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7 Iron and Metalworking

Sergio Onger and Valerio Varini

Introduction

The metalworking areas in Lombardy's Pre-Alps belong to a centuries-old Alpine tradition. Natural factors – minerals and water power – combined with technological improvements in the early modern age to enable the establishment of a substantial manufacturing sector in the region's major valleys. Improvements were made over time by the skilled workforce and by organisation as an industrial district, while many of those working in the sector alternated manufacturing with the modest demands of running small mountain farms.¹ These favourable conditions vanished with the advent of the industrial revolution, when the limits of the sector were exposed by the scarcity of raw materials and high energy costs at the start of the 19th century. This imposed a general modernisation process in order to combine the availability of adequate production factors with efficient processing and then product placement on a wider market. These productive, organisational, and commercial challenges involved Lombardy's entire economy but were even more directed at iron and metalworking, among the region's most established sectors and one with centuries of rural tradition.

The opening of the European markets brought the structural weaknesses of Lombardy's metalworking sector to light, and it was increasingly marginalised by the profound changes in the sector at the European level. The advent of the age of steel, represented by the dominance of the Ruhr area, also meant that Lombardy's production system became marginal. The need for a revival became a vital matter for the entire Italian economy, and even more so for the region that had become the leader of Italy's industrialisation thanks to radical changes launched during the Napoleonic period.

In this process, Lombardy managed to use a combination of tradition and innovation to develop original solutions. Although these were undervalued for many years as being too different from the evident industrial concentrations that were widely appreciated in Europe, there are some important similarities with the procedures adopted in areas with a long

tradition of metalworking, like Birmingham and the Black Country in England.²

The intention of this chapter is to recount the events marking the development of this sector in Lombardy.

From Traditional Production to Change (1797–1859)

When the Cisalpine Republic was created in 1797, all Lombardy's metalworking centres were reunited. Those in the valleys of Brescia and Bergamo entered the new state together with the iron and metalworking districts in the area of Lake Como. These production poles could boast centuries of tradition, but in more recent times they had followed quite different paths. While the western territories under Habsburg rule had modernised their production plants during the last years of the 18th century, production techniques in the eastern provinces of Bergamo and Brescia had remained unchanged.³ The valleys of eastern Lombardy had been under Venetian rule for four centuries and constituted a vast iron and metalworking district with an original integrated system based on a set of traditional methods. Although the weight of tradition acted as a curb on impulses to modernise, the sector continued to make effective use of techniques that had been replaced elsewhere. These valleys appeared to drive technological innovation in 15th- and 16th-century Europe, developing the first expertise in the use of blast furnaces but were then constrained by the inherent limits of Alpine metalworking. Exploiting widely available supplies of iron ore and water power, they worked on a small scale to supply a broad range of products ranging from light firearms to agricultural implements.⁴

In the early years of the 19th century, the total annual output of Lombardy's iron and metalworking sector amounted to roughly 6,000 tonnes of pig iron, which was able to meet the increasing state demand for arms. This was an outstanding achievement, given that it was obtained without any substantial technical or organisational changes. There is just one case where state demand played an evident role in promoting technological innovation, and this involved the construction of an ironworks at Pontevico in 1803, which had four modern reverberatory furnaces with the capacity – enormous by regional standards – to produce almost 18 tonnes of pig iron a day. Belonging to Gaetano Paolo Cadolino from Cremona, the new foundry stood at an important junction of the river transport network connecting Lombardy to the Adriatic via the rivers Oglio and Po and was intended to supply iron bars and bullets to the military arsenals of the Italian Republic first and then to the Kingdom of Italy.⁵ On the other hand, efforts to increase steel output were much more disappointing. For example, although metallurgy expert Michele Scala received public funds to produce huge quantities of case-hardening steel, little was actually achieved.⁶

In eastern Lombardy, mining and metalworking were extremely underdeveloped. Venetian laws had caused excessive fragmentation of mine ownership, and the primitive mining methods used were possible only during winter. These factors, in addition to a largely unspecialised workforce of seasonal labourers and children, explain the low productivity and gradual abandonment of the less productive sites during the Austrian Restoration period. Another problem was the growing shortage of fuel as mature woodland began to disappear in the late 18th century, reducing the production of charcoal, which became increasingly expensive to the extent that it accounted for 50% of the final cost of pig iron. Lignite deposits at Leffe were located too far from the furnaces, and while peat was plentiful in the territories of Brescia and Como, its heat-producing capacity was uncertain. These alternative fuel sources were never seriously tried out in the primary smelting furnaces and were used to a certain extent only in the middle of the century in re-smelting plants.⁷ The growing fuel shortage and the high consumption of the traditional smelting furnaces meant that foundries could operate for only 6–7 months of the year, and that the workforce was forced to depend also on agriculture.

The region's easternmost areas were more fortunate: Valsabbia and the Salò area obtained supplies of cheaper charcoal from neighbouring Trentino and could even relocate there some of the production stages that required most energy. An example is provided by the Glisenti. In the first decades of the 19th century, Giovanni Glisenti had already amassed considerable wealth from industry and commerce. In 1812 he expanded his activity outside Valsabbia and bought a forge for secondary processing on the border with Trentino. Around 1840 he invested in the Giudicarie area, setting up a factory in Creto with two furnaces *alla contese*. His sons continued his work after his death, diversifying their investments in the timber industry and buying a sawmill at Pinzolo. They consolidated ties with the ironworkers, who were supported by the traditional *Verlags system*, and expanded their commercial network to Brescia.⁸

By 1820, Lombardy had 38 primary smelting furnaces (17 in Bergamo, 11 in Brescia, 9 in Como and 1 in Sondrio), almost all described as obsolete and 266 “great” furnaces (with one or two hammers), which made pig iron into iron bars (150 in Bergamo, 66 in Brescia, 50 in Como).⁹ The province of Bergamo, which at this time also included Valcamonica, was Lombardy's leader in primary smelting, accounting for almost two-thirds of the region's total output.

Lombardy's primary smelting furnaces were square-sectioned until the 1840s. No important technological changes had been made since the 16th century, when the introduction of huge water-powered bellows had been a decisive innovation enabling the industry to abandon the use of low-grade clayey ore. Furnace structure had then remained the same, except for a small increase in the height of the tower (*cannecchio*) due to increased production capacity following the introduction of ventilation

by hydro-wind horns in the 17th century. This new system used water falling into a tank to generate more air for combustion than the traditional bellows powered by the waterwheel.¹⁰

One reason why the use of these obsolete furnaces (*alla bergamasca*) continued is that many were owned in partnership by several mine owners and were managed by *maestri*, who made sure that each partner received the due amount of pig iron. Although joint ownership was a factor favouring continued use, it eventually discouraged any kind of investment and meant that production became rigidly organised.¹¹

The lack of structural progress was compensated by the expertise of the ironworkers in the various valleys, where a plentiful and skilled workforce was available at a low cost. Despite their gradual depletion, the local deposits of iron ore still provided the foundries with sufficient supplies. Diversification in the various towns was based on particular production niches requiring certain skills: specialist expertise in the use of "small" forges meant that the towns in the Brescia area's Valtrompia produced firearms, while agricultural implements were made in Valsabbia.¹²

In 1842, geologist and metallurgist Giulio Curioni estimated pig iron production in Lombardy at 8,000 tonnes per year,¹³ and by the end of the 1850s he estimated it to have risen to just under 13,000.¹⁴ However, Lombardy accounted for only about a twentieth of the Habsburg Empire's total output,¹⁵ and this decline was partly due to the depletion of the deposits that had ensured the success and European fame of Lombardy's metalworking sector in the late mediaeval and early modern periods. The shortage of iron ore and high cost of charcoal drove the region's metalworkers to reduce or abandon pig iron production and to concentrate increasingly on using imported iron and scrap.

This occurred in the Lecco area in the second half of the 18th century, when the use of scrap iron reduced fuel costs by 30% compared with pig iron. The use of scrap had two effects on the area's production structure and its future. First, the need to ensure a constant supply of raw material led producers to develop a dense network of relations and commercial exchanges inside Lombardy and with the rest of the Peninsula. The second effect involved production specialisation, since the iron obtained by annealing was particularly suitable for producing iron wire and all its derivatives: nails, screws, buckles, chains, rings, and springs. During the Austrian Restoration, this production system flourished, with the construction and modernisation of production plants. Over 130 "small" forges, almost all concentrated in the Gerenzone valley and with an average of just over 2-3 workers each, constituted a system that used rudimentary technology to produce a vast assortment of articles mostly destined for export.¹⁶

The dynamism of the sector is well illustrated by the story of the Badoni family, one of the Lecco area's most important entrepreneurial dynasties. From the early years of the century, Giuseppe and his son Carlo were engaged in the commerce and production of iron from reused scrap. In

1829, his grandson Giuseppe was sent to Germany to study new ways to organise work and new technologies, and in the second half of the 1830s the family built modern mechanised factories to manufacture nails. A combination of business acumen and careful marriage strategies meant that by the third generation the hybrid figure of the merchant-producer had been transformed into a modern businessman: Giuseppe married the daughter of a wealthy family of silk traders and also held public offices.¹⁷ In the early 1850s, the new blade factory at Bellano applied modern technology and used an innovative process based on peat. On the contrary, the five primary smelting furnaces in the area stopped working in the first decades of the century, although those on the western side of the lake benefited from the concentration of mining and metalworking in the hands of a single family of silk merchants from Como, the Rubini, who had been buying up the plants at Dongo and Cardano since the end of the 18th century. Over the course of 40 years, Dongo became one of Italy's most important ironworks.¹⁸

During the Austrian Restoration, as in the Como area during the 1700s, eastern Lombardy also had to face competition from Styria and Carinthia in Austria, where iron was produced at a much lower cost.¹⁹ Lombardy's biggest weakness was in the first stage of the process: mining and the manufacture of pig iron from iron ore. Traditional pig iron production might be useful for the few plants making a particularly high-quality product for specific uses, like steel at Bagolino, but there were greater advantages to be obtained from using scrap, as was done in the Lecco area, since this enabled a more flexible and elastic response to the growing demand for iron goods. However, attempts to import scrap iron for re-smelting encountered strong resistance from those who were still tied to traditional production processes. Hindered by the authorities and the traditionalists, in 1836 Giovanni Andrea Gregorini Senior was forced to suspend imports of scrap, as was the Milanese Vincenzo Rossi in 1837, depriving the forges at Vezza d'Oglio and Sovere of their raw material.²⁰ Only in the 1840s are there reports of scrap iron being used in this area. In 1844, gunsmith Marco Cominazzi presented an "easy method for the application of hot air to the fires where iron flows" in order to reduce fuel consumption and produce a more malleable material; he stressed that the process was able to melt scrap iron, in a period when "our traders buy a great deal of nautical scrap at auction".²¹

The 1840s were years of change, when significant innovations were adopted with the primary aim of reducing charcoal consumption. Originally from Alsace, Giorgio Enrico Falk arrived at the Dongo ironworks as an advisor and then became a partner. He was responsible for introducing the English style blast furnace in 1840 and also Lombardy's first rolling mill, which replaced the old process of beating with a hammer and was constructed using cylinders made in the same foundry. A few years later, he introduced modern forms of puddling, used with pig iron to produce an iron that could then be beaten.²² The new company, known

as "Rubini, Falck, Scalini & C.", used iron ore from the immediate area and from the Bergamo area to melt down items made of pig iron to produce malleable iron. In a short time, the company was able to increase its output from 420 tonnes to 1,000 tonnes in 1842, employing around 500 workers including miners and woodcutters.²³ In 1844, across the region, on the border between the territories of Bergamo and Brescia, Giambattista Cavallini a metallurgist with years of experience in France and Switzerland collaborated with Silvio Damioli and Giulio Curioni to modify the cross-section of the Pisogne blast furnace from square to round; a system of coiled pipes took in air from outside the furnace, which was heated by the smelting gases and then blown into the furnace by machine. This furnace, which had received substantial investments thanks to its principal shareholder Damioli but was jointly owned, was soon imitated because it reduced fuel consumption by over 20%.²⁴

The scarcity and high cost of fuel drove modernisation of the smelting furnaces. At the beginning of the 1850s, almost all furnaces in the territory of Bergamo were rebuilt to the Pisogne model. Their number rose from ten in 1850 to 13 in 1859, while pig iron output in 1851 was double what it had been in 1821. Similar changes occurred in the territory of Brescia, where all five furnaces operating in 1856 had a round cross-section.²⁵

Given that the general situation had become more receptive to innovation, Giovanni Andrea Gregorini Junior did not face the same resistance to change as his father. After travelling in Switzerland, Styria, and Carinthia, in 1855 he purchased the former royal factory at Castro near Lovere on Lake Iseo, and relocated there some of his father's secondary production stages. He then installed a reverberatory furnace, the only one of the 12 in Lombardy located outside the territory of Lecco, which used peat as fuel and processed scrap iron, and there he began to produce wrought and calendered iron and steel.²⁶ Until this time, Lombardy had produced a limited quantity of mostly natural steel, which also enjoyed a good reputation abroad.

Production was traditionally concentrated in the higher areas of the Seriana, Camonica, and Sabbia valleys, where charcoal from resinous plants was more plentiful. These valley forges had two fires – one for the bars and the other for boiling them. Around five tonnes of charcoal were needed in order to produce one tonne of steel from pig iron. Gregorini's new Castro steelworks accounted for 63% of Lombardy's steel output (150 tonnes out of 237).²⁷

In 1854, Bartolomeo Facchi transformed his foundry at Mompiano a few kilometres north of Brescia with the installation of three cupola furnaces and modern machinery. His 45 workmen produced 300 tonnes of pig iron via secondary smelting, which was then made into various kinds of nails *in situ*.²⁸ At the end of Austrian rule, the Brescia's metal products from secondary processing were in demand not only in the Kingdom of Lombardy-Venetia but also in the Po valley duchies, Tuscany,

and southern Italy. Arms manufactured in Valtrompia or assembled in Brescia also found outlet markets in the Po valley duchies, Tuscany, and Romagna.²⁹

Some of these emerging businessmen would be responsible for the post-Unification success of Lombardy's iron and steel industry, and all were heirs to skills that had been acquired and handed down for generations in the small communities that operated as industrial districts. These communities consisted of small labour-intensive family run businesses with limited fixed capital expenditures and were extremely skilled in the production of finished goods, which meant that they were able to deal with competition. This was the only way this manufacturing sector managed to operate, and in certain cases to achieve success, despite the evident problems it faced. Over the course of the century, some were able to transform a small-scale activity into an industrial concern but did not lose contact with their own districts. They were able to regenerate the surrounding area, transforming obsolete sites into modern factories; most importantly of all, they made the best possible use of the skilled workforce to which they themselves had originally belonged.³⁰

Italian Unification: the First Results of Modernisation

The plurality of production poles was based on advanced specialisation. This encouraged the establishment of distinct areas of expertise but did not prevent the competition between producers driving the general process of modernisation that began in the second half of the 19th century.

In the harsh conditions of the 1860s, only particular circumstances – like the national and European demand for arms – allowed the now "struggling" iron and steel industry to survive.³¹ In general, "the impoverishment of the national pig iron industry . . . was almost in its death throes", and this was even more true of Lombardy, where the sector was beset by a fundamental organisational impediment that effectively prevented all attempts at a revival. It was now necessary to replace the ageing system of jointly owned smelting furnaces with concentrated ownership.³²

The advent of steel in the 1860s led to the concentration and expansion of production plants and developed interaction between "the mining industry, steel industry and railway", dealing a hard blow to the weak revival attempts made in Lombardy. A new approach was now needed to overcome the marginal situation of the Alpine metalworking industry, which was unable to simply imitate the "technology of the steel industry . . . of Britain".³³ Nonetheless, some rather hesitant technological innovations proved to be essential, including the Siemens-Martin (open-hearth) furnace. Although it was actually "slower and therefore less suited to satisfying demands for rationalisation and organisation of labour", the new furnace had a 2-fold advantage: it allowed the processing of scrap iron and enabled adaptation to the many demands of the region's entire

manufacturing industry. Consequently, by the end of the century Italy had just a few isolated Bessemer furnaces but around 50 Siemens-Martin furnaces, mostly situated in Lombardy.³⁴

Innovation in the steel industry produced changes in its organisation in Europe, and similar changes also in Italy, including Terni's use of Tuscan ore from Elba. The same processes of selection and concentration also occurred in the Po region.

European innovations were adopted by industrialists who were determined to capitalise on the rather hesitant experiments already launched, and the pupils of Lombardy's major training schools – especially the *Politecnico di Milano* – made major contributions. These included men like Giulio Sagramoso, who became “director of Forges de la Providence of Hautmond” before founding the *Società fonderie d'Acciaio Vanzetti e Sagramoso* at Milan in 1889; and “in October 1862 Devincenzi . . . was president of the commission set up to carry out experiments in Sheffield, led by Bessemer . . . on converting into steel Italian pig iron from Lombardy” treated in the Gregorini and Damioli furnaces.³⁵

Established international relations played a determining role in the careers of the region's major innovators. The importance given to experience abroad is shown by their interest in the Bessemer converter. In 1862, just over five years after its installation in Sheffield, technicians and workers from Brescia travelled to Europe's major metalworking and machinery manufacturing sites, visiting Lyon, Saint Etienne, and Paris and stopping in London at the International Exhibition before continuing on to Manchester, Liverpool, Sheffield, Birmingham, and Enfield. They could directly evaluate the Bessemer's potential for iron and metalworking in Lombardy and the Brescia area in terms of costs and productivity. In general, events like the visits to international exhibitions, especially the London exhibition, allowed local industrialists to understand the limits and difficulties of Lombardy's Alpine metalworking industry faced with the problem of how to increase production while reducing costs and energy consumption.³⁶

One general course of action involved replacing the now obsolete charcoal-fired blast furnaces with reverberatory furnaces processing scrap iron, while Siemens-Martin furnaces were used for refinery. This process received a further stimulus when the new Gotthard tunnel opened up the Po valley area to imports of German iron. The fact that trade was now easier than before also accentuated fears of foreign competition, leading to demands for higher tariffs. These were obtained in the late 1880s when customs duties were revised to include typical regional products, like small metal goods and the semi-finished products from the first rolling mills in the territory of Lecco.³⁷ Even with the sector's extreme differentiation, the higher customs tariffs provided important protection for Lombardy's producers.³⁸

In this context, it became urgently necessary to combine the traditional characteristics of Alpine metalworking with the technological

developments now used abroad. At the same time, it was also important to maintain a distinct specificity as a barrier to direct competition with other Italian and foreign producers, who were intent on fully exploiting the economies of scale in enormous factories.³⁹ It was no easy task to modernise the single metalworking poles, where competitive imitation led to the selection of firms that first became local leaders, subsequently emerging at the national level and competing also outside Italy.

In a sort of competitive osmosis, with wide circulation of expertise and imitations of more effective solutions, some firms emerged as leaders. Some of these even operated in marginal areas, which were then able to participate in the ongoing process. Among the businesses paving the way for the emergence of the leaders of change was Migliavacca, whose Vobarno ironworks produced a small amount of moulded iron for trade and from the early 1880s attracted much of the metalworking industry in Val Sabbia. These medium-sized businesses like Gregorini of Castro di Lovere, Glisenti of Villa Cogozzo and Carcina, and Rubini of Dongo produced up to a quarter of Italy's total iron output and 10% of its steel.⁴⁰

While the entire industry was obliged to concentrate and specialise production, change was led by the region's strongest firms. Access to financial resources allowed these enterprises to achieve results and fulfil their potential for growth, and events in the banking sector, with the advent of “external forces” like the *Credito Italiano* or the *Banca Commerciale*, provided effective financial support for the region's emerging businesses.⁴¹ In order to have a fuller understanding of the development features of Lombardy's metalworking industry it is useful to concentrate on the leading firms and highlight the characteristics that distinguished them in terms of Italy's fully integrated steel working cycle, and also make a possible comparison at the international level. The individual production poles found their separate leaders, who succeeded in combining production, the market, and organisation, and the focus will mainly concentrate on the firms personified by family dynasties of owners: Glisenti, Gregorini, and Falck.

The Glisenti family can be traced back to the 16th century. As mentioned, the revival was launched by Giovanni Battista and he was followed by Francesco Glisenti in 1867, whose business activity drew on his exceptional knowledge of European technological and organisational methods. He decided to concentrate his metalworking and machining (firearms) at Carcina in the valley bottom and moved his commercial headquarters down into the urban area of Brescia to capitalise on the railway system that enabled him to sell his products rapidly and competitively. The choice to remain in the local area enabled Glisenti to obtain the natural resources found in the adjacent valleys and to make use of a skilled workforce that mainly worked at home.⁴² He produced a broad range of small parts, ranging from firearms to agricultural and domestic implements. This activity combined the traditional concern for product

quality with expertise that had accumulated over time and was enhanced by a social organisation in which the local family units engaged in a diverse range of economic activities, from various manufactured goods to mountain farming. The entire production system was organised in a sequence of manufacturing stages, starting with the smelting furnaces and followed by the refining crucibles. These produced large masses of molten steel that were poured into moulds to make pipes and filaments as basic components for the mechanised processes carried out in part directly by Glisenti or by the small workshops in the surrounding area.

Glisenti perfected the entire production cycle, specialising in firearms manufacture for which the firm obtained huge public contracts. Successes at international exhibitions like Paris in 1867 meant that it also won contracts to supply foreign governments. This allowed Francesco Glisenti in 1873 to make widely discussed technical and organisational modifications to the old furnace at Tavernole, which he had bought outright and now renovated by installing two Siemens furnaces with smoke recovery to save on fuel. A second production plant near Carcina had the first Siemens-Martin furnace in Italy, installed in 1883. In the early 1880s, this complex integrated production system employed a workforce of around 880 along the entire production chain from mining to manufacturing small metal objects. The final products were then sent to the city warehouse to supply a wide range of consumers. Other important interventions came over time, such as the addition of a rolling mill and the involvement of technical experts in management. The death of Francesco Glisenti in 1887 came at a particularly difficult time, and the complicated passage to the next generation signalled the start of a slow decline. Nevertheless, it should be stressed that his career made a decisive contribution to modernisation of the entire production system in the Val-trompia production pole and that even when its fortunes were in decline, the firm promoted the use of electricity and its quotation on the Milan stock exchange gave access to more consistent financial resources.⁴³

There are important similarities in the rise of the Gregorini family, another metalworking dynasty. In the first half of the 19th century they began to reorganise the sector's entire production system in the adjacent Val Camonica. Relocation onto the shores of Lake Isco in the lower valley meant that water transport and the nascent railway network provided access to the region's major cities and to the rest of Italy.

The growing scarcity of local raw materials was overcome using scrap iron, one element in the successful systemic combination of factors, especially the various uses of electricity, which were fully deployed in the following century. It should be stressed that these changes made it possible to preserve the accumulated expertise applied to the various secondary processes spread across the territory and also to maintain social stability and order. The expansion of iron and metalworking with the production of a vast range of goods for local consumption and – increasingly – also

for the national market means that straightforward quantitative comparisons have little meaning. Important production poles in the Brescia valleys continued for years to manufacture arms, and consumers appreciated the many products of Gardone Valtrompia and nearby Lumezzane (cutlery, shears, agricultural implements, knives and swords). These manufacturing activities were based on a highly skilled workforce, which enabled them to attract external investments and create networks with firms in the Lecco area. For example, in the 1880s Radaelli of Lecco set up a factory at Gardone to process semi-finished products.

Glisenti and Gregorini can therefore be seen as pioneers, whose success allowed other firms to modernise their own operations. The principal novelty was that firms were now located in the urban area of Brescia, where they could exploit the economic benefits of concentration and reduce transport costs. Firms like Ceschina Busi and Tempini or Franchi would become strongholds of the incipient industrialisation at the end of the century and the epicentre of a considerable manufacturing concentration. These ventures were launched by a growing group of entrepreneurs from traditional production sectors like the silk industry and benefitted from the availability of consistent financial resources. The banking sector came to the forefront in 1896, when Italy's principal credit institute, the Banca Commerciale, contributed to the merger of Franchi, Gregorini, and Metallurgica Bresciana, which created a major industrial group that would later play a leading role in the iron and metalworking industry. This laid the groundwork for a decisive move towards the formation of companies that would be leaders in their own areas of the region and capable of channelling the resources and skills of their entire province towards the production poles at Lovere, Carcina, and the provincial capital Brescia. In the years leading up to WWI, these firms made important progress by increasing steel output via an innovation that would have a decisive effect on the sector's development during the 20th century: the electric furnace. Its origins can be traced back to 1887, when industrialist Agostino Bonara built a factory at Darfo in Valcamonica to produce "*latta stagnata*" and replace foreign imports.⁴⁴

Bonara's company was constituted in London in 1890 to produce tin-coated sheeting, encouraged by the promising prospects offered by the expanding food industry and the trade barriers raised to protect nascent Italian production.⁴⁵ English technical expert and engineer E.W. Hampton designed a project for one Bessemer converter and four Siemens-Martin furnaces capable of producing 300 tonnes of malleable steel for thin sheeting, employing a workforce of 300. Bonara's sudden death in 1895 jeopardised the project, and the firm was declared bankrupt. Nonetheless, some entrepreneurs were still willing to take risks and continue Bonara's project using the more promising innovation of electricity to produce steel in furnaces designed by Ernesto Stassano.⁴⁶

The use of electricity solved the problem of the endemic fuel shortage of fuel by exploiting a resource that was in plentiful supply in the Alpine valleys: running water. This opened a way forward that allowed Lombardy's metalworking sector to compete with the highly competitive, fully integrated steel production cycle. Stassano patented his process and carried out trials before the new furnace made its industrial debut at Corna di Darfo. Its benefits of adaptability were perceived immediately, as this enhanced the extremely varied kinds of manufacturing activity carried out in the Brescia valleys without destroying the character of the traditional small manufacturing sites scattered across the territory.

The excellent results were achieved, which made it possible to rapidly raise the capital for the waterworks projects required to produce electricity, and so the Darfo plant was completed. It concentrated on the direct production of steel with an initial capacity estimated at roughly ten tonnes per day;⁴⁷ its first molten steel began to flow in March 1900, at the dawn of the new century.⁴⁸

The same features can be seen in parallel around Lake Como, the other area with the greatest concentration of iron and metalworking. The revival here coincided with the close ties established between the most important local families of entrepreneurs (Badoni, Falck, Bolis, Radaelli, and Rubini). They also worked closely together when it came to putting pressure on the government during the 1860s to ensure that protectionist tariffs favoured their most important products, especially drawn steel fine wires (under 3 mm in diameter). This demonstrates that their range of actions extended far beyond the mere production of iron and metal to include secondary manufacturing processes of various goods – agricultural tools, household objects, and items for clothing, destined for both Italian and foreign markets.⁴⁹

This area also faced the problems caused by the endemic weaknesses of the metalworking industry and the impact of the steel age, so that the manufacturing district faced strong foreign competition. The use of scrap iron made it possible to increase the competitive advantages offered by their mechanical expertise in a complementary relationship with Lombardy's other production poles.⁵⁰

Rail links with Milan, more efficient access to outlet markets, and hydro-electric power enabled more efficient localisation of production units, thereby increasing agglomeration economies that were primarily intangible, like workforce skills, which consolidated the Lecco manufacturing district.⁵¹

This can be seen from the figures: in 1868 foundries employed an average of 7.5 workers, whereas the average in 1900 was 15.3. Most foundries were still organised as "workshops run by the owners or by their tenants, helped by family members and at most by apprentices",⁵² although there were also some more solid production units, including Badoni, the Carenificio of Arlenico, and Caleotto, each employing several hundred workers. The originality of this situation consisted of the collaboration between the different production units.

Giorgio Enrico Falck was followed by his son Enrico, and the family's success paved the way for a process of industrial concentration, which began at Arlenico. Then in the early 1870s, the Falcks collaborated with the most important local merchant families, the Radaelli and the Bolis, to aggregate a large number of foundries and concentrate manufacturing in a single production plant: the Laminatoio di Malavedo. When he died unexpectedly, his wife stepped in, enabling the firm to continue on the course he had set towards overcoming its competitors in the production of wire rods. Enrico's son Giorgio Enrico Junior went abroad for the usual training at some of the important factories in the Ruhr area and was fully aware of the opportunities and challenges related to the nascent process of industrialisation. He began to move production towards the region's principal urban area, in parallel to the developments in the Brescia area. In 1895, Falck bought a share in the Rogoredo foundry just outside Milan. Far from representing a radical break with the region's traditions of localisation, this event heralded a dual polarisation of the Italian steel industry and accentuated sectorial interdependence with the engineering industry. This movement towards the city took place in stages: Carlo Vanzetti's Milan steelworks in 1888, a rolling mill for pipes in 1899, the Laminatoio Nazionale at Sesto San Giovanni in 1906, completed with Acciaierie e Ferrerie Lombarde (AFL) at Sesto San Giovanni.

It is worth focusing on this final event, the culmination of the transformations affecting the region's iron and metalworking sector and the *viaticum* for the 20th-century transformation of the regional and Italian economy. Careful attention to the development of consumption played an important role, with urban expansion towards the end of the century generating a strong demand for infrastructure investments, such as sewage systems, water supplies, and pipelines for the electricity industry. This extended to agriculture and cut across all production sectors, generating a demand for a vast range of mechanical machine tools. Innovative entrepreneurs responded quickly to supply the iron, pipes and networks this expansion required; they understood the changes taking place and attracted investors – even from outside Italy. Their response was enabled by some important technological applications, of which the most important was the use of Siemens-Martin furnaces to smelt scrap iron. This freed the industry of its traditional reliance on depleted local ore deposits, and cities became attractive as industrial sites providing raw materials and railway connections. Falck's experiments at Rogoredo were a success, and in 1901 he established a rolling mill alongside the steelworks to increase added value by manufacturing semi-finished products.⁵³

The success of Rogoredo became the starting point for an even more ambitious operation. With financial help from the Banca Commerciale,⁵⁴ Falck established AFL in January 1906. What made this initiative original was the identities of its promoters: Angelo Migliavacca contributed the Vobarno works, and the Rubini family brought in the Ferreria di Dongo.

This united two production plants located in the areas of Lombardy with the highest concentration of metalworking activity. The nascent firm intended to build a steelworks plant with two distinct objectives. The first was to meet the entire region's demand for steel, and the second was to obtain access to scrap and pig iron supplies and a workforce. The agricultural village of Sesto San Giovanni could offer both of these, since the St. Gotthard line could supply coal and scrap from outside Italy, while the Milan–Monza tramway could transport workers from the Bergaino and Como areas. The Milan area and the cities along the base of the mountains between Como and Brescia now became the primary outlet market for the steel produced. The new steelworks had Siemens-Martin furnaces with a capacity of 30–35 tonnes and its rolling trains of different thicknesses to manufacture products for the flourishing mechanical engineering industry. Despite some initial problems, the results were quick to arrive.

Working at full capacity, AFL accounted for 9% of Italy's total iron and steel production, an even more significant achievement considering how far the age-old original Lombard aim of producing manufactured goods was scrupulously pursued over time. The firm, known as Falck, forged ahead and became the leader of its entire sector. This role increased in the following years with the introduction of electric furnaces using energy from the firm's own power stations in Valtellina and also because Giorgio Enrico promoted a sectorial association capable of negotiating legislation to regulate competition and exerting a direct influence on tariff policies.

The foundations had been laid for a metalworking industry capable of achieving complete success in the 20th century.

Notes

* This chapter is the joint work of the authors. They jointly composed the *Introduction*, S. Onger authored the section *From Traditional Production to Change (1797–1859)*, and V. Varini wrote the part on *Italian Unification: the First Results of Modernisation*.

1. Colli 1999, p. 7.
2. Leboutte 1997, p. 104; Behagg 1984; Berg 1996, pp. 256, 262–263.
3. Marchesi 2003, pp. 112–113.
4. Belhoste 1982; Cuomo di Caprio, Simoni 1991.
5. Cova 1988, pp. 138–139.
6. Onger 2011b, pp. 394–399.
7. Trezzi 1988, p. 276.
8. Onger 2011a, p. 107.
9. Carera 1988, p. 230.
10. Calegari 1989; Cima 1991, p. 161.
11. Carera 1988, p. 229; Simoni 1994, p. 93.
12. Tedeschi 2001, p. 204.
13. Curtioni 1842, pp. 9–11.
14. Curtioni 1860, pp. 90–91.
15. Caizzi 1972, p. 153.
16. Colli 1999, pp. 12–18.
17. Colli 1999, pp. 22–23.

18. Cafaro 1988, pp. 184–185.
19. Cova 1994, pp. 14–18.
20. Mocarrelli 1997, p. 737.
21. Onger 2010, p. 120.
22. Frumento 1952, pp. 57, 62 e ss.
23. Romano 2012, p. 65.
24. Marchesi 2003, pp. 249–250.
25. Trezzi 1988, pp. 274–275, 1994, p. 318.
26. Gregorini 1993.
27. Curtioni 1860, pp. 103–105, 153.
28. Onger 1995, p. 51.
29. Trezzi 1988, p. 261.
30. Mocarrelli 1997, pp. 742–745.
31. Frumento 1952, p. 126.
32. Frumento 1952, pp. 129–130.
33. Wengenroth 1999, p. 3.
34. Giannetti 2003, p. 321.
35. Brianta 2007, p. 294.
36. Onger 2010, pp. 37–38.
37. Colli 1999, p. 33.
38. Zaninelli 1990, pp. 111–112.
39. Bonelli 1975.
40. Mori 1978, p. 25.
41. Mori 1978, pp. 31–32.
42. Mocarrelli 1997, pp. 721–759; Onger, Varini 2005.
43. Onger 2011a, pp. 109–124.
44. Lungonelli 1991, pp. 31–33.
45. Schiannini 2015, p. 277.
46. Gaggio 1992, pp. 789–809.
47. Schiannini 2015, p. 306.
48. Bonelli 1975.
49. Colli 1999, p. 31; Zaninelli 1988.
50. Pozzobon 1982, p. 171.
51. Colli 1999, p. 42.
52. Colli 1999, p. 89.
53. Varini 2006, p. 47, 2014.
54. Wengenroth 1991.

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