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Research Paper

Zombification of the economy? Assessing the effectiveness of French government support during COVID-19 lockdown

Mattia Guerini[a,b,*], Lionel Nesta[c,d,e], Xavier Ragot[f], Stefano Schiavo[g,e]

[a] *University of Brescia, Italy*
[b] *Fondazione Eni Enrico Mattei, Milan, Italy*
[c] *Université Côte d'Azur, CNRS, GREDEG, France*
[d] *SKEMA Business School, France*
[e] *Sciences Po Paris, OFCE, France*
[f] *Sciences Po Paris, Department of Economics and OFCE, France*
[g] *University of Trento, Italy*

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ABSTRACT

This paper evaluates the risk of zombification of the French economy during the COVID-19 pandemic crisis, as a result of the unconditional financial support provided to firms by public authorities, to limit the impact of lockdown measures. We develop a simple theoretical framework based on a partial-equilibrium model to simulate the liquidity and solvency stress faced by a large panel of French firms and assess the impact of government support. Simulation results suggest that those policies helped healthy but illiquid firms to withstand the shock caused by the pandemic. Moreover, the analysis finds no evidence of a "zombification effect", as less productive companies did not disproportionately benefit from government support.

1. Introduction

This paper aims to evaluate the risk of "zombification" of the economy as an unintended consequence of the measures enacted by the French government to support workers and firms during the recent COVID-19 pandemic. Faced with the possibility that the strict lockdown rules imposed to limit the diffusion of the virus could lead to collapsing demand and widespread business failures, resulting in massive layoffs and a cascade of bankruptcies spreading across the whole economy, several countries introduced a wide range of public support policies (Garicano, 2020; Odendahl and Springford, 2020; OECD, 2020b, 2021b).

The severity and scale of the sanitary crisis called for quick action and did not allow for finely-tuned, carefully-designed measures. Rather, most governments extended broad-based and often unconditional support to firms, which included a combination of job-retention schemes and state-guaranteed loans (OECD, 2020a). As in other countries, French authorities set up two important measures: (i) the job retention scheme called Partial Activity Scheme ("Dispositif d'Activité Partielle", AP) allowing firms to temporary lay off substantial shares of their workforce and (ii) the State-Guaranteed Loans ("Prêt Garanti par l'Etat", PGE) facilitating

* Corresponding author.
E-mail addresses: mattia.guerini@unibs.it (M. Guerini), lionel.nesta@univ-cotedazur.fr (L. Nesta), xavier.ragot@sciencespo.fr (X. Ragot), stefano.schiavo@unitn.it (S. Schiavo).

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access to additional financial resources for illiquid firms.[1] As a result of such public support, firm liquidations in France dropped by 50% in 2020 and remained stubbornly low well into 2022.[2] In fact, the fall in bankruptcies has been pervasive across several countries (OECD, 2021c).

This stylized fact led several authors to warn against the possible side effects of public support schemes. Because they are non discriminatory, such schemes may hamper the "cleansing effect" of market selection, preventing unproductive firms from being forced out of the market (Banerjee and Hofmann, 2020; Laeven et al., 2020; Helmersson et al., 2021; Araújo et al., 2022) and leading to a "zombification" of the economy. Reports by the OECD (2021a,b) find that the number of "zombie" firms – defined as companies with an interest coverage ratio lower than one for three consecutive years – has spiked in 2020. As a consequence, the question arises as to whether COVID-related support policies increase the possibility that inefficient firms remain active thanks to public funding, reducing the efficiency of market selection and reducing the so-called "cleansing effect" of recessions (Caballero et al., 2008; Foster et al., 2016; Merikyll and Paulus, 2022).

To assess the risk of zombification, this paper combines micro-simulations and regression analysis to investigate the impact of the job-retention scheme enacted by the French government on the liquidity and solvency of French companies. In doing so, the paper relates to two complementary streams of the existing literature. The first concerns the use of microsimulations to determine the scale of disruption generated by the pandemic and the associated public-health measures, and to call for public intervention to limit the impact on the economy (see for instance the early contribution by Schivardi and Romano, 2020). The second investigates possible drawbacks in the form of low-productivity firms remaining in the market and limiting the productivity-enhancing reallocation of resources (Merikyll and Paulus, 2022), in a context where some concerns about "zombification" had already emerged before the onset of the crisis. Questions about the ability of market selection to direct resources toward the most productive companies and the effects of misallocation of credit on productivity and growth (Caballero et al., 2008) had grown louder in the last decade, when loose monetary policy made it easier for (quasi-)zombie firms to access credit and roll-over debt (McGowan et al., 2018; Acharya et al., 2020; Sedláček, 2020; Schivardi et al., 2020).[3]

We find that the French government support has been successful in reducing the number of firms facing financial distress throughout the early phases of the pandemic. At the same time, we find no evidence of a zombification effect. Our results suggest that temporary, unconditional support for firms facing large, unexpected declines in demand can dampen the negative effects of transitory shocks without hindrance on the market selection process.

The remainder of the paper is organized as follows. Section 2 presents a brief overview of the related literature, while Section 3 provides a description of the theoretical framework that underlies our simulation exercise. Section 4 presents the data, the scenarios and the simulation results, which form the basis for the econometric analysis in Section 5, where we study the impact of the job-retention scheme on different firms and evaluate the risk of zombification. Section 6 concludes.

2. Literature review

The size and scale of the economic shock triggered by the pandemic and by the restrictive measures enacted by several countries (e.g., lockdowns and social distancing) led economists to predict a "perfect storm" hitting firms and leading to widespread bankruptcies (see for instance Hevia and Neumeyer, 2020). An early survey of American small businesses, run by Bartik et al. (2020) in late March 2020, showed that just a few weeks into the crisis, mass layoffs and closures had already occurred, raising concerns that those temporary halts would become permanent, also in light of the financial fragility of many small firms, a condition that emerges from the same data.

Questions about the proper functioning of market selection have led several scholars to exploit data from the early stage of the pandemic to investigate the possible link between the unprecedented scale of government support and the sharp fall in firm exit rates observed during the pandemic. Cros et al. (2021) use data from 2020 to investigate whether the same factors that predict firm failures in 2019 are at work during the first wave of the pandemic. While it may be too early to detect the full impact of the lockdown on firms, their preliminary evidence suggests that productivity and leverage remain the main drivers of firm exit, so that market selection continues to operate along the same lines as before.

Merikyll and Paulus (2022) exploit data on the entire population of Estonian firms over the period 2004–2020 to investigate the link between job reallocation and productivity. They find that, unlike previous recessions, during the COVID-19 crisis, the within-sector reallocation is very weakly associated with productivity, suggesting that the generous job retention scheme put in place by the government has negative effects on aggregate productivity, and prevents the reallocation of resources toward more productive firms.

Employing the World Bank Enterprise Survey to study the correlation between exit and productivity during the pandemic, Muzi et al. (2022) find that more productive and innovative firms are more likely to survive the crisis. Their results suggest that the cleansing process is disrupted in countries which have introduced policies imposing a moratorium on insolvency procedures, even if their data and methodology do not allow them to identify firms that would have exited even in absence of the sanitary crisis.

Finally, Kozeniauskas et al. (2022) use information on around 7,000 Portuguese firms covering the first wave of the pandemic (April–July 2020) and confirm the lack of any appreciable increase in the exit rate during the period, also finding that higher-

[1] A more detailed presentation of the support measures is provided in Section 4.

[2] See e.g. https://www.banque-france.fr/en/statistics/business-failures-france-2022apr.

[3] In fact, the productivity slowdown and weak business dynamism observed in several OECD countries are often considered two symptoms of economic malaise associated with a reduction in market selection efficiency (Storz et al., 2017). Similarly, zombification could constrain the post-pandemic recovery by limiting productivity growth and preventing an efficient allocation of resources (Sedláček, 2020).

productivity firms experienced smaller declines in employment, with a larger share of active resources being channelled towards them (in relative terms, given that the economy is shrinking). They also find that lower-productivity firms are more likely to take up government support, and that the fall in exit rates benefits primarily low-productivity firms, whose survival probabilities increase.

All these early studies, however, face at least two limitations. First, the small number of business failures makes proper identification difficult due to the paucity of information. Liquidations, bankruptcies and exit procedures, that are often lengthy during normal times, had been further slowed down, or *de facto* frozen, by lockdown measures. As such, the true effect of the pandemic on firm demography may take years to materialize. At the same time, widespread reliance on public support schemes by many firms may conceal the true state of their financial health. As a consequence, it is very difficult to identify illiquid but viable firms that have been hit by the pandemic from those that were experiencing difficulties even before the onset of the crisis.

Almost in parallel to these early empirical assessments, the lack of well-defined quantitative frameworks to estimate the impact of a large temporary shock on the economy led scholars to develop a range of methodologies to predict firm survival and exit, often with the aim of informing policymakers and suggesting appropriate support measures. One example is presented by Buera et al. (2021), who develop a fully micro-founded macroeconomic model with financial and labour market frictions that allows them to make quantitative predictions about the impact of lockdown measures on aggregate macroeconomic variables such as GDP, employment and firm dynamics. In their simulations, the effect is temporary as long as job retention schemes are in place, even if young firms operating in non-essential sectors are much more likely to exit.

Closer to our approach are contributions that aim to analyse the risk of business failure induced by the pandemic. This requires the use of micro-simulations, that is, frameworks that mimic the behaviour of individual firms facing the COVID-19 shock and from which one can recover the evolution of firm-level financial variables. Two main setups have been implemented. The first model is the one by Schivardi and Romano (2020), whose analysis is later extended to a larger number of countries by Demmou et al. (2020). This framework assumes that there are limits to a firm's ability to adjust the use of its production inputs, despite a possible fall in its sales. In these *partial adjustment* models then, following the sudden and massive demand shock induced by lockdown measures, companies cannot reduce their demand for factors of production by the desired amount. Such rigidity leads to a mismatch between the fall in revenues and the reduction in input-related costs, potentially leading to negative profits. This setup has the virtue of being very simple. However, it relies on a completely *ad hoc* adjustment process and lacks strong theoretical micro-foundations.

Gourinchas et al. (2021) follow a different approach and starts from an alternative hypothesis: rather than coping with an excessive amount of inputs, labour supply is rationed by the lockdown, so that firms substitute (unavailable) labour with more intermediate materials, leading to sub-optimal choices with respect to a normal situation. In that model, companies face three concurrent shocks: (i) a negative demand shock; (ii) rationing in labour supply due to confinement measures; (iii) a fall in productivity induced by remote working. In particular, Gourinchas et al. (2021) assume a negative productivity shock of -20%, which leads to a higher demand for inputs, tilted toward materials due to labour shortages. The result is a sub-optimal choice of input which may result in transitory losses and a reduction in both liquidity and equity.[4]

The micro-simulation approaches by Schivardi and Romano (2020); Demmou et al. (2020) and Gourinchas et al. (2021) share a number of common elements. The most important assumptions, which we also incorporate in our setup, are (i) the presence of nominal rigidities in both output and input markets, so that prices are fixed and companies take them as given; (ii) the existence of some kind of constraint on input markets, either in the form of rationing induced by the lockdown or adjustment frictions, which drive firms away from optimal input choices and introduce a wedge between the dynamics of revenues and costs.

The theoretical framework developed in the next Section combines the partial adjustment mechanism by Schivardi and Romano (2020) and Demmou et al. (2020), with a theoretical micro-foundation of firm behaviour, similar to Gourinchas et al. (2021).

3. Theoretical framework

We develop a partial-equilibrium model where firms minimize costs. Each sector $j = 1, \ldots, J$ is populated by a finite number of companies, denoted by $i = 1, \ldots, N$. Given the focus on the lockdown period and the short time horizon of the model, we consider output and input prices as fixed. Apart from this assumption, we do not take any stance on the prevailing market structure, allowing for the presence for, yet not imposing, market power on either product or factor markets. Although fixed in our model, observed prices may depart from competitive prices in all markets since they may not reflect the equalization of marginal cost and revenue.[5]

3.1. The model

Cost minimization In each time period, firms face a level of demand Q^d_{it}, which is assumed to be known and decide on quantities taking (fixed) input and output prices as given. Thus, firms solve the following one-period cost minimization problem[6]:

[4] In this framework, a negative productivity shock is crucial to obtain a significant increase in firm failure rates. In fact, since firms can always reduce the amount of factor inputs that are used, they can compensate demand shocks. As a consequence selection and exit only depend on the presence of fixed costs being larger than operating profits.

[5] That is, we do not assume perfect product and factor markets. Although prices are fixed during the sanitary crisis, actual prices may reflect past bargaining behaviour. This in turn may translate into a wedge between revenue shares and output elasticities of any factor. See for instance Caselli et al. (2021) for evidence pointing to this direction.

[6] In a period of high uncertainty as it was the 2020, characterized by new ordinances at weekly cadence, it was impossible for firms to make forecasts further ahead in time. This is the reason for which we avoid modelling the firms' behaviour as an inter-temporal optimization problem.

$$\begin{cases} \underset{L_{it},M_{it}}{\arg\min}\ C_{it} = P_L L_{it} + P_M M_{it} + P_K K_{it} \\ \text{subject to} \\ Q_{it} \le \mathcal{F}(K_{it}, L_{it}, M_{it}) = \omega_{it} K_{it}^{\beta_K} L_{it}^{\beta_L} M_{it}^{\beta_M} \\ Q_{it} \ge Q_{it}^d \end{cases} \tag{1}$$

where the choice variables are the demand for labour (in hours worked, L_{it}) and intermediate materials (M_{it}).

Given the time horizon of the model, we assume capital stocks to be invariant over the simulation period, such that firms invest in maintenance without investment in additional productive capacity: $K_{it} = K_i$. Therefore, the objective function is a linear cost function (C_{it}) accounting for the presence of two variable inputs and one fixed input. Prices P_K, P_L and P_M refer to the user costs of capital, hourly wage and price of materials, respectively. The first constraint is a Cobb-Douglas production function $\mathcal{F}(K_{it}, L_{it}, M_{it})$ with three inputs, where ω_i measures firm-specific total factor productivity (TFP) and the β exponents represent factor elasticities.[7] The second constraint is the demand level, determined by Equation (2).

Demand We model firm-specific shocks as demand shifters:

$$Q_{i,j,t}^d = Q_{i,j,t_0}^d (1 + \xi_{i,j,t}) \tag{2}$$

where $Q_{i,j,t}^d$ is the demand faced at period t by firm i, belonging to sector j. The term Q_{i,j,t_0}^d is the firm-specific demand as time t_0 (i.e. January 2020). The term $\xi_{i,j,t}$ – which can be either positive or negative – represents the demand shifter. Its absolute value determines the magnitude of the shock, while its sign determines the nature of the shock.

Variable factor demand Optimal demand for the variable factor inputs is:

$$L_{it}^{\star} = \left[K_{it}^{-\beta_K} \frac{Q_{it}}{\omega_{it}} \left(\frac{P_M}{P_L} \frac{\beta_L}{\beta_M} \right)^{\beta_M} \right]^{\frac{1}{\beta_L+\beta_M}} \tag{3}$$

$$M_{it}^{\star} = \left[K_{it}^{-\beta_K} \frac{Q_{it}}{\omega_{it}} \left(\frac{P_L}{P_M} \frac{\beta_M}{\beta_L} \right)^{\beta_L} \right]^{\frac{1}{\beta_L+\beta_M}}$$

Partial adjustment We take into account the fact that in most real-world situation, companies' adjustments of the flexible inputs may not be instantaneous. In fact, companies orders for intermediate inputs are lumpy and workers may not be immediately dismissed due to the rigidity of many contracts. This implies firms may not be able to reach optimal quantities $L_{it}^{\star}$ and $M_{it}^{\star}$, but rather adjust partially as follows:

$$\hat{L}_{it} = L_{it-1} + \gamma_L (L_{it}^{\star} - L_{it-1}) \tag{4}$$

$$\hat{M}_{it} = M_{it-1} + \gamma_M (M_{it}^{\star} - M_{it-1})$$

where the parameters $\gamma_L, \gamma_M \in [0, 1]$ describe the speed of adjustment for the flexible factors and the hat (e.g. $\hat{L}_{it}$) indicates that the variable has been only imperfectly adjusted. At one extreme, $\gamma_M = \gamma_L = 1$ imply that firms can immediately adjust both inputs at the optimal levels. At the other extreme, if $\gamma_M = \gamma_L = 0$, then the two inputs are fixed and firms cannot adjust.[8]

Liquidity dynamics Liquidity holdings (Λ) of firms evolve according to the following law of motion:

$$\Lambda_{it} = \Lambda_{it-1} + \ell_{it} \tag{5}$$

where cash flow ℓ_{it} is defined as:

$$\ell_{it} = PQ_{it} - P_L L_{it} - P_M M_{it} - P_K K_i - T_i. \tag{6}$$

Equation (6) states that cash flow is the difference between revenues from sales and production costs, which include the wage bill ($P_L L$), the cost of intermediate products ($P_M M$), the fixed costs of capital ($P_K K_i$) and the corporate tax bill (T_i). Both the fixed costs and the tax bill are kept constant over the simulation horizon. Writing Gross Operating Income as $\Pi_{it} = PQ_{it} - P_L L_{it} - P_M M_{it}$, Equation (6) can be rewritten as $\ell_{it} = \Pi_{it} - P_K K_i - T_i$, implying that liquidity equals gross operating income minus fixed costs and corporate taxes.[9] Finally, it is worth noticing that we abstract from modelling dividends distribution.

[7] See Appendix A for details on the estimation procedure.

[8] This setup is similar to one proposed by Schivardi and Romano (2020), with the main difference that our adjustment is micro-founded and approaching the optimal values $L_{it}^{\star}$ and $M_{it}^{\star}$ rather than proportional to the demand shock.

[9] This is a reasonable assumption in the short-term.

Financial stress A company is said to face liquidity stress whenever $\Lambda_{it} < 0$. This implies that the sum of liquidity holdings at the end of the previous accounting period Λ_{it-1} and the current gross operating profits Π_{it} are smaller than the sum of the firm's fixed costs plus the tax bill:

$$\begin{aligned} &\Lambda_{it} < 0 \\ &\Lambda_{it-1} + \Pi_{it} < P_K K_i + T_i. \end{aligned} \tag{7}$$

The same definition has been recently adopted by Demmou et al. (2020) and Gourinchas et al. (2021).

Illiquid firms, however, may continue operating by raising new debt, either *via* bonds or new loans, albeit with some limitation. A company is said to be insolvent when liquidity holding Λ_{it} becomes negative, and in absolute value exceeds equity E_{it}. The insolvency condition therefore reads:

$$\begin{aligned} &\Lambda_{it} + E_{it} < 0 \\ &\Lambda_{it-1} + \Pi_{it} + E_{it} < P_K K_i + T_i \end{aligned} \tag{8}$$

where the second form of Equation (8) suggests that a firm shuts down whenever all liquid and illiquid resources – i.e. the left hand side – are insufficient to cover financial and tax charges – i.e. the right hand side. In this situation, also short-term borrowing would be unfeasible because neither investors in corporate bonds nor a bank would rationally provide funds to such a firm.[10]

Timeline of events At each time period, the following sequence of events takes place:
1. Firms observe the new level of demand $Q^d_{i,j,t}$ defined by Equation (2);
2. firms determine their optimal amount of flexible inputs $(L^\star_{it}, M^\star_{it})$ according to Equation (3);
3. firms take into account the partial adjustment constraints and use the inputs $(\hat{L}_{it}, \hat{M}_{it})$ as defined by Equation (4);
4. firms produce the amount Q_{it} using the Cobb-Douglas technology in the first constraint of Problem (1);
5. firms' cash flows are updated according to Equation (5).

At the end of each accounting period t, both financial conditions are updated, thereby determining the share of illiquid and insolvent firms. We have two additional remarks. First, liquidity and solvency are the results of a host of factors including productivity, output elasticities, operating profit, and financial health of the firms in terms of debts and fixed costs. Their complex web of interactions makes prediction a difficult exercise, and micro-simulations can be considered an appealing tool for policy evaluation. Second, in the absence of external financial resources, absence of cash makes it impossible for firms to cope with the drop in demand while covering their variable and fixed costs, implying that illiquid firms become insolvent. That is, the share of illiquid firms should be interpreted as an upper bound for the rate of insolvency in the absence of support from financial institutions. The wedge between the number of firms experiencing liquidity and solvency issues can be used as a proxy for the contribution of the financial sector to firm survival.

3.2. Model comparison

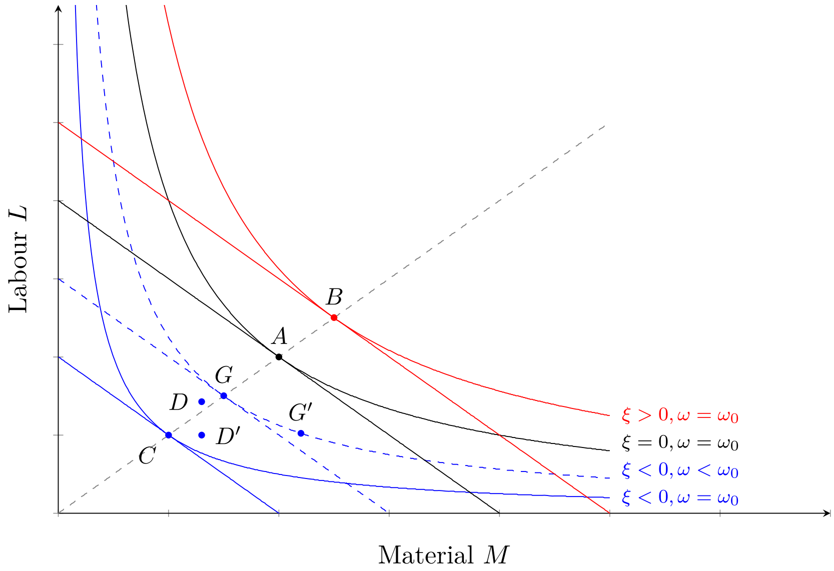
Fig. 1 provides an illustration of our theoretical framework, as well as its relationship with the alternative modelling strategies described in Section 2.

All firms start from a baseline, pre-COVID situation represented by point A. This implies an optimal choice of labour $L^\star$ and material $M^\star$, given the fixed capital stock K and the productivity ω_0. The case of a positive demand shock ($\xi > 0$), experienced for example by firms in sectors producing essential goods during the pandemic, is envisaged in Point B and is coloured in red. In such a case, we assume that the firms can make optimal choices and expand seamlessly. The case of a negative demand shock ($\xi < 0$), forces instead the firms to downsize. Absent any frictions, firms would move to point C. In this case, the fall in revenues translates into a fall in profits and jeopardizes the survival of firms whose fixed costs exceed the profits. However, if there are frictions in the adjustment process (as in the *partial adjustment model* by Schivardi and Romano, 2020), firms cannot reach the new optimal level for both labour and materials ($L^\star$ and $M^\star$). Point D illustrates such a situation in the absence of any policy action, while point D' envisages a situation in which the firms can reach $L^\star$ by virtue of the job-retention scheme of the government, but cannot reach $M^\star$.[11]

Point G, instead, illustrates the case postulated by Gourinchas et al. (2021). It lays on an isoquant that is a dashed blue curve in order to jointly characterize a lower level of production (blue colour) and a lower labour productivity (dashed line), such that $\omega < \omega_0$. The conjunction of these two shocks places the optimal choice at G, with firms necessarily asking for more inputs with respect to the point C, that has an equivalent level of production. Furthermore, in Gourinchas et al. (2021) firms are also rationed in the labour market due to the lockdown measures, and they compensate for this additional constraint by increasing their demand for intermediate goods, moving to point G' and further increasing their production costs.

[10] A condition for which a firm would be able to operate even when this condition is met, is that fresh capital is provided by shareholders, by a controlling firm, or by an acquiring firm. These, however, are situations that go beyond the scope of this paper.

[11] Details on the job-retention scheme are provided in Section 4.1.



Black, solid lines represent the isoquant and linear isocost function in the pre-COVID-19 equilibrium, with optimal input choices at point A. Red lines represent the isoquant and linear isocost function following a positive demand shock with optimal input choices at point B. Blue, solid lines represent the isoquant and linear isocost function following a negative demand shock with optimal input choices at point C. The dashed blue lines add to the same negative demand shock a negative productivity shock which increases the amount of inputs required to produce the same output as in point C. Points D and D', G and G' represent suboptimal constrained choices as defined in our model and that of Gourinchas et al. (2021). (For interpretation of the colours in the figure(s), the reader is referred to the web version of this article.)

Fig. 1. Firm input choices under different model settings.

4. Simulations

In the previous section we described the behaviour of firms according to our model, and we compared it with few notable alternative modelling strategies. In the current section, we describe the different simulation scenarios, which allow us to provide an estimate of the number of French non financial firms facing liquidity and/or solvency issues as well as to evaluate the effectiveness of the French public support initiatives. In either case, to properly identify firms whose problems are due to the COVID-19 crisis and would not have experienced any troubles otherwise (and thus overcome the difficulties faced by Muzi et al., 2022), it is necessary to build two counterfactual scenarios. One without COVID-19 and one with COVID-19, but without any public intervention.

4.1. Scenarios

We simulate three different scenarios. Each scenario is a combination of a given demand dynamics and policy support, if any. These are the followings: (i) a *COVID + Gov* scenario which combines the observed evolution of demand for 2020, and introduce the job-retention scheme implemented by the French government; (ii) a *COVID* scenario, which takes into account the actual fall in demand as in (i), but rules out the support measure implemented by the government; (iii) a notional *No-COVID* case, in which the counterfactual monthly demand for 2020 is estimated to set up a "business as usual" dynamics. To do this, we apply time series techniques on monthly industrial production data over the 2012–2019 period. The three scenarios, therefore, differ along two dimensions: the demand shifters (ξ) and the firm ability to adjust its labour input (either $\hat{L}$ or L^*).

In all three scenarios, we assume that financial institutions provide financial resources to companies until cumulative debts exhaust firm equity. Although this seems like a reasonable assumption in normal times, one could object that with high uncertainty, the financial market does not operate accordingly. However no later than March 2020, the French government pledged €300bn in order to cover credit losses in case a company defaulted on a bank loan ("Prêt Garanti par l'Etat"). In other words, the risk of default was borne by the state rather than banks. This scheme aimed at facilitating access to additional financial resources for illiquid firms, although loan decisions remain within the hands of financial institutions.[12] Hence, all scenarios are based on the assumption that firms remain active so long as their net equity is positive.

We now present the three scenarios, starting from the *COVID + Gov* scenario which is the one reflecting what has been implemented in France. We then present the two counterfactual scenarios: the *COVID* scenario without state intervention, and the *No-COVID* scenario.

[12] Repayment carries over the 6 forthcoming years, with a possible extension up to 10 years. The first two years may leave companies free from repayment duties. Benitto et al. (2022) report that as of January 2022, €145bn had been lent out to more than 700,000 firms, and the anticipated loss for the Government is €1.4bn.

4.1.1. *The COVID scenario with government support (*COVID + Gov*)*

The first scenario naturally builds upon the observed dynamics of demand. Absent information on the monthly demand addressed to companies, we use sector level data, implying that firm i demand shifters are approximated by sector j's shifters: $\xi_{i,j,t} \simeq \xi_{j,t}$. Demand shifters are computed as the percentage gap between the observed level of demand at time t with respect to January 2020: $\xi_{j,t} = \frac{IP_{j,t}-IP_{j,0}}{IP_{j,0}}$, where IP represent the observed, 4-digit industrial production index, and where $t=0$ indexes January 2020. It follows that $\xi_{j,0}=0$ in January 2020 for all sectors. Notice that the term $\xi_{j,t}$ can be either positive or negative, and depends on the nature of the shock. For example, the demand for pharmaceuticals product expanded in 2020 (i.e., $\xi_{j,t}>0$), while the demand for hotels and restaurant plummeted (i.e., $\xi_{j,t}<0$).

In our framework, we assume that the COVID-19 lockdown introduced slackness on the materials market. Although firms face a shortage in demand, they cannot fully adjust their demand for materials to this newly depressed level of demand. To reflect this, we set $\gamma_M = 0.50$, limiting the ability of firms to reach optimal $M^\star$. This constrains them to revise only 50% of their contractual arrangements with suppliers per simulated month, thereby reaching $\hat{M}$.

Within days from the first lockdown though, French authorities set up a job-retention scheme to provide support to firms and workers.[13] This is an extension of the so-called Partial Activity Scheme ("Dispositif d'Activité Partielle", AP), which had been operational since 2008.[14] Originally, authorities would cover a fixed amount of almost 8 euros per hour not worked, while firms compensated temporally laid-off workers up to 70% of the gross wages. Instead, during the pandemic, public funds would cover 70% of the original gross wage (amounting to approximately 84% of the net compensation received by employees), while the remaining wage loss may be covered at the discretion of employers (Vincent, 2021). This allowed companies to temporary lay-off a substantial share of the labour force at virtually no cost.[15] Within our modelling framework, this implies that in the *COVID + Gov* scenario firms reach their optimal level of employment $L^\star$ without any sluggishness. Formally, this implies that we set $\gamma_L = 1$ in the *COVID + Gov* scenario.

4.1.2. *The COVID scenario without government support (*COVID*)*

With respect to the demand shocks, the *COVID* scenario is perfectly equivalent to the *COVID + Gov* one, with the exception of the government support to firms on the labour market. Because of the absence of the job-retention scheme, we simply set $\gamma_L = 0.20$ and $\gamma_M = 0.50$.[16]

4.1.3. *The* No-COVID *scenario*

In this scenario, we let the economy run *as if* COVID-19 had not occurred, where firms can optimally choose L and M according to Equation (3). This is tantamount to assuming that $\gamma_L = \gamma_M = 1$.[17]

The difficulty lies in the establishment of a counterfactual demand dynamics, had the pandemic crisis not occurred. To make out-of-sample forecasts, we exploit information on the dynamics of output for each sector of the economy prior to March 2020. In particular, we rely on standard time-series techniques, estimating sector-specific AR(1) processes with monthly dummies to take into account seasonal components of demand. The sample data cover the period from January 2012 to December 2019 ($T=96$) and the estimated model is express by:

$$g_{j,t} = \rho_s g_{j,t-1} + \delta_{j,m} + \varepsilon_{j,t} \tag{9}$$

where $g_{j,t}$ measures the growth rate of industrial production in sector j at time t; ρ_j represents the first-order autoregressive parameter for a specific sector; and $\delta_{j,m}$ captures the sector-specific monthly components of demand. Equation (9) can be consistently estimated by OLS (Hamilton, 2020).[18]

We then employ our estimates $\hat{\rho}_j$ and $\hat{\delta}_{j,m}$ to carry out the iterated one-step-ahead predictions of the growth rate for all subsequent months, covering the period from January 2020 to April 2021[19]:

$$\hat{g}_{j,t+1} = \hat{\rho}_j g_{j,t} + \hat{\delta}_{j,m} \; . \tag{10}$$

Finally, to estimate the demand shifters in the *No-COVID* scenario, we normalize industrial production in January 2020 – i.e. $\xi_{j,0}=0$ in January 2020 for all sectors – and we iteratively forecast the index value of industrial production for all subsequent months using the following equation:

[13] For a brief yet exhaustive overview of the different measures introduced by the government, see Cros et al., 2021.

[14] Ordinance n.2020-346, 27 March 2020 (https://www.legifrance.gouv.fr/dossierlegislatif/JORFDOLE000041913361/).

[15] UNEDIC, the organization responsible for the implementation of AP, estimates the overall cost for public authorities to be €35bn in 2020 and 2021 (UNEDIC, 2022).

[16] Higher order, general equilibrium consequences on the dynamics of demand are left aside, for their identification lies outside the scope of this paper.

[17] This is in line with Gourinchas et al. (2021) who, however, assume that firms can always adjust to the optimal level of inputs, even in presence of the pandemic. In turn, they assume a negative productivity shock under COVID-19, in order to generate high-enough exit rates.

[18] To ensure stationarity of the processes, we transform all the series in growth rates. All p-values of the sector-specific Augmented Dickey-Fuller (ADF) tests, computed on the residuals of Equation (9) are smaller than 10% (99% of them are below the 5% threshold) indicating that any autocorrelation in the data has been taken into account either by the AR(1) component or by the monthly dummies.

[19] April 2021 has been chosen as the end date because it is exactly one year after the economic policies to tackle COVID-19 in France have been carried out and because we believe that one year is a reasonable time-span in which the assumption of fixed prices is reasonable.

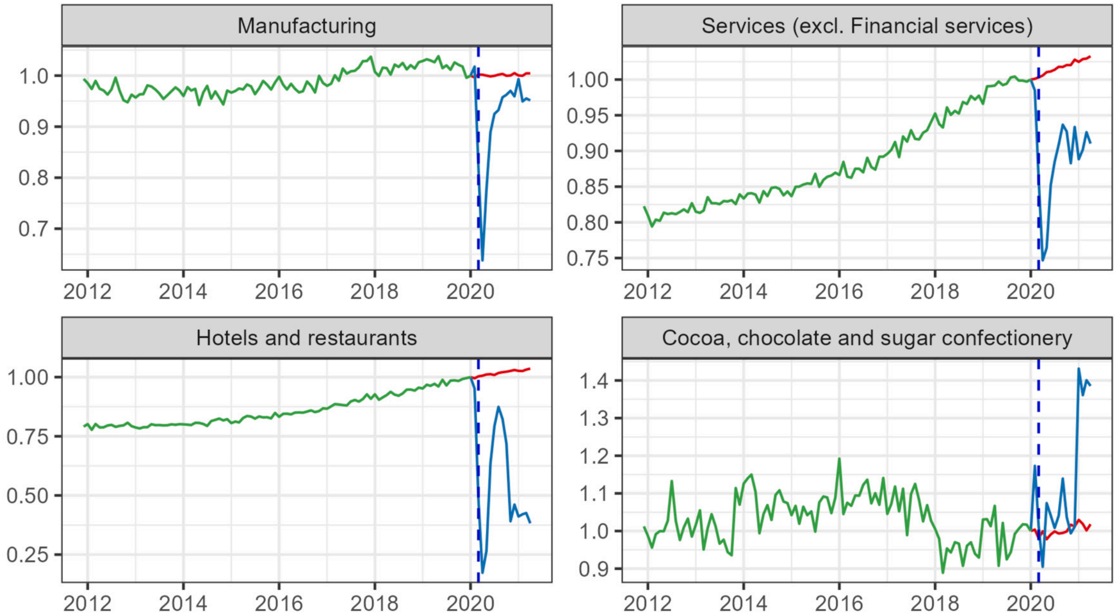


Fig. 2. Time evolution of value added indexes (January 2020 = 1) in selected sectors from January 2012 to April 2021. Observed historical values are depicted in green. Observed post COVID-19 values are coloured in blue. Predicted values for the *No-COVID* scenario are in red.

$$(1+\hat{\xi}_{j,t}) = (1+\xi_{j,0})\prod_{k=0}^{t}(1+\hat{g}_{j,k}) = \prod_{k=0}^{t}(1+\hat{g}_{j,k}) \tag{11}$$

Fig. 2 provides instances of the evolution of values added running from January 2012 to April 2021 for four sectors: Manufacturing; Services (excluding financial services); Hotels and restaurants; Cocoa, chocolate and sugar confectionery. Observed values prior to the global lockdown appear in green. Empirical values during the sanitary crisis appear in blue. For the first three sectors, the lockdown translated into an unprecedented fall into economic activity (-35%, -25%, and -80% respectively) as displayed by the blue lines. Activity in Cocoa, chocolate and sugar confectionery instead was up 40% during the second wave of the lockdown. Such a positive dynamics was shared (albeit with different intensities) by about 1 in 9 sectors of the economy. Finally, the red line represents the counterfactual value added index under the *No-COVID* scenario as forecasted by Equation (11).

4.2. Data source and simulation parameters

The initial conditions for the simulation exercise are the balance sheet data for 2019, as reported in the FARE database maintained by the French Statistical Office (INSEE), which represents a snapshot of the situation of French companies before the beginning of the pandemic and is based on tax filings by companies. FARE 2019 includes more than 4 million companies (4,356,764). However, we exclude from the analysis companies with incomplete information; firms in Agriculture, Forest and Fishing (AZ), Finance and Insurance (KZ) and Public Administration, Education, Human Health and Social Work (OQ) sectors; legal persons and organizations subject to administrative law, as well as self-employees and craftsmen. The reason for leaving these companies aside of our analysis is that their decisions on the amount of factors of production employed do not necessarily comply with the logic of our simulation model, which is based on cost minimization and on a production function framework.

The set of firms that belong to our simulation exercise includes 752,603 companies (or 17.2% of FARE's legal units) covering more than 10.5 million jobs (76.2% of FARE jobs), and €914bn of added value (i.e. 74.1% of FARE). The simulation takes as a reference the legal units. Thus we do not model possible resource flows among companies belonging to the same business group (or between parent and subsidiaries), which could affect their financial distress.

Output elasticities ($\beta_K, \beta_L, \beta_M$) are estimated using a Cobb-Douglas production function based on balance sheet data (taken from FARE) for the years 2012–2019 (see Appendix A).

The size of the demand shock ($\xi_{j,t}$) at the 4-digit industry level (referenced as level $A732$ in the French nomenclature) for the *COVID* scenario is taken from INSEE.[20] In particular, we use industry-specific value-added indexes recorded over the COVID-19 period to capture the size of fluctuations to demand during the pandemic. The same data source, but for the 2012–2019 period, is instead used to forecast the value added for the counterfactual *No-COVID* scenario presented in Section 4.1.3. Table 1 provides the values of the parameters used in the three simulations relating to the speed of adjustments (γ), the demand shifters (cross-sectoral averages of ξ), output elasticities (cross-sectoral averages of β), and firm efficiency (average value of firm-specific ω).

[20] See https://www.insee.fr/fr/recherche?q=Indice+production+industrielle&debut=0.

Table 1
Summary of model parameters.

Symbol	Economic Interpretation	Value
γ_M	Speed of adjustment in the intermediate inputs market	0.500
γ_L	Speed of adjustment in the labour market	1.000
γ_L	Speed of adjustment in the labour market (*COVID* scenario only)	0.200
ξ	Demand shifter	-0.097[a]
ξ	Demand shifter (*No-COVID* scenario only)	0.033[a]
β_K	Output elasticity of capital	0.022[b]
β_L	Output elasticity of labour	0.210[b]
β_M	Output elasticity of materials	0.728[b]
ω	Efficiency parameter (total factor productivity)	5.648[c]

[a] Numbers denote 4-digit ($A732$) sector average.
[b] Numbers denote 2-digit ($A88$) sector average.
[c] Firm average ($N = 752,653$).

4.3. Simulation results

Fig. 3 presents the broad trends emerging from the simulations for the three scenarios. The top panel provides the cumulative share of illiquid firms, whereas the bottom panel reports the cumulative share of insolvent firms. Recall that the share of illiquid firms can be interpreted as representing an upper bound for the share of insolvent firms in the absence of support from financial institutions. In all scenarios, and regardless of the measure of financial stress, we observe an upward trend that is at odds with the observed fall in the number of liquidations in 2020. However, we should bear in mind that we are not simulating a failure rate, but rather the unobserved financial health of firms.

Unsurprisingly, the pandemic has a sudden, brutal and sizable impact on the liquidity of French companies. The drastic drop in revenues determined by the lockdown, the presence of frictions in the markets for factors of production and of fixed costs that do not adjust to the level of production (or adjust very slowly) drain the liquidity of non-financial firms. The fraction of companies experiencing solvency (liquidity) issues climbs up to 3.4% (16%) by the end of the simulation. This contrasts with an insolvency (illiquidity) rate of around 1.9% (5%) in April 2021 under the baseline No-COVID scenario.

Fig. 3 provides two additional insights. The first one concerns the impact of the partial activity scheme on solvency, which is large and positive. The measure reduces the number of insolvent companies, trimming it by 0.8 percentage points (from 3.4 to 2.6%) in April 2021.[21] The second one is that a number of firms face solvency issues irrespective of the pandemic (1.9%), implying that they are unprofitable even when the economy is growing. These companies are generally smaller, less productive, more indebted and have a lower level of liquidity than the others. This evolution is qualitatively similar to the results presented in OECD (2021a), despite the fact that the analysis is based on a sample of firms with different characteristics.

Fig. 4 presents the share of firms in financial stress, and exhibits substantial cross-sector heterogeneity across the three scenarios. The red bars display the estimated rate of firms under the COVID scenario with government support. The dark grey and blue bars display the estimated rate under a No-COVID and a COVID scenario without government support, respectively. The rankings of shares are consistent with our expectation, where the COVID+Gov bars systematically appear median with respect to the other two scenarios. Focusing on the red bars, companies experiencing liquidity problems as of April 2021 under the COVID scenario vary between a minimum of 2% (*Construction*) to a maximum of 31% (hotels and restaurants, i.e. *IZ - Accommodation and food service activities*). The two sectors most affected are hotels and restaurants on the one hand and household services (*Other service activities*) on the other hand, the latter featuring almost 14% of illiquid firms. Other sectors (including manufacturing) display rates below 10%. Shifting to solvency problems delivers a very similar classification. *Accommodation, food and household services* are still very affected, with around 7% firms being insolvent.

5. Public support and firm solvency: a policy evaluation exercise

5.1. Firm sorting

The first set of questions concerns the financial stress of firms across the different scenarios. Did public financial support relieve firms from financial stress during the sanitary crisis? We proceed in two steps. First, we look at the solvency stress of firms under the two scenarios. Table 2 discriminates among firms suffering from solvency stress in the No-COVID and in the COVID scenarios without government support. Consistently with Fig. 3, it shows that the number of insolvent firms raises from 1.9% to 3.4%. It also shows that the vast majority (726,438 firms, representing 96.5% of our sample) of firms have sufficient resources to escape from insolvency stress in either scenario. Among the 25,697 financially-stressed companies of the COVID scenario, more than half (13,772) show similar problems also in normal times, whereas our simulations reveal that almost 12,000 firms would become insolvent because of the crisis, absent any government support. A small number of firms (468) enjoy an improvement of their financial condition following

[21] This would amount to roughly 30,000 companies being relieved from insolvency stress, relative to the 4 millions companies composing the French economy.

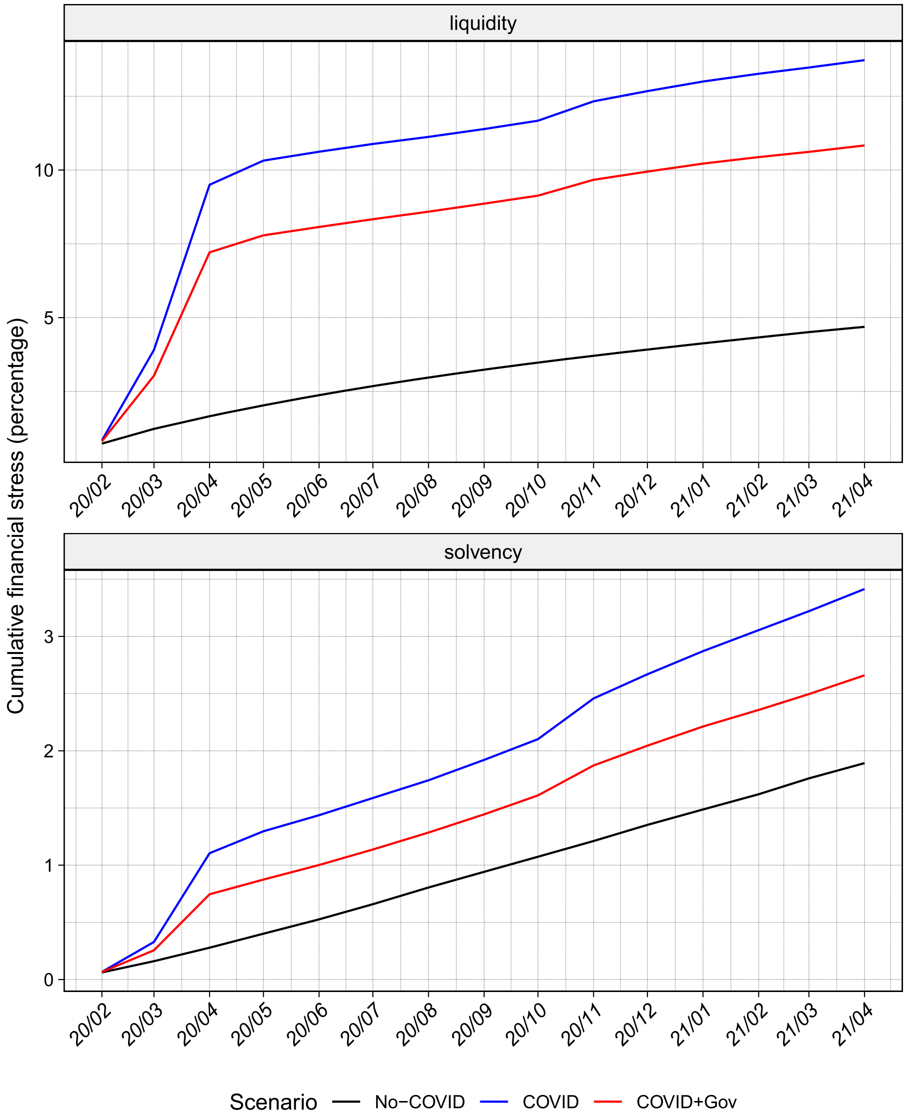


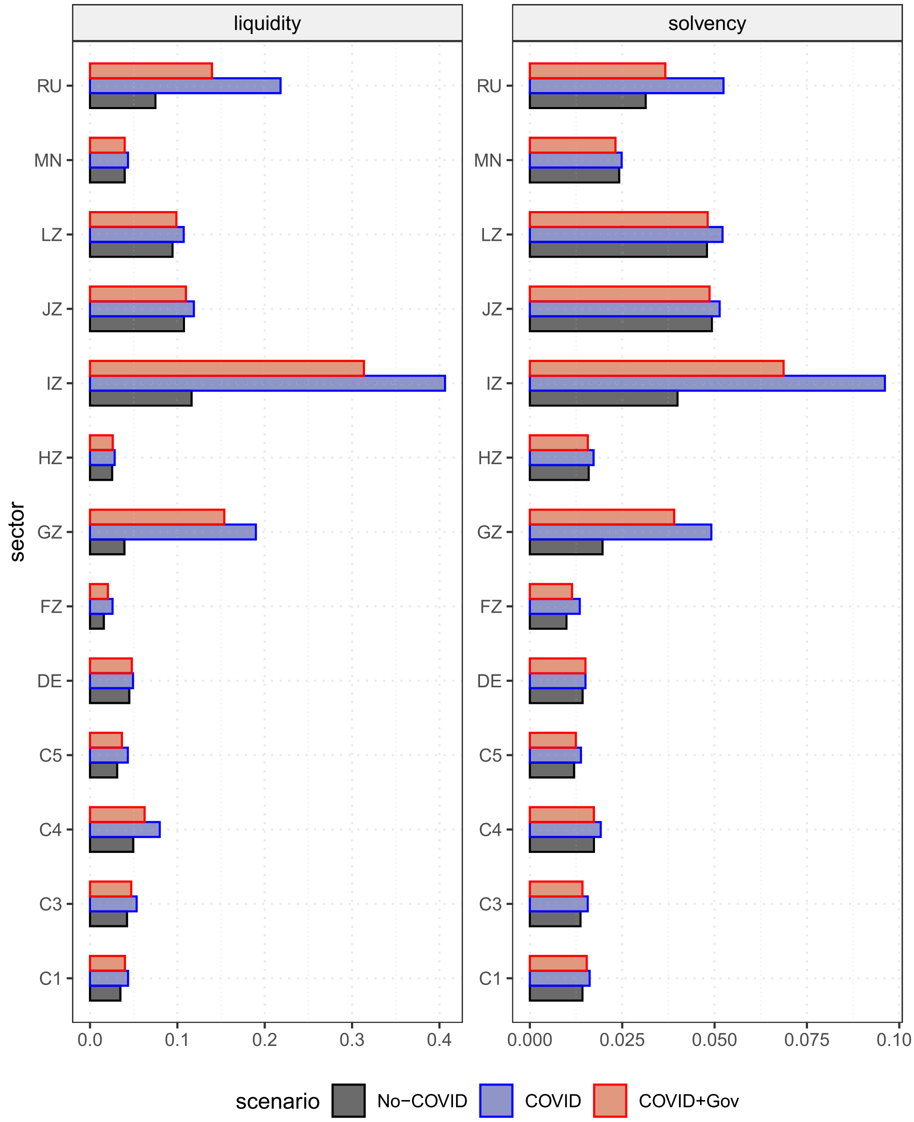
Fig. 3. Dynamics of cumulative financial stress, as estimated from our simulations and according to the three different scenarios. Top panel: share of firms with liquidity issues. Bottom panel: share of firms with solvency issues.

the pandemic: this stems from the positive demand shock induced by the lockdown on few sectors (including utilities, and a range of telecommunication and transport services).

Relative to firms being financially stressed in both scenarios (bottom right quadrant), firms not suffering from the global lockdown (upper left quadrant) are generally larger (PQ_0), more productive (ω_0), less indebted (Lev_0), and face relatively low fixed costs. Firms suffering from the lockdown (upper right quadrant) appear financially healthy, both in terms of fixed costs and leverage. At the same time, they show a relatively low level of productivity ($\omega_0 = 2.85$).[22]

Our simulations allow retrieving the estimated cumulative AP resources received by firms, which altogether amounts to €21.5bn. Most resources (€19,75bn, 97.5% of AP spending) are taken by firms that would not be threatened in either scenarios, even with the absence of the job retention scheme. In the same vein, firms facing solvency stress in both scenarios represent 1.1% of overall AP resources (€220 ml). Firms entering into solvency stress due to the COVID crisis gather 1.3% of overall AP resources (€270 ml). Overall, these preliminary figures cast some doubts on the need for a job retention scheme. In the end, the bulk of AP funds accrued to 760,000 companies which did not need them in the first place. Our stand on this issue is far more moderate. First and foremost,

[22] This raises the issue of the selection effect of the lockdown. Table 2 reveals that amongst the 25 thousand companies being solvency stressed under the sanitary crisis, those that face solvency stress even in normal times are more productive than those remaining financially healthy. Our interpretation is that high productivity does not perfectly equate with financial health. Although related, the two do not map perfectly, so that market selection depends also on characteristics other than productivity.



C1: Manufacture of food products, beverages and tobacco products; C3:Manufacture of electrical, computer, electronic equipment & machinery; C4: Manufacture of transport & equipment; C5: Other manufacturing; DE: Electricity, Gas, Steam; FZ: Construction; GZ: Wholesale and retail trade; repair of motor vehicles and motorcycles; HZ: Transportation and storage; IZ: Accommodation and food service activities; JZ: Information and communication; JZ: Financial and insurance activities; MN: Professional, scientific, technical, support service activities; RU: Other services activities.

Fig. 4. Cumulative share of firms being stressed in their liquidity (left panel) and in their solvency (right panel), by aggregate sector.

AP is also a demand policy. Had AP not been implemented, the effect of the sanitary crisis on final demand would presumably have been much fiercer than observed. Second, although most firms can financially cope with the negative effects of the lockdown, that their financial health may still have deteriorated.

The second step raises the question of the effect of government support on solvency stress. If anything, a well-functioning government support should favour financially-healthy firms in normal time (i.e. under the No-COVID scenario) while being unsupportive with insolvent one. Table 3 displays the effect of government aid on solvency for the 25,697 firms made potentially insolvent by the crisis, corresponding to the right column of Table 2. This allows us to address two issues.

The first relates to a type-II error in government support: did the government help firms that would have experienced solvency stress in any case? Table 3 shows that 307 among the 13,772 solvency-stressed firms (only 2%) have actually benefited from government support, becoming solvent during the crisis. Hence, government support has, by and large, not supported unhealthy firms. The second question relates to a type-I error: did the government fail to support firms that would not have experienced solvency stress under a No-COVID scenario? This applies to 11,925 firms. We observe that for almost half of them (5,371 companies, amounting 45% of financially health firms under the No-COVID scenario), government support has been key to support them throughout the sanitary crisis.

Table 2
Solvency stress under the *No-COVID* and *COVID* scenarios.

	COVID		
	No	Yes	Total
No-COVID			
No	$N = 726,438$ $PQ_0 = 374.03$ $AP^{€} = 19.75$ $AP/PQ_0 = 0.11$ $\omega_0 = 5.74$ $Lev_0 = 13.83$ $FC_0 = 23.99$	$N = 11,925$ $PQ_0 = 243.48$ $AP^{€} = 0.27$ $AP/PQ_0 = 0.13$ $\omega_0 = 2.85$ $Lev_0 = 44.64$ $FC_0 = 7.76$	$N = 738,363$
Yes	$N = 468$ $PQ_0 = 142.47$ $AP^{€} = 0.02$ $AP/PQ_0 = 3.40$ $\omega_0 = 1.92$ $Lev_0 = 10.83$ $FC_0 = 17.18$	$N = 13,772$ $PQ_0 = 120.00$ $AP^{€} = 0.22$ $AP/PQ_0 = 1.41$ $\omega_0 = 3.21$ $Lev_0 = 160.77$ $FC_0 = 228.39$	$N = 14,240$
Total	$N = 726,906$	$N = 25,697$	$N = 752,603$

The Yes/No answers refer to whether a firm is experiencing a solvency stress in the scenario specified in the rows/columns. N: Cumulative number of firms at the end of the simulation. For example 11,925 companies are experiencing solvency stress in the *COVID* scenario whereas they would not experience it in the *No-COVID* scenario; PQ_0: average sales as in January 2020; $AP^{€}$: simulated cumulative amount of AP resources received between March 2020 and April 2021, in billions of euros; AP/PQ_0: simulated cumulative amount of AP resources received between March 2020 and April 2021, relative to average January 2020 sales; ω_0: average Total Factor Productivity as in January 2020; FC_0: average fixed costs, as defined by monthly corporate taxes plus payment of principal and interest as in January 2020 (i.e. $p_K K + T$); Lev_0: average leverage, as measured by debts to suppliers and other third parties, relative to equity as in January 2020.

Table 3 also displays the expected frequency of each type of firms if the effect of government support on firms solvency were random. The gap between the observed (N) and the expected ($\hat{N}$) number of firms is an indication of the capacity of the support to sort correctly amongst firms. This suggests that government support, despite not being targeted, did not support financially unhealthy firms and did make a difference for firms that *deserved* to be supported.

5.2. Zombification

We now move to the core of our empirical exercise, namely the evaluation of the policy measures enacted by the French government to mitigate the impact of the pandemic on firms.

We focus on the 11,925 companies which display no solvency issue under the notional No-COVID scenario, while facing a solvency problem in the baseline partial-adjustment model with no job retention scheme. Among these companies, we further discriminate among those that are made solvent by Activité Partielle (5,371) and the others (6,556). Note that by doing so, we avoid the obvious correlation between the amount of public help received by a firm and its financial fragility that stems from the fact that less productive firms have higher costs and thus are more likely to face liquidity and solvency issues when hit by a negative shock, as reported in Table 2.[23] When we properly account for this selection bias, we immediately see that firms with no solvency issue enjoyed a larger amount of government support as a fraction of their output, beside being on average larger, more productive, and having a stronger financial structure (with average values being significantly different across groups).

To address more directly the question of the effect of AP on French firms, we run a series of probit regression models in which the dependent variable is an indicator that takes value 1 if the company has faced solvency issues at any time in our simulation and the main explanatory variable is the amount of government support via AP normalised by sales. Columns (1–3) of Table 4 show that the job retention scheme reduces the likelihood of facing solvency issues, and this remains valid when we add additional controls such as productivity, fixed costs and leverage, all of which have the expected sign: size and productivity reduce the probability of becoming insolvent, while higher leverage and larger fixed costs increase it.

The issue of zombification can be addressed by means of an interaction term between the amount of public support received by the company and productivity. A positive coefficient would signal that AP has benefited mostly low-productivity firms, thus rising the risk of a zombification of the economy. Column (4) of Table 4 provides little support for this hypothesis, because the interaction term displays a positive but not significant coefficient.

[23] In Appendix B we report the estimates from a regression on the whole sample, showing that it is subject to a sample selection bias.

Table 3
Solvency stress under the *No-COVID* and *COVID + Gov* scenarios, conditional upon firms that are facing solvency stress under the *COVID* scenario.

	COVID + Gov		
	No	Yes	Total
No-COVID			
No	$N = 5,371$ $\hat{N} = 2,635$ $PQ_0 = 332.47$ $AP^{€} = 0.17$ $AP/PQ_0 = 0.14$ $\omega = 3.01$ $Lev_0 = 32.12$ $FC_0 = 6.36$	$N = 6,554$ $\hat{N} = 9,290$ $PQ_0 = 170.50$ $AP^{€} = 0.10$ $AP/PQ_0 = 0.12$ $\omega = 2.73$ $Lev_0 = 54.90$ $FC_0 = 8.90$	$N = 11,925$
Yes	$N = 307$ $\hat{N} = 3,043$ $PQ_0 = 68.01$ $AP^{€} = 0.03$ $AP/PQ_0 = 0.35$ $\omega = 2.77$ $Lev_0 = 69.45$ $FC_0 = 31.72$	$N = 13,465$ $\hat{N} = 10,729$ $PQ_0 = 121.19$ $AP^{€} = 0.21$ $AP/PQ_0 = 1.43$ $\omega = 3.22$ $Lev_0 = 162.85$ $FC_0 = 232.64$	$N = 13,772$
Total	$N = 5,678$	$N = 20,019$	$N = 25,697$

The Yes/No answers refer to whether the firm is experiencing a solvency stress in the scenario specified in the rows/columns. N: Simulated cumulative number of firms at the end of the simulation. For example $6,554$ companies are experiencing solvency stress in the *COVID+Gov* scenario whereas they would not experience it in the *No-COVID* scenario; $\hat{N}$: Expected number of firms being financially stressed if the effect of government support on firm solvency were random; PQ_0: average sales as in January 2020; $AP^{€}$: simulated cumulative amount of AP resources received between March 2020 and April 2021, in billions of euros; AP/PQ_0: simulated cumulative amount of AP resources received between March 2020 and April 2021, relative to average January 2020 sales; ω_0: average Total Factor Productivity as in January 2020; FC_0: average fixed costs, as defined by monthly corporate taxes plus payment of principal and interest as in January 2020 (i.e. $p_K K + T$); Lev_0: average leverage, as measured by debts to suppliers and other third parties, relative to equity as in January 2020.
$\chi^2 = 6,804.6$ ($p = 0.000$). The χ^2-value implies that this effect is statistically significant, where the null hypothesis is that there is independence in the financial status of firms across the two scenarios.

The overall results could, however, conceal important heterogeneity across different sectors of the economy. Indeed, a quick look at the sample of firms included in the analysis reveals that 45% belongs to wholesale and retail trade, and another 41% to hotels and restaurants, two of the sectors that have been more severely affected by the pandemic.

To investigate the presence of industry-specific effects, we run the regression model on specific subgroups of firms and obtain interesting insights displayed in Columns (5–7) of Table 4. In wholesale and retail trade (GZ) productivity has no significant effect on the probability to face solvency stress and even if the interaction term is positive and significant, the vast majority of firms in the sample (up to the 95^{th} percentile of the productivity distribution) lies in the region where AP has no meaningful effect on the dependent variable (see the bottom-left panel of Fig. 5). The situation is different in the accommodation and food service sector (IZ), where AP reduces the probability to undergo solvency stress and 90% of the firms in the sample seem to benefit from it. Moreover, the interaction term is not significant, suggesting there is little evidence to support a process of zombification among hotels and restaurants. A similar, albeit stronger, effect is found for companies operating in all other sectors, for which the impact of the job retention scheme is positive while the differential effect across the productivity distribution is small and not significant (see the bottom-right panel of Fig. 5).

6. Conclusion

This paper has addressed the issue of the possible negative effects of job retention schemes and other support measures enacted by governments in many advanced countries at the onset of the COVID-19 pandemic, when strict lockdown rules and the sharp contraction of aggregate demand threatened an avalanche of business failures. Because most of the policy measures were meant to offer companies a lifeline and did not discriminate among them, the risk of supporting non-viable firms is high. Beside being a poor use of public resources, such an outcome could undermine the recovery phase since zombie firms would absorb productive resources (such as capital, labour and credit), reduce entry by creating congestion, and act as a drag on productive investment and market reallocation.

Table 4
The determinants of the probability to experience solvency stress during the COVID global shutdown.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All sectors				GZ	IZ	Others
AP/PQ_0	-0.166***	-0.172***	-0.218***	-0.230***	-0.502**	-0.685**	-0.330**
	(0.0426)	(0.0427)	(0.0437)	(0.0870)	(0.214)	(0.328)	(0.135)
ω_0		-0.287***	-0.495***	-0.480***	0.762	-0.345	-0.252*
		(0.0575)	(0.0594)	(0.114)	(0.565)	(0.559)	(0.145)
$AP/PQ_0 \times \omega_0$				0.009	0.664***	0.291	0.034
				(0.0611)	(0.249)	(0.346)	(0.0821)
FC_0			0.209***	0.210***	0.099***	0.420***	0.345***
			(0.0172)	(0.0176)	(0.0232)	(0.0370)	(0.0435)
Lev_0			0.196***	0.196***	0.217***	0.267***	0.037
			(0.0106)	(0.0106)	(0.0151)	(0.0193)	(0.0264)
PQ_0	-0.0835***	-0.0649***	-0.162***	-0.162***	-0.0599***	-0.310***	-0.210***
	(0.0126)	(0.0132)	(0.0159)	(0.0162)	(0.0220)	(0.0404)	(0.0411)
Constant	-0.323***	0.042	-0.011	-0.029	-0.460	-0.141	-0.029
	(0.0512)	(0.0891)	(0.0934)	(0.150)	(0.458)	(0.489)	(0.215)
$\frac{\partial \Pr}{\partial AP}$	-0.0638***	-0.0658***	-0.0811***	-0.0820***	0.0436	-0.163***	-0.100***
	(-0.0163)	(-0.0163)	(-0.0162)	(0.0171)	(0.0348)	(0.0466)	(0.0234)
Observations	11,925	11,925	11,925	11,925	5,377	4,895	1,653
LL	-7968	-7955	-7740	-7740	-3378	-3247	-1039
LR	478.9	503.8	933.6	933.6	273.4	289.1	90.43
Pseudo R-squared	0.029	0.031	0.057	0.057	0.039	0.043	0.042

Probit model estimated by maximum likelihood methods. *** p<0.01, ** p<0.05, * p<0.1. AP/PQ_0: estimated perceived amount of Activité Partielle, relative to sales in January 2020; ω_0: estimated level of Total factor Productivity in January 2020; FC_0: Fixed cost defined as monthly corporate taxes plus payment of principal and interest in January 2020; Lev_0 Leverage, initial level of debts to suppliers and other third party, relative to equity; PQ_0: monthly level of sales in January 2020. All explanatory variables are entered in natural logs.

We have developed a micro-founded simulation framework that replicates the dynamics of liquidity for a sample of 750,000 French firms across different scenarios and sheds light on the effect of support measures implemented by the government. We find that the policies have been successful in significantly reducing the number of firms facing financial distress throughout the first part of the pandemic. Government support has mainly benefited financially healthy firms, whereas companies already under stress did not manage to overcome their problems thanks to additional public funds. Furthermore, we find no evidence of a zombification effect, since the impact of government support on relieving firms from insolvency is constant over the productivity distribution. This should be seen as evidence that temporary, unconditional support may be a relevant policy tool to overcome deep but transitory shocks such as the COVID crisis with little or no distortion in market selection.

Last, the use of microsimulations has allowed establishing counterfactual scenarios, a means by which we could single out the effect of a specific policy scheme on firm performance in the context of the COVID crisis and the ensuing lockdown. The ability to screen out confounding factors affecting firms' fate requires a set of relatively strong assumptions that, while made explicit in the paper, would probably need to be adapted in case the methodology were to be applied to other contexts. Fixed input and output prices, for instance, or the exclusion of investment or technical change as a possible adaptation mechanism adopted by firms are justified in the case of a short term demand shock such as the lockdown, but are less palatable in other circumstances such as an energy shock. Future microsimulation exercises should therefore consider longer-term strategic decisions by firms, and comparing simulated versus actual firm performance represents a possible avenue for validating the model and gauging the role of different assumptions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Access to confidential firm-level data, on which this work is based, has been made possible within a secure environment offered by CASD - Centre d'accès sécurisé aux données (Ref. ANR-10-EQPX-17). We thank the editor as well as two anonymous referees for their valuable comments and suggestions.

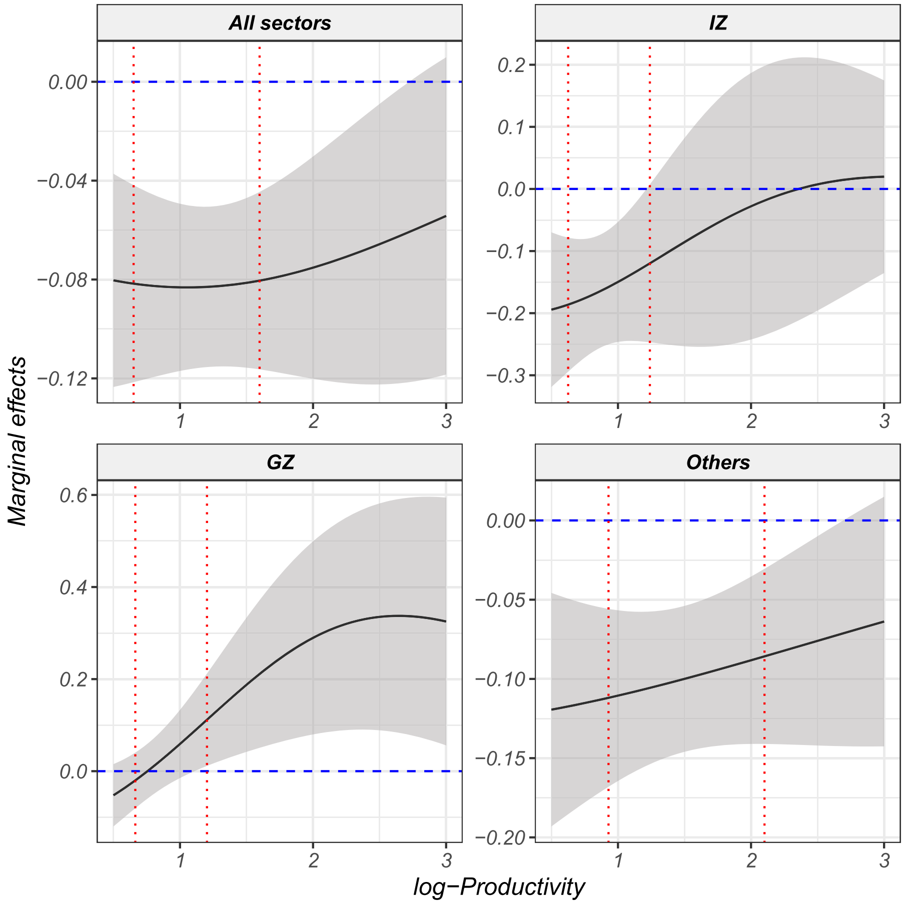

Fig. 5. Estimated marginal effect of AP on the probability of experiencing solvency stress (black line) with its 95% confidence interval (grey shaded area). The dashed blue horizontal line represents the zero, above (below) which the estimated effect would (would not) imply a zombification of the economy. The dotted red vertical lines represent respectively the 5th and 95th percentile of the productivity distribution in the specific sector. Note: y-axis scale varies across quadrants.

Appendix A. Production function estimations

The methodology used to compute unbiased estimates of the output elasticities with respect to our inputs follows Petrin and Levinsohn (2012) and is related to the use of inputs to control for unobservables in production function estimations, as set out by Olley and Pakes (1996), Levinsohn and Petrin (2003), Ackerberg et al. (2015) and Wooldridge (2009). The basic idea behind this approach is that the estimation of a production function may suffer from endogeneity bias because of a correlation between unobserved productivity shocks and inputs. This issue is solved by including lagged values of specific inputs as proxies for productivity. The methodology employed in this paper starts with a first step reading:

$$q_{it} = g\left(k_{it}, l_{it}, m_{it}\right) + \epsilon_{it}, \tag{A.1}$$

where q_{it} is the natural logarithm of output of firm i at yearly time t, and k_{it}, l_{it}, and m_{it} are respectively the natural logarithms of capital, labour in terms of hours worked, and materials used by the firm. In equation (A.1), we use a third-order polynomial on all inputs and their interaction terms to obtain estimates of expected output, $\hat{q}_{it}$, and an estimate for ϵ_{it}. This first step is included to net out pure error term, i.e. measurement errors, in the measure of output and productivity (Ackerberg et al., 2015; De Loecker and Warzynski, 2012).

Then, we use a general production function of the following type:

$$\hat{q}_{it} = f_s\left(k_{it}, l_{it}, m_{it}, \mathbf{B}\right) + \omega_{it} + \epsilon_{it} \tag{A.2}$$

where our inputs are transformed into the output according to the production function f_s, $\mathbf{B}$ is the parameter vector to be estimated in order to calculate the output elasticities, ω_{it} is the firm-level productivity term that is observable by the firm but not by the econometrician and ϵ_{it} is an error term that is unobservable to both the firm and the econometrician. Leaving subscripts i and t aside for simplicity, function f_s is assumed to be of a Cobb-Douglas log-form and reads:

Table A.1
Estimated output elasticities and revenue shares.

Code	Sector name	N	α_K	α_L	α_M	$\hat{\beta}_K$	$\hat{\beta}_L$	$\hat{\beta}_M$	$\hat{\lambda}$
C1	Manufacture of food products, beverages and tobacco products	24,999	0.080	0.355	0.565	0.025	0.189	0.775	0.989
C3	Manufacture of electrical, computer, electronic equipment & machinery	5,562	0.056	0.296	0.648	0.018	0.206	0.773	0.997
C4	Manufacture of transport equipment	1,605	0.047	0.259	0.694	0.018	0.167	0.805	0.990
C5	Other manufacturing	46,022	0.068	0.332	0.600	0.035	0.243	0.706	0.984
DE	Electricity, Gas, Steam	5,118	0.148	0.221	0.631	0.054	0.178	0.755	0.987
FZ	Construction	128,605	0.061	0.346	0.594	0.032	0.208	0.732	0.972
GZ	Wholesale and retail trade; repair of motor vehicles and motorcycles	207,893	0.054	0.187	0.760	0.018	0.116	0.847	0.981
HZ	Transportation and storage	28,992	0.071	0.359	0.570	0.043	0.244	0.681	0.968
IZ	Accommodation and food service activities	94,079	0.078	0.347	0.575	0.030	0.165	0.830	1.025
JZ	Information and communication	24,609	0.017	0.479	0.503	0.027	0.345	0.655	1.026
LZ	Financial and insurance activities	24,322	0.155	0.408	0.437	0.071	0.298	0.664	1.034
MN	Professional, scientific, technical, support service activities	118,218	0.115	0.494	0.391	0.001	0.372	0.608	0.982
RU	Other services activities	42,579	0.069	0.481	0.450	0.019	0.280	0.698	0.997
All	All economy	752,603	0.074	0.338	0.589	0.024	0.217	0.749	0.989

*** N is the number of firms. Source: FARE 2012–2019. Capital shares α_K have been computed assuming constant returns to scales such that $\alpha_K = 1 - \alpha_L - \alpha_M$.

$$f_s = \beta_K k + \beta_L l + \beta_M m \tag{A.3}$$

Observe that function f_s is allowed to change across two-digit sectors, as implied by the subscript s. Thus, the parameter vector is composed of three parameters for each sector. The sector decomposition is the two digit level (referenced as level $A88$ in the French nomenclature).

Different estimators may be used to estimate the production function in equation (A.2). The preferred estimator in this paper is the Wooldridge-Levinsohn-Petrin (WLP) estimator, as derived from Wooldridge (2009) and implemented in Petrin and Levinsohn (2012). The main reason is that it corrects for the simultaneous determination of inputs and unobserved productivity by proxing the latter with firm-level material inputs. Moreover, it does not assume constant returns to scale, it is robust to the Ackerberg et al. (2015) criticism of the Levinsohn and Petrin (2003) estimator and it is programmed as a simple instrumental variable estimator.

We assume that both labour and materials are a variable input with no rigidity in a business as usual (No-COVID) scenario. We instrument current labour and materials with the first and second lags of labour as well as the second lags of capital and materials. In addition, the WLP estimator requires the variables affecting the productivity process to be specified. We assume that productivity is a function of lagged capital and materials. Year fixed effects are also included to take into account time-variant shocks common to all firms. All these additional regressors are not included in the function f_s. Given $\hat{f}_s$, estimated total factor productivity $\hat{\omega}_{it}$ eventually reads:

$$\hat{\omega}_{it} = \hat{q}_{it} - \hat{\beta}_K k_{it} + \hat{\beta}_L l_{it} + \hat{\beta}_M m_{it} \tag{A.4}$$

Alternatively, one could use the factor shares in revenues, α_K, α_L and α_M, as proxies for their output elasticities (see e.g. Gourinchas et al., 2021, for such an assumption). The cost would be that of assuming perfect product and factor markets. We choose instead to assume perfect markets away and let the series of output elasticities depart from their respective revenue shares.

Table A.1 presents the average revenue shares for labour L and materials M. The estimation sample contains 752,653 firms. The factor shares conform to the usual characteristics that materials represent most of the costs (59% of total sales), whereas labour costs represent on average one-third of total sales (35%). The estimated factor elasticities $\hat{\beta}_M$ and $\hat{\beta}_L$ amount to 0.73 and 0.21, respectively. Overall, firms operate below constant returns to scale, as the sum of factor elasticities $\hat{\lambda} = 0.96$ lies below unity.

Table A.1 also reports the estimated output elasticities from a Cobb-Douglas production function by two-digit industry, using the Wooldridge (2009) methodology. There is substantial heterogeneity across industries in the parameter estimates. The average capital elasticity $\hat{\beta}_K$ ranges between 0.001 in *Professional, scientific, technical, support service activities* to 0.07 in *Financial and insurance activities*. The values for $\hat{\beta}_M$ range between 0.60 (*Professional, scientific, technical, support service activities*) and 0.86 (*Wholesale and retail trade; repair of motor vehicles and motorcycles*), $\hat{\beta}_L$ takes values ranging between a minimum of 0.103 (*Wholesale and retail trade; repair of motor vehicles and motorcycles*) and a maximum of 0.39 (*Professional, scientific, technical, support service activities*). Estimated returns to scale $\hat{\lambda}$ are close to unity for most of the sectors, with values ranging between 0.94 (*Other manufacturing*) and 1.03 (*Financial and insurance activities*).

Table A.1 also reports mean values of revenue shares. We observe a significant wedge between the output elasticities and the revenue shares. This suggests the presence of market imperfections in the product and factor markets. In turn, these relate to various factors affecting perfect composition such as the presence of entry barriers on the various markets, industry structures, the skill composition of labour, etc. Caselli et al. (2021) provide evidence of imperfect product and labour market imperfections in France based, where they show that product and labour market imperfections can be inferred from the combination of the series of β and α.

Table B.1
The determinants of the probability to experience liquidity and solvency stress during the COVID global shutdown.

	(1)	(2)	(3)	(4)
AP/PQ_0	0.806***	0.294***	0.100***	-0.270***
	(0.005)	(0.006)	(0.006)	(0.007)
ω_0		-1.306***	-1.367***	-0.749***
		(0.007)	(0.008)	(0.010)
$AP/PQ_0 \times \omega_0$				0.458***
				(0.005)
FC_0			0.281***	0.340***
			(0.003)	(0.003)
Lev_0			0.163***	0.170***
			(0.002)	(0.002)
PQ_0	0.095***	0.076***	-0.117***	-0.130***
	(0.002)	(0.002)	(0.003)	(0.003)
First cutoff	0.000	-0.417***	0.666***	-0.029
	(0.018)	(0.019)	(0.018)	(0.020)
Second cutoff	0.818***	0.465***	0.666***	0.910***
	(0.018)	(0.019)	(0.019)	(0.020)
$\frac{\partial \Pr}{\partial AP}$ (No issues)	-0.124***	-0.042***	-0.014***	-0.033***
	(0.001)	(0.001)	(0.001)	(0.001)
$\frac{\partial \Pr}{\partial AP}$ (Liquidity issues)	0.083***	0.029***	0.095***	0.025***
	(0.001)	(0.001)	(0.001)	(0.001)
$\frac{\partial \Pr}{\partial AP}$ (Solvency issues)	0.041***	0.014***	0.004***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	752,603	752,603	752,603	752,603
LL	-257,009	-240,253	-232,736	-228,259
LR	93,191	126,702	141,736	150,691
Pseudo R-squared	0.153	0.209	0.223	0.248

Ordered probit model estimated by maximum likelihood methods. Outcome variable $Y = 1$ if the firm has neither liquidity nor solvency issues. Outcome variable $Y = 2$ if the firm has liquidity issues. Outcome variable $Y = 3$ if the firm has solvency issues. *** p<0.01, ** p<0.05, * p<0.1. AP/PQ_0: estimated perceived amount of Activité Partielle, relative to sales in January 2020; ω_0: estimated level of Total factor Productivity in January 2020; FC_0: Fixed cost defined as monthly corporate taxes plus payment of principal and interest in January 2020; Lev_0 Leverage, initial level of debts to suppliers and other third party, relative to equity; PQ_0: monthly level of sales in January 2020. All explanatory variables are entered in natural logs. Outcome = 1 if firms have neither liquidity nor solvency issues.

Appendix B. Naive regression with sample selection issue

A naive ordered-probit regression on the whole sample of firms (Table B.1) suggests that AP increases the likelihood of a firm facing financial distress, while lowering the chances of it encountering no difficulties. This could mistakenly been interpreted as indicating that the policy has performed very poorly or, actually, in reverse. What is more, an interaction between the measure of policy support and productivity displays a positive and significant coefficient, which implies that the negative effect of the policy is particularly harmful to productive firms, possibly because by interfering with market selection it is propping up inefficient companies and putting additional competitive pressure on the more productive ones. These results, instead, are the outcome of a large sample selection bias.

References

Acharya, V.V., Crosignani, M., Eisert, T., Eufinger, C., 2020. Zombie credit and (dis-)inflation: Evidence from Europe. Working Paper 27158. National Bureau of Economic Research.

Ackerberg, D.A., Caves, K., Frazer, G., 2015. Identification properties of recent production function estimators. Econometrica 83 (6), 2411–2451.

Araújo, J.D., Garrido, J., Kopp, E., Varghese, R., Yao, W., 2022. Policy Options for Supporting and Restructuring Firms Hit by the Covid-19 Crisis. Departmental Paper Series. IMF, Washington, DC.

Banerjee, R.N., Hofmann, B., 2020. Corporate zombies: Anatomy and life cycle. BIS Working Papers 882. Bank for International Settlements.

Bartik, A.W., Bertrand, M., Cullen, Z., Glaeser, E.L., Luca, M., Stanton, C., 2020. The impact of Covid-19 on small business outcomes and expectations. Proc. Natl. Acad. Sci. 117 (30), 17656–17666.

Benitto, H., Hadjibeyli, B., Maadini, M., 2022. Analysis of France's state-guaranteed loan scheme at end-2021. Tresor Econ. 303. 10 pages.

Buera, F.J., Fattal-Jaef, R.N., Hopenhayn, H., Neumeyer, P.A., Shin, Y., 2021. The Economic Ripple Effects of COVID-19. Working Papers 28704. NBER.

Caballero, R., Hoshi, T., Kashyap, A., 2008. Zombie lending and depressed restructuring in Japan. Am. Econ. Rev. 98 (5), 1943–1977.

Caselli, M., Nesta, L., Schiavo, S., 2021. Imports and labour market imperfections: firm-level evidence from France. Eur. Econ. Rev. 131, 103632.

Cros, M., Epaulard, A., Martin, P., 2021. Will Schumpeter catch Covid-19? Covid Econ. 70, 49–69.
De Loecker, J., Warzynski, F., 2012. Markups and firm-level export status. Am. Econ. Rev. 102 (6), 2437–2471.
Demmou, L., Franco, G., Calligaris, S., Dlugosch, D., 2020. Corporate sector vulnerabilities during the Covid-19 outbreak: assessment and policy responses. Technical report. OECD Coronavirus Hub.
Foster, L., Grim, C., Haltiwanger, J., 2016. Reallocation in the great recession: cleansing or not? J. Labor Econ. 34 (S1), 293–331.
Garicano, L., 2020. The COVID-19 bazooka for jobs in Europe. In: Baldwin, R.E., di Mauro, B.W. (Eds.), Mitigating the COVID Economic Crisis: Act Fast and Do Whatever It Takes. CEPR Press, London.
Gourinchas, P.-O., Kalemli-Özcan, Ş., Penciakova, V., Sander, N., 2021. Covid-19 and small- and medium-sized enterprises: a 2021 "time bomb"? In: AEA Papers and Proceedings, vol. 111, pp. 282–286.
Hamilton, J.D., 2020. Time Series Analysis. Princeton University Press.
Helmersson, T., Mingarelli, L., Mosk, B., Pietsch, A., Ravanetti, B., Shakir, T., Wendelborn, J., 2021. Corporate zombification: post-pandemic risks in the euro area. In: Financial Stability Review. May 2021. ECB, pp. 92–99.
Hevia, C., Neumeyer, P.A., 2020. A perfect storm: COVID-19 in emerging economies. In: Djankov, S., Panizza, U. (Eds.), COVID-19 in Developing Economies. In: Vox eBook Chapters, vol. 1. Centre for Economic Policy Research, pp. 25–37. Chapter 1. https://ideas.repec.org/h/cpr/ebchap/p330-01.html.
Kozeniauskas, N., Moreira, P., Santos, C., 2022. On the cleansing effect of recessions and government policy: evidence from Covid-19. Eur. Econ. Rev. 144 (C).
Laeven, L., Schepens, G., Schnabel, I., 2020. Zombification in Europe in times of pandemic. VoxEU.org. October 11.
Levinsohn, J., Petrin, A., 2003. Estimating production functions using inputs to control for unobservables. Rev. Econ. Stud. 70 (2), 317–341.
McGowan, M.A., Andrews, D., Millot, V., 2018. The walking dead? Zombie firms and productivity performance in OECD countries. Econ. Policy 33 (96), 685–736.
Merikyll, J., Paulus, A., 2022. Were jobs saved at the cost of productivity in the Covid-19 crisis? Bank of Estonia Working Papers wp2022-5. Bank of Estonia.
Muzi, S., Jolevski, F., Ueda, K., Viganola, D., 2022. Productivity and firm exit during the COVID-19 crisis: cross-country evidence. Small Bus. Econ.
Odendahl, C., Springford, J., 2020. Bold policies needed to counter the coronavirus recession. In: Baldwin, R.E., di Mauro, B.W. (Eds.), Mitigating the COVID Economic Crisis: Act Fast and Do Whatever It Takes. CEPR Press, London.
OECD, 2020a. Government Support and the Covid-19 Pandemic. Technical report. OECD, Paris.
OECD, 2020b. Job retention schemes during the Covid-19 lockdown and beyond. Technical report. OECD, Paris.
OECD, 2021a. Business dynamism during the Covid-19 pandemic: Which policies for an inclusive recovery? Technical report. OECD, Paris.
OECD, 2021b. Covid-19 government financing support programmes for businesses: 2021 update Technical report. OECD, Paris.
OECD, 2021c. OECD SME and Entrepreneurship Outlook 2021. OECD Publishing, Paris.
Olley, S.G., Pakes, A., 1996. The dynamics of productivity in the telecommunications equipment industry. Econometrica 64, 1263–1297.
Petrin, A., Levinsohn, J., 2012. Measuring aggregate productivity growth using plant-level data. Rand J. Econ. 43 (4), 705–725.
Schivardi, F., Romano, G., 2020. A simple method to estimate firms' liquidity needs during the Covid-19 crisis with an application to Italy. Covid Econ. 35, 51–69. 7 July.
Schivardi, F., Sette, E., Tabellini, G., 2020. Identifying the real effects of zombie lending. Rev. Corp. Finan. Stud. 9 (3), 569–592.
Sedláček, P., 2020. Lost generations of firms and aggregate labor market dynamics. J. Monet. Econ. 111, 16–31.
Storz, M., Koetter, M., Setzer, R., Westphal, A., 2017. Do we want these two to tango? On zombie firms and stressed banks in Europe. Working Paper Series 2104. ECB.
UNEDIC, 2022. Activité partielle: Etat des lieux et perspectives. Unedic Analyses. UNEDIC.
Vincent, C., 2021. Job Retention Schemes in Europe: France. European Trade Union Institute, Brussels.
Wooldridge, J.M., 2009. On estimating firm-level production functions using proxy variables to control for unobservables. Econ. Lett. 104 (3), 112–114.