I. Estimates of corporate cleansing during COVID-19 – using firm-level data to measure its productivity impact

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Abstract: *This section traces one of the channels through which the COVID-19 pandemic affects aggregate productivity – namely aggregate productivity changes linked to the exit of vulnerable firms ("cleansing" through firm exit). The impact of the exit margin on productivity is obtained by: (1) quantifying the impact of the pandemic on sales; (2) simulating the impact of this reduction in sales on firm-level accounts from the ORBIS database to identify financially vulnerable firms; (3) connecting financial vulnerability and pre-pandemic productivity. Our simulations suggest the pandemic would not induce additional cleansing effects as compared with a counterfactual no-COVID-19 scenario. The reason is that the COVID-19 shock adversely affected the financial health of not only low-productivity firms, but also high-productivity ones. These findings suggest that broad-based policy support implemented in connection with the pandemic did not imply foregone productivity growth through the exit margin. ([1])*

I.1. Introduction

The COVID-19 pandemic and the associated restrictions on economic activity exposed firms to liquidity and solvency stress. Plummeting sales caused uncertainty as to whether firms could survive without liquidity. ([2]) This type of uncertainty was quickly resolved thanks to extensive public support and the feared surge in insolvencies did not happen. Yet, beyond the immediate crisis impact, another reason for uncertainty emerged. It related to whether firms in some sectors would be able to operate by changing their business model, to minimise risks to public health and mitigate the effects of social distancing measures taken by public authorities on activity. Operating in an environment where close human contact must be avoided raised questions about firms' ability to adopt teleworking, the digitalisation of the production process and the reliance on disrupted supply chains. These elements naturally affect productivity at the firm level and hence at the aggregate sectoral level, via changes in within-firm productivity and possibly within-sector reallocation effects. ([3]) Of particular importance is the case in which the reallocation mechanism takes the form of cleansing mechanism, which sees unproductive firms being replaced by new, more productive and viable firms in the aftermath of recessions. Part of the cleansing mechanism, namely - the exit of unproductive firms - is the focus of the present section.

Before presenting our empirical results it is worth mentioning that several methodologies have emerged to assess the impact of the crisis on the corporate sector. Some studies carry out simulations using pre-pandemic information on firm characteristics available from firm-level corporate accounts. ([4]) Other studies match pre-pandemic corporate accounts taken from comprehensive administrative data (business registries) with information on sales, costs, and support effectively received by firms in 2020. ([5])

([1]) The authors wish to thank Emiel Afman, Alessandro Turrini, Lukas Vogel and an anonymous referee for their useful comments and suggestions.

([2]) See Meyer, B, E. Mihaylov, J. Barrero, S. Davis, D. Altig and N. Bloom, (2022), 'Pandemic-Era Uncertainty', *Hoover Institution Economics Working Papers*, April 11, 2022.

([3]) Within-firm productivity growth is the main driver of sectoral productivity growth. The economic mechanisms of interest are the channels through which the COVID-19 shock gives firms incentives to invest, innovate, and improve productivity. Empirical evidence suggests that sectoral productivity growth may be boosted by the pandemic because both the initially productive and the lagging firms took the shock as an impetus to invest and innovate (see e.g. Harasztosi, P, L. Maurin, R. Pal, D. Revoltella and W. van der Wielen (2022), 'Firm-level policy support during the crisis: so far so good? ', *EIB Economics Working Papers* 2022/01). It remains to be seen to what extent these initially productive or catching-up firms succeeded in gaining market share. If they are shown to have gained market share, within-firm productivity growth would also be linked to within-sector reallocation effects, further increasing sectoral productivity.

([4]) Examples include Connell Garcia W. and Ho V., (2020), 'What Types of Firms become Illiquid as a Result of COVID-19? A Firm-Level Perspective using French Data', *ECFIN Discussion Paper* 136, Demmou L. and Franco G., (2021), 'From hibernation to reallocation: loan guarantees and their implications for post-COVID-19 productivity', *OECD Economics Department Working Papers* 1687, Ebeke C., Jovanovic N., Valderrama L. and Zhou J., (2021), 'Corporate liquidity and solvency in Europe during COVID-19: the role of policies', *IMF Working Paper* 2021/056 (March), Gourinchas, P.-O., Kalemli-Özcan S., Penciakova, V., and Sander, N., (2020), 'COVID-19 and SME Failures'. *NBER Working Paper* #27877 and Archanskaia E. , E. Canton, A. Hobza, P. Nikolov and W. Simons (2022), 'The sectoral nature of the COVID-19 shock: a novel approach to quantifying its economic impact', *European Economy Discussion Paper* 162.

([5]) See, for instance, Altomonte, C., M. Demertzis, L. Fontagné and S. Mueller, (2021), 'COVID-19 financial aid and productivity: Has support been well spent?' *Policy Contribution 21/2021, Bruegel*, Bighelli T., F. Di Mauro and T. Lalinsky, (2021), 'COVID-19 government support and its consequences for productivity: cross-country evidence', *CompNet Policy Brief* #14, Cœuré B. ed., (2021),

Yet other studies match pre-pandemic corporate accounts with firm replies to surveys, in some cases carried out *ad hoc*, to assess the impact of COVID-19 and related measures. ([6]) Finally, certain studies take advantage of high-frequency data collected by private companies on the universe of firms. ([7])

This section follows the first approach to simulate the impact of the COVID-19 shock and of the associated policy support measures on the financial health of the corporate sector over the course of the pandemic and in the recovery phase. Documenting which firms are more likely to exit allows us to quantify the effect of COVID-19 on aggregate productivity, but only through the exit margin. ([8]) This approach has the least stringent data requirements. To run scenarios and construct counterfactuals, it is sufficient to have pre-pandemic information on firm characteristics from corporate accounts together with the sectoral information on the COVID-19 shock and on the policy support packages.

For pre-pandemic information on firm characteristics, we rely on the ORBIS database, combined with almost real-time simulations of the COVID-19 sales shock to arrive at firm-specific liquidity and solvency stress. The *ex ante* productivity characteristics of financially vulnerable firms allow us to pinpoint the effect of the crisis on aggregate sectoral productivity by identifying the types of firms that were most affected. By simulating the exit-related cleansing mechanism induced by the COVID-19 crisis, our analysis helps to interpret the so far inconclusive evidence on the productivity effects associated to within-sectoral reallocation in the context of the pandemic.

We find that pockets of financial stress exist in the most affected sectors. We run two simulations, with and without the COVID-19 shock on sales. We show that the connection between firm productivity and financial vulnerability is weaker in the presence of the COVID-19 shock than in normal times. ([9]) The reason is that both high and low-productivity firms suffer a negative profitability shock in connection with the pandemic and may become financially vulnerable. This finding implies that the pandemic does not bring significant additional cleansing effects. This result confirms the view that broad-based COVID-19 support did not imply foregone opportunities of productivity growth via cleansing effects. Other papers focusing on a set of EU Member States show that concerns voiced in connection with the potentially negative impact of COVID-19 support measures on aggregate productivity were mostly overstated. ([10])

The next subsection briefly presents the main channels through which the COVID-19 pandemic affected productivity, concentrating on three different aspects: within-firm productivity, reallocation across sectors and reallocation within sectors. Next, we present firm-level evidence on financial vulnerability and connect it with *ex ante* productivity characteristics. We then present some

'Rapport final du Comité de Suivi et d'évaluation des mesures de soutien financier aux entreprises confrontées à l'épidémie de Covid-19', Freeman D., Bettendorf L., and Y. Adema, (2021), 'Covid-19 support distorted the process of creative destruction in the Netherlands', *VoxEU*, 3 November and Lalinsky T. and R. Pál, (2021), 'Efficiency and effectiveness of the COVID-19 government support: Evidence from firm-level data', *EIB Working Paper* 2021/06.

([6]) Bloom N., Bunn P., Mizen P., Smietanka P. and G. Thwaite, (2020), 'The Impact of COVID-19 on Productivity', *NBER Working Paper* #28233 and Harasztosi et al., op. cit. (2022).

([7]) See Andrews D., Charlton A. and A. Moore, (2021), 'COVID-19, productivity, and reallocation. Timely evidence from three OECD countries', *OECD Economics Department Working Paper* #1676 and Chetty R., Friedman J., Hendren N. and M. Stepner, (2020), 'The Economic Impacts of COVID-19: Evidence from a New Public Database Built Using Private Sector Data', *NBER Working Paper* #27431.

([8]) We use firm-level data to document dispersion in productivity using COVID-19-related shocks to industry-specific sales, which are applied symmetrically to all firms in a given industry and which propagate to profits, liquidity and solvency. We do not model reallocation of market shares from exiting towards new or surviving firms. The data available are a cross-section and thus do not allow an assessment of dynamic effects.

([9]) By 'normal times' we mean a hypothetical replication of normal business activity in the absence of a COVID-19 shock as predicted by a set of criteria and applied during the years that COVID-19 took place. A firm's normal business activity corresponds to its activity in 2018, the latest year observed in our dataset. Note that the COVID-19 simulation accounts only partially for the extensive support received by firms (we assume a temporary stop of interest expenses and tax payments and bigger sensitivity of labour costs to drops in sales, see Box I.1).

([10]) Evidence from administrative data matched with the universe of public support measures for France, Italy, and Germany shows that the bulk of support was allocated to firms in the middle of the productivity distribution (Altomonte et al., op. cit. (2021)). Support was broadly productivity neutral in France and Germany, while in Italy medium and large firms with higher productivity received proportionally larger guaranteed loans. Bighelli et al., op. cit. (2021) analyse administrative data for Croatia, Finland, Slovakia and Slovenia and find that firms in the middle of the productivity distribution received the most support. A recent study for Flanders (Belgium) finds that market share reallocation to more productive firms, whether subsidised or not, was sustained over the course of the pandemic. This study also finds that policy support helped firms preserve productivity growth and reduced the likelihood of exit (Konings J., Magerman G., and Van Esbroeck D., (2022), 'The Impact of Covid Rescue Policies on Productivity Growth and Reallocation', *mimeo*.)

results related to the cleansing mechanism. The final subsection contains our concluding remarks.

I.2. Channels through which COVID-19 affects productivity

The main channels through which the COVID-19 pandemic could affect productivity are ([11]):

Within-firm productivity

A reduction in output due to activity restrictions and health-related work absences, combined with measures to retain employees because of the hiring and retraining costs, led to a mechanical decrease in labour productivity (output per worker). Social distancing measures also entailed a cost that likely decreased productivity, i.e. time spent implementing safety measures rather than producing goods and services. Although these effects were estimated to be sizeable at the start of the pandemic, they became more moderate in the subsequent phases, due to less stringent restrictions and adaptation measures by firms. ([12]) In addition, the prolonged succession of lockdowns may have caused deterioration of skills and underinvestment in terms of both physical and human capital that can directly lower productivity. The downsizing of business operations resulting from the inability to operate at full capacity and any subsequent underinvestment may also have affected economies of scale and reduced the efficiency of production (i.e. multifactor productivity).

Reallocation across sectors

The effects of the COVID-19 pandemic on corporate sales were strongly sector-specific. Economic activities that rely on frequent and close contacts with customers or between employees, such as Hospitality, Transport, and on-site Retail trade industries were hit relatively hard. Demand was in part reallocated away from contact-intensive industries and toward 'safer' goods and services, leading to increased production in the latter industries. In practice, in the first months of the pandemic demand was redirected away from relatively less productive industries (e.g. Hospitality), towards more productive ones (e.g. Manufacturing of Electronics). This cross-sectoral reallocation of activity led to a short-lived increase in aggregate productivity. ([13]) ([14])

Reallocation within sectors

Within-sector productivity gains arise when certain firms in a given sector adapt better to the new business environment, gradually becoming more productive, gaining market share and pushing the less productive firms out of the market (cleansing mechanism). Firm-level evidence on cleansing effects in the context of the first waves of the pandemic is still rather scarce and thus far inconclusive. While some studies find that firms that exited after the outbreak of COVID-19 were on average less productive, ([15]) other studies estimate cleansing effects to be weak. ([16]) Moreover, some studies find that firms with relatively high productivity were also among the most affected by the COVID-19 shock in terms of the reduction in revenues or the increase in the risk of insolvency. ([17]) The interpretation of the results has to take into account that evidence in these studies, collected after the onset of COVID-19, relies largely on data for 2020, and that policy support measures have been strong and consistent

([11]) The empirical exercise presented in this section relies on total factor productivity (TFP), also called multifactor productivity, as a measure of firm productivity. The pandemic however had an impact on productivity in its various forms, including labour and capital productivity. In principle, therefore, the channels through which the pandemic affects productivity concern not only TFP, but also productivity in a wider sense including some positive implications of the pandemic on productivity, i.e. by accelerating digitalisation. For a more elaborate overview see Jolles, M. and E. Meyermans (2021), 'The structural economic impact of the COVID-19 pandemic on the euro area: a literature review', *Quarterly Report on the Euro Area (QREA)*, Vol. 20, No. 1 and Croitorov, O., Filippeschi J., M. Lichetta, P. Pfeiffer, A. Reut, W. Simons, A. Thum-Thysen, A. Vandeplas and L. Vogel (2021), 'The macroeconomic impact of the COVID-19 pandemic in the euro area' *Quarterly Report on the Euro Area (QREA)*, Vol. 20, No. 2.

([12]) Bloom, N., P. Mizen and S. Taneja, (2021), 'Returning to the office will be hard', *VoxEU*, 15 June.

([13]) Bloom et al., op. cit. (2020) document, on the basis of survey data on the UK, that the contraction of relatively less productive sectors was associated with an increase in both aggregate labour productivity and aggregate total factor productivity (TFP) at the start of the pandemic.

([14]) Note that some of these reallocations might be more persistent, such as the shift towards online retail. If such activities are characterised by higher productivity, the cross-sector reallocation might have an impact on aggregate productivity that persists after the pandemic subsides.

([15]) e.g. Altomonte et al., op. cit. (2021), Andrews et al., op. cit. (2021) and Lopez-Garcia P. and B. Szörfi, (2021), 'The impact of the COVID-19 pandemic on labour productivity growth', *ECB Bulletin 7 (chapter 4)*.

([16]) e.g. Hadjibeyli B., Roulleau G. and A. Bauer, (2021), 'Live and (don't) let die: the impact of COVID-19 and of public support on French firms', *Direction Générale du Trésor Working Papers* #2021/2 (April).

([17]) e.g. Altomonte et al., op. cit. (2021), Harasztosi et al., op. cit. (2022).

during this period, potentially slowing down the reallocation process. ([18])

Preliminary evidence indicates that more digitalised firms were better able to absorb the COVID-19 shock. ([19]) The incidence of telework is associated with a lower contraction in output following the COVID-19 lockdowns, both on a macro-level and on a sectoral level. Recent OECD analysis on data for Australia, New Zealand and the UK shows that firms with a more intense use of digital solutions and technologies (including teleworking) were able to contain labour shedding after the onset of COVID-19. ([20]) This confirms the presumption that the firms that were more productive before the pandemic hit may have been better able to adapt to the COVID-19 shock.

The rest of this QREA section evaluates the within-sector cleansing mechanism in the context of the pandemic by quantifying the contribution of the exit margin. By comparing the trajectory of firm sales, and the resulting levels of financial stress, in a pandemic and in a counterfactual scenario, we are able to identify firms at risk of exit in connection with the pandemic, and to draw some conclusions about the impact of the pandemic on sectoral productivity. ([21])

I.3. The pandemic, financial vulnerability and firm productivity

This subsection assesses the impact of the COVID-19 pandemic on corporate financial health, and connects these findings with firms' pre-pandemic productivity.

The first step builds on a simulation of the pandemic's impact on the financial health of the European corporate sector by the end of 2021, using firm-level data from the ORBIS database. We quantify the increase in the fraction of financially vulnerable firms in each industry due to the combined effects of reduced equity, higher leverage, higher future expenses on debt and reduced profitability associated with the COVID-19 crisis (the methodology is explained in Box I.1, note that in the simulations firms are classified as either vulnerable or viable based on the methodology). ([22])

The second step connects the results of simulations on the financial health of firms by the end of 2021 with their pre-pandemic characteristics. Specifically, we investigate the impact of firms' productivity before the onset of the pandemic on their likelihood to remain financially viable. We underpin a weakened connection between firm productivity and financial viability during the COVID-19 crisis relatively to the counterfactual no-COVID-19 scenario.

I.3.1. Magnified financial vulnerability in connection to the COVID-19 pandemic

Widespread losses incurred in connection with the pandemic affected corporate balance sheets and capital structures. A combination of reduced equity, higher leverage, higher future expenses on debt, and reduced profitability increased the fraction of firms that appear financially vulnerable. Our results on the magnification of financial vulnerability in each industry by the end of 2021 in connection with the COVID-19 pandemic are presented in Graph I.1. These results are obtained by identifying firms that become financially vulnerable after 2 years of activity under COVID-19 conditions while remaining financially viable otherwise.

Specifically, we take a firm and assess its financial health after 2 years of activity under COVID-19 conditions. In the COVID-19 scenario, we account for some policy support, namely the temporary suspension of interest expenses and corporate tax payments. As is common in the literature, we account for short time work schemes by increasing the sensitivity of labour costs to negative revenue shocks. We also simulate 2 years of activity for each firm in the absence of the pandemic, and characterise its financial health in this counterfactual no-COVID-19 scenario (see Box I.1 for details).

([18]) Yet, other studies, such as Konings et al, op. cit. (2022), document that in some parts of Europe (Flanders) market share reallocation to more productive firms, whether subsidised or not, was sustained over the course of the pandemic.
([19]) See Harasztosi et al., op. cit. (2021).
([20]) Andrews et al., op. cit. (2021).
([21]) An important caveat is that the analysis does not explicitly model resource reallocation due to the pandemic. Quantifying COVID-19-induced changes in productivity at the firm level, including purely positive impact on productivity, for example by speeding up the digital transition within firms, is also beyond the scope of this analysis.
([22]) See Archanskaia et al., op. cit. (2022), for more information.

Box I.1: **Approach to quantifying financial vulnerability**

This box describes the methodology used to assess the implications of the COVID-19 shock for financial vulnerability in the European non-financial corporate sector. The analysis is based on granular firm-level information contained in the ORBIS database. Two scenarios are simulated for 2020-2021: the COVID-19 scenario and the counterfactual scenario in which the COVID-19 shock does not materialise. ([1]) In the COVID-19 scenario, information on monthly turnover in each industry is combined with the assumption that costs do not fully adjust to turnover fluctuations. The combination of turnover and costs' fluctuations determines the distribution of profitability shocks in each country and industry. ([2]) In the counterfactual no-COVID-19 scenario, it is assumed that each firm obtains the same profits in 2020 and 2021 as in its latest available pre-COVID-19 financial statement. In each of the two scenarios, the evolution of profits allows simulating the evolution of corporate liquidity positions, equity, and liabilities. ([3]) Comparing these two scenarios helps to assess underlying financial vulnerabilities that may have accumulated in specific industries, which could translate into actual bankruptcies and unemployment in the aftermath of the COVID-19 pandemic, notably as emergency support measures are withdrawn. ([4])

We build on the most recent literature in choosing the criteria used to identify financially vulnerable firms. The first criterion identifies financial vulnerability through the risk of insolvency. Following McCormick et al. (2016), a firm is said to be insolvent if it fulfils at least one of the following criteria by the end of 2021: (i) the firm is predicted to have negative equity or (ii) the firm is unable to cover accumulated debt expenses with operating profits and finds itself by the end of 2021 in the top quartile of the pre-COVID distribution of leverage in the country-industry. ([5]) This definition of the risk of insolvency is a refinement in comparison to previous studies, which only look at equity depletion. ([6]) Accounting for the role of the debt burden allows assessing the impact of the pandemic on corporate financial health in a more comprehensive way. Indeed, increased borrowing used to address liquidity shortfalls in the course of the pandemic may affect the extent to which firms are able to cover debt servicing costs with operating profits in its aftermath.

The second criterion identifies financial vulnerability with help of a statistical criterion, the Altman Z-score model, which groups firms in three bins according to their risk of default. ([7]) As documented in Altman et al. (2017), this scoring model performs well in predicting bankruptcy in a sample of countries and industries. ([8]) In line with this literature, the risk of default is assessed based on the firm's simulated liquidity, profitability, capitalisation, and leverage by the end of 2021. Two variants of the Altman Z-score model are used, as one

([1]) The comparison of the COVID-19 scenario to a counterfactual 'no COVID-19' case was initially used by Gourinchas et al. (2020) to quantify the risk of insolvency associated with the pandemic, and the role of policy support measures in mitigating this risk.

([2]) The impact of the COVID-19 crisis on industry turnover and the implications in terms of corporate financial distress are described in Croitorov, O., J. Filippeschi, M. Lichetta, P. Pfeiffer, A. Reut, W. Simons, A. Thum-Thysen, A. Vandeplas and L. Vogel (2021), 'The macroeconomic impact of the COVID-19 pandemic in the euro area', *Quarterly Report on the Euro Area (QREA)*, Vol. 20, No. 2.

([3]) For methodological details and a comprehensive overview of the findings, we refer the reader to Archanskaia E. , E. Canton, A. Hobza, P. Nikolov and W. Simons (2022), 'The sectoral nature of the COVID-19 shock: a novel approach to quantifying its economic impact', *European Economy Discussion Paper* 162.

([4]) The simulations in the COVID-19 scenario take into account support provided by short-time work schemes. Following Schivardi F. and G. Romano (2020), 'A simple method to compute liquidity shortfalls during the Covid-19 crisis with an application to Italy', *Covid Economics: Vetted and Real-Time Papers* 35, July, this support is modelled as an increase in the sensitivity of labour costs to revenue fluctuations. The simulations also incorporate the effect of payment moratoria on the time profile of interest payments. Other subsidies (e.g. grants, solvency support) are not taken into account. Firms are assumed to address all financing needs through new debt with no equity issuance, thereby likely overestimating equity depletion in the non-financial corporate sector.

([5]) The use of this definition of insolvency is motivated by the fact that in the EU the obligation to file for insolvency may hinge on a liquidity test (inability to pay financial obligations as they become due) and/or on a solvency test (negative equity). See McCormick G., A. Keay, S. Brown, and J. Dahlgreen (2016), 'Study on a new approach to business failure and insolvency: Comparative legal analysis of the Member States' relevant provisions and practices'. DG JUST: European Commission Tender No. JUST/2014/JCOO/PR/CIVI/0075.

([6]) See Ebeke et al., op. cit. (2021) and Demmou et al., op.cit. (2021) who follow Carletti E., T. Oliviero, M. Pagano, L. Pelizzon and M. Subrahmanyam (2020), 'The COVID-19 Shock and Equity Shortfall: Firm-level Evidence from Italy', *CEPR Discussion Paper* 14831.

([7]) In relation to the COVID-19 pandemic, the Altman Z-score model was used in European Commission (2021), 'Corporate Solvency of European Enterprises – state of play'. *Note to the Eurogroup Working Group* (February).

([8]) Altman E., M. Iwanicz-Drozdowska, E. Laitinen, and A. Suvas (2017), 'Financial distress prediction in an international context: A review and empirical analysis of the Altman Z-score model', *Journal of International Financial Management and Accounting*, 28:2.

(Continued on the next page)

Box (continued)

puts more weight on liquidity while the other puts relatively more weight on profitability. (9) The firm is said to be at high risk of default according to this statistical criterion if, and only if, it is identified as being at high risk of default by the two specifications of the Altman Z-score model.

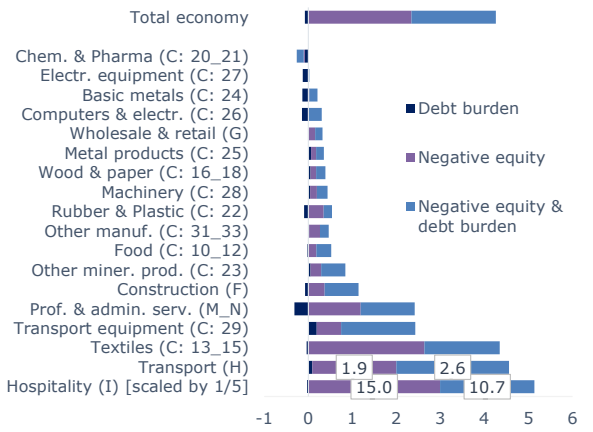
The firm is identified in our analysis as *financially vulnerable* by the end of 2021 when it *simultaneously* verifies the risk of insolvency criterion and the risk of default (Altman Z-score) criterion. The increase in the share of financially vulnerable firms associated to the COVID-19 pandemic is identified with the fraction of firms that appear financially vulnerable in the COVID-19 scenario while not being financially vulnerable in the counterfactual no-COVID-19 scenario.

An important caveat of the simulated COVID scenario must be underlined, as it may affect the quantification of more widespread financial vulnerability. As explained above, the simulations take into account the role of short-time work schemes in increasing the sensitivity of labour costs to revenue fluctuations. They also incorporate the effect of payment moratoria on the time profile of interest payments. However, other subsidies (e.g. grants, solvency support) are not taken into account. Moreover, firms are assumed to address all financing needs through new debt with no equity issuance. It follows that the simulations likely overestimate equity depletion and debt overhang in the non-financial corporate sector.

(9) The first specification is Z_1=6.56 WK/TOAS+3.26 EQUITY/TOAS+6.72 EBIT/TOAS + 1.05 EQUITY/TOTLIAB, where WK stands for working capital, TOAS stands for total assets, and TOTLIAB stands for total liabilities. $Z_1 \leq 1.1$ qualifies the firm as at high risk of default. The second specification is Z_2=0.717 WK/TOAS+0.847 EQUITY/TOAS+3.107 EBIT/TOAS + 0.42 EQUITY/TOTLIAB+0.998 TURN/TOAS, where TURN stands for turnover. $Z_2 \leq 1.2$ qualifies the firm as at high risk of default.

Unsurprisingly, we find the highest prevalence of firms at risk of financial vulnerability by the end of 2021 in the industries that were hit hardest by the COVID-19 shock. Graph I.1 shows the largest increases in vulnerability, compared to the counterfactual no-COVID-19 scenario, in the Hospitality (I) industry. These vulnerabilities originate from the depletion of equity following protracted periods of losses, but also from an increased debt burden. For the European economy as a whole, the COVID-19 crisis raised the share of vulnerable firms by around 4 percentage points (i.e. an increase of about two thirds compared to the counterfactual no COVID-19 scenario).

Graph I.1: **Increase in the share of financially vulnerable firms in the EU**
in pp, by criterion of insolvency



(1) This graph plots the increase (in percentage points) in the share of financially vulnerable firms in the COVID-19 scenario relative to a counterfactual scenario, in which the COVID-19 pandemic did not occur and in which profits are extrapolated based on pre-COVID levels. This increase is computed for the full population of firms in each industry and for the European economy. Representativeness is achieved by reweighting the ORBIS sample within each country-industry- size class cell, with population weights taken from Eurostat SBS data. Firms are identified as financially vulnerable if they have either negative equity or a high debt burden (i.e. the firm is unable to cover debt servicing costs with operating profits and, on top of that, the firm is highly leveraged), or verify both criteria, by the end of 2021. The firms are also required to be identified as high risk of default according to the Altman Z-score model, the latter assessment being based on firms' expected leverage, capitalisation, liquidity, and profitability by the end of 2021. See Box I.1 for details
Source: Own elaborations on ORBIS data

I.3.2. Firm productivity and financial vulnerability

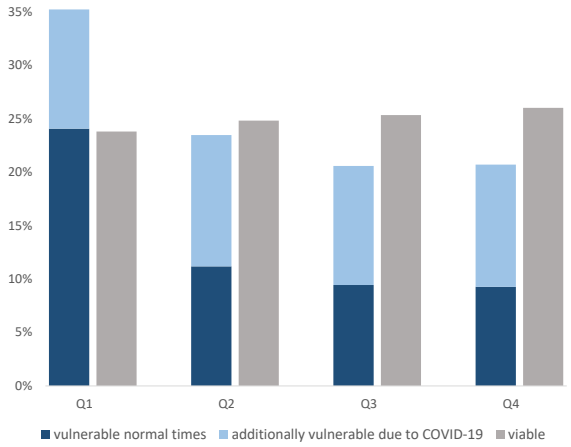
Having established the impact of the COVID-19 pandemic on corporate financial vulnerability in the previous subsection, we now connect these findings with firm characteristics. Specifically, we investigate the relationship between the financial health status of the firm and its pre-pandemic productivity. Our focus on firm productivity is motivated by its importance as a driving force of growth in the post-crisis recovery.

We document two salient facts. First, we find that less productive firms are more likely to become financially vulnerable. This result is to be expected as the financial health status of a firm is closely linked to the past trajectory of its profits. The latter hinges on a firm's fundamentals, such as its productivity. Second, we find that the link between financial vulnerability and pre-pandemic productivity is weakened in the context of the COVID-19 pandemic. In a given country and industry, more productive firms are as likely to become financially vulnerable in the COVID-19 scenario as are less productive firms (conditioning on firm viability in the no-COVID-19 scenario).

These findings are illustrated in Graph I.2. The graph plots the distribution of financially vulnerable firms (blue bars) side by side with the distribution of viable firms (grey bars) across the pre-pandemic multifactor productivity (or TFP – the choice of a productivity metric of this section) distribution. ([23]) While the firms that remain viable despite the COVID-19 crisis (grey bar) are distributed rather evenly across the productivity distribution, the blue bars suggest a concentration of financially vulnerable firms among the lowest productivity quartiles. The latter bars further distinguish those firms that would become financially vulnerable under 'normal conditions' (i.e. a no-COVID-19 counterfactual, obtained by extrapolating pre-pandemic revenue figures) (dark blue bars) from those that become vulnerable only in the context of the COVID-19 shock (light blue bars). The graph shows that the bulk of firms deemed financially vulnerable in the no-COVID-19 counterfactual are concentrated in the lowest quartile of the productivity distribution. Conversely, the link between pre-pandemic productivity and (additional) financial vulnerability in the aftermath of COVID-19 is not visible, as the distribution of additionally financially vulnerable firms (light blue bars) is close to uniform across the productivity quartiles.

Graph I.2: **Distribution of EU firms across TFP quartiles**

(%), across TFP quartiles - Dec 2021



(1) TFP is computed as the Solow residual, using sectoral factor shares reported in Eurostat. TFP quartiles are computed within each country and sector, based on firm-level information reported in 2018 financial statements. The firm data are weighted by firm size, sector and country to make results representative for the EU economy. The set of financially vulnerable firms is considered separately from the set of viable firms, i.e. the four blue bars sum to 1, and the four grey bars sum to 1.

Source: Own elaborations on ORBIS data

Graph I.2 suggests a weaker-than-usual connection between firm productivity and financial vulnerability in the context of the pandemic, as indicated by the equal size of the light blue bars across the TFP quartiles. In Box I.2, we empirically test this relationship by means of a probit model for the likelihood to remain viable (i.e. avoiding a state of financial vulnerability) in each of the two scenarios. The productivity of the firm has a significant positive impact on its likelihood to remain viable in the no-COVID-19 case, compared to an insignificant effect for COVID-19 viability.

In the next subsection, we quantify the impact of the weaker-than-usual connection between productivity and financial vulnerability during the COVID-19 crisis on the functioning of a particular aspect of the cleansing mechanism, namely the exit of vulnerable firms.

([23]) Unless otherwise specified, the results still stand when using labour productivity (value added per worker) as a measure.

Box I.2: **Productivity and likelihood of financial viability: a probit model**

We assess the impact of firm productivity on the likelihood of financial viability (i.e. the absence of vulnerability as defined throughout the article) in the COVID-19 scenario and in the counterfactual no-COVID-19 scenario (also referred to as 'normal times') while conditioning on a set of firm characteristics. For each industry, the following probit model is specified:

$$Y = \beta_0 + \beta_1 Productivity + \beta_2 Age + \beta_3 Size + \beta_4 CashRatio + \beta_5 DebtRatio + \alpha + e$$

where Y is the dichotomous dependent variable, which equals 1 in case the firm remains financially viable and 0 otherwise. **Productivity** represents firm-level productivity, measured as total factor productivity (TFP). Age and size (number of employees) are firm-level control variables. CashRatio and DebtRatio are further control variables at the firm level that represent the firm's ratios of cash-to-assets and debt-to-assets relatively to its peers (measured as quartile of the pre-pandemic distribution within the country-industry). A dummy α is included to control for countries. We find the probability of remaining financially viable as:

$$\mathbb{P}(Y = 1|X, \alpha) = \mathbb{P}(Y \leq X'\beta + \alpha) = \Phi(X'\beta + \alpha)$$

with Φ(·) the standard normal cumulative distribution function (CDF). ([1]) The probit framework is better suited than a linear probability model, as the predicted probabilities in the latter model are not limited between 0 and 1.

Table 1 presents the results of the probit regression in the two scenarios for the ca. 150 000 firms in Manufacturing (C). Column (1) displays the results for the likelihood of remaining financially viable in the no-COVID-19 scenario ('normal times'). Column (2) displays the results for the likelihood of remaining viable in the COVID-19 scenario. In the latter case, 'normal times' vulnerable firms are dropped from the sample. Productivity has a significant positive impact on the firm's likelihood to remain viable in normal times, compared to an insignificant effect in the COVID-19 scenario. The firm's liquidity buffer and its reliance on debt further play a role in determining its likelihood of remaining viable (with the expected sign), in both scenarios. We focus on the productivity variable in this box, but detailed results for the control variables are available upon request.

Table 1: Probit regression results for probability of financial viability, Manufacturing (C)

Probability of financial viability	**No COVID-19 (normal times) (1)**	**COVID-19 (excluding normal times vulnerable) (2)**
Productivity (TFP)	0.522***	0.023
Age (base: 0-3 years)		
4-10 years	0.115***	-0.160***
10+ years	0.125***	-0.052**
Size (100 employees)	0.012	-0.007**
Cash-to-assets ratio (base: quartile 1)		
Quartile 2	0.178***	-0.040*
Quartile 3	0.447***	0.163***
Quartile 4	0.586***	0.668***
Debt-to-assets ratio (base: quartile 1)		
Quartile 2	-0.459***	-1.005**
Quartile 3	-1.048***	-1.930***
Quartile 4	-2.361***	-2.641***

*** p<0.01, ** p<0.05, * p<0.1

([1]) Alternatively, if a logit model were specified, the CDF would be that of the logistic distribution. The choice between probit and logit depends on personal preference. Estimates from both models are typically similar (up to a scaling factor) and the interpretation of each estimator is straightforward when focusing on marginal effects, as we will do here.

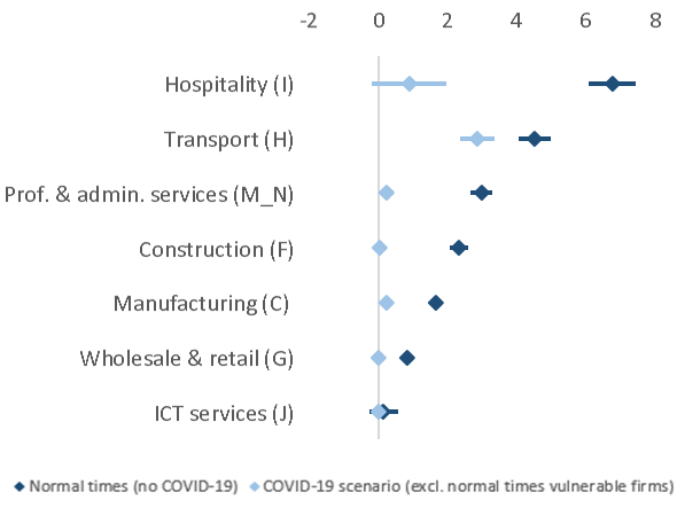
(Continued on the next page)

Box (continued)

While it is straightforward to evaluate the significance of the coefficients in a probit (or logit) model, interpreting their magnitude is not. Indeed, in contrast to a linear model, the marginal impact of one variable is not constant, but depends on the value of the variable as well as that of all other independent variables. Therefore, to assess the impact of productivity on financial viability we need to choose values for each of the regressors. This is done by evaluating marginal effects, which allow to back out the marginal impact of a 1-unit change in productivity on the probability of remaining viable, keeping all regressors fixed at a specific value.

Graph 1 shows the marginal effect of firm productivity on the likelihood to remain financially viable, in 'normal times' and in the COVID-19 scenario. In each industry, we evaluate the marginal effect of total factor productivity (TFP) for a firm with an above-median debt-to-assets ratio and mean values for all other variables. ([2]) Productivity has a significant positive impact on the likelihood of avoiding financial vulnerability in normal times across all industries. A typical firm in the Transport industry (H), for instance, would face a 0.8 percentage point increase in the probability to remain viable in normal times for a one standard deviation increase in TFP. ([3]) The impact of productivity on avoiding financial vulnerability in the context of the COVID-19 pandemic, while controlling for 'normal times' vulnerability, is significantly lower across all industries, up to the point of insignificance in most.

Graph 1: Marginal effect of TFP on probability of financial viability (95% confidence interval) – evaluated at above-median debt-to-assets ratio and mean values for other variables



([2]) The choice for these values is motivated by the strong impact productivity should have on likelihood of viability for a highly indebted firm.

([3]) Starting from the mean value for TFP in this industry, a one std. dev. increase corresponds to a rise of 18%, which leads to a 0.18*Marginal Effect = 0.18*4.5 = 0.8 p.p. increase in probability.

I.4. Quantifying the impact of the cleansing mechanism on productivity

In this subsection, we quantify the potential cleansing effect of the COVID-19 shock, by computing the impact on sectoral productivity under the hypothesis that all firms identified as financially vulnerable (see above) exit in the course of 2022. We evaluate the potential of the cleansing mechanism following the COVID-19 crisis by comparing the impact on aggregate productivity of the exit of financially vulnerable firms, both in normal times and in the COVID-19 crisis scenario. We document significant cleansing effects associated with firm exits in the counterfactual no-COVID-19 scenario, resulting in a boost to aggregate TFP of ca. 2.5%. ([24]) Despite more exits under the COVID-19 scenario, the TFP gain linked to cleansing is slightly lower, with an

([24]) This finding is in line with Bartelsman, E., J. Haltiwanger and S. Scarpetta (2009), 'Measuring and Analyzing Cross-country Differences in Firm Dynamics' in Producer Dynamics: New Evidence from Micro Data, University of Chicago Press, January 2009.

increase in TFP of 2.3%. We conclude that the crisis does not appear to bring additional cleansing effects, a finding that holds in most industries. As shown in the previous section, the main reason underlying this result is the weak connection between pandemic-related financial vulnerability and *ex ante* productivity. To the best of our knowledge, this is the first simulation of the impact of the COVID-19 crisis on sectoral and aggregate productivity.

For the quantification of cleansing effects, we build on the simulations of financial health for each firm in the ORBIS sample, obtained using the methodology described in Box I.1 and discussed above. We distinguish between three different subsamples: (i) all firms, (ii) all firms that remain financially viable after 2 years of normal activity, and (iii) all firms that remain financially viable in the COVID-19 scenario. We compute the potential change in productivity (i.e. the cleansing effect) that would arise under the hypothetical exit of all vulnerable firms in the no-COVID-19 and in the COVID-19 scenarios (i.e. the firms excluded from subsamples (ii) and (iii), respectively), by comparing aggregate productivity measures for each subsample. ([25])

Graph I.3 shows the change in aggregate productivity associated with the exit of financially vulnerable firms in each scenario (COVID-19 and no-COVID-19) at the industry-level for the EU as a whole. Graph I.4 presents these findings at the country-level (total economy). The dark blue bars in the two graphs indicate that there is a significant positive cleansing effect associated with exit in normal times, whereby less productive firms are more likely to shrink and exit, while more productive firms are more likely to survive. For the EU as a whole, this amounts to an approximately 2.5% increase in productivity if vulnerable firms exit the market in normal times (ca. 6% of the total number of firms).

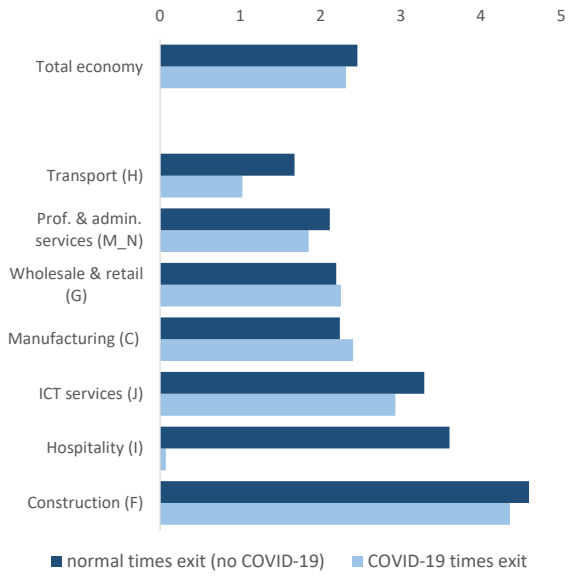
The light blue bars in Graphs I.3 and I.4 suggest that the COVID-19 shock does not bring about additional cleansing effects in most industries and countries. While the exit of the ca. 6% of firms that would have become vulnerable also in the absence of COVID-19 would lead to a 2.46% increase in aggregate TFP, the additional COVID-induced exit of another 4% of firms actually slightly reduces the aggregate productivity effect to 2.32%. ([26]) The small difference between the dark and light blue bars, across most EU industries and countries, suggests that a significant share of relatively productive firms are affected by the COVID-19 crisis. The fact that COVID-19 affected firms that were also productive pre-pandemic and thus in a relatively better position during other hypothetical crises suggests the presence of certain pandemic mechanisms, i.e. shocks to demand and supply that result in generalised vulnerability across the productivity distribution of firms. Investigation of these mechanisms remains a topic of future work.

The fact that the COVID-19 shock does not appear to bring significant additional cleansing effects implies that emergency support measures and the specific provisions, which suspended bankruptcy filings over 2020-2021, may not have had a major impact in terms of foregone productivity growth via the exit of low productivity firms. As these measures are phased out, cleansing mechanisms would start operating again.

([25]) The change in productivity is computed for each country-industry class. Using the size (number of employees) of each country-industry class obtained from Eurostat SBS as weight, we can compute weighted aggregate productivity changes at higher levels of aggregation, such as country-level, industry-level or total EU, ensuring representativeness.

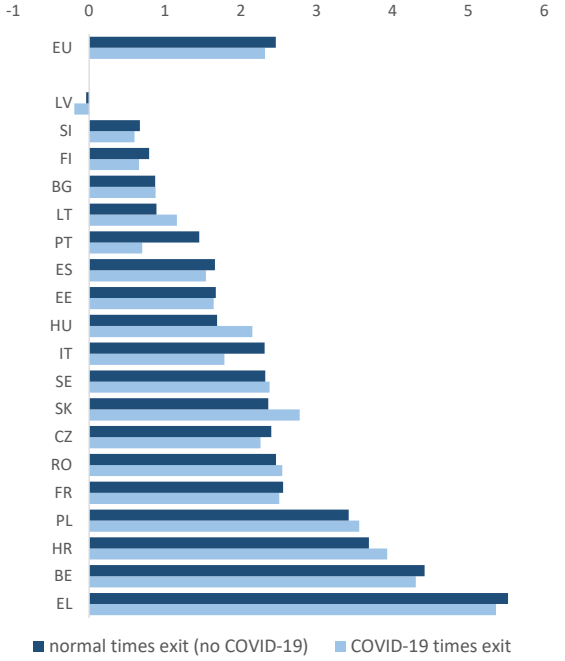
([26]) Using sectoral labour productivity rather than TFP as measure of productivity reaffirms the result that COVID-19 has overall not strengthened cleansing effects at the exit margin. The only important difference pertains to the hospitality sector, where labour productivity points to a strong additional cleansing effect. The discrepancy between both productivity measures in this industry is driven by a large difference in fixed assets between firms that exit due to the COVID-19 crisis and those that survive – the latter being twice as capital-intensive as the former. As the TFP measure accounts for fixed assets, while labour productivity does not, the exiting firms are of relatively high TFP and low labour productivity, ceteris paribus. Therefore, the exit of these primarily asset-poor firms reduces aggregate TFP in the Hospitality industry.

Graph I.3: **Change (%) in aggregate industry TFP due to exit of vulnerable firms,**
(%), EU aggregate



Source: Own elaborations on ORBIS data

Graph I.4: **Change (%) in aggregate country TFP due to exit of vulnerable firms,**
(%), total economy



Source: Own elaborations on ORBIS data

These results are obtained under the important assumption that the COVID-19 shock hits all firms within a given industry with the same intensity. In reality, firms that are more productive may have been better able to absorb the shock and to maintain their investment effort. There is some evidence pointing in this direction – see e.g., Andrews et al., op. cit. (2021) and Harasztosi et al., op. cit. (2022) – although more data is needed to reach a consensus. Further, it needs to be underlined that only exit is modelled, while no assumptions are made regarding entry or reallocation of market shares.

I.5. Conclusion

This section provides some empirical evidence on the functioning of one of the channels through which the COVID-19 pandemic may affect productivity in the EU. We use firm-level data and near real-time information on pandemic-related sector-specific shocks to simulate financial stress, which makes vulnerable firms more likely to exit, with implications for aggregate productivity through the exit margin. We find that this dimension of the cleansing mechanism was not magnified in the context of the COVID-19 pandemic, as compared to productivity-enhancing exit in the no-COVID-19 scenario.

This result can be rationalised as follows. The financial health status of the firm is largely determined by its cumulated past profits. The latter are determined by firm fundamentals, together with the ability of the firm to adapt to the specificities of demand. Consequently, we expect firm productivity to play an important role in determining corporate financial health in normal times. Yet, it is not clear that an exogenous shock, such as the COVID-19 pandemic, would favour more productive firms. Indeed, the ability to absorb a sudden reduction in profitability may be linked to the pre-shock strategy of the firm with respect to financing (debt vs equity), its investment effort, or other factors (e.g. its cost structure).

These findings have clear policy implications. Productivity growth is an essential contributing factor in the post-crisis recovery phase. It sustains growth in the aftermath of shocks so that output can return to its pre-crisis growth trajectory. During previous crises, public support was typically directed at keeping alive firms that were already under strain and thus tended to benefit the less productive firms. It was feared that COVID-19 support measures would similarly prop up weak firms, thereby pulling aggregate productivity down. The results presented in this article show that,

unlike previous economic crises, COVID-19 offered limited potential for cleansing through the exit margin, implying that the available access to broad-based policy measures was not associated with major foregone productivity gains via cleansing effects. As support measures are phased out, cleansing mechanisms would start operating again.

Looking forward, productivity-boosting policies could help firms achieve sustainable growth. Measures that step up investment in upskilling and reskilling are needed to ensure that skills are re-oriented in line with the green and digital transitions, which accelerated during the pandemic. Insolvency frameworks should be made easily accessible and transparent, as well as capable of swiftly distinguishing between those companies that can become viable after restructuring and those that should be liquidated. Finally, effectively implementing the recovery and resilience plans will bring about both an increase in public investment and structural reforms aimed at removing bottlenecks to investments.