jeppesen Crew Rostering Optimizer and validating this with several airlines, we have seen improvements such as earlier completion of a training plan, shorter calendar time to construct rosters as well as increasing instructor bid award.

3 - A Branch-and-Price heuristic for the Team Crew Pairing Problem
Mohamed Faouzi Benammour, *Guy Desaulniers*, *Frédéric Quesnel*

This work introduces the Team Crew Pairing Problem, a team-based extension of the classical crew pairing problem. Decisions involve pairings and crew slices (CS), where each CS is a fixed subset of crew members that remains together across its pairings. Each flight has a crew composition requirement and may be covered by exactly one main CS and a limited number of complementary CSs. We propose a mathematical optimization model solved by a branch-and-price heuristic based on duty-based pricing subproblems. Computational results assess the potential of the proposed approach.

■ HF-35

Thursday, 16:15-17:45 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Sustainability Logistics

Stream: Operations Research and Sustainability
Invited session
Chair: *Songsong Liu*

1 - Sustainable Supply Chain Network Design: A Multi-Objective Optimization Framework for Global Battery Supply Chains
Felix Westerkamp, *Christian Thies*

Supply chains have traditionally been optimized for economic efficiency, but regulatory pressure and stakeholder expectations are shifting attention toward ecological and social sustainability. This work presents a multi-period, multi-objective optimization framework for sustainable supply chain network design integrating economic, environmental, and social indicators directly into the objective functions. An a-posteriori approach generates a representative Pareto front to analyze trade-offs. A case study on lithium-ion battery supply chains demonstrates its relevance for firms and regulators.

2 - Decoupling Environmental Attributes: Book-and-Claim versus Physical Transfer in Sustainable Aviation Fuels
Müge Çakan, *Moritz Fleischmann*, *L. Beril Toktay*

Sustainable aviation fuels are central to decarbonizing aviation. However, production regions rarely align with demand. Book-and-claim decouples environmental attributes from physical fuel flows to bridge this geographic mismatch. Using a game-theoretic analysis, we examine how policy choice shapes market participation, aggregate adoption, and abatement. Our results reveal a structural tension: physical transfer insulates local production but could lead to market failure unless the local supplier is less carbon efficient, while book-and-claim maximizes aggregate adoption and abatement.

3 - Examining reverse logistics systems in construction and demolition waste: A bibliometric analysis
Maximilian Eisenmenger, *Yapa Mahinda Bandara*, *Nader Seyedkalali*, *Miles Weaver*

Circular economy research on construction and demolition waste often treats reverse logistics as a unified system despite its multidisciplinary, interdependent nature involving multiple actors. This paper examines construction and demolition waste reverse logistics literature, applying a PRISMA-guided bibliometric analysis. Using VOSviewer, keyword

co-occurrence and co-citation analyses identify clusters revealing interacting sub-systems. Results highlight fragmented domain interactions, proposing a framework to guide future research and support circular adoption in the construction industry.

4 - Game-Theoretic Analysis of Carbon Quotas Sharing in Supply Chains under Different Cooperation Structures
Chang Lyu, Songsong Liu

Carbon quotas are key constraints shaping firms' mitigation and production decisions in supply chains. Efficient sharing of these quotas is critical for coordinated emission reduction and sustainable performance. This study models quota sharing using a Stackelberg game with one supplier and two manufacturers. Monte Carlo simulations evaluate three sharing modes: simultaneous, vertical, and horizontal. Based on the results, a Shapley value-based allocation mechanism is proposed to improve cooperation stability and profit distribution among supply chain members.

■ HF-36

Thursday, 16:15-17:45 - Room: JUR - Seminar-Raum 42 (Building: JUR)

Resilience and Sustainability in Public Health

Stream: Building Resilient Systems
Invited session
Chair: *Navonil Mustafee*

1 - Rethinking Healthcare Service Resilience: A Critical Review and Development of a Resilience Framework for Healthcare Institutions
Gabriela Ciolacu, Siamak Khayyati, Emilia Grass

To assess a healthcare institution's capability to withstand adverse events, managers evaluate its resilience in responding and recovering from financial and non-financial losses. Based on a critical literature review, we propose a quantitative framework for evaluating healthcare service resilience that enables consistent comparisons across institutions and events. The framework integrates complex healthcare operations and provides a robust analytical assessment of resilience. To demonstrate its managerial value, we analyze the resilience of a Taiwanese hospital after a mass-casualty event.

2 - Resilience by Design: An Agent-based Simulation Approach to support Cyberresilience of Healthcare Networks
Abhilasha Bakre, Burcu Balcik, Emilia Grass

Digitization in hospitals has enhanced their vulnerability to cyberattacks. Moreover, shared IT systems like telemedicine and teleradiology, allow the spread of attacks across hospital networks with potentially life-threatening consequences. To address this we propose an agent-based simulation framework and a multi-hospital network topology. We model cyberattacks as contagions that propagate along these links, capturing the interdependencies of a hospital's IT landscape. Simulating this disruption caused by the IT-outage facilitates comparison of response and mitigation strategies.

3 - Upstream, Downstream, and In Between: The Impact of Government Regulation and Peer Monitoring on Firm Operational Efficiency
Jingwen Li, Ruiqi Liu, Shenyang Jiang, Dong Wu, Yong Jin

This study uses China's water quality network to analyze government regulation and peer monitoring effects on firm operational efficiency. Using a spatial regression discontinuity design, we find upstream firms have lower efficiency than downstream ones due to compliance costs. However, this gap narrows in regions with dense monitoring networks. High station density enhances pollution traceability, triggering peer monitoring that prevents downstream free-riding. Thus, spatial network design is crucial for equitably distributing regulatory burdens and mitigating competitive distortions.

4 - Integrating Extended Value Stream Mapping and Simulation to Analyse Sustainability and Resilience Trade-offs
Navonil Mustafee, Fatemeh Alidoost, Thomas Monks, Alison Harper

This study examines sustainability and resilience trade-offs in healthcare supply chains by analysing how operational buffers influence waste generation over time. We conceptualise buffer utilisation as a mechanism through which resilience and sustainability coevolve, distinguishing shortage-driven and resource-driven waste regimes. An extended value stream mapping approach integrated with discrete-event simulation is developed to capture buffering dynamics and objectives. The study demonstrates how buffer strategies shape system waste and highlights the need to balance different buffer types.

■ HF-37

Thursday, 16:15-17:45 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Dynamics of the Firm 2

Stream: Dynamics of the Firm
Invited session
Chair: *Moein Qaisari Hasan Abadi*

1 - Sticky price competition with environmental concerns
Sara Mesrar, Fouad El Ouardighi, Dieter Grass

This paper studies Markovian versus non-Markovian taxes on polluting emissions in a Cournot market. We develop a dynamic model in which two firms compete under sticky prices and reduce emissions through abatement. Pollution evolves with nonlinear environmental absorption. We compare three noncooperative equilibria—open-loop, closed-loop, and feedback Nash—and examine myopic versus farsighted control. The results highlight how tax design and strategic behavior shape environmental performance and market outcomes in dynamic settings.

2 - Dynamic coordination of production learning and pollution abatement in a supply chain
Moein Qaisari Hasan Abadi, Fouad El Ouardighi

We study the interaction between production learning and pollution in a supply chain. Higher production improves efficiency through learning but increases emissions. We develop a dynamic differential game in which experience and pollution evolve as state variables. Firms reduce costs through learning and control emissions via abatement efforts. Optimal equilibria are analyzed under cooperative and non-cooperative settings to examine the compatibility between efficiency and environmental sustainability.

■ HF-38

Thursday, 16:15-17:45 - Room: JUR - Seminar-Raum 44 (Building: JUR)

Systems Thinking

Stream: Soft OR and Problem Structuring Methods
Invited session
Chair: *Matt LLoyd*
Chair: *John Medhurst*

1 - Ontology-Based Representation of Economic Interactions in International Relations
Jeeseung Han, Sungho Park, Kangbae Lee

Economic interactions play a key role in shaping cooperation and competition among states in international relations, yet structured knowledge representation systems for analyzing these complex interactions remain limited. This study proposes an ontology-based framework for representing the economic domain of international relations. The ontology defines key actors and their relationships, enabling a structural representation of global economic interactions. The framework provides a knowledge-based approach for analyzing interstate economic relations and understanding global economic dynamics.

2 - Managing Complexity in the Edinburgh World Heritage Site Through an Integrated Approach Combining Multi-Criteria Analysis and System Thinking
Sebastiano Barbieri, Marta Bottero, Thomas Byrne, Caterina Caprioli, Juan Rios-Ocampo

Managing UNESCO sites requires understanding the complex interactions among tourists, local community, real estate market and heritage conservation. This research explores the integration of AWOT analysis with causal mapping to support decision-making in the Edinburgh context. The multicriteria analysis was initially applied to identify and prioritize management issues. The findings were then used to make explicit the underlying structure of UNESCO sites through causal mapping. Exploring the feedback structure allows for characterizing long-term sustainable management of World Heritage Sites.

3 - Causal loop diagrams for policy making support: insights from the REGENYSYS project
Matthew Hutcheson, Irene Pluchinotta

Causal loop diagrams (CLDs) are increasingly used for participatory modelling and can be effective tools to inform public policy decision making. Although best-practice guidance recommends combining CLDs with System Dynamics simulation models, many applications remain at the qualitative level. We reflect on the strengths and limitations of CLD modelling to support policy making in a REGENYSYS application, a Thames Estuary regeneration project in which we are collaborating with local authorities to design and implement transition experiments to promote a regenerative food system.

4 - Why do PSMs and Systems approaches work?
John Medhurst

Problem structuring and Systems approaches have a history that is intertwined with the history of Operations Research. Early approaches that are still popular to varying degrees include the Viable Systems Model, Soft Systems Methodology and the Strategic Choice approach. All of these approaches share some features in common, including diagramming and social interventions such as workshops. A question that seems to have received little attention is why exactly these sorts of approach are effective. This talk offers some initial thoughts.

■ HF-43

Thursday, 16:15-17:45 - Room: JUR - Seminar-Raum 63 (Building: JUR)

Metaheuristics 2

Stream: Metaheuristics
Invited session
Chair: *Thomas Stützle*

1 - An Adaptive Large Neighbourhood Search Heurisitc for the Electric Vehicle Scheduling Problem with limited charger availability
Jens Ettrich

Using exact methods to solve large instances of the Electric Vehicle Scheduling Problem does not guarantee that an optimal solution is found within a reasonable time; therefore, we propose a Large Neighbourhood Search heuristic to generate high-quality solutions quickly. Its efficacy is tested on a variation of Electric Vehicle Scheduling that includes dedicated charging stations, limited availability of chargers at the stations, and a non-linear charging function. Variations in the number of depots and charging stations, including single depot or single charging station cases, are considered.

2 - A Hybrid Genetic Algorithm with Multi-population for Capacitated Location Routing
Jin-Kao Hao, Pengfei He, Qinghua Wu

The capacitated location-routing problem involves selecting depots from a set of candidate locations and determining the routes required for a fleet of vehicles to serve customers while minimizing a combined cost function that includes depot opening costs, depot opening costs, vehicle utilization costs, and travel costs. This paper presents a hybrid genetic algorithm that organizes the population into multiple subpopulations according to the depot configurations being explored. The algorithm provides 108 improved upper bounds for four sets of 281 popular benchmark instances.

3 - A fast surrogate for strongly connected urban network orientation problem
Christophe Duhamel

Optimal solutions of the Strong Network Orientation Problem (SNOP) minimizing all-pairs shortest paths under strong connectivity exhibit a balance between in- and out-degrees at each node. We investigate the optimization of this local topological property as a fast surrogate objective. Periodic shortest-path evaluations are used to recalibrate the search during the ILS metaheuristic, combined with adaptive neighborhood selection. Experiments include synthetic grids and real urban street networks extracted from Le Havre to assess computation time and solution quality.

■ HF-45

Thursday, 16:15-17:45 - Room: HG - Seminar-Raum 01 (Building: HG)

Scheduling with Industrial Applications

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Zdenek Hanzalek*
Chair: *Antonin Novak*

1 - Resource-constrained Project Scheduling with Time-of-Use Energy Tariffs and Machine States: A Logic-based Benders Decomposition Approach
Corentin Juvigny, Antonin Novak, Zdenek Hanzalek

This paper studies an RCPSP integrating time-of-use energy tariffs and machine states, with state transitions incurring time and energy costs. The objective minimises a weighted combination of total energy cost and makespan. We propose monolithic CP and ILP models, as well as a logic-based Benders decomposition that combines ILP in the master and CP in subproblems. Experiments show that the latter outperforms the other two, both in computational time and solution quality. An extension of the LBBD approach to other energy-aware problems with machine states is set forth.

2 - Periodic scheduling of chains on dedicated resources
Zdenek Hanzalek, Josef Grus, Claire Hanen

The paper is inspired by periodic messages transferring data from sensors to actuators in cyber-physical systems. We study a strongly NP-hard periodic scheduling problem with harmonic periods, task chains, and dedicated resources. We transform the problem into a height-divisible 2D packing problem. We analyze the problem on several levels and provide proofs of complexity and approximation algorithms for several special cases. We propose a solution based on a constraint programming matheuristic and evaluate it on industrial-, avionic-, and automotive-inspired instances.

3 - Packing, Placement, Scheduling, and Routing for Personalized Pharmaceutical Production
Antonin Novak, Viktor Emil Korladinov, Zdenek Hanzalek

We study the personalized pharmaceutical production problem on a planar transport system as a two-level combinatorial problem. The tactical level integrates dispenser packing and placement with the objective expressed as the collection of Shortest Hamiltonian path problems with neighborhoods. At the operational level, the open-shop problem with take-give resources and setup times is solved with CP. The non-colliding trajectories of the transport movers are produced by routing using a set of collision-free waiting locations and with a polynomial procedure that iteratively adapts the schedule.

4 - Integrated Tactical Production and Workforce Planning with Embedded Flexibility in a Multi-Level Scheduling Framework
Gabriëlle Notredame, Antonin Novak, Broos Maenhout

This work presents a tactical optimisation model embedded in a three-level planning framework linking strategic, tactical, and operational decision-making. The model integrates production planning and workforce scheduling while translating strategic capacity decisions into operationally feasible plans. By incorporating explicit capacity buffers and substitutability mechanisms, it enhances flexibility and robustness across planning levels and supports coordinated decision-making. The main focus is on the tactical level while positioning it within the broader integrated planning architecture.

■ HF-46

Thursday, 16:15-17:45 - Room: HG - Seminar-Raum 02 (Building: HG)

Scheduling and Uncertainty

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Rainer Kolisch*
Chair: *Danjella Siemonsma*

1 - Near-Optimal Scheduling Policies for the Stochastic RCMPSP with General Duration Distributions
Philipp Melchiors, Rainer Kolisch

We study a stochastic resource-constrained multi-project scheduling problem (RCMPSP) with activity durations following general distributions. Projects are grouped into types, enabling a queueing-based representation of the project portfolio. We investigate reinforcement learning (RL) to derive near-optimal scheduling policies and compare their performance with analytically derived optimal policies.

2 - Time-windows in stochastic project scheduling
Danjella Siemonsma, Michael Dienstknecht, Kees Jan Roodbergen

We set time-windows for activity start times in a stochastic resource-constrained project scheduling problem with uncertain activity durations. The time-windows are optimized prior to project execution, subject to a penalty for the width of the window. During execution, we sequentially schedule the activities, minimizing the penalties incurred for deviations of the realized start-times from the time-windows. We model this as a two-stage stochastic problem with an MDP as second stage, jointly optimizing the time-windows and scheduling policy.

3 - Risk-Aware Stochastic Flow Shop Scheduling: A Matrix-Analytic Framework with Deep Reinforcement Learning Optimization
Lei Liu

This paper addresses stochastic flow shop scheduling by optimizing conditional value-at-risk. We model processing times via phase-type distributions, framing system dynamics as a continuous-time Markov chain. To facilitate exact risk evaluation, we introduce a constraint satisfaction model that constructs the CTMC state space. Furthermore, we develop a risk-sensitive deep reinforcement learning algorithm to find an optimal schedule. Extensive computational experiments validate the framework's efficiency and demonstrate its superiority in managing uncertainty compared to traditional approaches.

4 - Stochastic batch scheduling in an industrial context
Florent Hervers, Guillaume Derval, Quentin Louveaux, Xavier Renard

We consider a common industrial bottleneck: when to start an operation that takes a lot of time and can process many units in a single batch, with uncertainty on the arrival time of the units. A dynamic programming algorithm is developed for the deterministic case as a baseline. The performance of this algorithm is compared with simple rule-based methods to evaluate the trade-off between operational simplicity and decision optimality. The methods and results are validated both theoretically and computationally by using data from real industrial settings.

■ HF-47

Thursday, 16:15-17:45 - Room: HG - Seminar-Raum 03 (Building: HG)

Inventory management

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Anand Paul*

1 - Special Cases of the Joint Replenishment Problem (JRP): A Mathematical Analysis
Tim Stephan, Stefan Creemers

Optimal solutions for the JRP are poorly understood, even for small instances. Starting from a mathematical definition of the JRP, we prove the existence of optimal policies while characterizing a space of policies which can achieve optimality. Further, we provide optimal solutions and exact evaluation formulas for special cases with either no holding costs, no minor order costs, or no major order cost.

2 - Centralized and Decentralized Stocking, Transportation Cost and Demand Correlation
Anand Paul, Vashkar Ghosh, Lingjiong Zhu

Inventory pooling has been widely studied in operations management, most notably in the context of a multilocation newsvendor model in which a number of locations face random demands and centralized and decentralized inventory stocking policies are compared. We extend past work in two ways. First, we study the transportation cost of

serving a number of demand centers within a region; second we study centralized and decentralized stocking in light of demand correlation within the regions of operation, factors that have been overlooked in traditional inventory pooling literature.

■ HF-49

Thursday, 16:15-17:45 - Room: HG - Seminar-Raum 05 (Building: HG)

Financial Optimization and Political Risk

Stream: Robust and Resilient Optimization in Finance and Businesses
Invited session
Chair: *David Saunders*

1 - Which political beta? Measuring and hedging deep uncertainty in political risk
Giovanni Pagliardi, Somayyeh Lotfi, Stavros A. Zenios

We uncover significant divergence across multiple prominent ratings that proxy political risk. We construct political risk factors for each rating and find them consistently priced in the cross-section of international equity returns, yet portfolios formed to have low exposure to one political risk factor often load strongly on others. This raises the question "Which political beta?", posing a challenge for hedging political risk. We develop a novel robust port- folio selection model that hedges for all political risk proxies.

2 - Political risk and sovereign debt sustainability
Andrea Consiglio, Giovanni Pagliardi

We estimate how country-level political risk ratings affect yields and growth, documenting significant effects in both advanced economies and emerging markets. We propose a stochastic debt sustainability model with political risk induced by both channels, showing that shifts in rating levels or volatility can render debt unsustainable. Structural reforms improve political ratings and are as effective as quantitative easing. The model improves forecasts for Italy's 2014-2019 reforms and predicts higher debt risk from France's 2024 sn

3 - Causal Optimization: calibration, inference and decision support
Luis Seco

Large language models provide a feasible approach to the creation of directed acyclic graphs which allow the replacement of association logic with causal inference. This contribution will review a number of use cases in the areas of financial risk and sustainable development, which employ a large number of risk factors, related to features arising from world affairs and socioeconomic and political variables. It will also describe the optimization framework for optimal decision support.

4 - Sovereigns On Thinning Ice: Debt Sustainability, Climate Impacts And Adaptation
Matteo Calcaterra, Andrea Consiglio, Massimo Tavoni, Stavros A. Zenios

We develop a stochastic sovereign debt sustainability analysis that links climate-driven macroeconomic damages to optimal debt-financing strategies, and stress-test countries under IPCC marker scenarios, a wide range of climate impact functions, and adaptation. Climate shocks can materially worsen debt dynamics, as countries face persistent, potentially unsustainable debt paths. Publicly financed adaptation is welfare-justified but insufficient to fully avert climate-debt crises. Preserving current spending while maintaining debt sustainability appears unattainable.

■ HF-51

Thursday, 16:15-17:45 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Logistics Network Design

Stream: Hub Location and Network Design
Invited session
Chair: *Mehdi Sharifyazdi*

1 - A friend in need: Co-opetition between competing EV charging networks during partial disruption
Javaiz Parappathodi, Debajyoti Biswas

Electric vehicles are staring to make their mark as the go-to choice for mobility. However, EV networks are at an increased risk of cyberattacks and disruption due to reliance on high levels of technology. This paper models disruption on one network and explores the option of relying on competing EV charging networks to continue serving customers using a minmax objective function. For different levels of disruption on the selected network, we identify the best choice of competing network to have a tie-up. We use data from real life EV charging networks in UK for analysis.

2 - Maritime Logistics Network design for CCS in Nordic-Baltic region
Mehdi Sharifyazdi, Erna Engebrethsen, Ivan Cardenas, Juan Pablo Castrellon

This paper develops a multi-objective mixed-integer optimization model for maritime CCS logistics network design in Nordic-Baltic region. The model determines CO capture volumes, transport links, hub locations, and storage destinations for hard-to-abate industrial clusters of emitters. Using an epsilon-constraint approach, it minimizes annualized network costs and maximizes avoided emissions, accounting for network emissions from capture, liquefaction, transport, and storage. Results highlight the role of maritime transport and regional hubs in cost-efficient cross-border CCS deployment.

3 - Collaborative logistics networks in healthcare
Inez Puttemans, Kris Braekers, An Caris, Jean-Sébastien Tancrez

Healthcare institutions face rising financial pressure. Logistics is a key cost driver, indicating the need to rethink healthcare system organization. This study presents a Healthcare-specific Location-Inventory Problem to design efficient care hub networks by jointly optimizing locations and inventory. A key aspect is product standardization, aligning diverse preferred products into a standardized product. Consolidating institutions' inventories into care hubs reduces costs, with further savings from standardization. Sensitivity analyses show how parameter changes affect costs and design.

■ HF-52

Thursday, 16:15-17:45 - Room: KOL - PC Raum 1 (Building: KOL)

Provision of grid services via EVs and demand

Stream: Energy Markets & Systems
Invited session
Chair: *Miguel Anjos*

1 - Integrated Pricing and Scheduling Optimisation for Vehicle-to-Grid Systems with Endogenous User Participation
Qiaochu Fan

Vehicle-to-grid (V2G) turns EVs into mobile batteries that can deliver ancillary services to the power grid, but motivating drivers to participate remains challenging. This study models economic and operational interactions among the grid, a V2G aggregator and EVs in a day-ahead market, jointly optimising time-varying electricity prices and charge/discharge schedules. Plug-in behaviour is endogenous and responds to price signals and situational factors. We propose a space-time-energy flow formulation that maximises system efficiency while coordinating pricing and scheduling.

2 - Optimal Charge Scheduling of Electric Vehicle Fleets with Dynamic Pricing and Intraday Market Trading
Miguel Anjos, Eleni Michaelidou

We consider an electricity supplier for a large commercial EV fleet. The supplier uses a dynamic pricing scheme to maximize profit while taking into account the behaviour of the fleet and participating in V2G. We propose a bilevel optimization model to capture the interaction between the supplier (leader) and the EV fleet owner (follower). We reformulate the model as a single-level optimization problem using a KKT-based heuristic approach and solve the reformulation using an off-the-shelf solver. We present preliminary computational results to validate the performance of the proposed model.

3 - SmartChargeNet: An Improved GCN-driven Framework for Electric Vehicle Demand Forecasting and V2V Energy Coordination
Mengying Xu, Chen Wang, Shufen Dai

This paper develops a multi-subgraph spatiotemporal attention convolutional network for refined forecasting of electric vehicle charging demand. Based on the predicted demand distribution, a graph neural network based vehicle-to-vehicle matching and scheduling framework is proposed to optimize mobile charging resource allocation, thereby reducing grid load and improving peak shaving performance.

■ HF-57

Thursday, 16:15-17:45 - Room: HG - Seminar-Raum 07 (Building: HG)

Behavioral OR general papers 2

Stream: Behavioural Operational Research
Invited session
Chair: *Anita Onay*
Chair: *Ana Vieira*

1 - Magnitude Effects and Decreasing Impatience in Temporal Discounting: Models, Evidence, and Applications
Manel Baucells

A robust finding in time discounting is the magnitude effect, whereby a small payout is discounted more than a larger one. But little is known of what drives the effect in the presence of not one, but multiple future payouts. We address this question by testing a ceteris paribus design. Our main finding is that the discount rate decreases with the sum of cash flows and the highest cash flow. We also test two possible models that can account for magnitude effects and decreasing impatience. Finally, we perform an out-of-sample test of these models in a retention bonus application.

2 - When Digitalization meets Procurement and Substitution Decisions: An Operational Study in Restaurants
Xuan Wang, Zhou Chen, Zhengrui Jiang, Rowan Wang, Yinghao Zhang

This study analyzes how digitalization affects procurement, inventory pooling, and dish substitution in Chinese restaurants. We find that digital recommendation systems, while intended to improve operations, can disrupt natural substitution patterns and hurt pooling efficiencies. Laboratory experiments and simulation models reveal that when only part of the customer base uses such platforms, operational performance may deteriorate, highlighting that digitalization is not universally beneficial.

3 - When Do Groups Converge? Evidence from Deliberative Multi-Criteria Analysis
Moritz Egger, Michael Curran, Alice H. Aubert, Norman Kearney, Diana Hernandez Ventura, Guillermo Andres Zambrano Mohauad, Adriana Patricia Santos Ordonez, Johanna Jacobi

We study in an empirical case with cacao famers in Ecuador how deliberation shapes collective preferences. We facilitated a deliberative multi-criteria decision analysis about future development, adapting swing-weight elicitation. Farmers' preferences were elicited before and after deliberation. Comparing pre- and post-deliberation judgments, we analyze and measure with transferable indices convergence within working groups. Results show that deliberation can both stabilize and reconfigure preferences, increasing alignment in weights and scenario rankings depending on initial heterogeneity.

4 - Eliciting trade-offs on sacred values: Implicit vs. explicit methods
Eeva Vilkkumaa, Teemu Seeve, Gilberto Montibeller, Jyrki Wallenius

Important decisions often require making difficult trade-offs between objectives associated with sacred values related to, e.g., health, safety, or the environment. We carry out a survey with decision analysis professionals, an experiment with members of the general public, and interviews with professional decision-makers to study what kinds of preference elicitation methods - implicit pairwise comparisons vs. explicit trade-off questions - work best in supporting such trade-offs when considering cognitive difficulty, negative emotional response, and the number of elicitation questions.

■ HF-58

Thursday, 16:15-17:45 - Room: HG - Seminar-Raum 08 (Building: HG)

Logistics, Supply Chains and Resilience

Stream: Healthcare OR in developing countries
Invited session
Chair: *Kelly Cristina Poldi*

1 - A Matheuristic Optimization Algorithm for Inventory Management in Blood Supply Chains
Lasara Rodrigues, Carolina Reis Gualberto, Bruno Vieira, Lucas Batista

Blood Supply Chains face challenges associated with product perishability, limited shelf-life, supply and demand uncertainties, and the need for high service levels. This study proposes a multiobjective integer linear model and a matheuristic solution method that combines Variable Neighborhood Search and Fix-and-Optimize to support inventory management in blood centers. The results demonstrate the obtained solutions for a Brazilian blood center achieved full demand fulfillment, balanced inventory levels, and significantly reduced expiry waste in reasonable computational time.

2 - Modeling Drivers of Pharmaceutical Supply Chain Resilience under Counterfeit Risk: A Structural Equation Modelling and Necessary Condition Analysis Approach
Saumyaranjan Sahoo, Lokesh Vijayvargy

Pharmaceutical supply chains face severe counterfeit risks that threaten performance and patient safety. This study examines how anti-counterfeiting orientation, supply network synchronization, and Industry 4.0-enabled risk alertness jointly affect supply chain agility and performance. Using data from over 200 professionals, structural equation modelling and necessary condition analysis show that orientation acts through synchronization and digital alertness, and that all three capabilities are necessary for superior, resilient supply chain performance under counterfeit risk.

3 - Home Healthcare Delivery in Latin America
Elias Olivares-Benitez, Jennifer Guadalupe Flores Avila, Elena Valentina Gutierrez-Gutierrez, Jennifer Benavides Castillo, Samuel Nucamendi-Guillén, Maria Alejandra Lopez Ceballos, Netzahualpilli Delgado Figueroa

This study addresses a home healthcare delivery problem using a multiobjective optimization model. The model assigns patients to hospitals and designs routes for teams of nurses and physicians caring for patients with diverse conditions. It minimizes travel time, workload imbalance, and the number of staff required. AUGMECON2 is applied to generate Pareto fronts. Instances solved are based on healthcare data from Guadalajara, Mexico, and Cali, Colombia.

4 - An Integer Programming Approach for Drone-Based Aedes Aegypti Control
Kelly Cristina Poldi, Marcel Moro

This study presents an IP model for planning a dengue control operation targeting the Aedes aegypti mosquito using drones. The operation is divided into two stages: photographic mapping of locations (Stage 1) and application of insecticides (Stage 2). The objective is to determine which drone bases should be opened, as well as the corresponding drone routes, in order to minimize the total distance traveled and the operational costs. Instances were generated using a geospatial database of a Brazilian city, and the Stage 1 model was solved using two IP solvers, whose results are compared.

■ HF-59

Thursday, 16:15-17:45 - Room: KOL - Seminar-Raum 9 (Building: KOL)

Social Multi-Criteria Evaluation

Stream: Multicriteria Decision Making (MCDM)
Invited session

Chair: *Maria Cerreta*
Chair: *Simona Panaro*
Chair: *Nicole Ostlaender*

1 - MCDA for environmental decisions: Recommendations from a critical review
Judit Lienert

How can we improve the real-world relevance of research to support environmental decisions? The question was motivated by a meta-analysis of 34 MCDA reviews, mainly published in environmental journals. Results of the present review of articles from OR journals indicate adequate uncertainty treatment, but advanced modelling and integrating stakeholders in decision processes can be improved. Combining quantitative and qualitative methods means using and developing methods from soft-OR, behavioral OR, and for supporting practice interventions. We should also develop standards of documentation.

2 - Social Multi-Criteria Evaluation (SMCE) for Science, Technology, and Innovation (STI) initiatives in Sub-Saharan countries: Towards Cross-Cutting Sustainability Policies
Simona Panaro, Maria Cerreta, Benedetta Grieco, Pierre Rialland, Angela Sarcina

This contribution aims to describe the methodological approach developed for supporting the decision-making processes in some Sub-Saharan countries as they seek to address cross-cutting sustainability challenges. A Social Multi-Criteria Evaluation has been tested to help policymakers identify suitable transformative Science, Technology, and Innovation (STI) initiatives in collaboration with local stakeholders and experts, thereby improving the directionality of STI funding and the quality of public decisions.

3 - 20 years of Social Multi-Criteria Evaluation in policy assessment
Nicole Ostlaender

Social Multi-Criteria Evaluation (SMCE) is a methodological framework designed to support participatory decision-making in public policy. This contribution draws on a systematic literature review and an analysis of European Commission applications since 2020, offering a structured synthesis of how SMCE has been deployed across local, national, and international contexts. It examines the contributions SMCE has made to these decision-making processes, identifies patterns of use and recurring challenges, and discusses ideas for future directions in SMCE for evidence-based policymaking.

■ HF-60

Thursday, 16:15-17:45 - Room: KOL - Seminar-Raum 10 (Building: KOL)

Optimization and Analytics for the Future of Insurance

Stream: OR for Insurance, Banking and Financial Risk
Invited session

Chair: *Susanna Levantesi*

1 - Monitoring the interplay between longevity risk and health dynamics: the case of a Life Care Reverse Mortgage portfolio
Giulia Magni, Marilena Sibillo, Emilia Di Lorenzo, Giovanna Apicella

Life Care Reverse Mortgage portfolios are exposed to several risks, including disability, longevity, financial and house price risks. This study investigates the interaction between longevity risk and health dynamics, highlighting differences between males and females. Given the distinct gender survival and health trajectories, different impacts can be expected for the duration of LCRM contracts and the overall payout exposure. Incorporating these elements into risk assessment from the lender's perspective may facilitate the diffusion of this product while preserving the stability of lenders

2 - Pareto Optimality of a Shapley-Based Cashback Rule in Peer-to-Peer Insurance
Gabriella Piscopo

Peer-to-peer (P2P) insurance systems are based on the mutualization of risks within a community of policyholders, combined with mechanisms that redistribute the surplus or deficit resulting from the insurance pool. This article studies a proportional distribution rule for the residual amount derived from a cooperative gaming approach, using the Shapley value. Assuming CARA preferences (utilities) and elliptically distributed losses, we show that the Shapley-based allocation rule is Pareto-optimal.

3 - Fair Contribution Mechanisms in Peer-to-Peer Insurance: A Shapley Value Framework
Susanna Levantesi

Peer-to-peer (P2P) insurance allows individuals with similar risks to pool losses through digital platforms. A key challenge is designing fair and transparent contribution mechanisms. This paper proposes a cooperative game-theoretic framework for broker-based P2P schemes. Expected losses are shared equally, while deviations are allocated using the Shapley value applied to the Value-at-Risk of portfolio profit and loss. The model yields explicit contributions based on marginal risk. Numerical illustrations show that the rule enhances transparency and reduces cross-subsidization.

4 - A Rank-Size Analytical Framework for Central Bank Speeches: Topic Distribution and Structural Patterns
Pierpaolo Luchetti, Roy Cerqueti, Valerio Ficcadenti

Central bank speeches shape expectations, asset prices, and policy transmission. We analyse speeches by the Presidents of the European Central Bank and the Federal Reserve, asking whether their topic distributions display systematic rank size regularities. We find stable and interpretable regularities across speeches, together with differences across institutions, presidents, and time. The study extends rank size analysis from words to topics and offers a framework for systematically examining communication by Central Banks under uncertainty.

■ HF-62

Thursday, 16:15-17:45 - Room: KOL - Seminar-Raum 19 (Building: KOL)

Applications of MCDM 3

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Gwo-Hshiung Tzeng*
Chair: *James Liou*
Chair: *Sun-Weng Huang*

1 - Smart Warehousing Technology Selection via an Integrated MCDM Framework: A Dual Stakeholder Perspective
Ai-Kuang He, Sheng-Teng Huang

This study proposes an integrated MCDM framework to prioritize smart warehousing technologies from dual stakeholder perspectives. Importance-Performance Analysis (IPA) quantifies service gaps for warehouse operators and retailers, while Quality Function Deployment (QFD) translates stakeholder needs into technical weights. TOPSIS ranks ten candidate technologies by closeness to an ideal solution. Findings reveal cloud-based WMS and supply chain relationship management as top priorities, offering actionable implementation roadmaps for smart warehouse adoption.

2 - A Study on Risk Assessment of Business Continuity Factors for Transportation Critical Infrastructure—A Case Study of Keelung Port of Taiwan
Chun Nen Huang, James Liou, Chao-Che Hsu

Commercial ports are vital facilities and hubs for national economic development and societal stability. By applying the Consistent Fuzzy Preference Relations (CFPR) method, this research emphasizes the necessity for port managers to identify potential risks and disaster impacts to minimize the scope of infrastructure failure, thereby ensuring business continuity and the sustained operation of national functions.The primary objective of this study is to analyze common disaster types and identify significant risk factors affecting port business continuity.

3 - Prioritizing Resilience Capabilities in High-Value Consumer Goods Supply Chains: An MCDM-Based Empirical Analysis
Chi-Chu Ko

High-value consumer goods supply chains exhibit structural features distinct from traditional manufacturing systems, including high margins, brand sensitivity, and disruption asymmetry. Existing resilience models, largely grounded in redundancy-based logic, overlook capability interdependencies in such contexts. This study proposes an integrated MCDM framework to prioritize resilience capabilities under resource constraints. A hybrid DEMATEL-ISM approach models causal relationships and hierarchical structures, while Rough numbers and Dombi aggregation address ambiguity in expert judgments.

4 - A hybrid MCDM Model for Assessing Resilience of Mass Rapid Transit Systems
Chao-Che Hsu, Chun-Nen Huang, James Liou

As extreme weather increasingly disrupts public transit, research is shifting from simple risk assessment to holistic system resilience. Using Taiwan's MRT systems as a case study, this research employs SWARA and modified VIKOR to evaluate disaster response stages. The findings suggest that transit authorities must prioritize infrastructure protection and the pre-positioning of backup components (telecommunications, tools, and spare parts) to mitigate damage and ensure the rapid restoration of service levels during a crisis.

■ HF-65

Thursday, 16:15-17:45 - Room: HG - Hörsaal 27 (Building: HG)

Analytics Methods

Stream: Analytics
Invited session
Chair: *Steven Shugan*

1 - A new algorithm for anticlustering in Euclidean spaces
Philipp Baumann, Olivier Goldschmidt, Dorit Hochbaum, Jason Yang

Anticlustering is a combinatorial optimization problem that consists of partitioning a set of objects into equally sized groups (anticlusters) such that objects within the same group are maximally diverse. Achieving diversity within groups is important in various applications, including recent large-scale applications in machine learning. We present a new algorithm for anticlustering in Euclidean spaces that scales to millions of objects and hundreds of thousands of anticlusters, far exceeding the capabilities of existing state-of-the-art methods.

2 - Why Collinearity Breaks Learning Algorithms Suppression, Diagnostics, and Targeted Augmentation
Steven Shugan, Taikgun Song

Collinearity is often treated as a numerical instability addressed through regularization or variable reduction. We show this view is incomplete. Collinearity can break learning algorithms by inducing suppression: shared predictor structure orthogonal to the outcome that weakens signal recovery. We introduce diagnostics that isolate this outcome-orthogonal dependence missed by standard measures. Using simulations and public datasets, we show suppression is common and degrades learning performance. Targeted augmentation, rather than further redundancy reduction, restores suppressed information.

3 - Data-driven Two-layer Additive Risk Model
Honoka Yamashita, Naoki Nishimura, Yufu Kasahara, Shunsuke Kanemitsu, Yuchi Matsuoka, Shunnosuke Ikeda, Noriyoshi Sukegawa, Yuichi Takano

The two-layer additive risk model is a two-layer neural network with monotonicity constraints, and has high interpretability, allowing visualization of the contribution of each variable. However, it only considers the monotonicity of numerical variables based on domain knowledge. We propose an improved model that automatically learns numerical shape constraints and categorical aggregations directly from data. Experiments show that our method achieves comparable or superior prediction accuracy to baselines while maintaining high interpretability.

4 - Machine Learning Based Analysis of Time-dependent Queueing Networks
Siamak Khayyati, Ashwin Ittoo

Machine learning methods offer efficient solutions to the problem of analysing time-dependent queues via the analysis of time invariant epochs. This work extends this approach to queues of networks. Analysing a network of queues instead of a single queue requires characterizing the outgoing flow of each time-dependent queue. In this work, we give a method that predicts the output flow characteristics of a queue using neural networks. Using these trained models, we develop an algorithm to analyse a network of queues processing the nodes from the upstream to the downstream.

■ HF-66

Thursday, 16:15-17:45 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Equilibria in n-person games

Stream: Continuous and Global Optimization
Invited session
Chair: *Mirjam Duer*

1 - Branch-and-Cut for Computing Approximate Equilibria of Mixed-Integer Generalized Nash Games
Aloïs Duguet, Tobias Harks, Martin Schmidt, Julian Schwarz

We consider the important class of generalized Nash equilibrium problems with mixed-integer variables. They are known for failing to admit exact equilibria in general, so we introduce an approximate equilibrium concept and propose a branch-and-cut (BC) method that computes such approximate equilibria or proves non-existence. We show the validity of intersection cuts and best-response cuts under reasonable assumptions. We also show that the method terminates finitely for a large class of standard Nash equilibrium problems. We present numerical results of the BC method applied to flow games.

2 - Computing Extensive-Form Perfect Equilibria: From Characterizations to Differentiable Path-Following Methods
Shufan Ning, Yiyin Cao, Chuangyin Dang

This paper presents several characterizations of extensive-form perfect equilibrium for n-player extensive-form games with imperfect information and perfect recall. Building upon these characterizations, we develop differentiable path-following methods for the efficient computation of such equilibria. These methods are constructed by formulating artificial logarithmic-barrier games and convex-quadratic-penalty games, employing behavioral strategies and sequence-form representations, respectively. Numerical experiments demonstrate the efficiency of the proposed methods.

3 - Computing Nash Equilibrium in Behavioral Strategies: From a Characterization through epsilon-Perfect gamma-Nash Equilibrium to Differentiable Path-Following Methods
Chuangyin Dang, Yiyin Cao

Exploiting an auxiliary behavioral strategy profile and KW consistency, this paper develops a characterization of Nash equilibrium in behavioral strategies (NashEBS) for extensive-form games through epsilon-perfect gamma-Nash equilibrium with local sequential rationality. This characterization provides an effective resolution to the nonconvexity in Nash's original formulation. Capitalizing on the characterization, we propose differentiable path-following methods to compute a NashEBS through the formulations of barrier and penalty extensive-form games.

4 - Logit model formulation of Fujita-Ogawa model with heterogeneous players
Shunsuke Hayashi

Multiple sub-central business districts are formed in the suburbs of many large cities. Fujita-Ogawa (FO) model is an equilibrium model to analyze those agglomeration patterns. In this study, we assume the heterogenous attribute for each firm and further incorporate the logit model in which each player chooses his/her location and workplace in a stochastic manner. To find the equilibrium, we formulate the equivalent optimization problem and solve it by combining accelerated gradient method with balancing algorithm.

■ HF-67

Thursday, 16:15-17:45 - Room: KOL - PC Raum 3 (Building: KOL)

Renewable & Grid Infrastructure Planning

Stream: Energy Markets & Systems
Invited session
Chair: *Negar Akbari*

1 - Why wind deployment becomes expensive: large-scale spatial optimization with revealed preference disamenity costs
Yannik Pflugfelder

We propose a spatial optimization model for wind power expansion that accounts for local disamenities from wind turbines. Property value impacts are represented as distance-dependent external costs affecting surrounding areas. A greedy placement algorithm sequentially allocates turbines while updating marginal acceptance costs as nearby value stocks are depleted. Using high-resolution spatial data for Germany, the model identifies deployment paths minimizing total system costs and shows that accounting for acceptance strongly increases marginal expansion costs.

2 - Mathematical Optimization Methods for the Design of Blackout-Resilient Power Grids
Clément Damestoy, François Clautiaux, Thibault Prunet

We study the optimization of strategic decisions to enhance power grid resilience against blackout scenarios. We consider two subproblems: a response phase (load shedding and transmission switching) and a design phase (demand response contracts and battery storage deployment). We embed the Optimal Transmission Switching problem within a two-stage stochastic network design framework. Our solution approach adapts the Progressive Hedging algorithm within a Column Generation scheme. Numerical results demonstrate that our method is competitive compared to a compact model solved by a MILP solver.

3 - A Mixed-Integer Optimisation Framework for Integrating Hybrid Tidal Barrage and Offshore Wind Systems
Luciana Yamada, Flávia Barbosa, Luis Guimarães, Cagatay Iris

This paper presents a model that jointly optimises barrage location, turbine type and number, and sluice gate configuration while accounting for maritime navigation, infrastructure limits, and economic factors. The objective is to maximise investor returns by balancing construction and operational costs with energy revenues. Applied to a real-world case study, the analysis highlights how cable capacity, cost reductions, and wind variability influence system performance and economic viability. The framework supports decision-making for energy systems in maritime environments.

4 - Optimising Renewable Energy Allocation in Port Clusters: An Integrated Clustering-Goal Programming Framework
Negar Akbari

Ports are energy-intensive maritime logistics hub responsible for significant greenhouse gas emissions, requiring data-driven strategies for decarbonisation. This study proposes an integrated analytics framework combining unsupervised machine learning and optimisation. First, clustering algorithms are applied to identify groups of UK ports with similar energy demand and operational characteristics. Subsequently, an Extended Goal Programming model determines the optimal allocation of renewable energy technologies to support sustainable port enery planning.

Friday, 9:00-10:30

■ FA-01

Friday, 9:00-10:30 - Room: HG - Audimax

Tutorial Axel Parmentier

Stream: Tutorials
Tutorial session
Chair: *Nysret Musliu*

1 - An introduction to Combinatorial Optimization Augmented Machine Learning
Axel Parmentier

Combinatorial optimization augmented machine learning (COAML) is a novel and rapidly growing field that integrates methods from machine learning and operations research to tackle data-driven problems that involve both uncertainty and combinatorics. These problems arise frequently in industrial processes, where firms seek to leverage large and noisy data sets to better optimize their operations. COAML typically involves embedding combinatorial optimization layers into neural networks and training them with decision-aware learning techniques. This talk provides an overview of the field, covering its main applications, algorithms, and theoretical foundations. We also demonstrate the effectiveness of COAML on contextual and dynamic stochastic optimization problems.

■ FA-06

Friday, 9:00-10:30 - Room: HG - Hörsaal 07 (Building: HG)

Supply Chain Optimization

Stream: Supply Chain Optimization
Invited session
Chair: *Mohammad Nikoofal*

1 - Coordination in Urban Smart Farming Supply Chains under Demand Uncertainty
Hae Kyeong Jung, Yoonjea Jeong

This study develops a two-stage stochastic programming model for urban smart farming supply chains under demand uncertainty. The first stage determines production at farms and stores, and the second stage adjusts inventory, delivery, shortage, and disposal decisions for each scenario. The model reflects perishability through the FEFO policy and allows production and supply at farms and stores with store-to-store replenishment. A Progressive Hedging heuristic is used for large-scale instances. The results suggest that integrated planning can improve supply chain flexibility and responsiveness.

2 - Flexible order quantity contracts in a newsvendor model with uncertain supply
Dimitrios Pandelis

We consider a newsvendor model with a primary supplier characterized by random capacity with known distribution. To mitigate the risk associated with this supplier, the retailer can also procure from a reliable but more expensive supplier under a contract according to which he is allowed to return a portion of the order after the delivery by the primary supplier. We formulate the problem as a Stackelberg game between the retailer and the flexible supplier, with the latter being the leader, and characterize optimal contracts.

3 - Economic Incentives to Enhance Supply Chain Security
Mohammad Nikoofal, Mahsa Madani Hosseini, Mehmet Gumus, Manaf Zargoush, Saeed Beheshti

Supply-chain disruptions call for policies to boost firms' security, yet spillovers and slow returns cause underinvestment. A game-theoretic model compares subsidies (pre-incident audits) and insurance (post-incident inspections). Insurance excels with low baseline security; subsidies with moderate-high security and credible audits. Hybrid designs combining both outperform pure tools when monitoring is costly or investment gaps are large.

■ FA-07

Friday, 9:00-10:30 - Room: HG - Hörsaal 21 (Building: HG)

Stable Matching

Stream: Matching under Preferences
Invited session
Chair: *Péter Biró*

1 - Smart Lotteries in School Choice: Ex-ante Pareto-Improvement with Ex-post Stability
Péter Biró

In school choice, Deferred Acceptance with random tie-breaking yields a probabilistic assignment. We propose a 'smart lottery' mechanism that ex-ante Pareto-improves this assignment while remaining ex-post stable, i.e., decomposable into stable matchings under original priorities. This guarantees expected welfare gains over standard DA-with-lottery for any cardinal utilities, without sacrificing stability. Though NP-hard, we solve it via integer programming with column generation, showing substantially larger gains than post-tie-breaking efficiency improving methods.

2 - Compatible k-Relaxations of Fairness and Non-Wastefulness Under Hereditary Constraints
Zhaohong Sun

We study two-sided matching markets under hereditary constraints, where fairness and non-wastefulness often conflict and existing approaches typically prioritize one over the other. We instead relax both properties in a symmetric and controlled manner. We introduce two concepts indexed by k: envy-received up to k peers and non-wastefulness up to k objections. We prove that for any fixed k these properties are compatible and computable in polynomial time. Experiments show that even small relaxations deliver a strong balance between fairness and non-wastefulness.

3 - Stability improves warehouse layout configuration
Dimitrios Tsakoumis, Pavlos Eirinakis

In pick-and-place operations, the positioning of containers within the warehouse heavily affects the collection time for given multi-product orders, since it alters the distance matrix of the underlying TSP. In this work, we use a data-driven approach to infer the cost of placing each container in each possible position. Then, we utilize this cost to model the assignment of containers to positions as a (stable) matching problem. Surprisingly, our findings show that enforcing stability constraints yields superior layouts that lead to reduced collection time compared to minimum cost matching.

■ FA-08

Friday, 9:00-10:30 - Room: HG - Hörsaal 41 (Building: HG)

Prescriptive Analytics and Simulation

Stream: Descriptive, Diagnostic and Predictive Analytics
Invited session
Chair: *Amir Azadnia*

Chair: *Raul A. Araneda*

1 - Predictive Modeling of Aerobic Capacity Using Heterogeneous Data for Decision Analytics in Sport
Piotr Lukasiak, Adam Langowski

Genomic, phenotypic, and environmental data were integrated to advance decision analytics in sport. Using a cohort of more than 900 individuals, SNP profiles were combined with physiological and lifestyle variables to estimate VO2max. Additive polygenic scores, stepwise regression, LASSO, and neural networks were then compared within a common analytical framework. The most informative predictors of aerobic capacity were identified, and the value of multisource modeling was demonstrated, providing a solid basis for personalized exercise planning, athlete assessment, and decision support.

2 - The Role of Digital Platforms in Data Markets: How Platform-Shared Market Data through Advanced Analytics Empower Firm Innovation
Yubo Chen, Liu Yang

In collaboration with Alibaba, we examine how platform-shared data through advanced analytics affect retailers' performance. We find advanced data analytics increase retailer sales beyond the effects of descriptive analytics. Analytics leveraging platform-level market data generate larger and more persistent performance gains than those relying solely on firm-level data, with small retailers benefiting disproportionately. Mechanism analyses show that platform-shared data enable retailers to innovate their product assortments, expanding category scope and increasing new SKU introductions.

3 - A Prescriptive Simulation-Hybrid Optimization Framework for Capacity Planning in Minimally Invasive Gynecology
Raul A. Araneda, Rodrigo A. Carrasco

We propose a prescriptive framework integrating discrete-event simulation with a hybrid optimization approach to improve capacity planning in minimally invasive gynecology at CRS Cordillera, Chile.By capturing the complete patient pathway, from initial arrival to surgical intervention, our model identifies key bottlenecks in appointment scheduling and resource allocation.Simulation experiments demonstrate that this approach yields a 34% projected increase in patients receiving timely treatment compared to current baseline operations,providing a replicable strategy for public health management

4 - AI-Assisted Multi-Agent Decision Support System for Multi-Issue Negotiation in Sustainable Product Design
Amir Azadnia

This study proposes an AI-assisted decision support system for sustainable product design (SPD). The system integrates the Kano model, QFD, and fuzzy inference system within a multi-agent system, supporting multi-issue negotiation for SPD. An AI-enabled explanation layer converts sustainability scores into actionable managerial insights. The framework enables transparent trade-off analysis across economic, environmental, and social dimensions. An industrial lighting case demonstrates practical applicability for iterative negotiation and sustainability assessment.

■ FA-09

Friday, 9:00-10:30 - Room: HG - Hörsaal 50 (Building: HG)

Data sovereignty and optimization in cloud computing

Stream: Data Science meets Optimization
Invited session
Chair: *Grzegorz Pawlak*

1 - Data Sovereignty in Sovereign Cloud
Stanisław Galij, Grzegorz Pawlak, Slawomir Grzyb

Data sovereignty has remained one of the major concerns for companies, particularly in regulated sectors and jurisdictions, for more than two decades. Today, European organizations in particular are seeking sovereign cloud offerings based on EU providers to protect their strategic asset - the data. This research analyzes the building blocks of a full sovereign cloud stack and provides practical guidance on selection criteria for components used to build or adopt sovereign cloud solutions that meet data sovereignty requirements.

2 - Support Desk Robotization Using Machine Learning Techniques
Grzegorz Pawlak

The paper presents the design and development of an SDR (Support Desk Robotizer) system aimed at improving the efficiency of handling support requests and bug reports through automated similarity-based recommendation. The system focuses on grouping incoming issues and identifying the most relevant active and historical requests to accelerate problem resolution and knowledge reuse. The input data consists primarily of unstructured text collected from forms, emails, and call transcripts, optionally enriched with metadata such as request subject, sender role, and timestamps.

3 - A Metaheuristic for Multimodal Transport in a Decentralized E-commerce Distribution Network
Joris van Oers, Wesley de Vries, Quang Vinh Dang, Zumbul Atan, Ivo Adan

This paper addresses a mode selection and inventory allocation problem in a decentralized distribution network for e-commerce across Europe. The model jointly decides (i) how much storage capacity to reserve in a local distribution center, (ii) how to allocate stock to meet the fill rate level requirements, and (iii) what mode and shipping frequencies to use for replenishment. We optimize for costs and emissions using an NSGA-II algorithm, extended with a greedy heuristic and simulation. A large scale case study shows the scalability and effectiveness of our model in industrial problem sizes.

■ FA-10

Friday, 9:00-10:30 - Room: HG - Hörsaal 31 (Building: HG)

New Approaches for Routing Problems

Stream: Combinatorial Optimization
Invited session
Chair: *Konstantin Pavlikov*

1 - Smallest compact formulations with an application to TSP
Maurice de Kort, Ymro Hoogendoorn, Remy Spliet

We study smallest Integer Linear Programming formulations for combinatorial optimization problems with finitely many feasible solutions. We characterize the minimum number of variables required for the existence of an affine function that identifies the objective values of all solutions. Furthermore, we analyze how different solution representations affect the minimum possible number of constraints. We show how our results can be applied to determine the minimum number of variables for the Travelling Salesman Problem and bounds on the minimum number of constraints for various representations.

2 - The Generalized Travelling Salesman Problem: New Mathematical Programming Models and Exact Solution Algorithms
Jon Lilholt Sørensen, Giovanni Pantuso, Konstantin Pavlikov

This talk presents a new mathematical programming framework for the symmetric GTSP. The framework requires a significantly smaller number of binary variables. We develop a new exact solution algorithm for the problem that starts with a feasible solution provided by a heuristic. Then, it employs several families of valid inequalities to strengthen a formulation of the problem. Significant emphasis is placed on techniques to eliminate variables to reduce the feasible space. The computational study proves optimality of / improves BKSs for many currently unsolved GTSP instances.

3 - Modified Nearest Neighbor Algorithm for TSP Problems
Katya Rodriguez-vazquez, Eliseo Diaz-nacar

In this paper, a modification of the nearest neighbor algorithm is introduced. This proposal takes, as a reference, the solution of the Nearest Neighbor (NN) algorithm. Thus, routes are created by considering the second nearest node instead of the nearest node, and in the subsequent route, the third nearest node is chosen, creating routes until the farthest node is chosen as the next node in the route. This proposal is compared against NN algorithm based on a set of TSP benchmark problems (up to 666 nodes), showing that MNN is competitive in terms of solution quality in comparison to NN.

4 - Mixed integer linear programming for exact separation of valid inequalities for Vehicle Routing Problems
Konstantin Pavlikov

Capacity inequalities are some of the most well-known valid inequalities for the CVRP. This talk presents a technique to separate rounded capacity inequalities for the CVRP using mixed integer linear programming. Further extensions include two new families of capacity-based valid inequalities for the Heterogeneous CVRP, together with exact separation routines. The computational studies demonstrate that such inequalities can be separated efficiently for the CVRP and HCVRP.

■ FA-11

Friday, 9:00-10:30 - Room: HG - Hörsaal 32 (Building: HG)

OR in Agriculture II

Stream: OR in Agriculture
Invited session
Chair: *Carlos Monardes*

1 - Markov Decision Processes for Crop Rotation Problems
Jakob Geertsen Kristensen

We formulate crop rotation as a multi-objective Markov decision process, where yearly crop choices adapt to history-dependent disease and soil states across fields. The model evaluates trade-offs among yield, fertilization, and disease risk, with a potato case highlighting blight-sensitive rotations.

2 - A Matheuristic for the Multi-Commodity Two-Echelon Inventory Routing Problem with Perishable Products
Tugce Canbilen Suticen, Argyris Kanellopoulos, Tom van Woensel

We study a multi-commodity, multi-period two-echelon inventory routing problem with perishable products motivated by an agricultural distribution setting. Products are ordered from suppliers, transported to distribution centers, and delivered to customers over multiple periods. The problem is formulated as a mixed-integer linear program integrating routing, ordering, delivery quantity, and inventory decisions under perishability constraints. To solve large instances, we develop a matheuristic combining adaptive large neighborhood search with MILP-based partial optimization.

3 - Optimizing White Winemaking Logistics: A Robust Coordination Framework for Decentralized Cooperatives
Carlos Monardes

Chilean cooperatives face complex logistics, coordinating 1,000 decentralized growers. Since pisco relies on initial wine fermentation, its supply chains are linked. This research presents progress in optimizing harvesting through a dual strategy: proactive seasonal planning and reactive daily adjustments. Early results include analyzing maturity curves and formulating an adaptive robust optimization model. By integrating sugar incentives and plant capacity, the framework aims to maximize benefits while ensuring resilient scheduling.

■ FA-12

Friday, 9:00-10:30 - Room: JUR - Hörsaal 11 (Building: JUR)

Home Health Care Routing

Stream: Health Care Logistics
Invited session
Chair: *Caroline Ihloff*

1 - Imitation learning for dynamic home healthcare routing and scheduling with stochastic patients
Louise Tassin, Véronique François, Michel Gendreau, Elise Vandomme, Yasemin Arda

We study a stochastic and dynamic home healthcare routing and scheduling problem, where a service provider must decide daily on new patient acceptance, visit days allocation, and caregiver routing under uncertain patient arrival and length of stay. To address this challenge, we develop a hybrid framework integrating machine learning and combinatorial optimization. A neural network trained in an imitation learning fashion captures insights from perfect information solutions in order to guide daily decision-making. We provide preliminary results for instances that mimic real-life systems.

2 - The home health care routing and scheduling problem with vehicle sharing and time windows
Yuche Gong, Jiyin Liu, Rupal Mandania

This study proposes a vehicle-sharing and routing model for home healthcare. Some patients need to be served by multiple caregivers in synchronized visits, creating opportunities for vehicle sharing. Vehicles are equipped with Personal Transport Devices, enabling caregivers to leave main vehicles and travel independently for eligible services. An integer linear program is developed to capture vehicle sharing, time windows, skill levels and synchronization constraints in scheduling the services. Experiments show that the model makes 17.7% average cost savings compared to fixed-vehicle planning.

3 - A bilevel multi-period routing problem for home chemotherapy: a multi-agent deep reinforcement learning approach
Alexis Robbes

Home chemotherapy treatments must be delivered within strict time windows while remaining adaptable to patients' evolving conditions. To model this system, we formulate a bilevel optimization problem. The leader problem assigns a unique visit time slot to each patient for every treatment day over a multi-week horizon. To address this, we propose a multi-agent deep reinforcement learning approach that learns a shared policy for all vehicles to optimize each daily follower prob- lem, while the leader problem is solved using linear programming.

4 - Exchanging Patients in Home Healthcare Routing
Caroline Ihloff, Jonas Stein, Abdolkarim Sadrieh, Marlin Wolf Ulmer

The demand for home healthcare services is increasing, causing routing challenges and travel stress for caregivers. Providers often work in overlapping regions, indicating potential time savings through patient exchanges. This work models the issue as a multi-depot vehicle routing problem with mandatory assignments testing different exchange concepts: (1) exchanging a predefined patient subset, (2) keeping a constant number of patients per provider, and (3) exchanging a percentage of patients. Our findings show significant savings, even when concepts are very restrictive.

■ FA-14

Friday, 9:00-10:30 - Room: HG - Hörsaal 01 (Building: HG)

Ethics and Operational Research in different Cultures 1

Stream: OR and Ethics, and Societal Perspectives
Invited session
Chair: *Ulrike Reisach*
Chair: *Sadia Samar Ali*
Chair: *Leonidas Sakalauskas*

1 - Human-Centered Leadership Using Industry 5.0 in Managing Modern Slavery
Sadia Samar Ali

Modern slavery continues to threaten global supply chains, driven by economic, social, environmental, political-legal, and technological vulnerabilities. Building on these indicators as critical success factors, this study highlights the essential roles of ethical leadership and Industry 5.0's human-centric innovation in strengthening social sustainability. Using the DEMETAL framework to identify the cause and effect measures to evaluate the firms/system weaknesses, and transform organizational practices to resolve in ethical way.

2 - Ethics and Operational Research in different Cultures - Global-Indian collaboration
Jinal Parikh, Gerhard-Wilhelm Weber, İsmail Özcan, Jacek Dominik Śledziński, Yavuz Yilmaz

In this talk the authors will express how their collaboration which initiated in 2018 from the EURO and IFORS conferences has evolved and turned in global collaborations. Specifically, we will discuss how we align our research across countries and topics which are of common interest to everyone in the teams that we work in. Examples of OR cooperation from India with Germany, Poland, Spain and Turkey, EURO and IFORS.

3 - Monitoring without acting: the knowing-doing gap in smart city decision support systems
Akhmed Baikhojayev, Leonidas Sakalauskas, Mafura Uandykova

Smart cities invest heavily in data infrastructure, yet monitoring often fails to improve outcomes. This study quantifies the Knowing-Doing Gap in urban accessibility by comparing Vienna and Almaty. Using Smart Almaty's API and Vienna's data, we find Almaty achieves 97 percent monitoring coverage but under 1 percent real accessibility, while Vienna reaches 95 percent via closed feedback loops. Causal loop modeling shows institutional architecture, not data volume, determines if decision support becomes action. Implications for DSS design in transitional governance are discussed.

4 - A Spatial and Game-Theoretic Approach to Modeling Salary Expectations in the IT Labor Market
Jacek Dominik Śledziński, İsmail Özcan, Gerhard-Wilhelm Weber

The entry of Generation Z into the labor market creates new challenges for Human Resource Management (HRM), especially in regions with limited talent supply. IT professionals often have high salary expectations and lower organizational loyalty, forcing companies to rethink recruitment strategies. This study combines spatial data analysis with cooperative game theory to examine salary expectations. Using survey data from IT students, the Multivariate Adaptive Regression Splines (MARS) model predicts salary expectations based on spatial factors.

■ FA-15

Friday, 9:00-10:30 - Room: HG - Hörsaal 34 (Building: HG)

Dynamics in Games I

Stream: Algorithmic Game Theory
Invited session
Chair: *Yifen Mu*
Chair: *Yukun Cheng*

1 - A sample-based best-response dynamics in continuous games
Yifen Mu, Zhouming Wu

In continuous games, pure Nash equilibrium(NE) may not exist and there are few algorithms to solve the games. For continuous games with one-dimensional action space for each player, we propose a sample-based best response dynamics (SBRD), in which the best response of each player is approximated via finite sample points. We redefine the saddle and sink on the trajectory and investigate the dynamical properties of SBRD. Then we theoretically prove that SBRD admits a unique solution and converges to some critical point. Approximate NE can be found even when NEs do not exist in the game.

2 - Searching for Optimal Prices in Two-Sided Markets
Yiding Feng, Mengfan Ma, Bo Peng, Zongqi Wan

We study online pricing in two-sided markets where a platform posts prices to buyers and sellers, observes only accept/reject feedback, and maximizes gains-from-trade (GFT) or profit. We compare Single-, Two-, and Segmented-Price mechanisms. A Two-Price algorithm achieves optimal O(n2 log log T) regret for profit. For GFT, constant regret holds only in bilateral trade; larger markets incur inherent lower bounds and linear regret under Two-Price due to mismatch. Segmented pricing overcomes this, yielding sublinear regret and contextual extensions.

3 - An Adaptive Production and Pricing Approach for the Hierarchical Stackelberg Partially Observable Markov Game
Yang Deng, Yukun Cheng

Downstream orders are fixed before final settlement prices, so nonadaptive decisions under volatility can hurt all parties. We study how an upstream manufacturer jointly optimizes production and pricing while anticipating downstream responses. The problem is modeled as a hierarchical Stackelberg POMDP that combines DP-based follower optimization with learning-based leader control under partial observability. Calibrated experiments and a real SOE case show improved stability and coordination.

4 - How Sampling Shapes LLM Alignment: From One-Shot Optima to Iterative Dynamics
Yurong Chen, Yu He, Michael Jordan, Fan Yao

We study how the choices of sampling and reference policies affect preference alignment in large language models through Identity Preference Optimization. We show that instance-dependent sampling can improve ranking guarantees, while skewed on-policy sampling may cause overconcentration. For iterative alignment, where learned policies shape future data and references, we prove that oscillation and entropy collapse can arise, and identify stable regimes for convergence. Our analysis also extends to Direct Preference Optimization, with experiments on real preference data supporting the theory.

■ FA-16

Friday, 9:00-10:30 - Room: HG - Hörsaal 42 (Building: HG)

Sustainable Urban Deliveries with Alternative Modes

Stream: Emerging Delivery Ideas and Alternative Modes
Invited session
Chair: *Jakob Puchinger*
Chair: *Vera Hemmelmayr*

1 - A Scalable Filtering-Based Algorithm for Large-Scale Two-Echelon Quick-Commerce Delivery
Chijia Liu, Jakob Puchinger, Vera Hemmelmayr

We study a large scale multi trip two echelon vehicle routing problem where trucks replenish clustered satellites and autonomous vehicles deliver to customers with possible intermediate restocking. The objective is lexicographic: minimize fleet size first, then travel time. We solve it with a two stage approach. The second echelon uses a Best Fit insertion heuristic with a multi level filtering system and a label setting split for feasibility. Aggregated satellite demand is then used to solve the first echelon inventory routing problem with a MILP.

2 - Flexible Mode Integration in a Two-Echelon VRP for Sustainable Urban Logistics
Hai Yen Luu, Vera Hemmelmayr, Jakob Puchinger

We propose a novel urban delivery setting integrating low-emission modes and a fully accessible grey zone. This setting aims at increasing flexibility, while reducing delivery costs and environmental impacts. We adapt benchmark instances from the literature and solve them using a Large Neighborhood Search algorithm, testing both fixed and adaptive parameter settings for selecting destroy and repair operators. The results advocate for clean vehicle use in urban areas, particularly when the grey zone is fully integrated. Our findings support efficient delivery strategies and policymaking.

3 - Synchronous Truck-Robot-Drone Last-Mile Delivery
Omar Abou Kasm, Behrang Bootaki, Joe Naoum-Sawaya

The rapid growth of online shopping has intensified pressure on last-mile delivery systems. Traditional truck-based delivery faces congestion and environmental constraints. We develop a synchronous truck-robot-drone system in which a truck carries a multi-visit drone and single-delivery robots under energy and load capacity limits. The problem is formulated as a mixed-integer program and solved using a computationally efficient heuristic. Tests on the 2021 Amazon Last Mile Routing Research Challenge dataset demonstrate average time savings of 40%, reaching 52% for larger instances.

4 - Integrating mobile microhubs into two-echelon last mile delivery in a multi-period setting
Jiahua Tang, Jakob Puchinger, Vera Hemmelmayr

We study a multi-period two-echelon vehicle routing problem with time windows and integrated mobile microhubs (MP-2E-VRPTW-MM), where the mobile microhubs serve as flexible satellites and can be relocated together with trucks. A solution to this problem determines routes for trucks and robots as well as microhub locations. We propose a novel formulation for the MP-2E-VRPTW-MM and a heuristic approach to accelerate the solving process. Computational experiments are performed on benchmark instances and preliminary results demonstrate a reduction of carbon emission.

■ FA-19

Friday, 9:00-10:30 - Room: HG - Hörsaal 05 (Building: HG)

AI-Driven Systems Optimization

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Ivan Cardenas*

1 - A Scalable Data-Driven Framework for Characterising National Road Freight from GPS Data
Ivan Cardenas

We present a scalable data-driven framework to characterise national road freight from truck GPS data across four dimensions: flows, networks, trips, and activities. To recover trip structure from unlabelled trajectories, we combine domain knowledge with unsupervised stop inference rather than fixed a priori thresholds. Applied to nationwide Belgian tolling data, the framework reveals strong temporal and spatial concentration of freight activity and provides an empirical basis for targeted freight policies and operational planning.

2 - Integrating Graph Neural Networks with metaheuristics for Service Network Design
Javier Durán-Micco, Bilge Atasoy

We propose an agent-based simulation model representing the operations of a logistics service provider (LSP) in a multimodal freight transport network with uncertain travel times and demand. Simulation outputs are used to train a Graph Neural Network (GNN) that predicts total LSP profit as well as node-level performance. The trained GNN is embedded within a metaheuristic to solve the Service Network Design (SND) problem under uncertainty. The integrated approach translates to an efficient optimization method for large SND instances under realistic assumptions.

3 - Fairness and Revenue Trade-offs in Stochastic Capacity Allocation
Mosayeb Jalilian, Hamed Jalali, Alejandro Lamas

Revenue-maximizing capacity allocation policies may lead to unequal service levels across customer groups. Motivated by Littlewood's two-class demand model, this work studies fairness in stochastic capacity allocation. We analyze three settings that differ in the timing and uncertainty of demand across customer groups and characterize reserve levels that balance fairness and revenue. Analytical results quantify the resulting trade-offs between these two objectives and show how fairness requirements reshape allocation decisions, including in dynamic settings.

4 - Optimal Allocation Scheduling with Continuing Patients
Lars van der Meer, Maik Overmars, Eyal Castiel, Anne Zander, Werner Scheinhardt, Richard Boucherie

In the existing allocation scheduling literature, patients are often assumed to exit treatment after one period. However, in many healthcare applications, patients continue treatment for multiple periods. In this work, patients may continue treatment with a certain probability. With the presence of emergency arrivals and uncertain utilisation, we prove structural properties of the optimal policy and provide conditions under which a threshold policy is optimal. Our numerical experiments support the analytical results and provide insights into the effect of different sources of uncertainty.

■ FA-20

Friday, 9:00-10:30 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Relevant applications in routing problems I

Stream: Vehicle Routing and related problems
Invited session
Chair: *Daniel Bustos-Coral*

1 - Routing Optimization of Satellite Refueling Between Lunar and Geosynchronous Orbits Integrating ISRU
Öznur Meydan, Ecem Seyrek

Geostationary satellites often reach end of life due to propellant depletion rather than technological obsolescence. This study investigates a sustainable lunar based satellite refueling concept using In Situ Resource Utilization. A simulation framework models cislunar propellant logistics between lunar supply systems and GEO satellites. The servicing mission is formulated as a vehicle routing optimization problem with time constrained demand. Monte Carlo scenarios represent operational uncertainty and identify feasible mission configurations and tanker design parameters.

2 - Solving the routing problem of Martian rovers
Wojciech Burzyński, Mariusz Kaleta

In the talk, we will discuss progress in solving the Rover Routing Problem (RRP) - a specialised variant of the Team Orienteering Problem (TOP), where a fleet of Martian rovers must visit a subset of Points of Interest (PoIs) to conduct research.

We present a formal problem formulation and results from MILP solvers. Next, we will present the results of the Greedy algorithm to establish a baseline against which the results of the genetic algorithm will be compared. We will discuss a variety of mutation procedures and their impact on performance and the obtained results.

3 - A Green Multi-Objective Open Vehicle Routing Problem for Reverse Logistics with Consolidation Points and Dual Time Windows
Payam Rostami, Mohsen Afsharian

This paper proposes a green multi-objective open vehicle routing problem for reverse logistics that jointly optimizes cost, CO emissions, and customer satisfaction. The formulated mixed-integer linear program incorporates dual time windows and customer-based consolidation points to enhance efficiency and flexibility. Multi-objective optimization generates Pareto solutions revealing trade-offs among economic, environmental, and service objectives, with computational results showing improved routing and service alignment in urban return networks.

4 - Routing of scan cars for parking enforcement
Daniel Bustos-Coral, Augustin Delecluse, Pieter Smet, Greet Vanden Berghe

Scan cars, i.e., cars equipped with automatic number plate recognition cameras, are used by cities to monitor and enforce parking regulations. Compared to human officers, these vehicles offer greater efficiency and coverage. We address the problem of optimising the routes of a fleet of scan cars to maximise enforcement while minimising operational costs. In this talk, we introduce the problem, explain how it can be addressed as an arc routing problem, and discuss solution approaches to solve it.

■ FA-23

Friday, 9:00-10:30 - Room: HG - Hörsaal 02 (Building: HG)

Exact and Heuristics Algorithms for Bilevel Optimization under Uncertainty

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Simon Stevens*

1 - A Nonanticipative Dual Decomposition Algorithm for Stochastic Linear Bilevel Problems
Jakub Kašný, Ivan Eryganov

This work explores stochastic linear bilevel programming, a hierarchical framework for decision-making under uncertainty. As scenario counts increase, traditional solvers face exponential growth in complexity due to complementarity constraints. We propose the SB-NaDA algorithm, which uses dual decomposition to break the problem into independent scenario subproblems. Numerical tests show that while standard solvers scale poorly, SB-NaDA exhibits near-linear scaling and provides tight bounds for large-scale instances.

2 - On the complexity of bilevel linear programs in fixed dimensions
Sergei Ketkov, Oleg A. Prokopyev

We study bilevel linear programs (BLPs) assuming that one decision-maker has a fixed number of variables or constraints. While optimistic BLPs are known to be tractable when the follower has a fixed number of variables, we further prove that both optimistic and pessimistic BLPs are polynomially solvable when the number of follower constraints is fixed. In contrast, we show that the pessimistic BLP with a fixed number of follower variables is strongly NP-hard. Hence, the same instance of a BLP may be polynomially solvable in the optimistic setting, yet strongly NP-hard in the pessimistic case.

3 - Branch-and-Cut for Mixed-Integer Linear Decision-Dependent Robust Optimization
Simon Stevens, Henri Lefebvre, Martin Schmidt, Johannes Thürauf

Decision-dependent robust optimization (DDRO) problems are usually tackled by reformulating them using a strong-duality theorem. In this talk, we present the first tailored branch-and-cut method for mixed-integer linear DDRO problems, for which no duality theorem is available. To this end, we consider both intersection cuts that are only stated in the space of the upper-level variables of the respective bilevel reformulation and more tailored interdiction cuts for downward monotone uncertainty set models. We present a numerical study that demonstrates the applicability of our method.

■ FA-24

Friday, 9:00-10:30 - Room: HG - Hörsaal 03 (Building: HG)

Transitioning Research, Practice and Applications into Innovation

Stream: Knowledge, Technology, and Innovation Decisions
Invited session
Chair: *A. D. Amar*
Chair: *Juan Felipe Mora Saavedra*

1 - Relationship between Discount and Return when the Firm Undergoes Litigation
Januj Juneja, A. D. Amar

We examine the information content for abnormal stock return performance around the announcements of private placements of common stock made by firms undergoing litigation events and those that are not. In general, investors demand larger discounts when information asymmetry is high and cash flow constraints are high leading to a smaller return. We find that the inverse relationship between discount and return is more pronounced for firms undergoing litigation which we use to study litigation risk premia and the value of the marketability restriction by treating it as an American option.

2 - Global Business Services model and Process Innovation: an evaluation and uncertainty management system for ideas undergoing the fuzzy front end assessment
Juan Felipe Mora Saavedra

This research explores how GBS centers are intrapreneurs unlocking corporate value through process innovation by strategically adopting trending technologies such as AI and elevating their human-machine ecosystem. A literature review and a longitudinal quantitative study of 300+ ideas from one of the Top 20 global centers, allowed to propose an innovation system encompassing divergence and an alternative convergence evaluation model through MCDM framework for early stage, focusing beyond traditional financial metrics integrating human and AI evaluators to better identify value potential.

3 - Striking back against a disinformation campaign: Computational experiments for the market diffusion of an innovation
Frederik Tolkmitt, Christian Stummer

Competitors may launch a smear campaign through which negative disinformation about a new product or service is distributed among consumers in a certain market. In so doing, they aim at increasing consumers' uncertainty about the innovation's performance and, thus, delaying its market diffusion. In order to analyze the possible effectiveness of various types of disinformation campaigns as well as possible countermeasures against them in different market settings, we set up an agent-based model, implemented it in a simulation tool, and run extensive computational experiments.

4 - Building GenAI-Enabled Operational Capabilities in Manufacturing Firms
Bhawana Rathore, Rohit Gupta

The rapid advancement of Generative Artificial Intelligence (GenAI) is reshaping manufacturing operations, leading firms to heavily invest in GenAI-enabled solutions to enhance operational efficiency, product quality, and managerial decision-making. Despite this growing interest, many manufacturing organisations struggle to convert such investments into sustained operational value and enduring organisational capabilities. Addressing this gap, this paper examines how a mid-sized manufacturing firm implemented GenAI across its core production processes to strengthen shop-floor operation.

■ FA-25

Friday, 9:00-10:30 - Room: HG - Hörsaal 16 (Building: HG)

OR for Sustainability: Innovations and Applications

Stream: OR for Sustainability
Invited session
Chair: *Sarfaraz Hashemkhani Zolfani*

1 - Research on strategy of government dual subsidy in remanufacturing supply chain and analysis of influencing factors
Juhong Gao

This paper considers the segmentation of the consumer market and the government dual subsidy strategy, where to manufacturers' remanufacturing subsidies and to consumers' "trading the old for the new" and "trading the old for the remanufactured" subsidies. By constructing a Stackelberg game mode, obtains the equilibrium solution under the two kinds decision of subsidy ratio and subsidy total amount. Study the impact of implementing different government subsidy strategies on consumer utility, corporate profits and social welfare by numerical analysis.

2 - Welfare and Environmental Effects of Strategic Pollution Control under Reciprocal Dumping
Salvador Sandoval Bravo

This paper develops a partial equilibrium Cournot oligopoly model that determines the optimal pollution quota for a homogeneous good industry under conditions of reciprocal dumping between two countries. It also examines the consequences of these optimal values on the government implementation of certain strategic environmental policies and the effects of their application on consumers in the countries involved, as well as on producing firms and the environment in general, incorporating these variables into a social welfare function.

3 - A Bilevel optimization framework for urban textile recovery systems
Dámaris Arizhay Dávila Soria, José-Fernando Camacho-Vallejo, Mario A. Aguirre-López, José Guadalupe Flores Muñiz

This work presents a mixed-integer bilevel model for urban textile collection systems. A private collection company (leader) optimizes bin location and allocation, considering social accessibility metrics for the population and bin assignment to remanufacturers. The leader aims to maximize utility from both location and sales. In turn, remanufacturers (followers) determine bidding prices for allocated bins subject to viability constraints. The problem is solved using a reformulation and Variable Neighborhood Search metaheuristic. Computational results and key findings are presented.

■ FA-26

Friday, 9:00-10:30 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis X: Composite Indicators, and MCDM

Stream: Data Envelopment Analysis
Invited session
Chair: *Miguel Pereira*

1 - Internal benchmarking accounting for seasonality in water pumping station performance evaluation
Mariana Casalta, Flávia Barbosa, Jaime Gabriel Silva, Ana Camanho

This study develops an internal benchmarking framework to assess water pumping station performance over time while explicitly accounting for seasonal variations in water demand. Months with similar pumped volumes are grouped using cluster analysis, and performance is assessed relative to cluster-specific frontiers and a meta-frontier through a Benefit-of-the-Doubt composite indicator. A case study from a Portuguese utility over seven years shows stable performance and limited seasonal constraints, supporting robust, data-driven operational decisions and ensuring fair performance comparisons.

2 - A Sustainable Finance Index Based on Cross-Efficiency
Raquel Quiroga, Mar Arenas-Parra, Amelia Bilbao-Terol, Verónica Cañal, Alonso Perez-Hevia

Our objective is to develop a sustainable finance index to evaluate countries on this multidimensional concept using cross-efficiency analysis that aims to address some of DEA's drawbacks, such as ties among the evaluated units. These models improve the discriminatory power of DEA models by simultaneously working with auto-efficiencies and cross-efficiencies. Our meaningful variables are: Control over corruption, Rule of law, Political stability, Capital market, Number of green bond issuers, Green bond issuance, Renewable energy consumption, among others.

3 - Weight restrictions in radial DEA models without inputs or without outputs
Panagiotis Ravanos, Giannis Karagiannis

In this paper we assess known equivalences among DEA models without inputs or outputs and with a single constant input or output in the presence of weight restrictions. We show that all known equivalences hold if homogeneous weight restrictions are included in the respective DEA models, but the inclusion of non-homogenous weight restrictions results in orientation-specific equivalences. We discuss the implications of these results on empirical applications using two study cases related to the Commission's European Innovation Scoreboard and OECD's social institutions and Gender Index.

4 - Hybrid simulation and Benefit-of-the-Doubt aggregation for congestion management in emergency departments
Miguel Pereira, Fábio Soares, António Vieira

Emergency department crowding emerges from complex interactions between stochastic demand, limited resources, and behavioural feedback. This study proposes a hybrid decision-support framework combining discrete-event simulation and system dynamics to analyse congestion propagation and policy responses. Simulation outputs are synthesised using a Benefit-of-the-Doubt aggregation model to compare alternative resource reallocation strategies. Results show that balanced redistribution across care stages improves overall performance more effectively than isolated capacity expansions.

■ FA-27

Friday, 9:00-10:30 - Room: JUR - Hörsaal 13 (Building: JUR)

Smart Operations in Inland Ports and Waterway Networks

Stream: Maritime Logistics
Invited session
Chair: *Jeanine Vonkeman*

1 - Can we double inland waterway freight transportation in Germany: An agent-based simulation approach
Philipp Parche, Alexander Rave, Pirmin Fontaine

Germany's freight transport mainly relies on road and rail, which are already overused and weight restrictions and construction will lead to further congestion. To quantify the spare capaci-ty of inland waterways as an alternative mode, we present an agent-based simulation that considers ports and locks as bottlenecks, as well as their interdependencies within the network. With real-world traffic patterns derived from Automatic Identification System data and network information we provide a sensitivity analysis for sectional utilization and evaluate the impact of increased traffic.

2 - Optimisation for vessel movements within channels and waterways - systematic literature review
Ruwani Liyanage, Paul Corry, Christian Bierwirth

We present the first systematic literature review focusing on modelling and optimisation for vessel movements within channels and waterways, along with integrated planning with port facilities and landside operations. Channels and waterways are costly infrastructure with significant environmental impacts, making research in this area of critical importance. We propose a classification scheme that will assist future researchers in this area to quickly find relevant literature and methods for their research topics and application domains.

3 - Coordinating Policy, Infrastructure, and Fleet Decisions for Containerized Battery Swapping in Inland Waterways
Virgilio Ma Jr Ramos, Bilge Atasoy

Containerized battery swapping offers a pathway to zero-emission inland waterway transport but requires coordinated decisions by policymakers, infrastructure developers, and fleet operators with conflicting objectives. We model this as a multi-level, multi-period optimization problem capturing demand evolution across deployment phases. The model is reduced to a bilevel formulation via KKT conditions and solved with iterative bilevel decomposition and large neighborhood search. Experiments on the Dutch-Belgian corridor analyze battery improvements, carbon taxation, and deployment scenarios.

4 - Multi-objective optimization of river dredging plans for siltation control under environmental constraints
Jeanine Vonkeman, Kareem El Sayed

A multi-objective genetic algorithm is used to optimize the dredging sequence and starting month for a river-scale project operating under strict seasonal day/night environmental windows. The algorithm is applied to a discrete event simulation with 3 dredgers and varying siltation rates along the river. Compared to the baseline scenario, the optimized plans reduce the total project duration by 3 weeks and lowers cumulative sedimentation by 6%, demonstrating the value of evolutionary search for regulation-constrained maritime operations.

■ FA-28

Friday, 9:00-10:30 - Room: JUR - Hörsaal 17 (Building: JUR)

Methods for Maritime Optimization

Stream: Maritime Logistics
Invited session
Chair: *Ruibin Bai*

1 - A Cell-Based Branch-and-Cut Approach for the Ro-Ro Stowage Problem
MinGyu Shin, Wonwoo Cho, Kyungsik Lee

We address a roll-on/roll-off(Ro-Ro) stowage problem that minimizes rehandling operations. We propose a cell-based integer optimization model that captures path accessibility via connectivity conditions with respect to cargo access points, avoding explicit modeling of loading and unloading sequences. Based on the model, we develop an exact branch-and-cut algorithm. To scale to large instances, we exploit tree- and DAG-structured arc elimination to reduce the number of connectivity constraints. Computational experiments demonstrate the effectiveness of the proposed approach.

2 - Matheuristic for a complex liner shipping network design problem
Anandhu Dileep, Ahmad Hemmati, Rahul Nath, Mohammad Moshref Javadi, Kjetil Fagerholt

In this work, we study a complex case of designing a set of connected liner shipping routes to transport demands between a continental port and regional ports. Several features such as optional demands among regional ports, speed optimization, and demand transit time limits, are considered, making it more realistic compared to similar previous works. We develop a mathheuristic to tackle this problem. The matheuristic is shown to match closely with an exact model for small instances of the problem and outperform other algorithms on almost all instances of a restricted version of the problem.

3 - Preference Agile Multi Objective Optimization with Deep Reinforcement Learning: A Case Study in Dynamic Port Resource Allocation
Ruibin Bai

We propose a preference agile multi objective optimization (PAMOO) framework that enables dynamic adjustment of decision preferences through a deep reinforcement learning model. A calibration function ensures alignment between user inputs and learned policies. Experiments on real-world container terminal dispatching show that PAMOO outperforms popular MOO methods, achieving superior adaptability and generalization in dynamic port resource allocation.

■ FA-29

Friday, 9:00-10:30 - Room: HG - Hörsaal 30 (Building: HG)

Graph Theory and Applications

Stream: Combinatorial Optimization
Invited session
Chair: *Yiannis Mourtos*

1 - Optimization Modeling for Energy-Efficient FM Broadcasting: Evidence from the Italian National Network
Paolo Nobili, Antonio Sassano, Pasquale Avella

We evaluate the energy footprint of Italian FM broadcasting, where 16,776 transmitters generate high consumption and widespread self-interference. Using national regulatory data and international interference records, we estimate annual consumption at about 253 GWh, far exceeding comparable European systems. We develop a mixed-integer optimization model to assess coordinated power reductions. Results show that lowering transmission power can reduce energy use and electromagnetic pollution while maintaining, and in some areas improving, population coverage and service quality.

2 - Finding and Recognising Pareto optimal Colorings
Yiannis Mourtos, Michalis Samaris

We examine the list coloring problem in the case where the list of allowed colors for every vertex is linearly ordered, i.e., every vertex expresses strict and transitive preferences over its available colors. This generalises the House Allocation problem. We define and characterise Pareto optimal colorings and show that some but not all such colorings are obtainable through Serial Dictatorship. Verifying whether a given coloring is Pareto optimal is coNP-complete, therefore we examine the problem in certain special cases. We discuss applications, further optimisation results and extensions.

■ FA-30

Friday, 9:00-10:30 - Room: HG - Seminar-Raum 06 (Building: HG)

Predictions in Optimization

Stream: Machine Learning and Optimization
Invited session
Chair: *Dmitrii Chaikovskii*

1 - Integrated Frameworks for Data-Driven Problems with Missing Data
Hoda Bidkhori

Missing data is common in many data-driven optimization and machine learning problems. Traditional approaches typically follow a two-step process: first estimating missing values and then solving the corresponding stochastic optimization problem. However, accurate estimation often requires large datasets and complex statistical methods. In this talk, we present an integrated distributionally robust optimization (DRO) framework that jointly addresses missing data and loss optimization, providing tractable reformulations and finite-sample guarantees while outperforming traditional estimate-then-

2 - Thompson Sampling with Cumulative Oversampling for Budgeted Influence Maximization
Zhen Xu, Xinjie Xing

This paper studies influencer selection for online marketing campaigns with limited budgets. It proposes a cumulative oversampling (CO) technique to enhance Thompson Sampling (TS), generating optimistic parameter estimates with fewer posterior samples. Combined with an offline oracle, the algorithm jointly handles budget allocation, learning, and reward maximization. It achieves scaled regret comparable to UCB methods, without linear dependence on minimum edge observation probability, and outperforms UCB approaches in experiments.

3 - Optimization with Dynamic Constraint Learning
Ezgi Oztekin, Figen Oztoprak, Ilker Birbil

We propose Dynamic Constraint Learning, a data-driven framework for constrained optimization when constraint functions are unknown and cannot be queried during optimization. At each iteration, the method learns a local surrogate from nearby data and solves a subproblem within a data-supported trust region. Compared with offline global constraint learning, the approach uses local surrogates that adapt to the data distribution during optimization and can achieve solution quality comparable to that of global models while using simpler local models and smaller optimization subproblems.

4 - Ultrametric-constrained completion of mitochondrial DNA distance matrices via hybrid alignment and adaptive optimization
Dmitrii Chaikovskii

Distance matrices computed from mitochondrial DNA sequences are widely used in distance-based phylogenetic analysis, yet building a fully populated matrix can be computationally costly and missing entries are common. We propose a hybrid completion method that partially seeds gaps with global alignment estimates and then refines unknown distances by adaptive moment optimization of a triplet-consistency loss promoting ultrametric structure. Experiments show improved ultrametric consistency and accurate recovery versus common imputation and low-rank baselines.

■ FA-31

Friday, 9:00-10:30 - Room: JUR - Hörsaal 12 (Building: JUR)

Innovations and Sustainability in Last-Mile Logistics

Stream: Smart Logistics
Invited session
Chair: *Tho Le*

1 - From Resilient Last-Mile Distribution to Freight System Resilience
Miguel Jaller, Anmol Pahwa

This paper examines last-mile distribution resilience under demand disruptions and extends the insights to freight system resilience. Building on prior work that modeled alternative last-mile strategies using the resilience triangle and R4 framework, we quantify performance losses and recovery across delivery models. We then discuss how these methods inform a broader network-based approach that integrates commodity flows, hazard exposure, and redundancy analysis to support strategic freight resilience planning.

2 - Multi-Echelon Location-Routing with Micro-Depots and Heterogeneous Fleets under Low Emission Zone Entry Constraints
Fernando Arenas-Araya, Cristian Aguayo, Jorge Amaya, Sabine Limbourg

This research presents a three-echelon location-routing model that integrates micro-depots, heterogeneous vehicle fleets, and Low Emission Zone (LEZ) access regulations. The goal is to minimize operational costs while satisfying environmental constraints in urban distribution networks. We conducted case studies in Brussels and in a multicity network, analyzing scenarios under no LEZ, a moderate LEZ, and a full LEZ. The results illustrate how micro-depots, cleaner vehicles, and varying levels of demand influence the trade-offs between LEZ costs, emission reductions, and total kilometers driven.

3 - Evaluating Customer Satisfaction and Continued Intention to Use AI Virtual Assistants in Last-Mile Delivery Services
Dan Julius Ramirez, Vincent F. Yu

E-commerce growth strains last-mile logistics, driving the adoption of AI virtual assistants. This study evaluates consumer interactions, satisfaction, and continuous usage drivers using ISSM and SERVQUAL framework. A dual SEM and ANN approach assessed System, Information, and Service Quality, plus Anthropomorphism. Findings reveal Information Quality as a baseline, while Anthropomorphism and Service Quality best predict continued use. This helps delivery providers optimize AI interfaces.

4 - A Discrete-Time Q-Learning Approach for Scheduled Multimodal Middle-Mile Delivery
So Rim Han, ByungDuk Song

Multimodal middle-mile logistics face significant computational bottlenecks under strict operational schedules. To address this, we propose a discrete-time Q-learning framework that transforms routing and mode selection into a sequential decision-making process. By discretizing the operational day, our model uniquely aligns cargo assignments with fixed transport timetables and capacity constraints. This paradigm shift from global batch optimization to real-time sequential dispatching provides a scalable solution for complex, large-scale multimodal networks.

■ FA-33

Friday, 9:00-10:30 - Room: JUR - Hörsaal 15 (Building: JUR)

Train Rescheduling

Stream: Passenger Railway Transportation
Invited session
Chair: *Twan Dollevoet*

1 - Robust Train Dispatching
Giacomo Maggiorano, Bjørnar Luteberget, Carlo Mannino, Giorgio Sartor, Gautier STauffer

Railway dispatchers mitigate delays by adjusting train timings and order in real time. This problem can be modeled using an alternative graph, but this deterministic formulation is highly sensitive to uncertainty: even small perturbations may lead to infeasibility. We develop a dispatching approach robust to uncertainty in travel and dwell times: through a budgeted uncertainty model and a layered graph structure we derive robust feasibility cuts ensuring feasibility for a bounded number of arc weight deviations. We also provide a comprehensive evaluation framework for dispatching policies.

2 - Integrating Deep Reinforcement Learning and Mathematical Optimization for Real-Time Train Timetable Rescheduling
Ashkan Fouladi, Nikola Bešinović, Ostap Okhrin

Train operations often deviate from the planned timetable due to perturbations, requiring rapid Train Timetable Rescheduling (TTR). Traditional mixed-integer linear programming (MILP) provides high-quality solutions but is often too slow for real-time use, while deep reinforcement learning (DRL) enables fast decisions without optimality guarantees. This study proposes a hybrid framework where a graph neural network-based DRL model predicts routing decisions to reduce the MILP search space. The hybrid approach improves solution quality compared with standalone DRL or optimization methods.

3 - Real-Time Rescheduling of a Metro Line System with Regenerative Braking and Energy-Efficient Speed Trajectories: A Hamburg Case Study
Emanuele Cutore, Veronica Dal Sasso, Paolo Ventura, Claudio Gentile

This study proposes an Integer Linear Programming optimization model for the real-time and energy-efficient rescheduling problem of an urban rail network. The model's underlying graph structure integrates railway infrastructure and the electrical distribution system, enabling spatially accurate modeling of energy flows. The model uses a time-indexed formulation with a 1-second resolution and a 30-minute rolling horizon. In a real case study of an 11-station metro line in Hamburg, the proposed optimization can produce conflict-free and energy-efficient schedules in under 20 seconds.

4 - From Routes to Resources - A Model for Real-Time Train Dispatching with No-Wait Constraints
Luka Stärk, Niels Lindner, Ralf Borndörfer

Optimization for train dispatching promises to reduce delays. Yet scalable applications are rare. We present an efficient MIP model for the dispatching problem with no-wait constraints. Each train is a DAG of operations with velocity profiles, route reservations and releases. No-wait constraints between consecutive operations apply when the connecting velocity is positive. We transform the route-based exclusive infrastructure use of trains into an equivalent representation on resources. On real-life data from German dispatching regions, we compute near-optimal solutions within 60 seconds.

■ FA-34

Friday, 9:00-10:30 - Room: JUR - Hörsaal 16 (Building: JUR)

Airport Operations

Stream: Passenger air transportation: airlines and airports
Invited session
Chair: *Young Chun*

1 - A Matheuristic Method for Robust Air Transit Passenger Scheduling at Megahubs
Cemalettin Ozturk, Melis Tan Tacoglu, M. Arslan Ornek

Airlines pursue growth by expanding from mega-hubs to new airports while leveraging existing inbound connections from spoke networks. Outbound schedules must preserve transfer connectivity, as transfer passengers drive revenue, while uncertainty in arrivals and passenger demand increases complexity. We develop a large neighborhood search heuristic integrated with Monte Carlo simulation-optimisation to maximize profitability while reducing passenger spill and transfer waiting time. Validation with real mega-hub flight data demonstrates the robustness and scalability of the developed method.

2 - Optimal Airport Escort Manpower Planning with Flexible Shift and Working-Hour Strategies
Ching-Sheng Sun, Shangyao Yan, Chiao-Ling Lo

Escort services for passengers with reduced mobility are essential to airport operations; however, staff planning in practice largely relies on manual experience and lacks systematic optimization, often resulting in inferior solutions. To address this issue, the study develops a network flow-based manpower planning model that incorporates flexible shift and working-hour strategies to minimize total labor costs. A solution algorithm is proposed to efficiently solve the model, and computational experiments demonstrate the effectiveness and practical applicability of the approach.

3 - Designing the Two-Stage Screening Procedure for Airport Security Checkpoints
Young Chun

The airport security screening procedure is like a two-stage inspection plan in the manufacturing industry. In the paper, we deal with a two-stage screening procedure in which all incoming items are screened at the first stage. At the second stage, only a stratified random sample of screened items is inspected again to improve the outgoing quality. We formulate the two-stage screening procedure as a goal programming model. We then estimate model parameters via the MCMC method. An illustrative example shows its applicability to settings such as airports, land borders, and seaports.

■ FA-35

Friday, 9:00-10:30 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Sustainable Supply Chains II

Stream: Operations Research and Sustainability
Invited session
Chair: *Lea Franze*

1 - Pay or Abate - or Circumvent? - Supply Chain Level Analysis of Adaptation Strategies Under the EU CBAM Regulation
Tobias Breitenbach, Moritz Fleischmann

To combat carbon leakage under the EU's carbon neutrality ambitions, the Carbon Border Adjustment Mechanism (CBAM) levies selected imported emissions. However, its influence on strategic supply chain decisions remains insufficiently understood to date. This research develops a two-stage analytical model to assess location choices, greening investments, and profits, specifically accounting for circumvention risks. By analyzing SC-wide responses, the study evaluates CBAM's efficacy in balancing sustainability with competitiveness, providing a basis for assessing potential policy extensions.

2 - Structural Role Identification in Automotive Supply Chain Networks and Its Implications for Carbon Emissions: A Stochastic Block Model Approach
Lin Li, Meng Li

This study identifies structural roles in automotive supply chain networks using directed degree-corrected Stochastic Block Models and examines how role position shapes carbon emissions. Longitudinal data from listed firms across 2016-2025 classify firms into assemblers, tier suppliers, and brokers. Panel regression links role membership to Scope 1, 2, and 3 emissions separately. Broker-role firms show lower Scope 3 but higher Scope 1 emissions, revealing structural determinants beyond firm-level controls.

3 - An Effective NSGA-II-LP Matheuristic for Technology Adoption in Decarbonized Food Supply Chains
Seyed Mojtaba Sajadi

This research develops a bi-objective mixed-integer linear programming model for technology adoption in production, transportation, warehousing, and distribution in food supply chains, while accounting for return flows from unsold products and compatibility among technology choices. The epsilon-constraint approach is used to solve the model, and a novel NSGA-II-LP matheuristic is proposed. Computational results show that the proposed matheuristic provides high-quality solutions with strong computational efficiency for large-scale problems and offers a practical tool for technology planning.

4 - Supply chain planning under social sustainability considerations for lithium-ion batteries
Lea Franze, Karsten Kieckhäfer

We develop an optimization model that integrates decisions related to procurement strategies (e.g., supplier selection, supplier development, and raw material sourcing), location and capacity planning, and distribution planning. The research is motivated by social sustainability requirements, which are particularly relevant in the upstream supply chain processes. The model incorporates social life cycle assessment and activity analysis. We apply the model to the lithium-ion battery supply chain, which is notorious for human rights violations during raw material extraction.

■ FA-37

Friday, 9:00-10:30 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Dynamics of the Firm 3

Stream: Dynamics of the Firm
Invited session
Chair: *Michi Nishihara*

1 - Staged Capacity Investments under Uncertainty
Nathan Bun

This paper examines multiple lumpy investments in a firm's production capacity within an uncertain business environment. The firm decides the timing and scale of each investment. We show that the optimal investment size maximizes the profit over the expected duration until the next investment. In addition, more investment opportunities make

the firm invest earlier and in smaller amounts, using subsequent investments to expand production when demand rises sufficiently. This strategy is particularly beneficial if the firm has a few very inelastic customers.

2 - Strategic capacity investment in differentiated competition: a real options game approach
Xingang Wen, Jie Wu, Peter Kort, Jacco Thijssen

We investigate investment decisions (timing and size) of two firms under demand uncertainty: an incumbent expands its old product capacity, and an entrant invests to produce a new product, which is a partial substitute to the old one and is better received on market. We characterize the endogenous investment order and show that the incumbent is more likely to preempt the entrant if the product differentiation is small, and the incumbent is relatively strong in the old market. This is because the incumbent firm then has strong incentives to protect its monopolistic privilege.

3 - Minimal Technology Standards and Innovation Investment under Uncertainty
Luoyuan Gan

This study models optimal R&D intensity, investment timing, and capacity size under stochastic quality evolution (GBM) and minimum technology standards. R&D intensity balances running costs against higher growth expectations, while timing balances waiting for higher demand against early entry to cut R&D costs. To comply, firms either accelerate R&D to meet standards sooner or slow down to save costs. We characterize the conditions when R&D intensity postpones the threshold. Stricter standards reduce R&D, as firms slow research to save flow costs during the forced wait, discouraging innovation.

4 - Investment and financing with a project life cycle
Michi Nishihara, Takashi Shibata

We examine a dynamic investment and financing problem in a market incorporating a product life cycle, where market demand grows rapidly (i.e., the growth phase) until reaching a peak threshold (i.e., a turning point), after which the growth rate slows (i.e., the maturity phase). Debt financing decreases the investment threshold and increases the possibility of investment in the growth phase. A firm enters in the growth phase with high leverage and faces high default risk in the maturity phase. This can lead to a First In, First Out scenario especially with a bell-shaped market demand.

■ FA-45

Friday, 9:00-10:30 - Room: HG - Seminar-Raum 01 (Building: HG)

Surgery Scheduling

Stream: Surgery scheduling
Invited session
Chair: *Alex Kuiper*

1 - Strategic and Tactical Surgery Planning under Uncertainty
João Paulo Francisco da Silva, Lucas Ribeiro Bortoletto, Rafael Crivellari Saliba Schouery, Edilson Arruda

We propose an integrated surgical planning framework that jointly addresses strategic and tactical decision levels in public health systems, where resource constraints and demand uncertainty are prevalent. The framework captures the dynamics of monthly patient demand and models the evolution of waiting lists to promote long-term stability. Additionally, it incorporates the stochastic nature of surgical durations in order to balance the risks of cancellations and overtime. Finally, it is empirically validated using real data from the Hospital de Clínicas at the University of Campinas - Brazil.

2 - A novel modeling approach to elective surgery scheduling
Sven Mallach

Operating room planning is a key task in hospital management. In the open scheduling variant, a room, day, and time is to be assigned to each surgery selected from a waiting list. Prevalent exact models are based on integer programming and employ variables that involve the four according indices. To reduce the number of variables, we present a novel approach with disaggregated decisions, along with a new occupancy-based model whose variables refer to surgeons rather than surgeries. In addition, we show how a pure three-index model can be obtained, and we report on computational experience.

3 - Block scheduling in practice: An optimal decomposition strategy for nonidentical operating rooms
Alex Kuiper

We develop and implement a Master Surgery Schedule for a real-life hospital. Through action research, we identify the issue of split blocks. While this can improve consistent patient outflow, it also incurs additional turnaround costs. To address this trade-off, we introduce an optimal two-level decomposition approach. The first level assigns specialties to days using a mixed-integer linear program with goal programming for the outflow. The second level refines these day-level assignments by matching them to ORs. These can be solved efficiently by formulating it as a min-cost max-flow model.

■ FA-46

Friday, 9:00-10:30 - Room: HG - Seminar-Raum 02 (Building: HG)

New scheduling models

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Natalia Shakhlevich*

1 - Energy-constrained single-machine scheduling to minimize the number of late jobs with partial recharge and generalized due dates
Renjie Yu, Daniel Oron

We study a single-machine scheduling problem where each job requires both processing time and rechargeable energy under a fixed energy capacity. We consider a generalized due date setting, where due dates are assigned to positions in the sequence. The objective is to minimize the number of late jobs by jointly determining a feasible schedule and a recharge policy. We develop a dynamic programming algorithm and a branch-and-bound algorithm. Extensive numerical experiments show that they perform well across diverse settings. We also examine two extensions with common and job-specific due dates.

2 - Modelling Edge-to-Cloud Offloading as a Scheduling Problem
Natalia Shakhlevich, Thomas Erlebach, Akiyoshi Shioura, Jie Xu

Edge-to-Cloud offloading has become an important research area in distributed computing. Unlike the mainstream research, in our study we treat the problem from the scheduling perspective, modelling it as a system of parallel machines of two types. Edge processing does not incur substantial communication delays, but processing capacity might be limited. Cloud processing benefits from more powerful and abundant resources, but it may be downplayed by data transmission overheads. In our study we develop exact and approximation algorithms for different versions of the problem.

3 - Lot Streaming with Variable Sublots: Cross-Operation Dependency in Scheduling Problems
Yu Chuanzhao, Fan Jiaxin, Shen Weiming

Lot streaming (LS) enables jobs to advance across operations in variable sublots (VS) before the entire lot, introducing complex cross-operation time dependencies. Rather than focusing on sublot sizes or counts, this study identifies continuous downstream triggering without upstream blocking as the primary mechanism influencing scheduling performance. By explicitly modeling this dependency structure, the proposed framework provides a unified, shop-independent explanation of LS effects and clarifies when and why LS leads to performance improvements.

4 - Modeling and Solving Workflow Scheduling Problems on Shared Computing Units
Anke Stieber, Andreas Fink

The research addresses the workflow scheduling problem on shared computing units. A set of interdependent tasks, originating from a workflow, requires processing by computing units such as virtual machines, while respecting precedence constraints and capacity restrictions. This problem arises in cloud systems allowing multiple tasks to share resources to reduce energy consumption. We present two model formulations for this integrated model of workflow scheduling and vector bin packing. Experiments show that exact methods can solve small-sized instances within practical computation times.

■ FA-47

Friday, 9:00-10:30 - Room: HG - Seminar-Raum 03 (Building: HG)

Freight transportation

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Neslihan Cevik*

1 - A Time-Expanded Bilevel Optimization Framework for Modeling Information-Driven Disruptions in Multi-Modal Networks
Daniel Cabrera, Andres Gonzalez, Kash Barker, Ahti Salo

We propose a bilevel framework to evaluate rail network vulnerability to strategic disinformation. We model users transitioning between information states using various spreading dynamics. These states, combined with an O-D matrix, feed a Time-Expanded Network (TEN) that captures temporal entries and waiting times. At the upper level, an intelligent attacker selects components for "perceived degradation," restricting disinformed users' paths. The follower TEN determines optimal travel routes.

2 - Collaborative multimodal freight transportation under uncertainty
François Gilet, Stefan Creemers, Jean-Sébastien Tancrez

Multimodal transportation is an important lever to reduce truck dominance in the freight transport sector, but has seen little adoption in the past. One reason is that multimodal capacity often has to be booked while companies still face demand uncertainty. Our research explores how horizontal collaboration, in the form of capacity pooling, can reduce costs and increase the multimodal share by reducing overall uncertainty. We develop a newsvendor-inspired method to find the optimal joint capacity, which we use to measure the benefits of collaboration under various cost and demand parameters.

3 - Synchromodal Bi-Objective Two-Stage Stochastic Optimization for Container and Power Unit Allocation
Milton Caballero, Andres Gonzalez

Container repositioning and power-unit deployment are typically planned in isolation despite operational coupling. We propose an integrated Bi-Objective Two-Stage Stochastic Mixed-Integer model to jointly allocate both under demand uncertainty. First-stage decisions cover repositioning and deployment, linked by leasing, while the second stage handles recourse flows. Using the ϵ-constraint method, we prove siloed strategies are mathematically dominated. A Florida network study shows coordination yields >40% savings for trucking with

4 - Dynamic Multi-Objective Driver Dispatching in Full Truckload Transport
Neslihan Cevik, Albert Schrotenboer, Tom van Woensel

The trucking industry faces driver shortages and pressure to reduce emissions. We study a dynamic multi-objective driver dispatching problem in full truckload transport where orders arrive over time and assignments must be made under operational and regulatory constraints. We propose a rolling-horizon framework combining constraint programming with cost-function approximations that capture future feasibility and driver workload balance. Computational experiments show substantial improvements in emissions, operational costs and workload balance.

■ FA-49

Friday, 9:00-10:30 - Room: HG - Seminar-Raum 05 (Building: HG)

Public transport and traffic

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Li Zhang*

1 - Managing Congestion Propagation in Public Transport Networks through Information-Induced Passenger Responses
Jiaci Wang, Fanlin Meng, Lina Zhang

Public transport disruptions necessitate effective operational responses to contain congestion and maintain network performance. This study investigates how information availability shapes passenger rerouting decisions and, in turn, influences congestion propagation across public transport networks. Using a dynamic modeling framework, it examines the interaction between individual adaptive behavior and system-wide flow dynamics to identify effective information policies that enhance public transport network resilience while balancing passenger adaptation with overall system performance.

2 - Number of spare batteries at an airport
Bela Vizvari

Some airports also serve e-aircraft. The airport charges the battery after arrival, one way of which is the Battery Swapping System, if the battery is replaceable. You can fly immediately after the replacement. You need so many spare batteries that the replacement can be used up immediately with a high probability. The arrival time of the aircraft is random. We model the daily traffic as a point process. The charging time can be fixed or random. We determine the number of spare batteries by optimization.

3 - A Predict-then-optimize Method for Bus Dispatching Problem under Metro Disruption Scenario with Destination Shifting
Li Zhang, Tingting Chen, Bin Yu

This paper designs bus bridging services (BSS) with destination shifting to address metro disruptions. Specifically, passengers take BSS to nearby locations and then go to destinations by other modes. We consider time-dependent demand uncertainty to capture unobserved and disruption-related demand. A dynamic scenario-based predict-then-optimize approach is developed. We first use a Temporal Fusion Transformer method to predict demand quantiles and generate demand scenarios. Then, a scenario-based stochastic programming model is proposed and solved by a Partial Benders Decomposition method.

■ FA-51

Friday, 9:00-10:30 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Airline Network Design

Stream: Hub Location and Network Design
Invited session
Chair: *Jinha Hibino*

1 - A Scalable Bilevel Continuous Approach to Profit-Maximizing Airline Hub-and-Spoke Network Design
Fernando Real-Rojas, Victor M. Tenorio, Luis Cadarso

We study the airline hub-and-spoke network design problem with profit maximization. Traditional MIP models become intractable for realistic networks because infrastructure decisions are binary and passenger capture is often described by a logit model. We propose a bilevel continuous approach: the lower level solves a convex entropy-regularized network design model that efficiently achieves logit share, while the upper level adjusts market weights to maximize profit. Fixed infrastructure costs are handled through an iterative penalty that prevents operating unnecesary routes and hubs.

2 - Multi-Period Service Design for Advanced Air Mobility with Passenger Choice
Yuhan Jiang, Xiaohan Zhou, Guglielmo Lulli, Shaopeng Zhong, Yu Jiang

Advanced Air Mobility (AAM) is emerging as a competitive option for urban and regional travel. We propose a multi-period AAM service design model that jointly optimises vertiport location, capacity, frequency, and pricing while capturing passenger choice. To solve the resulting choice-driven problem, we develop an exact method that transforms the MINLP into an ILP. Experiments on a 30-city UK network show strong interdependence between infrastructure and fleet investment, with the greater AAM benefits on city pairs with long ground travel times.

3 - Heuristic approaches for a point-to-point airline network design problem
Jinha Hibino, Shinji Imahori, Mihiro Sasaki

This study addresses a point-to-point airline network design problem (PPANP), which seeks an optimal location of a given number of edges to maximize the total captured demand. Since exact solvers are limited to small-scale instances, we present heuristic approaches for the problem. We first propose an efficient algorithm that identifies one additional edge to maximize the objective value. This method is utilized to (1) accelerate a constructive heuristic algorithm and (2) refine local search procedures. We evaluate the proposed heuristics through numerical experiments on large-scale instances.

■ FA-52

Friday, 9:00-10:30 - Room: KOL - PC Raum 1 (Building: KOL)

Market Equilibria and Clearing

Stream: Energy Markets & Systems
Invited session
Chair: *Miguel Anjos*

1 - Introducing Supply Function Equilibria for the Irish electricity market
Mel Devine, Davoud Hosseinnezhad, Seán McGarraghy

Many methodologies can model electricity markets, e.g., Supply Function Equilibria (SFE), Cournot, and cost minimisation. This work develops SFE models using bi-level optimisation with varying numbers of Stackelberg leaders and compares them with Cournot and cost-minimisation approaches. We replace the traditional quadratic form used in Cournot models with a stepwise linear load-shedding function, enabling application of the Strong Duality Theorem and formulation of SFE bi-level models as Mixed Integer Programs. The models are tested using detailed Irish power system data.

2 - Implementing Risk Aversion in a Realistic Multi-Stage Equilibrium Electricity Market
Dáire Byrne, Mel Devine

Due to the energy transition, markets are increasingly stochastic - thus, models must account for risk aversion. This work concerns a risk-averse equilibrium model of the Irish electricity market; following an investment stage, firms sell units via fixed-price forwards or in a stochastic pool. Capacity factors, marginal costs, and demand are stochastic. Parameters are derived from real data. The work presents the model and its results; it analyses the impact of risk aversion, market power, and forward markets on prices, profits, investment, and emissions, alongside policy recommendations.

3 - Uncertainty-driven long-term participation of a virtual power plant in the day-ahead market and a grid-balancing demand response auction
Álvaro García-Cerezo, Andrés Pleite-Paniagua, Luis Baringo, Ruth Dominguez

A risk-averse stochastic programming long-term planning model for the participation of a price-taker virtual power plant in the day-ahead electricity market and a grid-balancing demand response auction is proposed. Uncertainties, such as the activations of this demand response mechanism controlled by the system operator, are captured using scenarios, and the risk aversion is modeled through the conditional value-at-risk. A two-stage planning problem is formulated over a six-month planning horizon to determine the power reduction provided by the virtual power plant in the service.

4 - Adaptive Robust Optimization for Frequency-Constrained Market Clearing Problem
Ozlem Mahmutogullari, Hakan Ergun

The large deployment of offshore wind requires electricity market designs that account for efficiency and operational security. We develop an adaptive robust optimization approach for the market clearing problem under high wind penetration. We consider load and generation uncertainty along with tie line contingency. While day-ahead decisions are taken in the first stage, redispatch and balancing decisions are taken after uncertainties are realized. We use real North Sea data and show that a robust design enables higher utilization of wind farms and secures frequency stability across zones.

■ FA-57

Friday, 9:00-10:30 - Room: HG - Seminar-Raum 07 (Building: HG)

Behavioral OR general papers 3

Stream: Behavioural Operational Research
Invited session
Chair: *Ana Vieira*

1 - Combining Behavioural Observation and Physiological Signals to Analyse Interaction Dynamics in Mixed-Age Value-Focused Thinking
Ana Vieira, Alice H. Aubert, Hugo Plácido da Silva, Mariana Martinho, Gonçalo Ferreira, Benjamin Scheibehenne

Participatory decision support processes increasingly involve mixed-age groups whose demographic differences may activate subgroup faultlines that shape interaction dynamics. In this work we present the observational framework developed in the MAGIK project to analyse decision processes in mixed-age groups. During Value-Focused Thinking activities, behavioural observation is combined with physiological signals (e.g. autonomic synchrony) to capture engagement, conflict and convergence. We discuss the components of this framework and its potential advantages for studying group decision dynamics.

2 - Towards Preference-Aware Disassembly Line Balancing
Judith Schulze, Kerstin Schmidt, Christian Weckenborg, Thomas Spengler

Disassembly of waste electrical equipment is labor-intensive and involves diverse tasks. Assigning tasks without considering heterogeneous worker preferences may contribute to dissatisfaction, reflected in high sickness absence and turnover in recycling firms. Task-related preferences are elicited using a discrete choice experiment with recycling workers. Discrete choice models are estimated to account for preference heterogeneity. The resulting utility coefficients are integrated into a disassembly line balancing model to enable preference-based task assignment alongside economic objectives.

3 - Heterogeneity in Response to Interventions
Jessie Jiang, Chris Anderson

We test how consumers respond to Buy Now, Pay Later information disclosures in a study with 600 U.S. participants. Showing APR or total interest lowers BNPL uptake overall but not for people seeking to improve their credit scores. This self-identified group prioritizes monthly payments, consistent with stronger present bias. Our results show that nudge effectiveness varies across consumers, highlighting the need for targeted policymaking to protect vulnerable borrowers.

4 - Behavioral Operational Research and Behavioral Operations in Production Planning - A Systematic Literature Review
Marcus Brandenburg, Anita Onay, Christina Stampfer, Johannes Siebert

This study aims to pursue a systematic literature review on behavioral operational research and behavioral operations focusing on production planning problems. The result and synthesis of a content analysis including 132 papers provide insights into key themes of the research landscape and human-centered frameworks. The study indicates, inter alia, the need to distinguish in frameworks whether human aspects are addressed as human behavior (e.g. in decision making) or human factors (e.g. bias or emotion) or an integration of both, and it gives guidance for future studies.

■ FA-58

Friday, 9:00-10:30 - Room: HG - Seminar-Raum 08 (Building: HG)

Decision Support and System Modeling

Stream: Healthcare OR in developing countries
Invited session
Chair: *Jaime Palma-Mendoza*

1 - Statistical Learning Techniques Applied to Detection and Classification in Digitized Core Needle Biopsies of Prostate Cancer
Miguel Carrasco

In this talk, we present several approaches to a prostate cancer medical image classification problem. We outline the main challenges in developing a decision-support tool, from the initial concept to a prototype. In particular, we provide background on the disease, explain the usefulness of automatic cancer detection tools, review relevant computational models (mainly deep learning methods based on convolutional neural networks) and present an ongoing case study on cancer detection and aggressiveness classification, together with future objectives.

2 - Modelling community dynamics of antimicobial resistance in LMICs: A Hybrid Simulation Approach
Jayendran Venkateswaran, Avi Roy Chowdhury, Om Damani

Community level dynamics of Antimicrobial Resistance transmission is modeled & analyzed using hybrid agent and system dynamics methods. Each person agent embeds SD submodel capturing bacterial load, immune response, and antibiotic efficacy, enabling individualised infection trajectories. Behavioural attributes — interactions, dosage adherence, informal treatment probability, and self-medication tendency are captured. Model considers healthcare access in LMICs & environmental transmission via water bodies. Modeling challenges, formal/informal care pathways, and policy impacts are discussed.

3 - Optimal Radiotherapy Planning Considering Tissues Adjacent to the Tumor
Helenice Florentino, Gabriel Oliveira, João Manoel Miranda, Petra Bartmeyer, Juliana Freitas

Radiotherapy delivery relies on high-precision equipment, such as linear accelerators, whose performance depends on high-quality planning. This complex process requires considering tumor geometry, organ radiosensitivity, and tissue response to ionizing radiation. We propose a methodology integrating anatomical structure segmentation, including adjacent tissues, with optimization models. It determines optimal beam and beamlet configurations, balancing dose homogeneity, organ protection, healthy tissue sparing, and clinically relevant trade-offs.

4 - AHP model for Selecting Additive Manufacturing for Hospital Business Models in LMIC
Jaime Palma-Mendoza, Isaac Lemus Aguilar, Claudia Lizette Garay-Rondero, Luis Montesinos

This research develops an Analytic Hierarchy Process (AHP) model to support hospital decision-making on business models for additive manufacturing technologies (in-house, outsourced, hybrid) in Mexico for medical device production. Grounded in insights from the Business Model Canvas, the model integrates criteria such as demand volume, capacity, cost, logistics, and technical expertise. The AHP-based approach captures Low-Medium Income Countries constraints, enabling context-sensitive, transparent, and implementable decisions for healthcare innovation.

■ FA-59

Friday, 9:00-10:30 - Room: KOL - Seminar-Raum 9 (Building: KOL)

AI-MCDA interface 1

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Sarah Ben Amor*
Chair: *Renata Pelissari*
Chair: *Betania Campello*

1 - A probabilistic sorting MCDM methodology for index-based evaluation under temporal evaluation
Betania Campello, Caroline Mota

This study proposes a probabilistic multicriteria sorting approach for classifying alternatives based on composite index values under future uncertainty. The method integrates time-series forecasting with an outranking-based sorting mechanism, allowing index variability to be explicitly incorporated into category assignment. Instead of deterministic projections, confidence intervals are used to generate classification scenarios. The model is applied to countries using longitudinal index data, showing improved robustness and interpretability in transitions between development categories.

2 - Introducing fairness in multicriteria sorting: the FlowSort-Fair method
Renata Pelissari, Mercia de Sousa Rocha, Guilherme Pelegrina

Fairness has become a central topic in Artificial Intelligence. In multicriteria decision analysis, existing studies have mainly focused on fairness in ranking problems, while its implications for multicriteria sorting remain unexplored. This paper introduces fairness in multicriteria sorting through the proposed FlowSort-Fair method. Using statistical parity as a metric, we analyze disparities between protected and non-protected groups. A heuristic optimization approach explores criteria weights and category thresholds in FlowSort to obtain fairer classifications.

3 - Assessing AI Education Maturity in Undergraduate Management Programs Worldwide
Betania Campello, Leonardo Chang, Maria Vitória Ramos Vieira, Ketelen Santos, Claudia Affonso, Guilherme Pelegrina, Renata Pelissari

This study built a global database of undergraduate Management courses to assess how universities are responding to the rising demand for AI-related skills in the market and academia. Courses were classified into core AI subjects, prerequisites, support disciplines, tools, applications, AI ethics, and non-AI subjects. The framework enables proportional analysis of AI workload within curricula and provides a comparative measure of program maturity in integrating conceptual, technical, and ethical AI competencies.

4 - Identifying Gaps in Multicriteria Decision Making Methods through a Taxonomy-Based Analysis
Rodrigo Sukarie, Renata Pelissari

The growing diversity of Multi-Criteria Decision Making (MCDM) methods has made the selection of appropriate approaches for specific decision problems (DP) increasingly complex. Based on the taxonomy and database of 205 methods proposed by Marco Cinelli et al. (2022), this study investigates gaps between problem characteristics and available MCDM methods. By analysing combinations of DP features that are not supported by existing methods, the research identifies methodological gaps and highlights opportunities for developing new MCDM approaches better aligned with emerging decision contexts.

■ FA-60

Friday, 9:00-10:30 - Room: KOL - Seminar-Raum 10 (Building: KOL)

AI, Data and Decision Science in Insurance and Financial Markets

Stream: OR for Insurance, Banking and Financial Risk
Invited session
Chair: *Gabriella Piscopo*

1 - Predicting RMB Fixing-Market Divergence with Machine Learning
Emily Zhu

This study employs machine learning to predict divergences between the onshore CNY fixing and offshore CNH market rates. Using Bloomberg data from 2018-2025, it examines how CNH volatility influences PBOC fixing behavior, providing insights into hedge effectiveness, policy intervention, and managing corporate foreign exchange exposure.

2 - Efficient Nested Estimation of CoVaR
Yingda Song

We study the estimation of the systemic risk measure known as CoVaR, which quantifies the risk of a financial portfolio conditional on another portfolio being at risk. We identify two principal challenges: conditioning on a zero-probability event and the repricing of portfolios. To tackle these issues, we propose a decoupled approach utilizing smoothing techniques and develop a model-independent theoretical framework. Numerical results confirm the effectiveness of the decoupled estimators and provide practical insights for the selection of appropriate smoothing techniques.

3 - Strategic Investment in M&A: A Real Options Game Approach
Qiyuan Dai

This paper develops an integrated framework combining real options and game theory to analyze cross-border M&A under uncertainty. M&A opportunities are modeled as compound real options, capturing sequential decisions from acquisition to abandonment.A game-theoretic component models strategic interactions among multiple bidders, deriving equilibrium investment thresholds and optimal acquisition timing under competition. The model provides a rigorous basis for understanding how uncertainty and competition jointly shape cross-border M&A strategies.

■ FA-62

Friday, 9:00-10:30 - Room: KOL - Seminar-Raum 19 (Building: KOL)

Applications of MCDM 4

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Gwo-Hshiung Tzeng*
Chair: *James Liou*
Chair: *Sun-Weng Huang*

1 - Clinical Decision Support Framework for Family Caregivers of Patients With Advanced Cancer: A Fuzzy Delphi Consensus Study
Chia-Hsiang Lee, Chia Hsiang Lee, Yu-Cheng Kao

This study developed a clinical decision-support framework for family caregivers of patients with advanced cancer using the Fuzzy Delphi Method. A panel of 23 experts reached consensus on six symptom clusters and 24 indicators. Neuropsychiatric and respiratory symptoms emerged as the highest-priority decision contexts. The framework offers an evidence-informed foundation for nursing assessment, caregiver support, and future digital decision-support tools to improve timely symptom recognition, communication, and shared decision-making in advanced cancer and end-of-life care.

2 - Attribute Clustering-Based Objective Decision Model for Age-Friendly Cities (AFC) Strategic Resource Allocation and Governance
Tony Y. L. Chiang, Jian-Hua Xia, Carolyn Yan, Yi-Ling Tsai, Luna Y. F. Yu, Sun-Weng Huang, Gwo-Hshiung Tzeng

To optimize Age-Friendly Cities (AFC) resource allocation, this study develops a hybrid decision model integrating Logarithmic Percentage Change-driven Objective Weighting (LOPCOW), Method based on the Removal Effects of Criteria (MEREC), and Criteria Importance Through Intercriteria Correlation (CRITIC). These methods manage redundancy and determine priorities, eliminating bias. Finally, Rough Set Theory aggregates data for regional governance. Using East Asian cities, the model strengthens policy appropriateness and provides a strategic framework for sustainable urban development.

3 - Exploring Healthy and Happy Governance Strategies in Aged and Super-Aged Cities Using an Objective Aggregated Decision-Making Model
Luna Y. F. Yu, Jian-Hua Xia, Chang Chiayu, Fu-mei Pang, Tony Y. L. Chiang, Sun-Weng Huang, Gwo-Hshiung Tzeng

As countries enter aging and super-aged societies, promoting health and happiness is essential, and urban governance must respond effectively. This study develops a decision model using Integrated Determination of Objective CRIteria Weights (IDOCRIW) to determine indicator weights and Additive Ratio Assessment (ARAS) to evaluate and rank cities. A case from an East Asian country or region is examined to explore governance strategies for health and happiness in aging and super-aged cities. The findings provide recommendations for resource allocation and contributing to decision science.

■ FA-66

Friday, 9:00-10:30 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Nonconvex Global Optimization and Algorithm Tuning

Stream: Continuous and Global Optimization
Invited session
Chair: *Mirjam Duer*

1 - Optimizing 3D Kronecker Sequences generation for Low Star Discrepancy
Imène Ait Abderrahim, Carola Doerr, Martin Durand

The L star discrepancy is a measure of how uniformly a point set is distributed in a given space. Point sets of low star discrepancy are used as designs of experiments, as initial designs for Bayesian optimization algorithms, for quasi-Monte Carlo integration methods, and many other applications. In this work, we propose using automatic algorithm configuration to tune the parameters of Kronecker sequences. Focusing on the 3-dimensional setting. The obtained results outperform state-of-the-art constructions for sets of at least 500 points, and are competitive with the best known small sets.

2 - Exact Solutions to the Sparse Clustering Problem
Marten Soer, Wilco van den Heuvel

Minimum Sum of Squares Clustering (MSSC) is a well-known Machine Learning problem that partitions N observations into K clusters by using all available features. Standard MSSC cannot identify which features to ignore, leading to poor performance when data contains noisy or redundant dimensions. To address this limitation, recent work introduced feature weights that are bounded by Lasso and Ridge-inspired penalties to assure sparsity. In this paper, we are the first to find exact solution using a Difference-in-convex functions approach.

3 - A Globalized Semismooth Newton Method for Prox-regular Optimization Problems
Yuqia Wu

We are concerned with a class of nonconvex and nonsmooth composite optimization problems, comprising a twice differentiable function and a prox-regular function. We establish a sufficient condition for the proximal mapping of a prox-regular function to be single-valued and locally Lipschitz continuous. By virtue of this property, we propose a hybrid algorithm that combines the proximal gradient method with a semismooth Newton acceleration step, which is a globalized semismooth Newton method. Global and superlinear convergence are established under mild conditions.

4 - A Global Optimization Algorithm for Reverse Convex Quadratic Programming Using FJ Point Enumeration
Syuuji Yamada

This paper studies reverse convex quadratic programming problems with multiple convex quadratic constraints and one reverse convex quadratic constraint. The problem is reformulated as a parametric optimization problem, and global optimal solutions are characterized by FJ(Fritz-John) points of the subproblems. We propose an enumeration method for FJ points based on the optimality conditions of the parametric problem and combine it with a branch-and-bound scheme over the simplex of Lagrange multipliers to compute approximate global optimal solutions.

■ FA-67

Friday, 9:00-10:30 - Room: KOL - PC Raum 3 (Building: KOL)

Hydrogen & CCS Infrastructure Planning

Stream: Energy Markets & Systems
Invited session
Chair: *Lars Hellemo*

1 - Spatial and temporal optimization of carbon capture and storage infrastructure in industrial clusters
Luca Bertoni, Xiao Yang, Chiara Artini, Lorenzo Villani, Matteo Gazzani

Carbon capture and storage (CCS) is essential for decarbonizing hard-to-abate industries but requires complex infrastructure planning. We develop a mixed-integer linear programming (MILP) framework to co-optimize multi-modal CCS infrastructure design and operation, applied to industrial clusters in Northern Italy and Greece. Non-linear technology models are reformulated into a tractable MILP. Using real-world hourly emission profiles we capture the operational variability and its impact on system design and costs. The resulting model exceeds 35 million continuous variables and 300 binaries.

2 - Hydrogen Supply Chain Design Roadmap for Decarbonization of of Heavy-Duty Fleet based on Carbon Tax Scenarios
Sule Itir Satoglu, Fidan Eser

A hydrogen supply chain must be designed for a long horizon to support the decarbonization of heavy-duty fleets. In this study, we propose a bi-objective, multi-period optimization model to design a hydrogen supply chain serving heavy-duty fuel cell vehicle fleets across carbon tax scenarios. The model minimizes total daily system cost, including carbon costs, over the planning horizon while constraining carbon dioxide emissions using an Epsilon-Constraint approach, to reveal the trade-off. The model was solved for Türkiye. Carbon tax policies and supply chain design are jointly evaluated.

3 - Optimal policy mix for Sustainable Aviation Fuel under cap-and-trade mechanism: A Government-Airline two-stage sequential game framework
JaeYong Park, Hyunjun Han, Inho Jung, Jihyeok Jung

Sustainable aviation fuel (SAF) has attracted considerable attention as an effective tool for reducing carbon emissions the aviation sector, but airlines' adoption incentives are limited by its high cost. So, we analyzes the strategic interaction between the government and an airline as a two-stage Stackelberg game in a cap-and-trade, with a blending mandate, penalties, and subsidies simultaneously. We separately evaluates the effect of an SAF exemption scheme. Empirically, we provides policy implications through long-term simulations based on a representative Korean airline.

4 - Optimizing Infrastructure for Hydrogen Blends: A Mixed-Integer Non-Linear Programming Approach
Lars Hellemo, Raquel Alonso-Pedrero

To analyse the viability of hydrogen integration in natural gas infrastructure, we present an optimization tool that evaluates hydrogen transport through either admixing natural gas or repurposing pipelines for pure hydrogen pipelines. The model is formulated as a mixed-integer non-linear optimization problem that brings together pooling and flow-pressure formulations. The model is implemented as an extension to the open-source EnergyModelsX (EMX) framework and applied to a case study from the SHIMMER project.

Friday, 11:00-12:30

■ FB-01

Friday, 11:00-12:30 - Room: HG - Audimax

Tutorial Tal Raviv

Stream: Tutorials
Tutorial session
Chair: *Margaretha Gansterer*

1 - The design and operation of vehicle sharing systems
Tal Raviv

Car, bike, and e-scooter-sharing have emerged over the past two decades as a viable complement to public transit, filling gaps that conventional services leave unaddressed. Designing and operating these systems poses rich modeling and algorithmic challenges. Chief among them is maintaining adequate vehicle availability and parking capacity, a task that intertwines inventory routing and repositioning, dynamic pricing, facility location, charging scheduling, and maintenance planning. Effective models must capture the systems' dynamic and stochastic nature and endogenize user behavior, including responses to inevitable shortages. This talk surveys the state of the art in operations research on vehicle-sharing systems, distills insights from research and practice, and outlines open problems created by new technologies and operating modes.

■ FB-06

Friday, 11:00-12:30 - Room: HG - Hörsaal 07 (Building: HG)

Supply Chain Planning

Stream: Supply Chain Optimization
Invited session
Chair: *Omid Jadidi*

1 - AHP Model Structure Incorporating the SCOR Digital Standard for Supply Chain Re-design
Jaime Palma-Mendoza, David Salinas-Navarro, Andrés Alberto García León, Iván Arana

This research proposes an AHP structure that integrates the SCOR Digital Standard (SCOR DS) to prioritize supply chain processes for redesign. Building on previous research on the SCOR-AHP model, the framework adopts updated process types—Orchestrate, Plan, Order, Source, Transform, Fulfill, and Return—as decision alternatives. Standardized SCOR DS performance attributes and metrics serve as multicriteria for the hierarchy. The model provides a systematic, quantifiable approach for identifying critical processes in digitized supply networks, facilitating strategic transformation.

2 - Blockchain-Enabled Trust and Transparency in a Platform Supply Chain with New, Refurbished, and Remanufactured Products
Ishani Ray, Samarjit Kar

This study investigates a platform-based supply chain offering new, refurbished, and remanufactured products. Consumers do not trust remanufactured goods, whereas refurbished goods are characterized by quality uncertainty. Blockchain is introduced as a platform-provided service that enhances information transparency and builds trust. Pricing and quality choices under various conditions are examined using a game-theoretic model. The findings reveal that blockchain adoption significantly alters demand allocation, competitive interactions, and profitability across supply chain participants.

3 - Supplier Selection Problem with Random Demand and Supply
Omid Jadidi, Fatemeh Firouzi

Supplier selection and order allocation are critical decisions when both demand and supplier performance are uncertain. This study extends the traditional newsvendor framework by incorporating supplier reliability, allowing suppliers to deliver only a portion of the ordered quantity. A practical computational algorithm is developed to determine optimal order quantities in single and multi-supplier settings while considering price, reliability, and capacity. Numerical results show how supplier reliability and purchasing cost influence ordering decisions and expected profit.

4 - Three-Echelon Supply Chain Coordination under Green Multiplicative Demand
Rohit Gupta, Bhawana Rathore

Rising environmental pressure and green consumer demand require supply chains to integrate sustainability into pricing and contracts. This study develops a decentralized three-echelon model with price-elastic, green-sensitive demand where greening requires quadratic investment. Using wholesale price and two-part tariff contracts under a Stackelberg framework, we derive closed-form equilibria for four contract sequences. Results show greening increases with green sensitivity but decreases with cost and elasticity. The (L,L) sequence achieves full coordination and highest sustainability.

■ FB-07

Friday, 11:00-12:30 - Room: HG - Hörsaal 21 (Building: HG)

Stable Matching and Networks

Stream: Matching under Preferences
Invited session
Chair: *Ana Busic*

1 - Decentralized First-come-first-served Assignment of Capacitated Resources with Partially Observable User Preference
Yuhao Liu, Zhibin Chen, Joseph Chow, Xi Lin

This paper considers an assignment system where there are multiple types of capacitated resources (supply) preferred by corresponding types of users (demand), with the user-resource assignment conducted in a decentralized and first-come-first-served (FCFS) manner. The outcome of such a decentralized assignment system is highly non-unique depending on users' order of arrival. We aim to assess the best/worst-case system performance in terms of user satisfaction. An efficient algorithm is proposed and theoretical results on the system's price of anarchy and managerial insights are presented.

2 - Trading Networks with Bilateral Contracts
Zsuzsanna Jankó, Tamás Fleiner, Alexander Teytelboym, Akihisa Tamura

We consider a model of matching in trading networks in which firms can enter into bilateral contracts. In trading networks, stable outcomes, which are immune to deviations of arbitrary sets of firms, may not exist. We define a new solution concept called trail stabity. Trail-stable outcomes are immune to consecutive, pairwise deviations between linked firms. We show that any trading network with bilateral contracts has a trail-stable outcome whenever firms' choice functions satisfy the full substitutability condition. We prove results on the lattice structure and the rural hospitals theorem.

3 - Stability in contract-based project team matching problems with preferences over colleagues
Zexiao Wu, Genjiu Xu, Wenzhong Li

We study a project team matching problem in which workers evaluate not only their own contracts with projects but also the contracts offered to their potential colleagues. We propose the Contract Composition and Objection Negotiation (CCON) mechanism and show that it always yields a stable matching under the substitutes condition. Moreover, we establish an impossibility result showing that no mechanism can be both stable and strategy-proof. Finally, when all workers only wish to join single-worker projects, the outcome of the CCON mechanism coincides with that of the DA algorithm.

4 - Dynamic matching models under greedy policies: performance paradox and extensions to hypergraphs
Ana Busic, Josu Doncel, Jean-Michel Fourneau, Shu Li, Doan Dai Nguyen

We study a stochastic dynamic matching system in which items of different classes arrive according to independent Poisson processes. Unmatched items are held in queues, and feasible matchings are specified by a compatibility graph. We analyze the impact of the compatibility graph on average waiting times and demonstrate the existence of a performance paradox under greedy matching policies. For matching systems defined on hypergraphs, greedy policies may fail to achieve the maximal stability region. We introduce and analyze a new class of policies for matching systems on hypergraphs.

■ FB-08

Friday, 11:00-12:30 - Room: HG - Hörsaal 41 (Building: HG)

Pattern Detection, Classification and Forecasting

Stream: Descriptive, Diagnostic and Predictive Analytics
Invited session
Chair: *Fuad Aleskerov*
Chair: *Mostafa Rezaei*

1 - Integrating Descriptive, Diagnostic, and Predictive Analytics for Production Planning, Demand Forecasting, and Quality Management in Manufacturing
Juan Carlos Cisneros

This study integrates descriptive, diagnostic and predictive analytics to support production planning, demand forecasting and quality management in automotive manufacturing. A Power BI dashboard consolidates production and logistics data to improve transparency and insight. Diagnostic analysis identifies variability in SKD and CBU units, while predictive methods such as moving averages and exponential smoothing forecast demand and defects. Results show exponential smoothing as the most reliable method for medium-term planning, enabling improved resource allocation and decision-making.

2 - A Deep Learning Approach to Determining Treatment Response in Breast Cancer
Merve Mestan, Aslı Aksoy

Breast cancer, the most common cancer among women, requires accurate pathological evaluation to guide treatment planning. Biomarkers derived from pathological data are commonly used to predict treatment response; however, the manual evaluation introduces subjectivity. In this study, deep learning methods are applied to predict patient response to treatment based on pathological data. The results demonstrate high performance, suggesting that the proposed approach can support clinical decision-making by improving diagnostic accuracy and providing more objective treatment response predictions.

3 - Nested Pooling: An interpretable framework for batch and online probabilistic forecasting
Mostafa Rezaei, Armann Ingolfsson

We propose Nested Pooling, an interpretable framework for online probabilistic forecasting of sparse spatiotemporal demand. It learns a hierarchical tree that pools information across related groups and resolutions, letting fine-scale forecasts borrow strength from broader aggregates while preserving local structure. The method supports convex losses, including pinball and Huberized pinball, for quantile forecasting, updates sequentially under nonstationarity, admits regret guarantees, and outperforms strong baselines on EMS demand forecasting.

4 - Detecting Pre-Seismic Anomalies in GPS Displacements: Life Cycle Curves, Threshold Clustering, and Signal Patterns
Fuad Aleskerov, Aleksei Kosychev

Short-term prediction of large earthquakes remains challenging despite dense GPS observations. We adapt the LC curve method to detect anomalies in 5-minute horizontal GPS displacements preceding 196 events with magnitude M 6. Detection performance is assessed across a fine anomaly-threshold grid using Probability of Detection, False Alarm Ratio, and Critical Success Index. Additionally, pattern analysis is applied to LC-curve deviations for each event-station pair, revealing recurring pre-seismic signal shapes across seismically diverse cases.

■ FB-09

Friday, 11:00-12:30 - Room: HG - Hörsaal 50 (Building: HG)

Foundation models and optimization

Stream: Data Science meets Optimization
Invited session
Chair: *Patrick De Causmaecker*
Chair: *Ender Özcan*

1 - Optimal Regression Trees Using Piecewise Linear Functions
John Warwicker, Steffen Rebennack

Decision trees (DTs) not only provide a classification, but also a series of reasoning steps. Mixed-integer linear programming (MILP) models for building DTs optimise for the whole tree at once. We present the first formulation for optimal regression DTs using piecewise linear (PWL) decision rules, which allows classifications to be made as a composition of ReLU functions. We present extensions to classification trees, multivariate trees and general PWL DTs. Modelling paradigms are discussed to improve the performance of the approach, as well as experimental results on classical benchmarks.

2 - Support Vector Regression including Ordered Weighted Average
Luisa I. Martínez-Merino, Justo Puerto, Antonio Manuel Rodriguez-Chia

This work proposes a new Support Vector Regression (SVR) model that incorporates Ordered Weighted Average (OWA) operators to differently penalize deviations of observations from the epsilon-strip. We develop two nonlinear formulations: a continuous formulation for non-decreasing monotone weight vectors and a mixed-integer formulation for general weight vectors. To enhance computational efficiency, two heuristic approaches are introduced. Computational experiments have been carried out to show the performance of the exact and heuristic approaches.

3 - An Optimization Framework for Choosing Better Problems to Solve
Zohar Strinka

Optimization provides a toolset for exactly defining a problem space and the matching best solution. Operations researchers often refine the problem statement to ensure the optimal solution does not change, while making the problem easier to solve. In many cases we do change the problem (e.g., by switching to a linear relaxation) to find a better balance of tractability and validity. This approach, including the flexibility of changing the problem-space and definition of optimality, can be applied to problem-solving more generally.

4 - Data Science meets Optimization: stream closing and discussion
Patrick De Causmaecker

In 2016, the EURO/WG Data Science meets Optimization was created to bridge between two large domains of research essential in operations research. The successful streams at EURO and IFORS conferences and the activities at data and artificial intelligence focused conferences s.a. CPAIOR, IJCAI, AAAI and ECML created a fruitful forum of interaction. Since 2023, DSO also organizes biyearly summer schools attracting major attention. An overview of the DSO activities will be presented and there will be ample room for discussion with session chairs, stream organizers and board members.

■ FB-10

Friday, 11:00-12:30 - Room: HG - Hörsaal 31 (Building: HG)

Scheduling and Resource Allocation: From Fair Division to Operational Efficiency

Stream: Combinatorial Optimization
Invited session
Chair: *Bo Chen*

1 - Cooperative scheduling: A skill-set dependent approach to multi-agent scheduling
Daniel Oron, Johnson Phosavanh

We consider a new class of multi-agent scheduling problems in which some jobs can be completed by multiple agents, each with a different processing time. This can be used to model scheduling tasks to workers with different skill sets. This problem can be considered as a multi-stage optimization problem, where the assignment of jobs to agents needs to be decided, followed by the determination of an optimal schedule or vice versa. We show that this class of problems is neither strictly easier nor harder than the conventional competing or nondisjoint job set scenarios, and we provide an extensive

2 - Constant Weighted Maximin Share Approximations for Chores
Bo Li

We study the fair allocation of indivisible chores among agents with asymmetric weights. Among the various fairness notions, weighted maximin share (WMMS) stands out as particularly compelling. Despite its appeal, the existence of a constant-factor approximation for WMMS has remained an important open problem in weighted fair division. Prior to our work, the best known approximation ratio was O(log n), where n is the number of agents. In this paper, we make significant progress by presenting the first constant-factor approximation algorithm for WMMS.

3 - Joint Scheduling of Laden and Empty Containers with Turnover and Port-Level Availability Constraints
Eun-Seok Kim

Maritime logistics moves over 80% of global cargo, but trade imbalances often cause shortages or surpluses of empty containers at ports, leading to inefficiencies. This study proposes an integrated container scheduling problem that jointly handles laden container delivery and empty container repositioning. The model considers vessel capacity, port travel times, container turnover delays, and initial container availability. The problem is shown to be strongly NP-hard. We develop a mixed integer programming model and a Lagrangian relaxation-based heuristic.

4 - Resource allocation algorithm for multi-beam military satellite: future directions
Yifeng Xia

This paper examines challenges and trends in resource scheduling for multi-beam high-throughput military satellite communication systems. The problem features strong coupling among beams, time slots, bandwidth, and power, with NP-hard complexity in dynamic, uncertain environments. We analyze the shift from static to intelligent algorithms, including heuristic and deep reinforcement learning, enabling hierarchical decoupling and collaborative optimization.

■ FB-11

Friday, 11:00-12:30 - Room: HG - Hörsaal 32 (Building: HG)

OR in Agriculture IV

Stream: OR in Agriculture
Invited session
Chair: *Li Haiyan*

1 - [LATE CANCELATION] Strategic Incentives for Supply Chain Transparency Through Blockchain: A Game Theory Analysis
Behzad Maleki Vishkaei, Domenico De Giovanni

This paper develops a game-theoretic model between an insurer and an agricultural producer using blockchain oracles to automate damage reporting. While producers may inflate claims under information asymmetry, insurers can co-invest in blockchain to ensure transparency, cut fraud, speed reimbursements, and lower costs. Collaboration improves profits and reduces premiums, but may fail under specific economic and operational conditions.

2 - Opportunistic Behavior in Turbulent Markets: Ex-Ante or Ex-Post Pricing for Contract Farming?
Li Haiyan

Agricultural buyers adopt flexible pricing contracts combining guarantee price with market-based adjustment to mitigate farmers'side-selling. A key decision is whether to commit to adjustment rule ex ante or retain ex-post flexibility.We develop game-theoretic model of a buyer interacting with heterogeneous farmers and compare resulting acceptance and contract value. The results reveal trade-off between commitment and operational flexibility. The preferred mechanism depends on farmer behavior, yield enhancement,and market turbulence, with implications for welfare and income dispersion.

■ FB-14

Friday, 11:00-12:30 - Room: HG - Hörsaal 01 (Building: HG)

Ethics and Operational Research in different Cultures 2

Stream: OR and Ethics, and Societal Perspectives
Invited session
Chair: *Ulrike Reisach*
Chair: *Cathal MacSwiney Brugha*

1 - Trends and Perspectives of Ethics in Operational Research
Elias Olivares-Benitez, Samuel Nucamendi-Guillén, Abraham Mendoza, Simge Deniz

This study examines the relationship between ethics and operational research through a systematic literature review conducted following the PRISMA protocol. Descriptive statistics summarize journals, authors, affiliations, and citations, while a deeper analysis explores application domains, ethical principles addressed, and operational research methods used. The findings indicate an emerging interest in the interconnection between these disciplines, accompanied by a concurrent focus on sustainability concerns, and identify trends in the development of this relationship.

2 - Integrating Digital Twins into Smart Warehousing: A Practice-Based View Framework
Sadia Samar Ali, Jose Antonio Marmolejo, Rosario Landa Piedra, Gerhard-Wilhelm Weber, Ulrike Reisach

Smart warehousing increasingly relies on digital twin technologies to enhance operational efficiency, real-time visibility, and decision-making in logistics systems. However, existing research primarily focuses on technological capabilities while paying limited attention to the organizational practices that shape successful implementation. Methods. This study aims to identify and prioritize the critical success factors for integrating digital twins into smart warehousing using the Practice-Based View as the theoretical lens. Empirical input was obtained from six industry experts.

3 - Ethics and Operational Research - Comparing Perspectives in China, India, and Europe
Ulrike Reisach

Ethics are frequently interpreted as "it is important", and not all persons know why and where it could be important. By ethics we understand moral, normative values, judgments, institutional frameworks or recommendations. Different ethics and cultures might be in all countries, and their structures, stiles, behaviors and decisions could be quite manifold. We will give samples for China, India, and Europe.

■ FB-15

Friday, 11:00-12:30 - Room: HG - Hörsaal 34 (Building: HG)

Dynamics in Games II

Stream: Algorithmic Game Theory
Invited session
Chair: *Yifen Mu*

1 - A Network Topology That Maintains Monotonicity for Nash Flow Over Time
Changjun Wang, Xujin Chen, Xiyuan Deng

In this work, we study the Nash flow over time and focus on the monotonicity relationship between the inflow rate and the makespan of the overall flow. By structurally characterizing the dynamic evolution of the Nash flows over time on a specific class of networks, we prove that the Nash flow on these networks possesses the monotonicity property. This result generalizes the previously known monotonicity for chains of parallel paths.

2 - Correlated pairwise stability in network formation games
Yang Zhan

Networks are at the forefront of research in economics and operations research as powerful tools to model social and economic interactions. While computing pairwise stable networks or equilibria in network formation games is generally very hard, we combine the concept of pairwise stability and correlated equilibria and propose the notion of correlated pairwise stability. We show that correlated pairwise stable networks can be a Pareto improvement of pairwise stable networks, and their computation is formulated as a mixed integer programming problem.

3 - Randomized Max-Vertex-Coverage Interdiction with Matroid Constraints
Chenhao Wang, Changjun Wang

We study a new bilevel optimization problem, the Randomized Max-Vertex-Coverage Interdiction, modeled as a zero-sum Stackelberg game on a network between a leader and a follower. The leader randomly selects a constrained subset of vertices to protect, while the follower—after observing the leader's interdiction—chooses a subset of vertices to attack, aiming to maximize the vertex coverage over edges. The leader's objective is to determine an optimal randomized interdiction strategy that minimizes the follower's maximum coverage. We give an 8/3 approximation algorithm for the leader.

■ FB-16

Friday, 11:00-12:30 - Room: HG - Hörsaal 42 (Building: HG)

E-Commerce Deliveries and Inventory Routing

Stream: Emerging Delivery Ideas and Alternative Modes
Invited session
Chair: *Ruben D'Haen*

1 - Robust Collaborative Three Tiers Containerized Multimodal City Logistics Problem
Najib Errami, S. Ehsan Hashemi Petroodi, Jakob Puchinger, Walid Klibi

We study a stochastic collaborative three-tier multimodal city logistics problem in which freight flows move through multiple urban hubs using different transportation modes and are coordinated by a central orchestrator. The system extends traditional two-tier city logistics structures by introducing an additional distribution layer, multimodal operations within urban delivery networks and uncertainties. The problem is formulated as a service network design problem coupled with last-mile routing decisions, capturing the coordination of multimodal freight flows and hub operations.

2 - Balancing store and warehouse fulfillment in e-groceries
Ruben D'Haen, Ann Campbell, Charlotte Köhler, Jan Fabian Ehmke

As e-grocery sales surge, optimizing fulfillment is crucial. Retailers face a trade-off between store- and warehouse-based fulfillment. Stores offer fast delivery due to their central locations, but have lower picking efficiency. Conversely, warehouses offer efficient picking but higher delivery costs as they are usually located outside the city center. This research analyzes this trade-off by integrating order assignment and vehicle routing decisions. A metaheuristic algorithm is proposed to identify the parameters influencing the balance between store and warehouse fulfillment.

3 - Machine Learning-Assisted Inventory Routing in Physical Internet Logistics Networks
Pantelis Lappas, Luca Bertazzi, Demetrio Laganà

This study investigates an extension of the Inventory Routing Problem inspired by the Physical Internet paradigm. The proposed framework integrates inventory decisions, hub-based distribution, and vehicle routing. Machine Learning models are used to predict customer demands, while routing decisions are obtained using heuristics for the Vehicle Routing Problem. Experiments based on well-known IRP benchmarks illustrate how predictive analytics and hub consolidation can improve logistics efficiency and reduce total costs.

■ FB-19

Friday, 11:00-12:30 - Room: HG - Hörsaal 05 (Building: HG)

Advanced Computational Methods for Stochastic Programs

Stream: Stochastic Optimization with Industrial Applications
Invited session
Chair: *Pablo Diaz-Cachinero*

1 - Solving Two-Stage Stochastic Programs with Fixed Recourse via Dual Clustering and Constraint Generation
Pablo Diaz-Cachinero, Ricardo Gázquez, Roberto Mínguez

We address large-scale risk-averse two-stage stochastic programs with fixed recourse, where CVaR replaces the expected recourse cost. We propose a single-loop algorithm that integrates dual clustering and constraint generation, reducing the number of scenarios and cuts required to solve the deterministic equivalent. The method converges under mild conditions and stops when the reduced model reproduces the full-model CVaR within tolerance. Tests on stochastic facility location benchmarks deliver speed-ups from one to more than three orders of magnitude without sacrificing solution quality.

2 - Approximation of Probability Measures for Stochastic Optimization
Alois Pichler

Stochastic optimization problems often involve complex probability measures. This talk address the maximum mean discrepancy to quantify the distance of probability measures. We employ this distance to simplify stochastic optimization problems for computational/ numerical purposes.

3 - Scenario Generation for Risk-Averse Stochastic Programs
Boris Nijhoff, Ruben van Beesten

We develop scenario generation methods for risk-averse stochastic programs. The main idea is to generate more scenarios in parts of the support that correspond to high costs. We do so by means of weighted clustering or importance sampling. Candidate solutions are used to assess how high the costs are for the scenarios. The presented methods can handle general spectral and coherent risk measures (including mean-risk), as opposed to existing methods that can only deal with pure tail risk measures.

4 - Beyond Optimality: Diversified SALNS and Decision Trees for Two-Stage Stochastic Programming
Asta Susan Rustad, David Pisinger

Many optimization models omit subtle constraints that are difficult to formalize, making reliance on a single "optimal" solution risky—especially in two-stage stochastic programs with strategic first-stage decisions. We present a diversifying extension of Stochastic Adaptive Large Neighborhood Search that generates many diverse near-optimal alternatives. From these solutions, we build a decision tree that structures key decisions by importance, helping decision makers incorporate preferences not captured in the model while staying within the near-optimal solution space.

■ FB-20

Friday, 11:00-12:30 - Room: HG - Hörsaal 06 / Franz-König-Hörsaal (Building: HG)

Advances in complex routing problems

Stream: Vehicle Routing and related problems
Invited session
Chair: *Nils-Hassan Quttineh*

1 - Vehicle Routing Problem with Vertical Stacking and Horizontal Product Compatibility Constraints
Alejandra Gómez_Padilla, Isidro Sarquis Urzua Cevallos, Laura Plazola Zamora

In this work we solve a Vehicle Routing Problem (VRP) with some specificities of food logistics, where delivery efficiency is restricted by loading protocols. Our model explicitly incorporates two critical dimensions: horizontal tray-level compatibility to prevent cross-contamination, and vertical stack-order requirements (top/middle/bottom). These joint constraints are modelled; we then analyse the impact of physical loading rules on total distribution costs and fleet productivity.

2 - The Precedence Constrained Family Traveling Salesman Problem
Raquel Bernardino, Daniel Santos

We introduce the Precedence-Constrained Family Traveling Salesman Problem (PC-FTSP), which generalizes the FTSP by adding precedence relations between families. We propose several formulations and compare them theoretically and empirically. We also derive valid inequalities that strengthen the linear programming (LP) relaxations. As some formulations are non-compact, we design a branch-and-cut algorithm to solve them. Results show the non-compact formulations outperform the compact ones, and the inequalities effectively strengthen the LP bounds on our instances.

3 - On Modelling Soft Time Windows in Vehicle Routing Problems
Farouk Olatunji Ligali, Lars Magnus Hvattum, Dušan Hrabec

The Vehicle Routing Problem with Soft Time Windows (VRPSTW) allows controlled violations of service time constraints using penalty functions. Although relevant for many practical logistics applications, modelling approaches for soft time windows are less standardised in the literature. This work reviews selected VRPSTW formulations and investigates how different definitions of soft time windows influence solution methods. Preliminary computational experiments compare basic exact and heuristic approaches on benchmark instances to illustrate the impact of modelling choices.

4 - An exact method for a challenging VRP problem
Nils-Hassan Quttineh, Torbjörn Larsson

We outline an exact method for the Hierarchical Multi-Switch Multi-Echelon Vehicle Routing Problem, a new challenging variant of VRP. The problem includes a single depot, possible intermediate swap locations, and two separate fleets (depot and local vehicles) which are pulling swap-bodies. We expand upon an earlier column generation approach, which provides strong lower bounds, by including a Benders decomposition scheme for a subset of complicating variables in the MP. This scheme generate integer solutions and results in an exact method for the problem. Preliminary results are presented.

■ FB-23

Friday, 11:00-12:30 - Room: HG - Hörsaal 02 (Building: HG)

Applications of Stochastic Programming and Control Theory

Stream: Exact and Heuristic solution methods for Optimization under Uncertainty
Invited session
Chair: *Man-Chung Yue*

1 - Energy-Efficient Rendezvous Algorithms for Heterogeneous Multi-Agent Systems
Banu Kabakulak

This paper addresses energy-efficient rendezvous for heterogeneous multi-agent systems with agent-specific kinematic constraints, power consumption, and communication ranges operating in convex regions with denied zones. We develop centralized and distributed optimization models with exact polynomial-time algorithms and heuristic methods. The proposed C-MAS and D-MAS controllers integrate optimization-based rendezvous computation with distributed control. Simulations demonstrate effective consensus achievement and robust performance under dynamic conditions and agent failures.

2 - Optimal control of a pest population through total catastrophes
Epaminondas Kyriakidis

A pest population grows in an area according to a simple deterministic immigration-birth-death process. The pest population may be controlled through total catastrophes. The length of time until the occurrence of a catastrophe is exponentially distributed. We restrict our attention to the class P of control-limit policies that take controlling action if and only if the pest population size is equal or greater to a critical size. The control-limit policy that minimizes the expected average cost per unit time within the class P is found.

3 - A Sample Average Approximation Approach to Rotating Workforce Scheduling Under Uncertainty
Tristan Becker

In rotating schedules, uncertain staffing requirements can lead to costly shortages. We address this by modeling the Rotating Workforce Scheduling Problem as a two-stage stochastic problem. To handle the computational complexity, we compare a network flow model against a cutting plane approach, using Sample Average Approximation to evaluate the scenario space. In an extensive computational study, we investigate the marginal value of several flexibility options. Compared to a deterministic schedule, our stochastic approach significantly reduces the costs of handling uncertainty.

4 - Dynamic Sequential Polling of Service Requests Subject to a Deadline
John Turner, Jiamei Zhang

We study sequential polling of preferred partners for service request allocation under a deadline. Partners inspect requests one at a time, incurring random time costs. The firm polls partners without replacement until a request is accepted or time expires, triggering a secondary market auction. We develop a near-optimal dynamic policy that adapts the polling sequence based on available partners and remaining time, validated through extensive numerical experiments. Applications include ad impression allocation, ride-hailing dispatch, and contractor job assignment.

■ FB-24

Friday, 11:00-12:30 - Room: HG - Hörsaal 03 (Building: HG)

Cutting-edge and Emerging Works

Stream: Knowledge, Technology, and Innovation Decisions
Invited session
Chair: *A. D. Amar*
Chair: *Theresa Elbracht*

1 - Investigating the Critical Drivers of Revenue Growth Using a Dynamic Capital Allocation Framework
A. D. Amar, Januj Juneja

We construct two dynamic programming models that embed two longitudinal models to study the issue of how to maximize revenue growth subject to resource allocation constraints set in accordance with the firm's desire to maintain a balance between exploration or exploitation. We find that firms that take on more risky ventures would place more emphasis on exploration and investing in intangibles, whereas firms partaking of less risky ventures would engage more in exploitation and tangible investments from which we infer the magnitude of the market premium for investing in the intangibles.

2 - Research on the Impact and Mechanism of Chain-leading Enterprises' Platform Ecosystem Embedding on the Breakthroughs in Key Core Technologies of Chain-member Enterprises
Gengyan Luo, Chen Gong

As a crucial means of breaking down collaboration barriers, platform ecosystem embedding guides chain-member enterprises to achieve breakthroughs in key core technologies by strengthening the spillover effects of chain-leading enterprises. This study constructs a complex network game model for theoretical analysis and conducts empirical testing using data from Chinese manufacturing A-share listed enterprises from 2013 to 2023. Findings reveal that the platform ecosystem embedding of chain-leading enterprises can incentivize breakthroughs in key core technologies among chain-member enterprises.

3 - Impact of Breakthrough Innovation in Key Core Technologies on Urban Economic Resilience
Zhu Jiawei

To enhance China's urban economic resilience, this study builds a theoretical framework of heterogeneous innovation and introduces a CES production function. Empirically, using panel data of 300 prefecture-level cities (2000-2023), we apply a two-way fixed effects model to analyze the relationship between breakthrough innovation in key core technologies and urban economic resilience, and conduct heterogeneity tests by resource type. Results show this innovation significantly strengthens urban economic resilience, yet its effects differ substantially across city types.

4 - When Adoption Peaks Twice: An Agent-based Simulation of Saddle Curves in Innovation Diffusion
Theresa Elbracht, Franziska Klügl, Christian Stummer

Models of innovation diffusion typically assume a single-peaked, bell-shaped adoption curve. However, empirical studies suggest that the respective curves in several real-world instances feature two peaks, forming a saddle. Building on the well-established Bass model and chasm theory, we have developed an agent-based simulation of a market with two segments, in which consumer agents are tightly connected within their own segment but only sparsely connected to agents in the other segment. Based on extensive simulation experiments we identified market structures that generate saddle curves.

■ FB-25

Friday, 11:00-12:30 - Room: HG - Hörsaal 16 (Building: HG)

Integrated Climate Decision Models

Stream: OR for Sustainability
Invited session
Chair: *Chengfan Hou*

1 - Who Gains and Who Loses in Climate Strategies? An Analysis with the AD-MERGE Integrated Assessment Model
Olivier Bahn, Kamyar Amirmoeini, Kelly de Bruin, Pierre-Olivier Pineau

Climate change imposes uneven economic burdens across regions, calling for integrated assessments of mitigation and adaptation. Using AD-MERGE, a hybrid integrated assessment model formulated as a non-linear optimization problem, we examine alternative policy mixes under endogenous adaptation and varying levels of mitigation stringency. Results reveal distinct regional burden profiles, underscoring persistent disparities between vulnerable and wealthier regions. These findings highlight the importance of region-specific climate policy design to enhance equity and overall economic efficiency.

2 - Coastal Groundwater Management: Seawater Intrusion Prevention, Artificial Recharge, and Climate Adaptation
Chengfan Hou

Existing strategies fail to coordinate coastal groundwater production, seawater intrusion barriers (SWIBs), and managed aquifer recharge (MAR). Using stochastic dynamic models, we show optimal joint operations follow a threshold structure. SWIBs and MAR act as strategic complements at low water levels and substitutes at high levels. Abundant natural recharge or reduced low-level penalties prompts aggressive SWIB use at low levels but conservative use at high levels. Calibrated with real data, joint operations expand flexibility and stabilize aquifers better than using SWIBs alone.

■ FB-26

Friday, 11:00-12:30 - Room: HG - Elise-Richter-Saal (Building: HG)

Data Envelopment Analysis XI: Modeling and theory

Stream: Data Envelopment Analysis
Invited session
Chair: *Maria Trnovska*
Chair: *Andreas Georgiou*

1 - A Convex Relaxation Approach to Path-Based DEA Models under Selectively Convex Technologies
Maria Trnovska

Data envelopment analysis under selectively convex (SC) technologies provides a framework for modeling technologies that combine volume and ratio data. Existing models focus mainly on input- and output-oriented formulations and are typically solved using mixed-integer Big-M approaches. This paper develops a solution method for path-based DEA models under SC technologies. The method derives efficiency bounds using links between SC, FDH, and convex technologies and a convex relaxation of the original model; in some cases, the relaxation bound is exact.

2 - Measuring DEA Accuracy under Alternative Definitions of Technical Efficiency
Bernadett Bertóková, *Maria Trnovska*

In simulation-based evaluations of DEA accuracy true efficiency is commonly defined in output-oriented terms, which may favour output-oriented models. In the simulation design true efficiency may also be defined to align with the selected notion of efficiency using distance functions. In this study, we use a translog production function with carefully selected parameter values and several alternative definitions of true efficiency to examine and compare the accuracy of DEA models across different efficiency concepts.

3 - Dynamic design of dea-markov systems with endogenous targets and time horizon
Andreas Georgiou, *George Tsaples*, *Konstantinos Kaparis*, *Emmanuel Thanassoulis*

This work extends DEA-Markov models with two enhancements for dynamic system design. A Dual-Frontier framework jointly optimizes policies and targets under Markov balance constraints, distinguishing feasible from aspirational trajectories. An Open-Time Control formulation optimizes the planning horizon, quantifying trade-offs between transition time, policy effort and target attainment while preserving linearity and interpretability.

Acknowledgment This research was funded by the European Health and Digital Executive Agency, Project: 101138517, Tec4MaaSEs, HORIZON-CL4-202

■ FB-27

Friday, 11:00-12:30 - Room: JUR - Hörsaal 13 (Building: JUR)

Port-Hinterland Logistics Systems

Stream: Maritime Logistics
Invited session
Chair: *Zhaojie Xue*
Chair: *Jintao You*

1 - Long-haul Truck Routing and Scheduling Problem with Temporal and Spatial Restrictions in China
Jintao You, *Zhaojie Xue*, *Wenxiang Peng*

Long-haul trucking in China faces stringent spatiotemporal Hours of Service rules—restricting continuous/accumulated driving time and mandating rest only at designated locations. We propose a mixed-integer model for the Long-haul Truck Routing and Scheduling Problem with Temporal and Spatial Restrictions, treating accumulated driving time as a non-monotonic resource resettable at approved sites. A tailored labeling algorithm with three pruning strategies outperforms commercial solvers on large instances, showing that minor detours enable better rest scheduling.

2 - Optimizing Container Drayage Operations under Remote Driving Mode
Zhaojie Xue, *Xueying Huang*

Container drayage operations face high labor costs and idle time during (un)loading. Remote driving allows drivers to operate trucks without being physically present, enabling them to serve multiple trucks. This study investigates the Container Drayage Problem under Remote Driving Mode, coordinating truck routing and driver scheduling. A mixed-integer programming model and an adaptive large neighborhood search algorithm are developed. Results show remote driving can reduce driver requirements and costs. Sensitivity analyses identify conditions under which it delivers the greatest benefits.

3 - Multi-Stage Stochastic Optimization for Port-Hinterland Decarbonization with Learning Dynamics
Saptadeep Biswas, *Himadri Sen Gupta*

Maritime logistics handles 80% of world trade while contributing 3% of global greenhouse gas emissions. This study develops a multi-stage stochastic programming framework for port-hinterland decarbonization, jointly optimising infrastructure investments, carbon pricing, organisational learning, and leakage mitigation. Learning curves with forgetting dynamics are embedded as explicit state equations. A branch-and-Benders-cut algorithm achieves exact optimality. A hybrid policy instrument reduces system cost by 9-12% versus a carbon tax, while leakage mitigation eliminates 72% of carbon evasion.

■ FB-28

Friday, 11:00-12:30 - Room: JUR - Hörsaal 17 (Building: JUR)

Unmanned Vehicles Routing and Scheduling for Offshore Logistics and Maritime Operations

Stream: Maritime Logistics
Invited session
Chair: *Yantong Li*

1 - Off-shore Monitoring by Deploying Autonomous Unmanned Vehicles
Mahdi Moeini, *Emre Onal*

We introduce a multi-visit multi-drone Vehicle Routing Problem (m2VRP) and formulate it as a Mixed-Integer Linear Programming (MILP) model. Given a depot, a set of main vehicles as well as identical assistant autonomous vehicles, the objective of the m2VRP consists in routing the whole fleet to visit a given set of locations exactly once in minimal time. Due to computational challenges of the m2VRP, we use a matheuristic algorithm. The numerical results on benchmark instances demonstrate that the algorithm achieves near-optimal solutions in reasonable computation time.

2 - Mathematical formulations for the multi-station drone scheduling problem in shore-to-ship deliver
Jian Hu, *Yantong Li*

Shore-to-ship deliver is essential in maritime logistics but traditional tender boats are costly, slow, and risky. Motivated by the use of drones in nearshore logistics, this paper studies a multi-station drone scheduling problem for serving moving vessels. An integrated optimization model is developed, and computational experiments demonstrate strong solution quality and efficiency.

3 - Exact methods and a two-stage iterative heuristic for the carrier-vehicle traveling salesman problem
Yantong Li

We study the carrier-vehicle traveling salesman problem. We present a new MISOCP model with new valid inequalities, a logic-based Benders decomposition method with new Benders cuts, and a simple yet effective two-stage iterative heuristic. Results on Benchmark instances show the effectiveness and efficiency of the proposed model and methods.

■ FB-29

Friday, 11:00-12:30 - Room: HG - Hörsaal 30 (Building: HG)

Problems on graphs

Stream: Combinatorial Optimization
Invited session
Chair: *Pierre Pinet*

1 - A Characterization of Path-Length Matrices of Unrooted Binary Trees
Daniele Catanzaro

We present an alternative characterization of the Path-Length Matrices (PLMs) of Unrooted Binary Trees (UBTs), i.e., integer matrices encoding trees with n>=3 leaves and degree-3 internal vertices. We show that, for specific values of n, a single nonlinear equation suffices to replace a polynomial number of combinatorial disjunctive conditions ensuring acyclicity of UBTs. When optimizing over PLMs of UBTs, a linearization of this equation yields very tight ILP formulations, suggesting that linearizing nonlinear conditions may sometimes be more effective than classical disjunctive constraints.

2 - Branch-and-price strikes back for the k-vertex cut problem
Fabio Ciccarelli, Fabio Furini, Christopher Hojny, Marco Lübbecke

We study the k-Vertex Cut Problem, which asks to find a minimum-cost subset of vertices of a graph whose removal produces at least k connected components on the residual graph. We introduce an extended ILP formulation unifying existing models, along with a branch-and-price algorithm with tailored branching rules, valid inequalities, and symmetry-handling techniques. We prove our formulation dominates all previous ones in LP relaxation strength. Tests on 608 instances show our algorithm outperforms all competitors, solving 73 previously unsolved instances within a time limit of one hour.

3 - Generating extremal chemical graphs for a given degree-based topological index
David Schindl, Sébastien Bonte, Gauvain Devillez, Valentin Dusollier, Alain Hertz, Hadrien Mélot

A chemical graph is a simple connected undirected graph in which vertices represent atoms and edges represent chemical bonds. Degree-based topological indices are graph-theoretic descriptors computed as sums of edge weights, where each weight depends only on the degrees of its endpoints.

We present a method that, given integers n and m and a degree-based topological index I, generates chemical graphs with n vertices and m edges that are extremal for I, i.e., that maximize or minimize I among all such graphs.

4 - A Disaggregated Integer L-Shaped Method Adaptation for a VRPSD with Customer Delegation Recourse
Pierre Pinet, François Clautiaux, Ayse Nur Arslan

The Vehicle Routing Problem with Stochastic Demands (VRPSD) is a variant of the classical vehicle routing problem where customer demands are uncertain during route planning. The first-stage decision involves selecting vehicle tours before actual demands are known. After routes are set, demands are revealed, potentially leading to capacity violations. Disaggregated Integer L-Shaped (ILS) methods have been successful in solving the VRPSSD. We introduce a new recourse mechanism and adapt the Disaggregated ILS method to enhance its applicability in this context.

■ FB-30

Friday, 11:00-12:30 - Room: HG - Seminar-Raum 06 (Building: HG)

Optimizing Predictions

Stream: Machine Learning and Optimization
Invited session
Chair: *Benjamin Ivorra*

1 - A New Bilevel Approach for Hyperparameter Estimation in Optimal Classification Trees
José Emmanuel Gómez-Rocha, José-Fernando Camacho-Vallejo, Justo Puerto

This work addresses the problem of optimal hyperparameter estimation in classification trees. We consider a bilevel optimization framework for hyperparameter tuning, in which hyperparameter selection is integrated directly into the model training process through a hierarchical structure. Computational experiments conducted on several well-known datasets from the UCI repository show superior performance compared with several state-of-the-art methods.

2 - A Model-Agnostic Framework for Counterfactual Explanation for Binary Classification of Nodes in Networks
Mukul Gupta

Graph-structured data is prevalent in domains such as social, biological, and financial networks, where node classification often relies solely on structure due to the absence or privacy of features. In this work, a model-agnostic counterfactual framework is proposed that explains predictions by identifying the minimal set of edge additions or deletions needed to flip a node's label. Using a perturbation vector formulation, the method ensures sparse, plausible structural changes and provides interpretable, instance-level explanations validated on real-world datasets.

3 - A Two-Stage Stacked Learning Method for Feature Selection with Interaction Terms
Eiki Kawahara, Jun-ichi Takeshita, Hiroshige Dan

The number of features in machine learning models has increased recently. As a result, problems such as reduced interpretability and overfitting have become more prominent, making feature selection increasingly important. Previous work by Takano and Miyashiro formulated best subset selection as a mixed-integer optimization problem. However, this approach is computationally expensive and limited to linear models. To address these limitations, this study proposes a two-stage stacked learning method that combines kernel ridge regression with neighborhood search to capture feature interactions.

4 - Robust SVM Classification Models with lp Quasi-Norm Based Feature Selection
Benjamin Ivorra, Miguel Carrasco, Julio López, Angel Manuel Ramos

This work studies robust support vector machine classification models with feature selection based on lp quasi-norm optimization in high-dimensional settings. The approach relies on nonconvex regularization

combined with optimization-based formulations and reweighted iterative algorithms. The resulting models promote sparse solutions and improved robustness to data perturbations. Numerical experiments on benchmark datasets illustrate the behavior of the method and its relevance for optimization-based machine learning and decision support applications.

■ FB-31

Friday, 11:00-12:30 - Room: JUR - Hörsaal 12 (Building: JUR)

Advanced Vehicle Routing & Electrified Logistics Optimization

Stream: Smart Logistics
Invited session
Chair: *Tho Le*

1 - Introducing the Electric Vehicle Scheduling and Charging Problem with Time Windows, Mixed Fleet, and Bidirectional Charging (E-VSCP-TWMFV2G)
Tom Winkler

Decarbonizing road freight requires fleet operators to coordinate scheduling and charging decisions to minimize operating costs. We introduce the Electric Vehicle Scheduling and Charging Problem with Time Windows, Mixed Fleet, and Bidirectional Charging (E-VSCP-TWMFV2G). This mixed-integer linear program (MILP) is a holistic optimization framework for partially electrified heavy-duty truck fleets that jointly decides fleet disposition, vehicle assignment, and charging with bidirectional vehicle-to-grid (V2G) use-cases under time-varying electricity costs and V2G remuneration.

2 - A Branch-and-Price Algorithm for the Mixed Capacitated Arc Routing Problem with Intermediate Facilities
Juan Sebastian Riveros Perez, Jean-François Cordeau, Jorge E. Mendoza

Residential waste collection is naturally modeled as an arc routing problem in which service is performed along streets. This work studies the Mixed Capacitated Arc Routing Problem with Intermediate Facilities. We propose the first Branch-and-Price algorithm for this problem, based on a set-covering reformulation that exploits the sparsity of arc routing networks and tailored pricing subproblems. The closest existing exact approach reformulates the problem as a node routing problem and applies only to the undirected case. Computational results demonstrate the effectiveness of the approach.

3 - Joint Routing and Speed Optimization for Connected and Automated Vehicles via Deep Reinforcement Learning
Songsong Liu, Qirui Cheng

This work jointly optimizes routing and speed for connected and automated vehicles in signalized networks. A mixed-integer nonlinear programming model is formulated, highlighting the limitations of traditional bilevel optimization. To solve this hybrid discrete-continuous control problem, a PDQN-SAC framework is adopted. Illustrative experiments show an optimality gap of less than 2% against exact solvers. In real-world networks, the proposed method outperforms bilevel approaches through adaptive green-wave tracking and intelligent detouring, ensuring real-time spatiotemporal efficiency.

4 - Integrated Yard Management: Exact Offline Planning and Heuristic Real-Time Scheduling for Autonomous Fleets
Latifa Belhocine, Guillaume Martin

In a dynamic scheduling framework for autonomous electric tractors in a warehouse, the problem is initially formulated as a Mixed-Integer Linear Programming extension of the Flexible Job Shop problem to minimize makespan. For real-time rescheduling, we developed a fast heuristic that relies on First-Come-First-Served rules for incoming trailers and Earliest-Due-Date rules for outgoing ones. Coupled with simulation, this approach instantly adjusts missions to address field contingencies such as battery depletion or pedestrian detection, ensuring workflow continuity.

■ FB-33

Friday, 11:00-12:30 - Room: JUR - Hörsaal 15 (Building: JUR)

Emerging trends in Passenger Transportation

Stream: Passenger Railway Transportation
Invited session
Chair: *Paul Corry*

1 - A Game-based Model for Pricing and Timetabling in Liberalised Passenger Railway Markets
Ricardo Garcia-Rodenas, Maria Luz Lopez, Julio Alberto López-Gómez, José Ángel Martín-Baos, Nikola Bešinović, Jan Eisold

We propose a game-theoretic model for pricing and timetabling in liberalised passenger rail markets under vertical separation. Railway undertakings compete for train paths (on-rail competition) and subsequently set fares facing passenger demand (off-rail competition). Passenger choice is modelled through a nested logit structure. The resulting bi-level equilibrium model determines path bids and ticket prices. A column generation algorithm is developed and validated using data from the Spanish HSR Madrid-Barcelona corridor.

2 - Balancing the Fleet: An ILP Approach to Homogeneous Tram Dispatching
Michael Kahr, Markus Leitner, Rosario Paradiso

We address the homogeneous usage dispatch problem in public transit operations. The goal is assigning trams to trips to balance fleet mileage, which is critical for maintenance and investment planning. We propose a graph representation and a compact integer linear programming (ILP) formulation. To improve tractability, we introduce a relaxed model where optimality is enforced via cuts based on the compact formulation. Computational experiments on (pseudo-)real-world instances demonstrate the framework's efficacy in significantly reducing the Gini coefficient of fleet usage.

3 - Optimizing Robustness in Railway Rolling Stock Planning Through Dwell Time Balancing
Rackel Dahdouh, Stéphane Dauzere-peres, Hugo Belhomme

Tight dwell times in rolling stock plans increase the risk of delay propagation in railway operations. A plan that optimizes the balance of dwell times helps to better absorb delays by avoiding excessively short dwell times. Instead of only considering minimum dwell times at stations, we introduce a penalty within a column generation framework to incentivize longer dwell times when possible. Computational experiments on freight instances show that robust plans can be obtained without significantly increasing nominal costs. These results motivate extending the approach to passenger operations.

4 - DesRail: a new discrete-event-simulation library for high-performance rail network simulations
Paul Corry

DesRail is a new open-source discrete-event-simulation (DES) library under development for rail network simulations, designed for high-performance-computing (HPC), flexible to model any network topology, entirely configurable through input data, with animation capability. DesRail seeks to overcome limitations of existing software and methods, to provide a suitable platform for research into simulation-optimisation or reinforcement learning for rail network operations. It can simulate timetabled or randomly generated services under fixed-block signalling and dynamic routing.

■ FB-34

Friday, 11:00-12:30 - Room: JUR - Hörsaal 16 (Building: JUR)

Airline Operations

Stream: Passenger air transportation: airlines and airports
Invited session
Chair: *Xunhao Wu*

1 - Inventory Control and Dynamic Pricing with Strategic OTA Intermediation: Online Learning and Dynamic Procurement
Yuankai Zhang, Qilong Li, Qiong Tian, Hai-Jun Huang

Online travel agencies (OTAs) increasingly shape airfare distribution, yet most airline revenue management models treat them as passive channels. We study a dynamic game between a monopolistic airline and a strategic OTA that can delay ticket purchases after collecting customer orders. The airline learns demand and sets prices using an inventory-aware Thompson Sampling framework, while the OTA optimizes procurement from a private order backlog. Results show OTAs can gain 20-25% market share through intertemporal arbitrage, but strong direct-channel loyalty limits this advantage.

2 - On Airline Flight Cancellation, Loadfactor, and Weather
Fredrik Odegaard

This empirical study analyses inter-airline flight cancellation rates as driven by route, distance, weather, and loadfactor, and the intra-airline flight cancellation due to "carrier" viz-a-viz "weather". Based on 2024 and 2025 US domestic air passenger transportation and weather data, we fit a multinomial logit-model to predict airline specific carrier and weather cancellation rates, respectively.

3 - A branch-and-price approach for the aircraft maintenance location-routing problem
Xunhao Wu, Lingxiao Wu

We study the aircraft maintenance location-routing problem in airline operational planning that jointly optimizes maintenance facility location and aircraft routing decisions. To address this problem, we first propose a connection-based mixed-integer linear programming formulation and introduce several valid inequalities to strengthen it. Furthermore, we propose a branch-and-price approach to deal with large-scale instances. Finally, the performance of the proposed model and solution approach is evaluated through numerical experimental studies based on real operational data from an airline.

■ FB-35

Friday, 11:00-12:30 - Room: JUR - Seminar-Raum 41 (Building: JUR)

Role of Behavior in Sustainable Systems

Stream: Operations Research and Sustainability
Invited session
Chair: *Samuel Rodriguez*

1 - Green or Red? Designing ESG Audit Information Disclosure for Investment Risk Sharing
Noam Shamir, Jae-Hyuck Park, Hyoduk Shin

Retailers face ESG risks from suppliers yet often rely on coarse third party audits despite having better private information. We model a retailer choosing between full auditing and delegated disclosure. Full transparency can halt trade after poor outcomes, weakening supplier incentives to invest in ESG. Coarse disclosure can pool outcomes, sustain trade, and increase upstream investment. This improves expected payoffs for both parties. Optimal disclosure becomes less precise with higher product value but more precise under stronger ESG penalties.

2 - Hinder or Facilitate? The dual-edged effect of perceived busyness on consumer pro-environmental behaviour
Chen Yang

Based on resource conservation theory, this research explores how perceived busyness affects pro-environmental behavior. Through four experiments, we identify a dual pathway: perceived busyness can increase emotional exhaustion, reducing pro-environmental behavior (resource loss), or boost self-efficacy, encouraging it (resource gain). Consumers' happiness orientation moderates this effect. These findings provide valuable insights for green marketing strategies.

3 - Adoption of Industry 4.0 Technologies and Its Impact on Sustainability in Mexican SMEs
Andrés Alberto García León, Eva Selene Hernández Gress, Jaime Palma-Mendoza

Industry 4.0 technologies are driving organizational transformation and enhancing sustainability, especially in SMEs. This study analyzes their impact on Mexican SMEs using a quantitative approach combining surveys and modeling. Data on technologies such as IoT, big data, cloud computing, and automation, along with sustainability indicators, were examined. Results show a positive effect on sustainability through improved efficiency, reduced environmental impact, and better decision-making. However, barriers such as limited resources and expertise highlight the need for strategies and policies.

4 - Modeling Strategic Behavior in PPPs with Bilevel Optimization
Samuel Rodriguez, Camilo Gomez, Andres Gonzalez

Public-Private Partnerships (PPPs) suffer from principal-agent incentive misalignment. We propose a mixed-integer bilevel optimization framework to model strategic interactions between public authorities and private contractors in infrastructure maintenance. A modular decision-support system combines bilevel and bi-objective models to explore trade-offs and enforceability. Results show that Pareto-efficient solutions can be infeasible, while higher-value cooperative outcomes exist beyond bilevel optima, informing improved contract design.

■ FB-37

Friday, 11:00-12:30 - Room: JUR - Seminar-Raum 43 (Building: JUR)

Dynamics of the Firm 4

Stream: Dynamics of the Firm
Invited session
Chair: *Rusudan Kevkhishvili*

1 - Investment Decisions with Learning Options under Knightian Uncertainty
Hiroto Ishii, Junichi Imai

We study irreversible investment under Knightian uncertainty where a firm has learning options (experiments) before committing. Experiments yield success or failure, updating beliefs and shrinking the ambiguity set. We characterize the optimal policy by a quasi-variational inequality and establish well-posedness via viscosity solutions. Our key economic implication is that failure, by reducing ambiguity, carries positive informational value. If failure sufficiently shrinks the ambiguity set, higher failure probability induces earlier experimentation and brings forward the commitment decision.

2 - Capacity investment and market-driven price caps in electricity markets with construction delay
Peter Mwangi, Jacco Thijssen

We develop a continuous-time model of capacity investment in electricity generation under stochastic demand and construction delays. Optimal investment creates an endogenous market-driven price cap at pledged capacity. The cap rises with investment cost, time-to-build, price volatility, and the electricity risk premium, and falls with demand elasticity. Construction delays allow prices to remain elevated after capacity is pledged, highlighting a tension between price stabilization and investment incentives and suggesting welfare-improving policies through market design.

3 - Credit Risk Assessment with the Consideration of Equity Market Liquidity Risk
Rusudan Kevkhishvili

Since liquidity risk influences market data used for credit risk analysis, this study proposes a new framework for analyzing a firm's financial performance by explicitly incorporating the channel through which the equity market liquidity affects estimated asset value dynamics. By distinguishing the intrinsic value of a stock (reflecting the profit-generating capability) from its market price, this new framework allows us to quantify the effect of liquidity risk on credit risk assessment with a computationally simple procedure.

■ FB-45

Friday, 11:00-12:30 - Room: HG - Seminar-Raum 01 (Building: HG)

Surgery Scheduling 2

Stream: Surgery scheduling
Invited session
Chair: *Stefan Kempter*

1 - Reducing overtime in Operating Room scheduling: A chance-constrained model driven by machine learning duration predictions
Constanza Lorca, Daniel Otero-León, Robert Riggs, Thomas Shin

Elective operating room scheduling often relies on surgeon-estimated durations and historical averages that do not account for case duration variability. This study presents a framework that integrates machine learning models to improve case-level duration estimates and a mixed-integer linear programming scheduling model with chance constraints to reduce overtime risk. Computational simulations using real surgical case data demonstrate a 46% average overtime reduction and a 14% improvement in prime-time utilization compared with the hospital baseline over a six-month period.

2 - A Two-stage Stochastic Programming Approach for CRNA Scheduling with Handovers
Osman Ozaltin, Abhishrut Sinha, Ankit Bansal, Michael Russell

We study a two-stage stochastic integer program for assigning Certified Registered Nurse Anesthetists to operating rooms under uncertain surgery durations. The model captures trade-offs among staffing levels, handovers, and understaffing. To solve the resulting binary stochastic program, we develop an Integer L-shaped algorithm with strengthened LP Benders cuts based on valid inequalities that describe the convex hull of a subset of second-stage constraints. Computational results using real data show efficient solutions to realistic instances and reveal key staffing insights.

3 - Steering Overtime in Operating Room Scheduling with the Use of General Phase-type Distributions
Stefan Kempter, Jens Brunner

The operating room (OR) department is vital for hospitals, being one of the costliest but also most revenue-generating departments. However, the inherent stochasticity of surgery durations makes planning and managing surgeries difficult. We focus on the advance scheduling problem for ORs and develop a decision support algorithm to calculate and manage the probabilities of under- and overutilization. Hereby, we exploit the properties of phase-type (PH) distributions and simulated annealing. We underline the applicability of PH distributions by a simulation based on historical data.

■ FB-46

Friday, 11:00-12:30 - Room: HG - Seminar-Raum 02 (Building: HG)

The world of scheduling

Stream: Scheduling in Manufacturing and Beyond
Invited session
Chair: *Luis Salazar*

1 - Scheduling and Energy-Aware Coordination of Two-Fleet AGV Systems
Luis Salazar, Mohammadmohsen Aghelinejad, Yassine Ouazene

This work addresses scheduling two fleets of homogeneous AGVs transporting products from suppliers to clients via depots, considering load and energy constraints. We present a MILP based on a visit-indexed formulation and a second arc-flow model. Instances of varying sizes evaluate their strengths and limitations. A metaheuristic is also developed to efficiently solve larger instances, balancing solution quality and energy considerations while minimizing the overall makespan.

2 - A Reduced Bucket Search Algorithm to Solve the Multi-Mode Resource-Constrained Project Scheduling Problem
Alfredo S Ramos, Joel-Novi Rodríguez-Escoto

The Multi-Mode Resource-Constrained Project Scheduling Problem (MRCPSP) is an NP-Hard optimization problem. Project tasks are to be scheduled considering execution modes, and resoure and precedence constraints, with the objective of minimizing the makespan. A Reduced Bucket Search (RBS) matehuristic algorithm is proposed. It iteratively solves the problem, considering buckets of binary variables and the tasks' slack, to bound the search space. Tested on benchmark instances, the RBS povided solutions of very similar quality compared with an exact method, in a fraction of the computing time.

3 - The development of a practical scheduling system using a cloud-based low-code development platform
Taho Yang

The present study uses a cloud-based low-code development platform (LCDP) to develop a customized scheduling system for a microbial fermentation manufacturing factory. LCDP was adopted for the system due to its advantages in customization, flexibility, and cost. The Microsoft Platform has been adopted as the LCDP for the present case. The results are promising. The system has been released to the company's daily operations. It significantly improves the productivity of the manufacturing system, resulting in a 10% increase in throughput and a 60% decrease in the planner's labor hours.

■ FB-47

Friday, 11:00-12:30 - Room: HG - Seminar-Raum 03 (Building: HG)

Dynamic systems

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Jizhou Lu*

1 - The optimality of (s, S) hiring policy on a workforce planning problem and Binomial K convexity
Zhen Chen, Roberto Rossi, Belen Martin Barragan, Armagan Tarim

We consider a workforce planning problem in which staff turnover in each period follows a Binomial distribution. The objective is to minimize total hiring costs while satisfying the minimum staffing requirement in each period. We introduce the concept of Binomial K-convexity and prove that the optimal hiring policy follows an (s, S) structure: hire up to S when the workforce falls below s in a given period, and do not hire otherwise. Additionally, we propose a piecewise approximation method to formulate a mixed-integer linear programming model for solving the problem.

2 - Risk-Aware UAV Operations in Congested Airspace: A Hierarchical Optimization Framework
Ming Luo, Jingrong Bai

The rapid expansion of UAV applications is increasing pressure on shared airspace, where congestion and operational uncertainties may significantly affect safety and efficiency. This paper develops a hierarchical optimization framework for risk-aware UAV operations in congested airspace. A system operator allocates airspace capacity across flight corridors at the upper level, while at the lower level UAV operators determine routing and scheduling decisions under stochastic travel times and congestion effects. Operational risk is incorporated using CVaR to control extreme disruption scenarios.

3 - Information Security and Information Quality on a Capacity Sharing Platform
Jizhou Lu

Capacity-sharing platforms are growing fast, but whether they leak partner firms' private information has received little attention. This paper builds a multi-period stochastic model with two firms buying from one platform. We study when the platform is more likely to leak information and how source errors and transmission errors affect this choice. Results show that stronger competition makes leakage more likely, while possible cooperation makes privacy protection more likely. Source errors have no effect, but transmission errors may reduce leakage.

■ FB-49

Friday, 11:00-12:30 - Room: HG - Seminar-Raum 05 (Building: HG)

Service Network Design under Uncertainty

Stream: Optimization under uncertainty in Transportation, Logistics and Supply Chains
Invited session
Chair: *Simon Belieres*

1 - The dynamic same-day delivery problem with walking, parking and stochastic customer requests
Ninja Scherr, Sara Reed, Ann Campbell, Barrett Thomas

In this talk, we present the same-day delivery problem with walking, parking, and stochastic customer requests. In this problem, customers request service and expect delivery on the day of their order. The service provider aims to maximize the overall profit given the available resources. We describe the problem and model it as an MDP. We propose different policies for the problem that differ in how they delay the dispatching of the delivery vehicle. In a computational study, we show the impact of the different policies on overall costs for different parking search times.

2 - Periodic Home Care Scheduling under Decision-Dependent Uncertainty: A Learning-Effect Approach
Yossiri Adulyasak, Seyede-Saeede Hosseini, Louis-Martin Rousseau

We address the periodic home care routing and scheduling problem by incorporating a "learning effect" driven by caregiver-client familiarity. Empirical data shows that the mean and variance of service duration decrease as visits accumulate. We develop a chance-constrained optimization model to maximize scheduled visits while meeting service-level requirements. Specifically, uncertainty is endogenous, as the service time distribution depends on prior caregiver assignments. Experiments demonstrate that our approach significantly reduces schedule variability compared to exogenous models.

3 - Adaptive Expeditionary Logistics Planning Under Non-parametric Uncertainty
Mathieu Dahan, Haden Boone

In this work, we study adaptive expeditionary logistics planning under multiple sources of operational uncertainty. To address this stochastic scheduled service network design problem, we integrate a reinforcement learning approach with mixed-integer programming methods based on dynamic discretization discovery to learn adaptive decision policies that revise routing plans during execution. Using simulation-based evaluation, we show that the proposed approach improves demand fulfillment and robustness compared with traditional static optimization strategies on military logistics instances.

■ FB-51

Friday, 11:00-12:30 - Room: HG - Seminar-Raum Geschichte 1 (1st floor, st. 10) (Building: HG)

Network Design

Stream: Hub Location and Network Design
Invited session
Chair: *Ricardo Gázquez*

1 - Continuous cascading failures of wireless sensor networks under a novel sequential attack strategy
Liping Jiang, Jianwu Xue, Bei Wu

As wireless sensor networks (WSNs) become interconnected, attackers conduct attacks as a dynamic sequence with stochastic timing to maximize their impact. Therefore, we examine continuous cascading failures in WSNs under a novel sequential attack strategy and evaluate the resulting network vulnerability. The sequential attack modeled by a homogeneous Poisson process. To mitigate the cascading failures triggered by such attack, a latency-congestion-sensitive routing scheme is designed to redistribute load. Finally, we evaluate network vulnerability with different attack strategies.

2 - Large-Scale Network Optimisation using Ensemble Simulation
Tom Murarik

Ocado Logistics Data Science presents an optimisation framework for rich facility location problems. We provide an operational cost for a given scenario: the locations of a set of facilities and the geo catchment areas for each of those facilities. Using a custom just-in-time compiled interface, we can search this vast decision space very quickly in parallel. This ensemble simulation evaluated millions of facility combinations, incorporating constraints and edge-cases devised by stakeholders across the business. The findings directly drove decisions in Ocado Retail's network expansion.

3 - A Multiperiod Optimization Approach for Expanding Self-Amplifying Hypergraphs under Synergy Laws
Ricardo Gázquez, Víctor Blanco, Juan Francisco Ocaña-Rivas

Higher-order interactions arise in chemical, ecological and socio-economic systems and can be naturally modeled using directed hypergraphs. We develop mathematical optimization models for the temporal expansion of such structures and the identification of self-amplifying subhypergraphs. The proposed multiperiod formulations integrate structural constraints, kinetic information and equity criteria, leading to MILP/MINLP models that capture the dynamic growth of hypernetworks. Applications include the analysis and visualization of evolving chemical reaction networks.

■ FB-52

Friday, 11:00-12:30 - Room: KOL - PC Raum 1 (Building: KOL)

Energy Policy & Multi-Criteria Assessment

Stream: Energy Markets & Systems
Invited session
Chair: *Brigitte Castañeda Rodriguez*

1 - Value-focused modelling to generate alternatives (VF-MGA) integrates energy system modelling and multi-criteria decision analysis
Jonas Finke, Emily Bergup, Sebastian Schär, Valentin Bertsch

Energy system models (ESMs) and multi-criteria decision analysis (MCDA) are often used in isolation in energy planning. We propose value-focused modelling to generate alternatives (VF-MGA) as a novel combination of the two and demonstrate its benefits for the decarbonisation of a university campus. We highlight how the MCDA's objective hierarchy informs the MGA algorithm; the MCDA's preference elicitation relies on MGA results; and MGA results are evaluated according to stakeholder preferences, providing a better understanding of must-haves, choices and consensus solutions.

2 - Comparison of Multi-Criteria Models Integrated with GIS for Small-Scale Wind Energy Allocating
Juan Jose Galeano Florez, Yony Fernando Ceballos, Julian Andres Castillo Grisales, Laura M. Cardenas, Maritza Jimenez, Cesar Nieto-Londoño

This study compares two spatial multi-criteria decision analysis (MCDA-GIS) approaches for siting small-scale wind energy in Hatonuevo, Colombia. A compensatory model (AHP) and a non-compensatory model (ELECTRE-TRI) were evaluated using GIS-based criteria. Results indicate that AHP tends to overestimate high-suitability areas because strong criteria can compensate for weaker ones. In contrast, ELECTRE-TRI applies veto thresholds, producing a more conservative classification. These findings highlight how decision logic can significantly influence spatial planning for renewable energy.

3 - Dual Market under the Reward-Penalty Mechanism: A Study on Coordinated Emission Reduction Strategies between Power Generation and User Enterprises
Lifang Wang

As a key sector of carbon emissions, the effectiveness of emission reduction in the power industry directly affects energy transition goals. Diverging interests between power generation and users make it difficult for both parties to spontaneously form coordinated emission reductions. To address this, this paper designs government reward and punishment mechanisms, constructs a tripartite evolutionary game model, solves for the evolutionary game equilibrium, and proposes strategies to promote coordinated emission reductions between power generation and users based on the equilibrium results.

4 - Climate Policy and Structural Change: Evidence from Latin America
Brigitte Castañeda Rodriguez

We study how energy prices shape decoupling in Latin America using data for 21 countries (1990-2021). We analyze two channels: the technique effect (within-sector efficiency) and the composition effect (reallocation). Higher energy prices induce a persistent composition effect, shifting activity toward services. However, in manufacturing and transport, higher prices correlate to short-run increases in energy intensity, reflecting a perverse technique effect during economic booms. Policies must address both structural and efficiency channels.

■ FB-57

Friday, 11:00-12:30 - Room: HG - Seminar-Raum 07 (Building: HG)

Behavioral OR general papers 4

Stream: Behavioural Operational Research
Invited session
Chair: *Marius Wittke*

1 - A Bayesian Theory-of-Mind Network Game for Consensus Management: Incentive and Interaction Interventions under Latent Reciprocity Inference
Yuanyuan Yin, Jianfeng Cai, Wenting Han, Zhenyi Wang

We propose a Theory-of-Mind-Enhanced Adaptive Consensus Mechanism for dynamic group decision-making under resource constraints, preference heterogeneity, asymmetric information, and strategic masquerading. By embedding Bayesian posterior beliefs about others'cooperation into peer effects, it builds a cognitively weighted influence network with evolving interactions. Under budget limits, it optimally combines interaction, incentive, and information interventions to achieve soft consensus at minimum cost, while clarifying preference adjustment and cognitive peer effects.

2 - Research on Low-Carbon Transition Technology Selection and Regional Layout of the Iron and Steel Industry—An Agent-Based Model Analysis
Shiyan Chang

This study focuses on the low-carbon transformation of the iron and steel industry, adopting an Agent-Based Model (ABM) . Existing studies mostly focus on macro low-carbon technology pathways, while ignoring the micro decision-making logic of plants. The ABM constructed in this study can capture the micro decision-making behavior of plants. By depicting the heterogeneous attributes of plants and the interaction mechanis between multiple agents, it realizes the dynamic simulation of the low-carbon transition.

3 - Focus Optimization Models for Making a Decision under Uncertainty with Focus Theory of Choice
Peijun Guo

The focus optimization model is proposed for making a decision under uncertainty with the focus theory of choice. The new formulation is a bi-level programming model where upper-level and lower-level programs are maximin or minimax problems, We obtain the analytic solutions with the assumption that the probability density function is quasi-concave. As an example, a newsvendor problem is analyzed by using the focus optimization model and managerial insights are gained to explain the behaviors of the optimistic and pessimistic retailers.

4 - Throwing Good Money After Bad: Escalation of Commitment in Investment Projects - A Behavioral Real Options Perspective
Marius Wittke

Investment projects often involve managerial flexibilities (e.g., abandonment options) that can be valued using real options analysis. However, this approach typically assumes complete information, which is rarely available in practice. Under incomplete information, decisions rely on subjective estimates and are therefore prone to cognitive biases. A prominent phenomenon is escalation of commitment, the tendency to persist with failing projects. This simulation study analyzes how such cognitive biases drive this phenomenon, affect real option valuation, and how their impact can be mitigated.

■ FB-58

Friday, 11:00-12:30 - Room: HG - Seminar-Raum 08 (Building: HG)

Location and capacity planning

Stream: Healthcare OR in developing countries
Invited session
Chair: *Trang Luu*

1 - A Hybrid Epidemiological, Machine Learning, and Optimization Framework for Respiratory Health Planning in Resource-Constrained Settings
Ignasi Neira

We present a hybrid framework for respiratory health planning in resource-constrained settings. The method learns from past seasons and uses the early observed trajectory of the current season, while incorporating epidemiological insights through optimization-based constraints. Unlike standard step-ahead forecasting approaches, it projects the remainder of the seasonal trajectory, enabling earlier and more informed resource planning. The framework is well suited to limited-data settings and helps health authorities anticipate demand and allocate resources more effectively.

2 - A Bi-Objective Spatiotemporal Optimization Model for Equitable Deployment of Fixed and Mobile Healthcare Units
Braulio Gomez, Rodolfo Mendoza-Gómez

This mixed-integer bi-objective programming model plans fixed and mobile health units in vulnerable areas, maximizing coverage and minimizing costs. To avoid duplication, it counts coverage per demand unit only once. It considers availability, compatibility, and territorial equity. The applicability of the approach is illustrated by a case study of the Health Caravans in Mexico City, proving to be an effective tool for improving service distribution and resource efficiency.

3 - Optimizing telemedicine clinic locations for accessible and equitable rural healthcare
Ali Ghavamifar, Jens Brunner, Mohammad Fattahi

This study develops an optimization framework for locating telemedicine clinics in rural healthcare regions. The model integrates patient choice, accessibility, service congestion, and equity considerations to support more effective healthcare planning. Using a case study from rural Denmark, the results show how clinic placement can improve access, reduce travel burden, and support fairer service provision across rural communities.

4 - Queueing-Based Capacity Allocation to Reduce Time-to-Treatment to Acute Care in Low- and Middle-Income Countries
Trang Luu, Alex Kuiper, Michel Mandjes, Dick den Hertog

Acute emergencies like stroke require rapid care, yet resource scarcity and network congestion hinder access in developing regions. We propose a queueing-based framework to optimize capacity allocation using discrete resource models. By leveraging convexity properties, we derive an efficient marginal allocation algorithm. Unlike static benchmarks, our approach accounts for uncertainty by targeting expected waiting times and probability of meeting a time-to-treatment threshold. Results using Vietnam's stroke care data demonstrate that our method produces optimal, scalable solutions.

■ FB-59

Friday, 11:00-12:30 - Room: KOL - Seminar-Raum 9 (Building: KOL)

AI-MCDA interface 2

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Renata Pelissari*
Chair: *Sarah Ben Amor*
Chair: *Betania Campello*

1 - Positioning political manifestos in 2024 European Elections on environmental issues: a Multi-Criteria LLM framework approach
Sajid Siraj, Franco Corti

This research develops a multi-criteria LLM ensemble framework to measure environmental commitment in 2024 EU Parliament manifestos across Austria, France, Germany, Italy, and Spain. Using sentence-level scoring, three LLMs (GPT-4, Claude Sonnet, GeminiPro) independently assess salience and position on environmental and climate dimensions, with predictions aggregated into robust estimates. Validated against the Chapel Hill Expert Survey 2024, the framework offers cost efficiency, multilingual capability, replicability, and transparency, complementing rather than replacing expert-based approach

2 - Enhancing Sustainable Foresight through Dynamic Attribute Pools in Human-AI Collaborative Group Decision Making
Shuning Pan, Yuanxiang Dong, Hangyang Li, Luqi Wang, Jingyu Lv

This study proposes a human-AI collaborative decision support framework to enhance sustainable foresight in risk assessment. By using large language models to extract potential risk attributes from enterprise reports, it captures weak signals that traditional methods might miss. A dynamic attribute pool mechanism updates and refines attributes throughout the decision process, while a human review ensures the credibility of AI-generated signals. The framework improves early risk identification, promotes expert consensus, and strengthens adaptive decision-making, enhancing resilience.

3 - An AI-Augmented Robust Facilitated MCDA Framework for Public Policy-Making
Dimitrios Stranis, Nikos Tsotsolas, Sofia Ioannidou

This research work proposes an extension of a robust facilitated MCDA framework for public policy-making by embedding AI as a bounded decision-support layer. AI is mapped across eleven stages, from problem structuring and alternative generation to scenario building, robustness evaluation and monitoring. An illustrative municipal waste-management case shows that hybrid policy pathways, where AI augments analysis, but humans retain responsibility for values, trade-offs and final choice, could improve robustness than purely conventional or purely digital strategies.

4 - Machine learning based Preference Elicitation in Interactive MCDM
Srinivas Prasad

We study machine learning based preference elicitation strategies in the context of Interactive Multiple Criteria Decision Making. The techniques provide scoring mechanisms that allow for semi-supervised learning and fine tuning of preference elicitation strategies to reduce the number of pairwise comparisons needed. Some empirical results comparing the effectiveness of the elicitation strategies are presented.

■ FB-60

Friday, 11:00-12:30 - Room: KOL - Seminar-Raum 10 (Building: KOL)

AI and Risk Management

Stream: OR for Insurance, Banking and Financial Risk
Invited session
Chair: *Stefan Trueck*
Chair: *Masahiro Toshiro*

1 - Development and Comparison of Credit Scoring Models with Reject Inference for Educational Loans in Japan
Masahiro Toshiro, Chihiro Funakoshi, Kenzo Ogi, Norio Hibiki

Banks employ credit scoring models in loan screening. Commonly, models are developed using only data from accepted applicants with known repayment. Such models involve a sample selection bias, as rejected applicants with unknown repayment are not considered. In response, studies examine models using reject inference to estimate repayment of rejected applicants. This study develops models with six types of reject inference (including Heckman's two-step estimation), using data from educational loans handled by Japan Finance Corporation. The practical usefulness of these models is then compared.

2 - Valuation of American Options by An Accelerated Static Hedging Method
Lung-fu Chang, Jia-Hau Guo, Mao-Wei Hung

This article proposes an accelerated static hedge portfolio (SHP) method for evaluating American options based on stochastic volatility and double jump processes. Our proposed model is an accelerated static hedge portfolio approach of Derman, Ergener, and Kani to evaluate American options by utilizing the Richardson extrapolation. Numerical results demonstrate that the numerical efficiency of our accelerated static hedge method is comparable to the least-squares Monte Carlo simulation method.

3 - Identifying Anomalies through Conflicting Indicator Combinations: A Human-AI Collaboration Approach to Detect Corporate Fraud
Xiao Yao

Detecting fraud requires examining combinations of contradictory financial indicators, not just single metrics. This study extracts industry-specific conflicting indicator sets by analyzing inquiry letters through a human-LLM collaborative approach. We establish the theoretical link to fraud based on accounting articulation. Using a sample of listed firms in China, we show these combinations significantly enhance fraud detection models. Results remain robust in sensitivity tests, with these indicators ranking as top predictors. Case analysis further validates the application value in practice.

4 - Sparse Portfolio Optimization with Dynamic Rebalancing using Topological Data Analysis and Multi-Source Data
Divyanee Garg, Aparna Mehra

This study proposes a two-stage framework for stock selection and portfolio construction using Topological Data Analysis. Multidimensional representations based on technical indicators and news sentiment are used to measure stock similarity and perform hierarchical clustering, from which representative stocks are selected. These assets are then incorporated into a portfolio-optimization model with dynamic rebalancing, accounting transaction costs, and short-selling constraints. Empirical results on S&P500 stocks show improved risk-adjusted performance compared with benchmark strategies.

■ FB-62

Friday, 11:00-12:30 - Room: KOL - Seminar-Raum 19 (Building: KOL)

Applications of MCDM 5

Stream: Multicriteria Decision Making (MCDM)
Invited session
Chair: *Gwo-Hshiung Tzeng*
Chair: *Sun-Weng Huang*
Chair: *James Liou*

1 - Evaluating the Impact of Sustainable Finance Taxonomy on Corporate Environmental Integrity
Yiying Li, Yu-Cheng Kao, Shu-Ying Chen, Y. Colette Peng

Sustainable finance taxonomies increasingly shape ESG capital allocation, but their value depends on whether they improve information quality, sharpen incentives, and reduce capital misallocation rather than add regulatory complexity. This study develops a multi-criteria framework to assess taxonomy design. Using the Fuzzy Delphi Method, we identify 18 indicators across five dimensions: regulatory authority, market incentives, data integrity, policy synergy, and transition inclusiveness. The findings identify data integrity and incentive alignment as central to effective capital reallocation.

2 - Extracting and Weighting Core Quality Performance Indicators for Strategic Alliance Partner Evaluation: A Hybrid Data Mining and Group MCDM Approach
Li-Chen Chang, Huai-Wei Lo, Yu-Hsun Chen

This study develops a hybrid data mining and group MCDM framework for evaluating strategic alliance partners from a quality management perspective. This study applies B-VC-DRSA to identify core performance indicators, and employs Bayesian BWM to aggregate expert judgments and determine the relative importance of the selected indicators. A case study using Restriction of Hazardous Substances (RoHS) assessment data from an electronics manufacturer demonstrates its effectiveness.

3 - Information Frictions and Institutional Adoption of IPO Ranking Systems
Shu-Ying Chen, Yu-Cheng Kao, Shang En Yu, Shinsiong Pang

During IPO waves, institutions often reach different screening decisions because analysts place unequal weight on profitability and cash-flow signals. Such heterogeneity impedes consistent portfolio formation and obscures performance attribution. We develop a framework to identify the key determinants of implementing an IPO ranking system that maps multiple accounting signals into a single auditable firm-quarter score. Using the Fuzzy Delphi Method, we aggregate expert beliefs and derive a parsimonious hierarchy for post-IPO monitoring.

4 - Exploring the Critical Factors Influencing Patent Grant Rates in the High-Tech Industry: A Case Study of the Laptop Computer Industry
Yu-shih Wang, Hanlung Liu

As R&D intensity and intellectual property competition intensify in high-tech industries, patent approval rates have not kept pace with filing volumes. This study examines key factors influencing patent approval rates in the notebook computer sector using the DANP (DEMATEL-based ANP) framework. Relevant dimensions and indicators are identified through literature review and expert interviews; DEMATEL maps causal interdependencies, and ANP yields importance rankings. Results provide actionable guidance for patent drafting, portfolio strategy, and R&D management, while addressing a gap in Taiwan.

■ FB-66

Friday, 11:00-12:30 - Room: JUR - Seminar-Raum 31 (Building: JUR)

Linear and Nonlinear Optimization

Stream: Continuous and Global Optimization
Invited session
Chair: *Mirjam Duer*

1 - A primal-dual method with polynomial complexity for large-scale linear programming
Xinwei Liu

We propose a new primal-dual interior-point method for large-scale linear programming problems with polynomial complexity. The method is developed based on minimizing the maximization of a logarithmic barrier augmented Lagrangian function over the dual multipliers. Our method is line search free and originally admits any non-interior starting point. Some preliminary numerical results are reported.

2 - An Entropy-Barrier Differentiable Path-Following Method to Compute a Stationary Point
Peining Yang, Yiyin Cao, Chuangyin Dang

To compute stationary points for continuous functions on convex polytopes, this paper proposes four differentiable path-following methods by constructing artificial stationary point problems that incorporate entropy-barrier, square-root-barrier, logarithmic-barrier and convex-quadratic-penalty terms into the objective function with a homotopy variable. Smooth homotopy paths are derived via optimality conditions and a fixed-point argument, each starting from a unique point and converging to a stationary point. Numerical experiments demonstrate the efficiency of the proposed methods.

3 - Beyond Feasibility: Steering Projection Methods via the Superiorization Methodology
Aviv Gibali

Projection methods are powerful, low-cost iterative solvers for massive, non-convex problems like IMRT and Image Reconstruction. However, finding any feasible point is often insufficient. This talk explores the Superiorization Methodology, a framework that "steers" feasibility-seeking algorithms toward high-quality, superior solutions. We analyze the perturbation-resilience of these methods, demonstrating how to optimize secondary objectives without the cost of full constrained optimization. Theoretical results and applications to complex real-world systems are discussed.

4 - A Decomposition-Based Framework for Optimal Pump Scheduling in Water Distribution Networks
Carlo Antonio Maria Gervasi, Claudia D'Ambrosio, Bissan Ghaddar, Stefan Ropke

This work presents a decomposition-based framework for optimal pump scheduling in Water Distribution Networks. ADMM handles binary scheduling decisions within the full hydraulic model, enabling distributed solution of the underlying mixed-integer nonlinear program. Graph partitioning techniques decompose large-scale networks into tractable subproblems, improving scalability. The framework is validated on benchmark networks of increasing complexity. Results highlight the potential of combining distributed optimization with network decomposition for operational pump scheduling.

■ FB-67

Friday, 11:00-12:30 - Room: KOL - PC Raum 3 (Building: KOL)

Sustainable Fuels & Industrial Decarbonization

Stream: Energy Markets & Systems
Invited session
Chair: *Aldo Bischi*

1 - Sustainable fuels for the lime industry: Trade-off analysis with multi-objective optimisation
Viktor Schüssler, Jonas Finke, Valentin Bertsch

Transitioning high-temperature processes towards climate neutrality is a key challenge. Hydrogen-based fuels can substitute fossil fuels and reduce environmental impacts like greenhouse gases but at the same time increase others such as material consumption. To explore trade-offs between costs and different environmental impacts we apply multi-objective optimisation to an energy system model of a reference lime plant. Environmental impacts of different fuel options are evaluated by life cycle assessment and integrated into the energy system model which is optimised using the AUGMECON method.

2 - Inverse multi-objective optimisation (MOIn) for the sector-coupled, industrial application of Carnot Batteries
Katharina Esser, Jonas Finke, Valentin Bertsch

Inverse modelling approaches, turning typical model inputs into outputs, enable integrating emerging technologies in energy system models to inform technology developers. We extend a multi-objective inverse optimisation approach and apply it to an automotive manufacturing facility with Carnot Batteries (CBs) as emerging technology, analysing drivers for technology developers, facility managers and policy-makers. Results show driver inter-dependencies in relation to one and/or two optimised techno-economic parameters of CBs and reveal development management and policy implications.

3 - Quantify derated capacity of thermal power plants with rising ambient temperature
Jie Xu, Philipp Castro, Christoph Weber

Large-scale optimization problems, such as energy system models, require realistic parameterization of constraints. Quantile regression can identify historical demonstrations of technical and economic limits under varying conditions, and this contribution extends the method to have piecewise linear representation for nonlinear relationships. One application is to quantify derated capacity of thermal power plants under rising ambient temperature using their generation time series. The heterogeneity across generation technologies, cooling methods, and cooling water types is also investigated.

4 - Techno-Economic Assessment of Micro Nuclear Reactors
Aldo Bischi, Giulio Giusti, Nicolò Zatta, Andrea Baccioli

Micro Nuclear Reactors (MNR) optimal design and scheduling is a challenging, large, multi-year, Mixed Integer Non-Linear Problem. It has been tackled via piecewise linearization and k-medoids clustering, reducing it to a few representative periods. The framework developed for microreactor-powered applications has been applied to reverse-osmosis desalination systems, demonstrating cost competitiveness under CO2 constraints and outperforming fully renewable islanded systems. Furthermore, its integration with flexible commodities demand has led to indirect long-duration energy storage.

Friday, 13:30-14:30

■ FC-01

Friday, 13:30-14:30 - Room: HG - Audimax

Plenary Karen Smilowitz

Stream: Plenaries
Plenary session
Chair: *Hector Cancela*

1 - Transportation Research for Social Impact in a Changing World
Karen Smilowitz

Humanitarian logistics presents a series of unique and urgent challenges. For example, at the core of disaster response lies the effective and equitable distribution of life-saving supplies to those in need. In such high-stakes environments, operations research holds significant potential to support decision-making—helping relief organizations save lives and resources while upholding principles of fairness, humanitarianism, and transparency. In this talk, we focus on humanitarian operations in a range of settings.

This talk will present opportunities and challenges related to transportation research that strives for positive social impact in a constantly changing world. In such settings, the objectives are often more difficult to quantify since issues such as equity and sustainability must be considered, yet efficient operations are still crucial. The talk will be both a look back over several decades of influential research and a look forward at the challenges ahead, focusing on key papers that span a range of related topics. We will explore how new platform technology is changing both the practice and study of humanitarian logistics. The talk will include open challenges for junior researchers to consider in their own work.

Friday, 14:30-15:15

■ FD-01

Friday, 14:30-15:15 - Room: HG - Audimax

Closing Ceremony

Stream: Special Sessions
Plenary session
Chair: *Richard Hartl*

1 - Closing Session
Richard Hartl

We will look back to IFORS 2026 and announce the winners of the EURO Doctoral Dissertation Award and the IFORS OR in Development Award. We will look forward to EURO 2027 in Athens and IFORS 2029 in Calgary.

CLUSTERS

Algorithmic Game Theory

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Analytics

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Track(s): 65

Auctions and Market Design

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Track(s): 7

Behavioural Operational Research

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Track(s): 57

Building Resilient Systems

Track(s): 36

City Logistics

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Combinatorial Optimization

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Continuous and Global Optimization

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Cutting and Packing

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Data Envelopment Analysis

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Data Science meets Optimization

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Data-Driven Demand Management

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Data-driven Operations Research

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Data-driven Stochastic (Inverse) Optimization

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Exact and Heuristic solution methods for Optimization under Uncertainty

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Forecasting in Energy

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From Models to Smarter Decisions: Harnessing OR + AI

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Global Leadership in OR for Women

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Health Care Logistics

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Healthcare OR in developing countries

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Humanitarian Logistics

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Integrated Planning in Manufacturing

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Knowledge, Technology, and Innovation Decisions

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Location Analysis

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Location Analysis for Urban and Digital Infrastructure

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Lot Sizing, Lot Scheduling and Production Planning

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Mathematical Optimization for Transparent and Fair Decision Making

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Moments in the History of OR and IFORS

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Multicriteria Decision Making (MCDM)

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Nonlinear Optimization

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Optimal Decision Making in Energy

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Optimization under uncertainty in Transportation, Logistics and Supply Chains

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OR and Accounting

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OR and Ethics, and Societal Perspectives

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OR in Space

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OR in Sports

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Passenger air transportation: airlines and airports

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Plenaries

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Prescriptive Analytics in Operations Management

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Quantum Optimization

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Retail Operations

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Robust and Resilient Optimization in Finance and Businesses

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Scheduling in Manufacturing and Beyond

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Selected Aspects of International Finance and OR

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Shared Mobility

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Smart Logistics

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Soft OR and Problem Structuring Methods

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Software for Operations Research

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Stochastic Optimization with Industrial Applications

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Supply Chain Optimization

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Surgery scheduling

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The Practice of OR: Stories of Solutions, Setbacks, and Successes

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Vehicle Routing and related problems

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Warehousing

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