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DISCUSSION PAPER SERIES

IZA DP No. 16606

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ABSTRACT

System Relevance and Firm Performance Due to COVID-19*

We study the impact of COVID-19 on firm performance. Using financial accounts of a large number of German firms, we document that industry affiliation is an important economic dimension of the crisis. Motivated by this fact, we analyze an important industry-specific regulation, system relevance, which allows businesses to remain open in times of lockdown and other restrictions. A difference-in-differences estimation strategy shows that relative revenues of system-relevant firms increase by 6–9 percent and profits by 17–25 percent due to COVID. Controlling for channels that are arguably not driven by the system-relevance regulation, the impact on revenues decreases but remains significant. Overall, results indicate that regulations affecting the ability to operate as well as industry-level shocks play important roles for firm performance during a pandemic-induced crisis.

JEL Classification: H12, L25
Keywords: firm performance, industry shocks, system relevance, COVID-19

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1 Introduction

European economies have suffered a succession of external shocks in recent years. These have put many businesses and households under strain as well as triggered unprecedented financial and regulatory policy interventions. The COVID-19 crisis is arguably the case in point. It upended many aspects of life and induced severe restrictions in order to sustain societal health among other public goods. These interventions came with potentially heavy economic costs, overall and in specific sub-units of the economy. Governments at the national and EU level accordingly spent trillions of euros in bailouts and support programs. To date, much is known about the macroeconomic developments since the beginning of 2020 when the crisis started. But detailed analyses about the actual performance of firms during this period and the impacts of specific policies are rather scant.

This lack of evidence may be problematic for at least three reasons. First, it is unclear which dimensions of the crisis had actual effects on firms' bottom lines and whether there were businesses which in fact benefited from it. To design targeted policy interventions in future (and to compensate or tax economic agents ex post), one needs to identify such heterogeneity at the disaggregated level. This may help understand the extent to which regulations (e.g., social distancing measures or mandated business shutdowns) affected economic activity, and still do so in various contexts, as opposed to individuals' changes in behavior (reductions in mobility and consumption patterns) that are independent of specific government interventions. Third, while economic growth declined in 2020 compared to prior years, it is unclear how much of this was due to COVID-19 and how much was due to other factors (such as deglobalization which had already started, e.g., see Goldberg and Reed, 2023). Comparing the outcomes of economic units with different exposure to the pandemic shock helps shed light on these questions.

In this paper, we study the relationship of an important COVID-related policy – designating specific industries as systemically relevant – with the realized perfor-

mance of German firms in 2020. System relevance implies that businesses are allowed to continue operating (produce, distribute, or sell to customers in person) during times of lockdown and social distancing measures, and that employees can go to work in many circumstances otherwise forbidden. A difference-in-differences (DiD) estimation approach shows that system-relevant firms' revenues increase by 6–9 percentage points in 2020 compared to firms in industries that are not system-relevant and earlier years. This effect is robust to controlling for alternative factors, varies by firm capital stock, raises profits, and has potentially important implications.

More broadly, we study the heterogeneity of a pandemic shock on firms across important economic dimensions. While regional variations are found to be of little importance, heterogeneity in economic performance across industries is substantial during 2020. This is underscored by a larger variation of firms' revenue growth explained by industry affiliation and larger commonality with revenue growth in other countries than in earlier years. A policy-relevant, and distinct from other factors, component of it is the regulation of specific sectors to be system-relevant, which is the focus of this paper.

We use information on German firms' revenues, employment, capital, and profits from Bureau van Dijk (BvD), an established commercial data provider.[1] This is available for a large share of firms including 2020, the first and arguably most incisive year of the COVID-19 pandemic, which we compare to the prior period of 2017–2019. We also collect information on average COVID-19 incidence rates across labor market regions, essential worker status by occupation, industry-specific closures, and firms' system relevance. The latter is largely determined by the two-digit industry that the business operates in, although in a subset of sectors it varies up to five-digit level.[2]

[1] We use log revenues as the main outcome of study because it should be most directly affected by the impact of supply and demand changes due to the pandemic shock. We analyze the effect on net profits for the subsample of firms where this is available in a second step.

[2] There are 82 two-digit and 976 five-digit industries in BvD. In some analyses we also show statistics for 18 sectors; these are the three levels of industry (dis)aggregation we use in this paper. There are 239 system-relevant industries at the five-digit level, pertaining to 23 system-relevant two-

Our descriptive analysis shows that the level of revenue growth shifted downward during 2020 compared to earlier years, consistent with an adverse macroeconomic impact of the COVID shock, while the dispersion of revenue growth increased. The share of variation in revenue growth explained by industry affiliation approximately quadrupled. This could be because of the pandemic but also other factors affecting industries differentially, or due to various policies that were implemented.

A key aspect of the COVID-19 restrictions and potentially important policy is the designation of specific industries to be system relevant. System-relevant industries were already defined in 2011. During the COVID crisis, firms in these industries faced substantially fewer restrictions than firms in industries that are not system relevant. Energy, Food, Finance and Insurance, Health, Information and Communication, Media and Culture, State and Administration, Transportation, and Water are broad sectors in which system-relevant industries are found. These are necessary for the basic functioning of the state, as their failure would result in disruptions to public safety or of the supply of essential services.[3] During the pandemic, firms in system-relevant industries were not subject to restrictions taken to contain the spread of COVID-19. Employees were not required to work from home, they were not furloughed, and even after contact with a COVID-19 positive person they were not obliged to quarantine.[4]

Our main analysis studies the effect of the COVID shock on system-relevant firms' performance. We do this using a difference-in-differences approach, which compares system-relevant to non–system-relevant firms' revenue growth in 2020 versus the preceding years. Consistent with parallel trends of the treatment and control group in the counterfactual (i.e., in 2020 if the pandemic had not occurred), ratios of system-relevant to non–system-relevant firms' revenues were constant during 2017–2019. We also control for potential confounding variables at the micro and aggregated level

digit industries. For more details, see Section 2.2 and Table E1 in the Appendix.

[3] The sectors are similar to "critical infrastructures" in the US in terms of their function and composition. Different from Germany, the US government introduced critical infrastructures only in August 2020 as a response to the COVID-19 pandemic.

[4] They did however follow standard containment measures, such as distancing and mask wearing.

interacted with year.

Estimations consistently yield that system-relevant firms' revenue growth is 6–9 percentage points higher compared to non–system-relevant firms in 2020. Given that average revenue growth in the sample is -1 percent, this implies that the impact of COVID-19 on system-relevant firms' revenue growth is positive even in absolute terms despite the economic crisis. The share of essential workers (measured by the average in the firm's industry) slightly reduces this effect to 5–6 percentage points, while much of its own impact disappears, when both are included in a joint estimation.[5]

These results show that there exist firms along identifiable and relevant dimensions that seem to have benefited from the COVID crisis. They do not distill the pure policy effect, however, since system-relevant firms may have profited from the pandemic due to general changes in behavior and consumption. Government support programs, such as the short-term work scheme and temporary VAT decrease, may indirectly also have had differential effects by system relevance.

Our next step refines the analysis to proxy for demand shifts that would have occurred even without the system-relevance regulation. We do this by controlling for revenue growth across industries in Sweden; a relatively similar country to Germany and one that is well-known to have had almost no COVID-related restrictions (including across sectors). Swedish revenue growth and revenue growth from German BvD data are strongly correlated in 2020 but not in earlier years, indicating a common impact of the pandemic. Including Swedish revenue growth in the DiD, the pandemic's effect on system-relevant firms drops by one third but remains highly significant. This is consistent with the system relevance regulation having a distinct impact beyond important common changes in demand due to the pandemic shock.

We finally study the impact of system relevance in relation to firms' capital stock and profits. Firms endowed with more capital did relatively better during the pandemic and this is significantly more so for system-relevant firms. Capital itself is not differentially changing by system relevance, as capital accumulation likely takes time,

[5] Industry-specific closures have no own effect on revenues or on the effects of the other policies.

but profits clearly are. Focusing on the subsample of firms that report positive profits, those that are system-relevant increased their profits by 17–25 percentage points in 2020 compared to non–system-relevant firms. Thus, relatively speaking, significant windfall profits have accrued to system-relevant firms.

This paper first contributes to the study of firm performance in times of crisis,[6] whereby for the COVID-shock mostly survey-based evidence about expected impacts has been available. For example, in Bartik et al. (2020) small US businesses consider themselves hard-hit by the pandemic. They respond lacking liquidity and facing hurdles to apply for public funds. In Bloom, Fletcher, and Yeh (2021) negative effects on sales are larger among offline firms, owned by females, blacks, or individuals with a humanities degree.[7] In the German context, Buchheim et al. (2022) find that sentiment about the duration of shutdowns significantly affected firms' employment and investment decisions. High frequency analyses in Buchheim, Krolage, and Link (2022) further show that nationwide domestic policy measures impacted businesses' outlooks much more than, e.g., foreign or regional developments.

Compared to these studies, we note that the pandemic had very differential impacts on firm performance by industry. This is also discernible as a common COVID-19 shock across countries. Given the size of these impacts, and their fundamental economic rationale of changing supply and demand for different outputs, other heterogeneities may partly be driven by their relation to industry affiliation. We further advance the existing evidence by studying actual performance changes that are mea-

[6] E.g., Giroud and Mueller (2017) analyze balance sheets to show that leveraged firms were responsible for the US employment decline in the financial crisis. These firms performed worse and acquired less debt. Other papers on the Great Recession include Alfaro and Chen (2012); Aghion et al. (2021).

[7] We obtain broadly consistent results with Comin et al. (2022), who show that firms with better technology seem more resilient, finding that firms with higher capital stock were more resilient and that system relevant ones profited even more from this. Barrero, Bloom, and Davis (2021), Bai et al. (2021), and Bloom, Davis, and Zhestkova (2021) highlight that working from home seems to help firms better navigate the crisis, indicating positive effects on sales, net-income, and stock returns. We also studied the heterogeneous COVID-19 effect across firms with high versus low work from home potential and did not find strong or robust evidence for the case of Germany.

sured from recent financial statements of a large share of German firms. Complementary to us, Balleer et al. (2022) study the underlying demand and supply drivers of changes in German firms' perceptions and price setting behavior.

Second, a number of papers analyze financial support policies, which are a common crisis response tool, in the COVID context. For example, Core and De Marco (2021) study the allocation of loans as part of a public guarantee scheme for small businesses in Italy. They show that fragile firms profited early-on from these schemes and that there are important heterogeneities of effects across the sizes and IT capabilities of banks that offer these loans. Konings, Magerman, Van Esbroeck, et al. (2023) exploit a COVID rescue policy in Belgium. They find that subsidized firms experienced an increase in productivity and were less likely to exit from the market.[8]

We argue that in a pandemic-induced crisis, physical restrictions (or lack thereof) are a key aspect of the policy response and have substantial economic effects.[9] For this, we focus on a specific regulation which (with minor differences) is used in a number of countries and that has a direct impact on firms' ability to operate. Related restrictions to operations, albeit prevalent and ongoing until very recently in various contexts, have so far received little attention in the literature. We provide first estimates of the potential costs of such policies on the firm side.[10]

The remainder of this paper is structured as follows. The next section explains the institutional background, the German government's response to COVID-19, and sample construction. Section 3 provides stylized facts on firm performance in 2020 and develops the empirical strategy. Section 4 reports the estimates of the impact of COVID-19 on system-relevant firms. In Section 5 we extend the analysis to firm capital

[8] Cororaton and Rosen (2021) on the contrary find evidence of reputational harm for public firms taking up loans via the Paycheck Protection Program in the US.

[9] This view is mirrored in Boddin, D'Acunto, and Weber (2020), where firms report that operating restrictions and demand changes, rather than financial contraints, are the key impacts of the crisis.

[10] By documenting the industry-level heterogeneity and impacts of the (relaxation of) operating restrictions, we finally suggest ways to identify winners and losers from COVID-19. This pertains to current debates in various countries about windfall profits for specific businesses during the different recent crises and who pays for the extraordinary costs that accrue to society as a whole.

and profits. The last two sections summarize further robustness tests and conclude.

2 Background and Data

2.1 Institutional Background and COVID Response

During March 2020, confirmed COVID-19 cases in Germany started to rise exponentially. The government (federal and state-level collaborating) responded by introducing measures to contain the rapid spread of the virus. These included lockdowns, social distancing, obligation to work from home where possible, border and school closures[11]; later in the year also mandated mask wearing and rapid antigen testing.[12]

As a counterpart to the containment measures, the government introduced exemption policies to keep the country functioning despite the general restrictions, and financial support policies to help hard-hit households and firms.

System relevance: An important policy to keep the state and essential services functioning was to exempt critical (or system-relevant) industries from the restrictions on the grounds that they provide crucial services in times of crisis. System-relevant industries had already been identified in 2011, in response to the financial crisis at the time. Federal and state governments agreed on nine broad sectors and 29 industries (23 in

[11] Schools were closed from mid-March to mid-April (Isphording, Lipfert, and Pestel, 2021). Only children of essential workers and some disadvantaged groups (e.g., single working parents without childcare alternatives) were eligible for emergency care. For the rest of 2020, schools outside summer holiday were open under strict hygiene measures but immediately closed for quarantine when cases were confirmed.

[12] Between March and May, Germany went through a rigorous lockdown. Individuals were allowed to leave their homes only for essential purposes (grocery shopping, pharmacy or a walk) or going to work in case they worked in essential occupations or system-relevant industries. In June some of the restrictions were relaxed and industries like Accommodation, Food and Beverages Services, Creative, Arts and Entertainment Activities, Travel Agency and Sports Activities, Amusement and Recreation Activities were opened under strict hygiene measures and testing. In October the second wave of COVID-19 started, making the government again shut down these industries as of November 1st (the so-called light lockdown). By then, mask wearing, testing and working from home were the norm.

our data as industries within Public Administration are not in BvD), which were considered to be critical infrastructures in cases of a pandemic, natural disaster, terrorism, and other threats. As per the definition by the Federal Ministry of the Interior in 2011, critical infrastructures are organizations and facilities with significance for the state community, the failure or impairment of which would result in lasting supply bottlenecks, disruptions to public safety, or other dramatic consequences. The broad sectors of system relevance are: Energy, Food, Finance and Insurance, Health, Information and Communication, Media and Culture, State and Administration, Transportation, and Water (German Federal Office of Civil Protection and Disaster Assistance, 2022). Appendix E reports the full list of two-digit industries with their system relevance and share of essential workers (Table E1) as well as details on the variation that exists even at the five-digit level (Table E2).

Employees in system-relevant industries were supposed to continue business as usual (i.e., no working from home recommendation) and when necessary work longer hours to ensure uninterrupted activity even during high incidence rates. Parents working in system-relevant industries could send their children to kindergarten and school as long as they were younger than 12 years old. In case of contact with a COVID-19 positive person they did not have to quarantine. The only case they were not allowed to go to work was if they tested positive with COVID-19.

Designating industries as critical and non-critical infrastructures has become a wide-spread policy. Most European countries introduced a classification of critical infrastructures after the financial crisis. The classifications and regulations pertaining to these industries are similar to Germany.[13] The US introduced a list of industries that are critical infrastructure only in March 2020 as a response to COVID. This list

[13] For instance, for the Netherlands, Austria, and France see Government of the Netherlands (2022), Ministry of Justice and Security, The Netherlands (2022), Chancellery of Austria (2022), Republic of Austria (2020), General Secretariat for Defence and National Security (SGDSN) of the Government of France (2022), and Ghoroubi, Counil, and Khlat (2022). The EU introduced the European Critical Infrastructure Directive in 2008, which included only sectors like energy and transportation. In December 2020, the European Commission proposed a new directive with ten sectors designated as critical (European Commision, 2020).

and the regulations (or exemptions) are again similar to the German one.[14]

Essential occupations: Another important exemption policy was the designation of essential workers. Employees in essential occupations enable state, health system, and other crucial services to remain functional. Workers were exempted from COVID-19 containment measures and also requested to work longer hours. The first essential workers list was introduced in March 2020. Identifying essential workers in Germany is challenging, since each state could come up with its own list and since the lists changed over time. We employ two lists of essential workers that have thus far been used in the literature (Koebe et al., 2020). The first list, otherwise known as the occupations of the "first hour", was issued in March 2020 and includes mostly occupations related to the Health Sector, Utilities, Administration, Sales of Food, Sanitary, Pharmaceutical, IT and Security. The second list, the so-called occupations of the "second hour", published later in 2020 was expanded to occupations such as teachers, veterinarians, and employees of the Banking, Finance and Insurance sector.

The system relevance and essential occupation regulations apply to related but different sets of workers. Employees of system-relevant industries could still go to work although they were not in essential occupations. One such example is administrative personnel in hospitals or residential homes for the elderly. On the flipside, employees of essential occupations could still go to work even if they were in an industry that was not designated as system-relevant.

Financial support: To cushion the negative impacts on workers and firms, the German government issued several packages of financial support. For large firms, the Economic Stabilization Fund (ESF) amounted to €600 billion and was intended to mitigate liquidity bottlenecks, support capital market funding, and strengthen firm

[14] The list includes the 16 sectors whose functioning are vital for the national (economic) security and public health or safety. Workers in these industries and in essential occupations were exempted from quarantine rules as long as they did not test COVID-positive. See more at: https://www.cisa.gov/identifying-critical-infrastructure-during-covid-19.

equity (German Ministry of Economic Affairs, 2022). Up to €400 billion were guarantees for corporate liabilities, €100 billion designated for capitalization measures, and €100 billion to refinance the KfW Special Programme 2020.[15] These schemes were mostly loans, entering firm financials under "liabilities" in the balance sheet.

Small firms and the self-employed were provided with emergency aid and loans totaling up to €50 billion (German Ministry of Finance, 2020; German Ministry of Economic Affairs, 2022). The emergency aid was a single payment of €9 thousand for three months for firms with up to 5 workers and €15 thousand for firms with up to 10 workers.[16] Emergency aids enter the income statement as "other operating income" (German: sonstige betriebliche Erträge), which is separate from revenues.

Firms were also supported via the short-term work allowance of the German Federal Employment Agency (2022). During short-term work, firms are reimbursed up to 67 percent of the worker's net salary. From the fourth month, a flat rate reimbursement up to 50 percent is possible if employees are willing to take up further training. Short-term work allowances are considered a transitory item that does not enter the financial statement but reduce "personnel costs". Firms also received full reimbursement of the social security payment for the employees in short-term work, which they could report as "other operating revenues" or as negative "personnel costs".

Another fiscal policy to help firms and households was the temporary value added tax (VAT) reduction from 19 to 16 percent (Federal Government of Germany, 2020). It intended to raise demand by having households spend and firms invest more.[17]

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[15] KfW (Credit Institute for Reconstruction) is a state-owned investment and development bank. To qualify for any of the three schemes, firms had to satisfy two out of three conditions: 1) total assets of at least €43 million; 2) revenues of at least €50 million or 3) more than 249 employees. Medium-sized firms and start-ups had to cross a valuation threshold by private investors of at least €50 million.

[16] This was combined aid coming from the federal and state governments, administered by the states. The first scheme was offered June–August 2020 and aimed to help with liquidity while the second one during September–December was mostly to help with fixed costs. Self-employed individuals also had easier access to unemployment benefits for 6 months. In addition, the KfW offered subsidized loans for entrepreneurs (that existed for at least 5 years) and start-ups (less than 5 years) as well as quick loans for firms with more than ten workers to afford small investments and operating costs.

[17] This may have changed revenues indirectly via a demand channel. Bachmann et al. (2021) find

Certain system-relevant and other firms were eligible for further government aid. Firms in the health care industry received special funding. Firms producing personal protection equipment, such as masks and devices to protect patients, obtained special "health care" funding. Part of this was the COVID-19 Hospital Relief Act, which supported hospitals with short-term liquidity and to employ additional medical staff. Depending on use, these items are either "liabilities" or "other operating revenues". In Appendix Section B we present a financial statement (balance sheet and income statement) of one of the firms in our sample and discuss its entries.

2.2 Sample Construction

Firm-level data: We obtain financials data from Bureau van Dijk (BvD; German vendor name is Dafne), a commercial provider. This contains individual firms' revenues, assets, employment, and profits in addition to background information such as firm size, five-digit industry specification, and district ("Kreis") where they operate. With revenues we mean the operating revenues from sales ("Umsatzerlöse"), whereas with profits we mean net profits ("Jahresüberschuss"). The information on assets includes their total with sub-component of fixed (as opposed to current) assets. Fixed assets comprise tangibles and intangibles as well as financial assets. We use tangibles as a proxy for the firm's (physical) capital stock; results are similar using fixed assets while intangibles are less systematically filled. On the other side of the firm's balance sheet are equity and liabilities. We use a recent update that covers 2020 for a substantial share of Dafne firms and download data for the years 2017–2020. We provide in Appendix B an example of an annual financial statement and explain the items on it.

Our data cleaning procedure follows Gopinath et al. (2017). First, we focus only on unconsolidated firms to avoid double-counting firms that report their balance sheet both via the parent company and individually. Unconsolidated accounts are the relevant economic units in a specific industry and location (physical address is fixed in a specific labor market region). Second, we clean the data set for basic reporting mis-

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that the temporary VAT reduction in 2020 did increase consumption, especially of durable goods.

takes. We drop observations with negative, missing or zero values in any of revenues, employment, and key asset types. We also conduct internal consistency checks to ensure that the reported data are free from measurement error and identify outliers. We perform checks that the following ratios are equal or close to one: 1) sum of current and fixed assets as a share of total assets; 2) sum of tangible, intangible, and financial assets as a share of fixed assets; 3) sum of equity and liability as a share of total assets. For all these ratios we trim the values in the bottom 0.1 and top 99.9 percentile and delete the observations in the top 99.9th percentile of net worth to remove outliers.

Finally, we construct a panel including firms that have reported in each of 2017–2020 to enable a comparison of firm performance across years. This sample results in a balanced panel of 37,655 firms. Summary statistics of key variables are shown in Appendix Table A1.[18] A strength of the data is that it covers both manufacturing and services sectors, since the latter may be particularly impacted by the pandemic. Our main outcome variable is firm revenue, as it should be most directly affected by supply and demand changes due to the pandemic.[19]

To assess the representativeness of the firm-level data from BvD, we compare it with the Structural Business Statistics (SBS) from Eurostat. SBS data are derived from the Census and cover the universe of firms in Germany with aggregated data on revenues, number of firms, and employment.[20] In Figure A1 we compare the growth rate of firms' revenues between 2019 and 2020 across 11 industry sectors that are also

[18] The cross-sectional dispersion of revenues declined from 2019 to 2020 although we find below that the variance of *revenue growth* is substantially higher in 2019–20 than 2017–18 or 2018–19. This is because revenues of smaller firms tended to grow relative to larger firms during the pandemic, reducing cross-sectional dispersion. We control for firm size in our regressions below.

[19] Gopinath et al. (2017) use value added and proxy it in BvD via revenues minus materials. The latter are not mandatory to report in the financials statement. We also do not have BvD data on the following four sectors: Public Administration and Defense, Activities of Households as Employers, Extraterritorial Organizations, and Other. Hence, we use variation across 18 sectors out of 22 overall.

[20] These data are available at the year and industry level. Hence, it is possible for us to compare the BvD data with the SBS for Germany at that level. A previous validation of BvD was by Gopinath et al. (2017), for the years 1999–2012 for the manufacturing sector. BvD was found well-representative of the industries in this sector. In this paper, we also provide a validation across sectors for Germany.

available in SBS. One can see that the revenue growths in BvD and SBS align well. The correlation of revenue growth between the two data sources is high (between 0.8 and 0.9) in every year between 2017 and 2020. Additionally, in Table A2, we compare the two data sources in terms of the share of workers, number of firms, and revenues across SBS firm size categories. BvD data covers a disproportionate share of larger firms and is thus more representative of the economic activity of such firms.[21] Table A3 finally shows the share of firms, employment, and value added of each of the 11 broad sectors; again BvD and SBS align quite well.

COVID indicators: We have constructed indicators that capture the COVID-19 shock across industries, occupations, and regions given that economic activity and containment measures varied at these levels.[22]

System relevance, as discussed above, is a regulation that largely pertains to 23 (out of 82) two-digit industries. We still use the official decree (Federal Republic of Germany, 2016) to identify the underlying 239 (out of 976) five-digit industries. We then code system relevance as a dummy which equals one for those detailed industries that are classified as critical infrastructure and zero otherwise.

Industry containment index is constructed from other regulations related to industry-specific shutdowns and business closures. We make use of the Corona Datenplattform website, which collects daily data on containment measures for specific types of economic activities (e.g., hotels, restaurants, fitness studios, or retail stores) at the district level. The containment measure for each specific activity is coded as one if they faced medium restrictions and two for high restrictions. Activities with no restriction are assumed to have experienced zero days without any sort of closure. We map these activities to the two-digit industries and sum over the whole year. Finally, information

[21] One reason for this is that BvD does not contain the self-employed. Our cleaning procedure also drops observations with negative, missing, or zero values on key indicators, which are more common among small firms.

[22] The indicators were constructed as part of the project "Labor Market Consequences of Covid-19 in the Digital Era" and in cooperation with experts at the Institute for Employment Research (IAB) and the Leibniz Centre for European Economic Research (ZEW) research institutes.

is aggregated to the federal level weighing by local employment size.

Essential occupations, also as discussed above, is another important regulation at the occupation level. We construct the average share of essential occupations in each two-digit industry to merge with the firm data at that level. The averaging is done using large administrative records on workers from SIAB (Sample of Integrated Labor Market Biographies; Berge et al., 2021).

Regional incidence rate is constructed using the seven-day local incidence rate and averaging over the year 2020. In line with prior literature (e.g., Buchheim, Krolage, and Link, 2022, also for Germany), results on this indicate that regional COVID rates played a minor role for firms and are relegated to Appendix C.

Final sample: The BvD data are in a last step merged with the industry indicators at the two-digit level (system relevance at five-digit). The final dataset is a balanced panel of 37,655 firms during 2017–2020, with 150,636 observations overall. Table E1 in the Appendix shows the share of system-relevant firms, essential workers of the "first" and "second" hour, and the industry containment index by two-digit industry.

3 Descriptive Analysis and Empirical Strategy

3.1 Descriptive Facts

Table A1 in the Appendix provides summary statistics of the most important firm balance sheet and income statement items such as employment, revenues, and different types of assets.[23] Average revenues increased during 2017–2019 but then declined from 2019 to 2020. By themselves, these aggregate statistics do not tell about impacts of the pandemic as revenues may grow or decline for various reasons.[24] To uncover

[23] There are fewer observations for employment because such information is not in the main balance sheet and not every firm reports it. Only fewer (and often larger) firms report profits. The more detailed the item, the higher the share of missings in the financial statements.

[24] We address potential sample selection issues, whereby firms that go bankrupt due to COVID-19 leave the sample, when we study (attrition in) the unbalanced panel in Appendix D. There is no clear

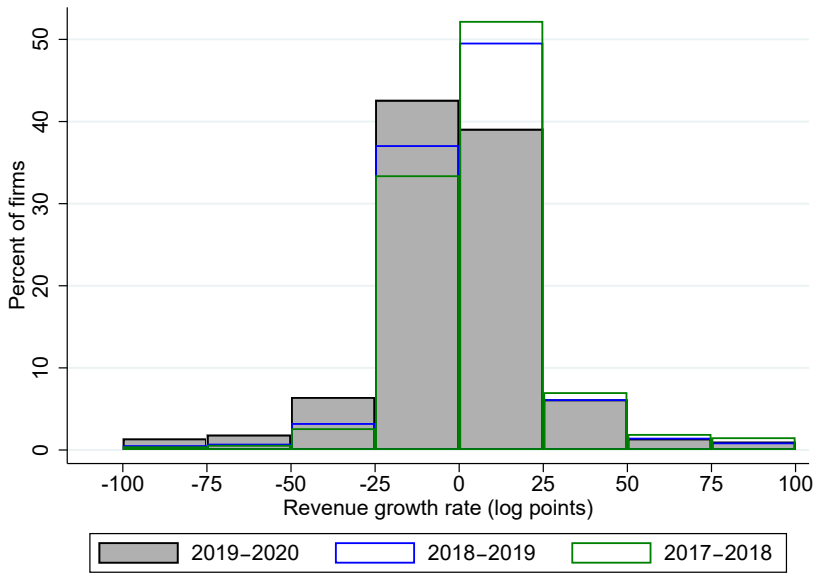

Figure 1. Distributions of firms' rates of revenue growth, 2017 to 2020

Notes: Growth rate of revenues for each year, calculated as one hundred times the difference in log revenues between the current year and the previous one. Balanced panel of 37,655 firms is used to produce the graph.

potential effects we therefore look at the distribution of revenue growth.

Figure 1 shows that firm revenue growth has been substantially slower from 2019 to 2020 compared to the growth rates of 2017–18 and 2018–19. More than ten percent of the mass of firms has shifted from a growth rate in the 0 to 25 percent bin to a growth rate in the -50 to 0 percent bins. This could still be due to the pandemic or to other factors, such as a general slowdown in economic growth and some of which can already be seen between 2017–18 and 2018–19.

An interesting question is therefore how growth rates differ with industry and region, which are also key levels at which the COVID shock varied. Table 1 shows this by help of an analysis of variance (ANOVA) of revenue growth. We report the ANOVA for the growth rates of 2017–18, 2018–19, and 2019–20, distinguishing between two-digit (columns 1–3) and five-digit (columns 4–6) industries.[25] The first row

evidence of system-relevant firms having a different probability to remain in the sample.

[25] A detailed table with full model, residual variation, and F-statistics is in Appendix A.

Table 1. ANOVA decomposition of firm revenue growth - industries and regions

		2-Digit Industries			5-Digit Industries		
		2017–18	2018–19	2019–20	2017–18	2018–19	2019–20
		(1)	(2)	(3)	(4)	(5)	(6)
Total variation		2,485	1,999	3,035	2,485	1,999	3,035
% share by	Industry	0.7***	0.8***	6.7***	3.9***	3.1***	11.9***
	LMR	0.5***	0.5***	0.5***	0.5***	0.5***	0.4**

Notes: ANOVA is run separately for revenue growth in periods 2017–2018, 2018–2019, and 2019–2020 with 37,655 firm observations, respectively. The first three columns are on 82 two-digit industries and labor market regions (141 LMRs), whereas the three following columns report results on 976 five-digit industries. Results of F-tests for the respective contributions of industries and regions are summarized by * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The detailed Table A4 is in the Appendix.

reports the total sum of squares and the following two rows show the explained variation by industries and labor market regions. Compared to 2018–19 and even 2017–18, the variance of revenue growth across firms substantially increased. This indicates that, together with the general decline in economic performance, more turbulence (variation around the mean growth rate) coincided with the COVID shock.

Plenty of firm-specific variation is unexplained in the ANOVA, given that many factors drive individual firms' performance from year to year. Yet in 2020 two-digit industries (82 unique values) can explain about 6.7 percent of the variation in revenue growth while labor market regions (141 values) account for only 0.5 percent. The explained variation when we run the ANOVA on five-digit industries (976 unique values) is almost 12 percent. Decomposing revenue growth in 2017–2018 and 2018–2019, the contribution of regions is similar whereas industries' contribution is consistently and substantially lower (by at least a factor of three).

One implication of industries playing such an important role in the COVID shock is that it should be true across countries. Table A5 in the appendix shows that the additional variation in industry-level performance has indeed high commonality between Germany and Sweden plus the Netherlands, Austria, and France. In the following, we

will use our proxies for industry-level shocks and the commonality across countries to exploit this variation in the context of COVID-19.[26]

3.2 Difference-in-Differences Strategy

We aim to estimate the effect of COVID-19 related factors on firm performance. To this end, we make use of industry variation in system relevance.

We employ a difference-in-differences technique, where we compare firms that are considered as system-relevant to the ones that are not, before and after the COVID-19 pandemic has started. The treatment group is composed of those firms operating in a system-relevant industry while the remainder of firms constitute the control group. System-relevant industries were already classified in 2011, after the 2008 financial crisis to identify the firms that are vital for the functioning of the state. That is, their definition is not endogenous to specific trends induced by COVID-19, including on our outcome variables.[27] The shock we study is the COVID-19 pandemic, which hit the German economy exogenously and unexpectedly.

Difference-in-differences can include detailed conditioning variables when using regression. Our estimation model in levels reads as:

$$\log(rev_{ist}) = \beta_1 SR_s + \beta_2 post_t + \beta_3 (SR_s \times post_t) + \alpha_i + \lambda_t + X_{ist}\gamma + \varepsilon_{ist}, \qquad (1)$$

where $\log(rev_{ist})$ represents the revenues of firm i in industry s at year t. The regressor SR_s is a dummy variable for the respective five-digit industry being system-relevant, i.e., for the firms being in the treatment group. The before and after dummy is denoted by $post_t$. It equals one for 2020 and zero for the years between 2017 and 2019.

[26] We have also studied region-level shocks by average local incidence rates. These results are relegated to Appendix Section Appendix C, since regions are much less important to explain the overall variation in Table 1 and their explanatory power has not increased during the pandemic. Indeed, results on regional shocks turn out smaller and less clear-cut than those at the industry level.

[27] Media and Culture (plus State and Administration, which is public sector and not in BvD data) were added during the COVID-19 period. Our results do not change when we exclude Media and Culture. See Table E4 in the appendix.

Our main regressor is the interaction of the two, with β_3 the parameter of interest. This represents the (conditional) average difference in log revenues between a system-relevant versus a non–system-relevant firm in 2020 compared to the pre-COVID-19 period 2017–2019.

In addition to controlling for differences between system-relevant and other firms pre-COVID-19 (SR_s) and general performance changes during the pandemic ($post_t$), we condition on other factors that might have differentially affected the performance of the treatment group and control group in the post-pandemic period. One such factor are fixed effects α_i, which at the same time account for detailed industries and bring the comparison of log revenues growth to the individual firm level as opposed to differences in performance between the groups.[28] Year dummies λ_t flexibly account for different time effects in the years 2017, 2018, and 2019. Further control variables $X_{ist}\gamma$ include employment size, capital stock (proxied by tangible assets), and labor market region by year as well as, in later comparisons, share of essential workers within the two-digit industry and industry-specific restriction measures aimed at virus containment. The potentially important variables of employment size, capital stock, and fixed effects could not be controlled for using only aggregate data.

One can also write model (1) in first differences:

$$\Delta\log(rev_{ist}) = \beta_2\, post_t + \beta_3\,(SR_s \times post_t) + \lambda_t + \Delta X_{ist}\,\gamma + \Delta\varepsilon_{ist}, \tag{2}$$

where $\Delta\log(rev_{ist})$ are firms' changes in log revenues ("revenue growth") from year $t-1$ to t and $\Delta X_{ist}\,\gamma$ changes in time-varying control variables. Year dummies λ_t and $post_t$ still represent general effects (changes here) during 2017–2018, 2018–2019, and the pandemic period 2019–2020, respectively, whereas time-invariant firm (α_i) and system relevance (SR_s) effects on the level of revenues are differenced out. The estimators (1) and (2) for β_3 converge to the same value under strict exogeneity of ε_{ist} (in a two-period model they are numerically the same) but generally differ in their

[28] This matters when the relative firm sizes within the groups change or, in our estimations in the unbalanced sample, when group memberships change due to entry or exit.

efficiency depending on specific assumptions about the error term's autocorrelation.[29]

We estimate (2) in robustness tests, but our main difference implementation of DiD is more general:

$$\Delta \log(rev_{ist}) = \beta_1 SR_s + \beta_2 post_t + \beta_3 (SR_s \times post_t) + \alpha_i + \lambda_t + X_{ist}\gamma + \varepsilon_{ist}. \qquad (3)$$

Compared to above, (3) allows for baseline differences of revenue growth rates between system-relevant firms at the group (represented by SR_s) or individual (α_i) level.[30] Given this, the coefficient of interest β_3 represents the conditional average difference in log revenue growth between a system-relevant versus a non–system-relevant firm in 2020 compared to the pre-COVID-19 period 2017–2019.

Under the parallel trends assumption and constant treatment effect in the two groups as well as over time,[31] β_3 from specifications (1) or (2) identifies the causal effect of the COVID shock – though not of the policy, see our later discussion – on the revenue performance (in logs or, approximately, percent) of system-relevant compared to non-relevant firms. The parallel trends assumption is that in the counterfactual (absent the shock) revenue growth during 2020 would have been the same for firms that are system-relevant and firms that are not. To assess the plausibility of this, we report the trends of system-relevant firms' relative revenues during the run-up to the pandemic. The alternative model (3) explicitly allows for differential pre-pandemic growth rates of revenues, such that β_3 represents an acceleration or deceleration of

[29] Strict exogeneity requires error terms to be uncorrelated with regressors in all periods, whereas first differences is also consistent under weak exogeneity (contemporaneous uncorrelatedness). This is more of a detail given our explicit identification argument based on the parallel trends assumption below. With serially uncorrelated errors one can show, however, that fixed effects are more efficient (i.e., estimates have smaller asymptotic variance) while with a random walk of the errors, first differences are more efficient. Since the truth is likely in between, we estimate and compare both models.

[30] In regression (1) this can be proxied by including sector- or firm-specific linear time trends, which we explored as an alternative specification.

[31] The second requirement is discussed by, e.g., Chaisemartin and D'Haultfœuille (2023) and in particular implies that system-relevant firms are hit to a different extent by the COVID shock than non–system-relevant firms but that the treatment effect is the same.

system-relevant firms' relative growth rates. The parallel trends assumption here is, absent the COVID shock, a constant differential growth rate of revenues. We estimate both types of specifications, with their alternative identification assumptions, and compare the results. Sensitivity to different controls in $X_{ist}\gamma$ is also studied.

Finally, we include further regulations, such as industry-specific containment measures and essential worker status of employees, to disentangle and quantify the effect of system relevance from these alternative factors. The industry containment index captures the variation in closure measures within non–system-relevant industries. Controlling for this index we provide evidence that our system relevance is not a measure that captures closure measures, but rather a regulation that allows specific industries to supply their products and services. We also account for the share of essential workers, who could be part of both system- and non–system-relevant industries, to disentangle whether the level of treatment is by the types of occupations in an industry as opposed to the whole industry itself.

In all estimations, we weigh firms by their workforce in 2017 to keep sampling weights unaffected by any changes during the study period. To be conservative when allowing for the within-industry correlation of the error terms, standard errors are clustered at the 82 two-digit industries. Clustering at the five-digit level gives similar magnitudes of standard errors. Currently, we do not have data beyond 2020 and as a result restrict our analysis of the COVID shock to that year. Under the assumptions discussed above, our estimates represent the effect of the COVID-19 pandemic on the relative revenues of a firm operating in a system-relevant industry.

4 COVID's Effect on System-Relevant Firms

This section studies the effect of the COVID shock on the performance of firms in system-relevant industries compared to firms that are in non–system-relevant industries. The analysis is entirely conducted in the balanced sample and we turn to the unbalanced one in the robustness Section 6.

4.1 Visual Evidence

We start descriptively. Figure 2 shows the relative revenue growth by sector. This is the coefficients plot from a regression of log revenues onto the interaction between the post dummy and a stratified set of industry indicators, with agriculture the omitted (baseline) sector. Except Construction, Water/Waste, Health, IT, and Finance/Insurance, all sectors performed worse than agriculture. We also distinguish between sectors that are composed fully of system-relevant (black color) or other industries (light gray), and the ones that contain both such industries (dark gray).

Sectors like Accommodation and Food Services or Art and Entertainment performed poorly, with relative drops of revenues around 25–40 percent between pre and post pandemic. Services in these sectors require a lot of personal mobility and contact, which were severely restricted during a large part of the year. These sectors were not classified as system-relevant (e.g., compared to Health, which also requires a lot of personal contact) and thus did not obtain exceptions in terms of containment measure (e.g., quarantine) or any support for their workers in terms of childcare.

The trends in Figure 2 thus seem consistent with prevalent views of how sectors have performed during 2020. Nonetheless, there are many effects on firms' revenue growth from one year to the other as seen in the ANOVA analyses of Section 3.1. These do not cease to operate during this crisis and separating them from the pandemic is needed. One would also like to identify the specific drivers of the pandemic's effect. We hence study the potentially important industry dimension of system relevance.

Figure 3 shows the evolution of system-relevant firms' relative revenues over the sample period. This is done by estimating an event study specification of log revenues onto year dummies interacted with the system relevance indicator of the firm's industry.[32] Since 2019, just before the COVID shock, is the omitted year dummy, relative

[32] In particular, Figure 3 plots γ_τs from the following model (with $\gamma_{2019} = 0$):

$$\log(rev_{ist}) = \sum_{\tau=2017}^{2020} \delta_\tau \times \mathbf{1}[\tau = t] + \beta\, SR_s + \sum_{\tau=2017, \tau\neq 2019}^{2020} \gamma_\tau \left(\mathbf{1}[\tau = t] \times SR_s\right) + \varepsilon_{ist}.$$

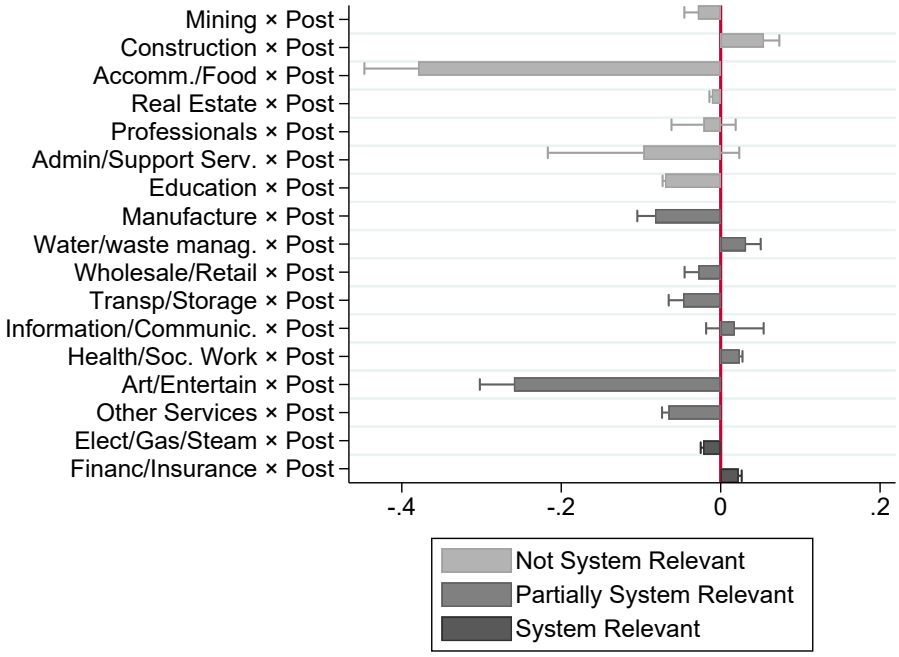

Figure 2. Revenue growth in 2020 (relative to Agriculture and Forestry)

Notes: This graph is from a regression of log revenues on the interaction between the post dummy and 17 sector dummies, absorbing year and firm fixed effects. We plot the point estimate and the 95% confidence interval of the interaction term, i.e., the relative sector-specific revenue growth in 2020. Shadings of the bars that are composed fully of system-relevant two-digit industries, partially system-relevant and non–system-relevant, and of fully non–system-relevant. Agriculture and Forestry (the first sector and partially system-relevant) is omitted. Standard errors clustered at two-digit industry.

revenues are normalized to zero and the other coefficients should be compared to it.

The event study in Figure 3 shows that trends in log revenues were similar between system-relevant and non–system-relevant industries in the years running up to the crisis. Relative revenues were one percent lower in 2018 – small and within the range of statistical error – and almost exactly the same in 2017 as in 2019. This lack of trends is in line with the parallel trends identification assumption of Section 3.

In contrast, relative revenues of system-relevant firms discontinuously and strongly increased in the pandemic year, rising by approximately 7 percent compared to non–system-relevant firms. Although the 95 percent confidence bar is wider than

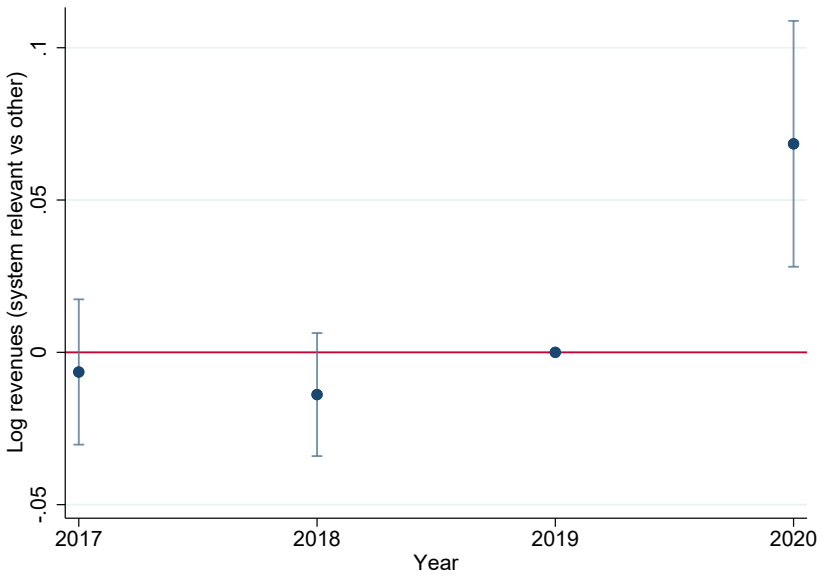

Figure 3. Impact of COVID-19 on system-relevant versus other firms' log revenues

Notes: This graph plots the event study impact of the pandemic (year 2020) on system-relevant firms' relative log revenues. The event study regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the two-digit industry level and 95% confidence bounds drawn around the point estimates.

in earlier years,[33] these differences are clearly statistically significant. Figure 3 thus already depicts our key empirical result: that the COVID shock appears to have had a significant positive effect on system-relevant firms' performance relative to other firms. In the remainder of this section, we will formalize and probe this result as well as study its underlying mechanisms.

4.2 Difference-in-Differences Estimates

Table 2 reports the estimate of the pandemic's effect on system-relevant as opposed to non–system-relevant firms. The first column estimates model (1) in levels of log revenues. This is closely related to the event study specification of Figure 3, showing that the pandemic leads to 7.5 log points (approximately 7.7 percentage points) higher

[33] This is due to the greater variance of firms' revenue growth during 2020 seen in Section 3.1.

revenue growth for system-relevant firms. The top parameter in column (1) further indicates that system-relevant firms have higher revenues in levels. We find that they are also about twice as large in terms of employment and assets in any of the years prior to 2020 (average profits do not systematically differ though).

DiD methods were developed to account for level differences between treatment and control groups. Still, column (2) of Table 2 adds key control variables to the estimation, including detailed firm size dummies and capital stock (proxied by tangible assets, see Section 5) in the initial year 2017 as well as labor market region – all interacted with year. The estimate on system relevance post-pandemic slightly increases, which indicates that it is not explained by differential effects of COVID-19 for firms of different sizes, firms located in different regions, or firms with different initial capital stock. Adding firm fixed effects in column (3), and thereby studying revenue changes conditional on a given firm (i.e., accounting for any unbalancedness in levels also for unobservables), does not affect results either.

The last three columns of Table 2 show results from the difference implementation (3) of the DiD model, with changes of log revenues ("revenue growth") as the outcome variable. Column (4) is similar to column (1) but allows for different growth rates among system-relevant firms already pre-pandemic. The corresponding coefficient turns out to be close to zero, as seen in Figure 3 above . Columns (5) and (6) again add interactions of region and firm size with year as well as firm fixed effects, respectively. The results show that the effect of system relevance on firm performance in the post-period is not driven by differential changes of revenue growth rates across firm size categories, capital stock, regions, or by individual firm composition.[34]

Overall, Table 2 shows a significant and robustly positive effect of the COVID shock on system-relevant firms' performance. The effect size is consistent across specifications at 6–9 percentage points higher revenues in 2020 compared to firms that are

[34] Results remain when dropping the two industries (mining and energy) for which the growth rate of revenues in the BvD data does not correspond to the one from SBS. These results are presented in Table E4. Results in the unbalanced panel are also similar (Table D2).

Table 2. DiD estimates on system relevance

	Log(Rev) (1)	Log(Rev) (2)	Log(Rev) (3)	Rev. Grth (4)	Rev. Grth (5)	Rev. Grth (6)
System relevance	0.944***	−0.193	—	0.002	0.010**	—
	(0.237)	(0.164)		(0.006)	(0.004)	
System relevance × Post	0.075***	0.087***	0.087***	0.072***	0.063***	0.063***
	(0.021)	(0.018)	(0.018)	(0.018)	(0.014)	(0.014)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	No	Yes	Yes
Firm FE	No	No	Yes	No	No	Yes
Observations	150,614	150,614	150,610	112,962	112,962	112,959
R-squared	0.050	0.767	0.994	0.032	0.077	0.370

Notes: The first three columns are from estimations (1), where the outcome variable is log revenues. The last three columns are from estimations (3), where the outcome variable is the change of log revenues ("revenue growth"). "Controls" include firm size category dummies following the SBS definition (five categories, in the initial year), labor market region (141 unique values) and tangible assets (in the initial year) interacted with year dummies. Main effects on post dummy are absorbed by the flexible year dummies. Main effects on system relevance are absorbed by firm fixed effects in columns (3) and (6). Regressions are weighted by the firm's number of workers in the initial year (2017). Standard errors clustered at the two-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

not system-relevant. Given on average a one percent drop of revenues in our sample during 2020, and a 4.6 percent drop of overall German GDP, this is substantial and suggests that the crisis raised system-relevant firms' revenues even in level terms

As discussed above, and in Appendix B with the example financial statement at hand, these outcomes are not directly affected by the government financial support summarized in Section 2.[35] Still, indirect or equilibrium impacts of policy measures would lead to more nuanced interpretations of the estimates in Table 2. For example, the expanded short-term work scheme may have incentivized negatively-hit (non–system-relevant) firms to produce even less than in a counterfactual without or with only the pre-existing scope of the scheme. Demand-stimulating impacts of the tem-

[35] Most importantly among these, loans enter financial statements via "liabilities" in the balance sheet while short-term work allowances are a transitory item not on the income statement.

porary VAT decrease (Bachmann et al., 2021) may also have benefited different types of firms differentially. The estimated effects of system-relevance on firm performance should then be interpreted within the broader policy mix and environment persisting in Germany during the pandemic.

4.3 Alternative Policies

There exist alternative, but related, policies that might have raised system-relevant firms' relative revenues during the pandemic.

We have discussed in Section 2 that workers in essential occupations were exempted from many of the COVID-related restrictions. This included having to physically go to work, not quarantine unless tested positive for COVID-19, and offer longer working hours. Parallel to our main DiD specifications for system relevance, we conduct estimations of COVID-19's effect on firms by the share of essential workers in their two-digit industry. This ranges from zero to one, with mean about 0.17 and standard deviation 0.18 for the occupations that were listed as essential initially ("first hour") and after a revision ("second hour"). Table E3 in the appendix shows that the share of essential workers raises firms' relative revenue growth during 2020. This effect of the pandemic is similar for the share of essential workers of both lists. It is statistically and economically significant as, ceteris paribus, firms with exclusively essential workers in their industry experience about 11–14 percentage points higher revenues during 2020 than firms in industries with no essential workers.

A question is to what extent system relevance and essential occupations constitute distinct variables with different and separate economic effects. We discussed that the two regulations are related, governing worker- and sector-level restrictions, but not perfectly: the correlation between system relevance and share of essential workers at the firm level is 0.53 for essential occupations of the first hour and 0.57 for those of the second hour. The reason is that the share of essential workers does not need to be close to one for the industry to be considered system-relevant. Workers of system-relevant firms still went to work even if their occupation was not classified as essential. At the

same time, essential workers are not only found in system-relevant industries.[36]

The first specifications of Table 3 show results where we include system relevance as well as share of essential workers in the estimations. The pandemic's effect by share of essential workers about halves and statistical significance almost disappears compared to the estimations without system relevance (Appendix Table E3), both for essential occupations of the first hour (column 1) and second hour (column 2). In contrast, the effect on system relevance itself drops rather modestly (from 0.075 in column I of Table 2 to 0.056) and remains statistically significant at the five percent level. These changes in coefficients reflect that system relevance and share of essential workers proxy related regulations, and that the variables are correlated, while in a horse race between the two the effect of system relevance turns out more persistent. Quantitatively, a one standard deviation higher share of essential workers is associated with a bit more than one percentage point higher revenue growth in 2020 (e.g., $0.18 \times 0.069 = 0.012$ in column 2). System relevant industries were also designated earlier while essential occupations were defined as a response to the pandemic.

Another pertinent policy in the pandemic were industry-specific firm closures aimed at virus containment. Specific industries, such as Accommodation, Food and Beverages Services, Creative, Arts and Entertainment Activities and Sports Activities, Amusement and Recreation Activities had to either partially or fully close during the first and second wave of the COVID-19 in 2020. The industry containment index captures the level of closure two-digit industries had to go through. As described in Section 2.2, our containment index for the year 2020 ranges between zero (lowest restrictions) and two (highest) for every day and specific industry. The index is then aggregated at the yearly level with a mean of 1.34 and standard deviation 2.23.

The system relevance indicator and the industry containment index are actually

[36] For example, the Gambling and Betting Activities sector is not a system-relevant industry. However, it contains a high share of workers in security and IT, which are essential occupations. Since Gambling and Betting Activities were still mostly closed during 2020, this example underpins our view (and the results below) that system relevance may be a better measure for the regulations impacting firms' ability to operate in the COVID-19 pandemic.

Table 3. Estimates including share of essential workers and industry-level containment measures

	Log(Rev) (1)	Log(Rev) (2)	Log(Rev) (3)	Log(Rev) (4)	Log(Rev) (5)
System relevance	1.081***	1.115***	0.955***	1.079***	1.112***
	(0.217)	(0.213)	(0.240)	(0.213)	(0.210)
System relevance × Post	0.056**	0.050**	0.074***	0.057**	0.051**
	(0.022)	(0.021)	(0.021)	(0.022)	(0.021)
Share essential workers-I	−0.389			−0.355	
	(0.489)			(0.500)	
Share essential workers-I × Post	0.054			0.050	
	(0.042)			(0.041)	
Share essential workers-II		−0.466			−0.431
		(0.506)			(0.522)
Share essential workers-II × Post		0.069*			0.064
		(0.041)			(0.041)
Industry containment index			0.042	0.039	0.038
			(0.045)	(0.046)	(0.046)
Industry containment index × Post			−0.006	−0.005	−0.005
			(0.006)	(0.007)	(0.007)
Year Dummy	Yes	Yes	Yes	Yes	Yes
Observations	150,618	150,618	150,618	150,618	150,618
R-squared	0.052	0.052	0.052	0.053	0.054

Notes: All specifications estimate equation (1), where the outcome variable is log revenues. Share of essential Work-I denotes the share of essential workers of the "first hour" and Share of essential Work-II the one of the "second hour". The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the two-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

not clearly related.[37] In fact, the COVID shock has no differential effect on firms' rev-

[37] Their correlation at the firm level is -0.014 and statistically insignificant. There are four example cases which help distinguish between system relevance and containment measures. First, Gambling Activities in the two-digit industry classification, are not system-relevant and faced containment measures almost throughout 2020. Their industry containment index is large at on average 7.38. The second case includes hotels (Accommodation), which are not system-relevant but some were still open for the essential workers who had to travel for business. In this case, the containment index is on average 7.14 but not as large as in gambling activities. Third are retail shops (Retail Trade) with a 47 percent share of system-relevant firms. These suffered closure measures and have a containment index of 5.25.

enues by the containment measures of their industry, neither in a DiD estimation with only the containment index (Appendix Table E3) nor when simultaneously including system relevance (column 3 of Table 3). At the same time, the pandemic's differential effect by system relevance is unchanged at about 7 log points higher revenues in that latter specification. The remainder of Table 3 reports that including the industry containment index on top of system relevance and share of essential workers also does not change the coefficients on these variables compared to columns (1) and (2).

This shows results are not exclusively driven by closures of specific industries or in other words by only those that are hard-hit by the pandemic. In a robustness check we exclude two-digit industries that experienced the most severe closures (policy) and that also suffered from a change in consumers' behavior (people being more cautious and avoiding going to hotels, restaurants, theater or fitness studios).[38] The results, in Appendix Table E4, show that effects of system relevance remain within 0.05–0.08.

Overall, this section indicated that system relevance is the most consequential, from the perspective of both statistical and economic significance, for firm revenues of the regulations directly aimed at businesses' operations. This supports the focus on system relevance as an important but so far less studied COVID-related policy.

4.4 Proxying for Industry-Level Demand Changes

The previous sections showed that the COVID-19 crisis had a robustly positive effect on system-relevant firms' relative performance. This matters for policy to the extent that decision makers are concerned with increases in revenues (and profits as shown below) that occurred as a windfall due to the pandemic.

A second policy-relevant question asks whether it is the direct effect of classifying given firms as system-relevant and letting them operate more freely in the restrictive

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The last case is when system-relevant firms never experienced containment measures. For them the containment index is zero (e.g., Human Health Activities, Residential Care Activities).

[38] In particular, the following two-digit industries are excluded: Accommodation, Food and Beverages Services, Creative, Arts and Entertainment Activities, Travel Agency and Tour Operator, Gambling and Betting Activities and Sports Activities, Amusement and Recreation Activities.

environment of the pandemic. Or whether other factors, including changes in demand patterns that occurred among households and businesses in conjunction with the crisis,[39] would have raised such firms' revenues even in absence of the system relevance designation. It seems impossible to fully disentangle such factors, since restrictions to activities and mobility may have interacted with households' own behavioral changes and were influenced by the same underlying force of COVID-19. Yet, one may still want to account for shifts in demand across industries that would have occurred due to COVID-19 anyway – i.e., in a situation without direct government intervention – and in particular where system relevance was not consequential.

Although imperfect, the closest proxy for such an ideal counterfactual is arguably the case of Sweden. Sweden is well-known to have had among the most lenient COVID-related restrictions in the world. At the same time it has an economic structure and society that are not too different from those in Germany. According to the Corona Commission Report in 2022 (Coronakommissionen, 2022) and Brusselaers et al. (2022), Sweden relied on voluntary changes in behavior and personal responsibility rather than strict measures, such as lockdowns, implemented in much of continental Europe. The strategy was to reach herd-immunity in a natural way and avoid shutdowns of social and economic life. Important for Swedish decision-makers was to take measures that are sustainable in the long-run and that are by and large accepted in the population. Hence, they used mainly communication campaigns informing people to, e.g., preserve distance at restaurants and workplaces or to restrict unnecessary family visits, especially of the elderly.

Life in Sweden continued as normal in various respects with notable exception that attendance at large political, religious or cultural events was not allowed (Coronakommissionen, 2022). No economic activity had to seize operations. There were only restrictions in terms of the number of people allowed to attend events (maximum of

[39] As a specific example, consumption patterns of leisure items may have shifted because people found it risky to go outside. This is generally thought to have lowered revenues in hotels, theater venues, dine-in restaurants, etc. and raised them for sellers of home appliances, hardware, consumer electronics, or video streaming businesses.

50 people at a time) and even use of masks was not mandated. Primary and lower secondary schools remained open, while upper secondary and universities education migrated online. This enabled parents with young children to continue work as usual. Similar to Germany, Sweden also highly recommended, but not mandated, work from home and provided large economic support to households (in the form of short-time work, tax deferral, etc.) as well as firms (loans and liquidity relief, support for fixed costs, lower employer contributions, etc.), see Andersen, Holden, and Honkapohja (2022). Sweden as a EU member country also has in place a classification for the critical infrastructures. However, since the whole economy in Sweden was open, there was no need to leverage this regulation. Most of the impact of the pandemic on economic performance in Sweden seems to be driven by individual behavioral changes and shifts in foreign demand (Andersen, Holden, and Honkapohja, 2022).

Section 3.1 showed that the explanatory power of industry affiliation for revenue growth and the commonality of this between Germany and other countries surged in 2020. We now use revenue growth across two-digit industries in Sweden as a proxy for the demand changes that might have occurred in Germany without the system relevance policy (and other restrictions such as the industry-specific containment measures studied above). The first two columns of Table 4 just verify our main results in the slightly smaller subsample where Swedish industries' revenue changes are available.[40] Columns (3, no further control variables) and (4, with our full set of controls) show that industry-level revenue changes in Sweden and Germany are closely related: sectors that in Sweden saw a one log point relative rise of revenues in 2020, experienced a (statistically significant at the one percent level) 0.77 log point relative rise in Germany in column (3). This effect is strong, and it is substantially stronger than in other years (see Table A5), which once more indicates that the pandemic induced changes of fortunes in different industries that exhibit substantial commonality across

[40] We downloaded two-digit industry-level revenues for the years 2017–2020 using Statistics Sweden (SCB)'s Statistical Database https://www.statistikdatabasen.scb.se/. These Swedish official statistics do not include data on Financial Service Activities and Insurance and Mining.

Table 4. Estimates approximating for potential behavioral changes

	Log(Rev) (1)	Log(Rev) (2)	Log(Rev) (3)	Log(Rev) (4)	Log(Rev) (5)	Log(Rev) (6)
System relevance	0.953***	−0.217			1.003***	−0.216
	(0.240)	(0.167)			(0.245)	(0.165)
System relevance × Post	0.074***	0.085***			0.048***	0.058***
	(0.022)	(0.019)			(0.017)	(0.014)
Revenue growth SE			−0.401	−0.241	−1.434	−0.025
			(1.596)	(0.521)	(1.530)	(0.477)
Revenue growth SE × Post			0.772***	0.764***	0.724***	0.706***
			(0.125)	(0.117)	(0.121)	(0.118)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes
Observations	148,954	148,954	148,954	148,954	148,954	148,954
R-squared	0.051	0.770	0.000	0.768	0.053	0.770

Notes: All specifications estimate equation (1), where the outcome variable is log revenues. "Controls" include firm size category (of the initial year), labor market region (141 unique values) and tangible assets (of the initial year) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the 2-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

countries. It also underscores the validity of the firm-level BvD data. [41]

The last two columns of Table 4 report that two thirds of the effect of system relevance remains even if we account for the growth of Swedish industries' revenues during the pandemic. This is the case despite the large own effect of the latter, which mostly persists, and because system relevance and Swedish revenue changes are correlated but way less than perfectly (correlation is equal to 0.19). The effect of system relevance is still a 5–6 percentage points higher revenues compared to other industries in 2020 and statistically significant at the one percent level. One way to interpret

[41] The main effects on revenue growth in this specification (e.g., −0.40 in column 3) are a technical control of the DiD and cannot gainfully be interpreted. Coefficients in Tables A5 (0.712) and 4 (0.772) are close but not exactly the same, since in the first 2020 revenue growth is regressed on Swedish revenue growth whereas in the second log revenue conditional on pre-period controls is the outcome.

these results is that system-relevant firms are to some extent in industries that would have benefited from the crisis even without any regulations or restrictions, since relative demand would have shifted in their favor (e.g., Manufacture of Basic Pharmaceutical Products or Human Health Activities). But to a substantial degree, system relevance also constitutes a distinct factor that is associated with the German policy decision to keep certain sectors operating. An industry that is system-relevant and had higher 2020 revenue growth in Germany than Sweden is for example Manufacture of Food (2.6 versus 0.5 percent), whereas Manufacture of Tobacco Products is not system-relevant and had lower revenue growth in Germany (-10 versus 3.2 percent).

5 Effects on Capital and Profits

We have found that system-relevant firms enjoyed comparative increases in revenues because of the COVID crisis. This section studies the effect of the pandemic on firms' capital and profits as well as whether businesses with larger capital stocks were better able to cope with the crisis. Among other things, we show that system relevance also went in hand with substantial windfall profits.

5.1 Firm Capital

One important question is whether different types of firms, conditional on a specific COVID shock by industry, were more or less able to cope with the crisis. Given the pandemic's well-known impact on social distancing and online activity, it may be that firms with complementary technologies or capital in place were more able to make the shift toward these activities. We have already accounted for the effect by different types of capital in the control variables specification of Table 2. We now examine this more explicitly. In particular, the BvD data provides information on firms' total assets as well as some important sub-components. Total assets are the sum of current assets and fixed assets. Whereas current assets can be converted into cash within a short time frame (usually a year), fixed assets are more long-term and cannot be easily converted

into cash, representing thus the capital investment of a firm.

Table E6 in the appendix reports that, in levels, all asset types are significantly positively related to log revenues, which is simply a reflection of firm size. We lag these variables by one year to not confound estimates with a potential effect of the crisis on capital accumulation and because capital accumulation takes time to have effects on revenues. The interaction terms in Table E6 with the "Post-"dummy are positive for fixed assets and its sub-component of tangible assets, which is our proxy for (physical) capital stock.[42] They are still an order of magnitude smaller than the main effects and about halve when industry$\times$year effects are included. This indicates that, in addition to more capitalized firms being somewhat more resilient, capital stock correlates with industry, which, as we have shown, is an important dimension of the COVID-shock.

In Table 5 we focus on tangible assets for the DiD specifications in our key industry-related dimension of system relevance. The positive effect of COVID-19 on system relevant firms' revenues is somewhat stronger for more capital intensive firms. In column (1), the bottom coefficient on the interaction between system relevance $\times$ log of last year's tangible assets $\times$ Post is 0.012 and significant at the five percent level. That is, system relevant firms in the post period had more than 0.01 percentage points higher revenue growth per one percent higher tangible assets. This interaction effect is still modest and only partly takes away from the main effect, which is a positive 7.2 log points (7.3 percentage points) increase even for less capitalized system-relevant firms. All these estimates are comparable in the alternative specifications of columns (2), with control variables, and (3), with firm fixed effects, and (unreported) with fixed instead of tangible assets.

Another question to be addressed in this section is whether the crisis affected firms' capital accumulation. This could for example be the case if system-relevant firms perceived more opportunities or had more funds at hand given the relatively

[42] Intangible assets and further sub-components (technical and office assets) are harder to study because they are often not filled (including 2020), raising the issue of selection effects in these regressions.

Table 5. Capital stock and firms' resilience to COVID shock

	Log(Rev) (1)	Log(Rev) (2)	Log(Rev) (3)
System relevance	0.017	−0.111**	—
	(0.066)	(0.043)	
Log(Lagged Tangible Assets)	0.656***	0.465***	0.062***
	(0.011)	(0.012)	(0.006)
System relevance × Log(Lagged Tangible Assets)	−0.099***	−0.048***	−0.017
	(0.023)	(0.017)	(0.012)
Log(Lagged Tangible Assets) × Post	−0.007**	0.000	−0.004*
	(0.003)	(0.004)	(0.002)
System relevance × Post	0.072***	0.070***	0.060***
	(0.015)	(0.011)	(0.009)
System relevance × Log(Lagged Tangible Assets) × Post	0.012**	0.010**	0.015***
	(0.005)	(0.004)	(0.003)
Year Dummy	Yes	Yes	Yes
Controls	No	Yes	Yes
Firm FE	No	No	Yes
Observations	112,962	112,962	112,962
R-squared	0.668	0.770	0.996

Notes: All specifications estimate equation (1), with outcome variable log revenues. "Controls" include firm size category (of the initial year), labor market region (141 unique values) and tangible assets (of the initial year) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors clustered at firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

positive impact of the pandemic, or if non–system-relevant firms invested to cushion some of the negative impacts. Table E7 in the appendix shows, however, that there was no detectable effect of system relevance × Post on the level of fixed or tangible assets. This may mean that the above hypotheses are either not as relevant or balance each other out, or that it simply takes time for firms to change their investment plans and implement them. In any case, during the year 2020, capital stocks have not differentially changed between system relevant and non–system-relevant firms. Revenues have diverged substantially even conditional on given relative capital stocks.

5.2 COVID-19's Effect on Profits

We have found that system-relevant firms' revenues substantially increased in the pandemic. We finally want to study whether this has gone in hand with significantly higher profits. This seems especially relevant given current proposals to tax firms' excess profits that accrued during the recent crises.[43]

BvD data only contain profits for a subset of mostly larger firms. In Table 6 we therefore first validate our results on revenues in the subsample that report positive profits throughout 2017–2020 (about 10 percent of firms but representing 43 percent of employment). The estimates are similar to the main effects on revenues of Table 2, with slightly smaller point estimates in the demanding specifications including rich controls and firm fixed effects (columns 2 and 3). Column (4) of Table 6 shows that, among firms which reported positive profits, these were 24.5 log points (26 percentage points) differentially higher in 2020 for system-relevant than non–system-relevant firms. Appendix Figure E1, which shows the event study graph, indicates there is no systematic pre-trend for relative profits in this sample either.

The remaining columns (5) and (6) of Table 6 corroborate the positive effect of the pandemic on profits for system-relevant firms. There are also firms that report zero or negative profits in any of the years 2017–2020. Appendix Table E8 shows an "extensive margin" effect for this larger subsample, whereby the probability to report positive as opposed to zero or negative profits in 2020 increases with system relevance. We also use an inverse hyperbolic sine (arcsine) transformation to include all reported profits in a continuous specification. Again profits of system-relevant firms are substantially larger in 2020 compared to earlier years and non–system-relevant firms.

Overall, we find that system-relevant firms experienced substantial windfall profits as compared to a counterfactual year 2020 without the pandemic.

[43] In addition to national levies in countries like Italy and the UK that have been implemented, on 30 September 2022 the European Council agreed to a temporary solidarity levy on fossil fuel companies' profits for the fiscal years 2022/23 (European Council, 2022). This is to redistribute surplus profits, which in normal times would have not occurred, to the most vulnerable during this crisis.

Table 6. Effects on revenues and profits (subsample with positive profits)

	Log(Rev) (1)	Log(Rev) (2)	Log(Rev) (3)	Log(Prof) (4)	Log(Prof) (5)	Log(Prof) (6)
System relevance	0.187	−0.255	—	−0.165	−0.590**	—
	(0.173)	(0.207)		(0.220)	(0.238)	
System relevance × Post	0.102**	0.050*	0.054***	0.245***	0.222***	0.169**
	(0.039)	(0.026)	(0.017)	(0.074)	(0.074)	(0.074)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	No	Yes	Yes
Firm FE	No	No	Yes	No	No	Yes
Observations	16,274	16,255	16,030	16,274	16,255	16,030
R-squared	0.009	0.459	0.991	0.003	0.257	0.873

Notes: All specifications estimate equation (1), where the outcome variable in columns (1)–(3) is log revenues for positive profits and in columns (4)–(6) it is log profits. "Controls" include firm size category (of the initial year), labor market region (141 unique values) and tangible assets (of the initial year) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the 2-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

6 Robustness Tests

Unbalanced panel. We start the robustness tests by estimating effects in the unbalanced panel. This contains firms that have not reported in specific years in the BvD data as well as ones that exit the market either due to COVID in 2020 or other reasons in any of the years. Although we are not easily able to distinguish between lack of reporting and firms actually exiting, we can at least rule out that results are driven by a combination of the two. First, Appendix Table D1 shows that there is a 1.5–3.5 log points higher probability of remaining in the sample in 2020 for system-relevant firms. This seems consistent with the generally positive impacts we found on firm outcomes. When studying the effects on revenues in the unbalanced panel we always control for firm fixed effects because bigger firms, which report earlier in BvD than smaller ones, are more often system-relevant and would otherwise lead to a selection bias for the year 2020. The results in Table D2 show once more that system-relevant

firms' revenues increased by approximately 5–8 log points.

Excluding specific industries. Next is to check whether results are driven by the industries for which BvD revenue data does not strongly correlate with the official statistics from SBS reported in Figure A1. The first two columns of Appendix Table E4 show that results are robust to the exclusion of these industries (the Mining and Energy sectors). Second, media and culture were added to the list of system-relevant industries during the COVID-19 pandemic via the Bund–Länder Working Group German Federal Office of Civil Protection and Disaster Assistance (2023). To assuage concerns about the nature of this addition, the middle columns of Table E4 remove these sectors, and estimates are again similar. In Table E4's next columns we also remove the health-related industries, such as Human Health Activities and Residential Care Activities, once more with no effect. Finally, in the last two columns of Table E4 we drop those industries that suffered the most from closures (supply) and changes in behavior (demand). The estimates of interest remain intact.

Dropping small firms. We drop small firms with up to 10 workers to ensure that our results are not driven by the emergency aid firms could have obtained in 2020. Estimates are presented in Table E5 and once again similar to the main results.

Effect on Profits. Provided that profits can be negative as well as positive, we also report on the effect of COVID-19 shock for system relevant firms on transformed profits. Profits are transformed using the inverse hyperbolic sine to account for negative values. Thus we obtain results on non-truncated profits sample reported in Table E8. The effect of system relevance is 0.301 in this specification, which is even larger than point estimates in the positive profits subsample of Table 6.

7 Conclusion

This paper has studied firm performance during the first and most incisive year of the COVID-19 pandemic. We first documented different economic dimensions along which firms' revenues (and profits) grew heterogeneously. While regional aspects turn

out negligible during the more tumultuous 2020, industry affiliation has a strong role in explaining the increased heterogeneity among firms. Revenue growth by industry also becomes more synchronized across countries. This indicates a common and substantial pandemic shock that varies by industry.

In the main analysis, we honed in on the performance differences along a specific and important industry-related dimension. System relevant firms have substantially higher revenue and profit growth in 2020 while pre-trends are parallel with non–system-relevant firms. Allowing for other factors, like firm size and capital, or policies, like essential worker status and industry-specific closures, has little effect on these estimates. Our difference-in-differences approach helps study the effect of the COVID shock on system-relevant compared to non–system-relevant firms but not of the policy itself, since general behavior changes induced by the pandemic, as well as indirect effects of government support programs, may have impacted system-relevant firms differentially. To approximate behavior changes, we control for industry-level revenue changes in Sweden, an arguably similar country that does not lever this regulation, finding that system relevance's effect remains significant.

There is an active academic and policy debate about how to support and tax firms in the context of economic shocks. In the face of large COVID-related supply and demand side disruptions, governments provided extensive support to both households and businesses.[44] Some of the programs that offer financial aid for firms to deal with the COVID shock have been studied. Cororaton and Rosen (2021) assess the characteristics of the firms that take up loans as part of the Paycheck Protection Program in the US. Core and De Marco (2021) study the allocation of loans as part of a public guarantee scheme for small businesses in Italy. They show that fragile firms profited early-on from these schemes and that there are important heterogeneities of effects across the sizes and IT capabilities of the banks that offer these loans. Konings, Magerman, Van Esbroeck, et al. (2023) exploit a COVID rescue policy that subsidized firms in the Flan-

[44] E.g., the US provided two trillion dollars of relief funds in 2020 as part of Coronavirus Aid, Relief, and Economic Security Act. Germany allocated €50 billion to small and €600 billion to big firms.

ders regions in Belgium. This policy increased the productivity of subsidized firms without harming the non-subsidized ones.

There exists less evidence on the effects of crisis-related regulations that directly affect business activity, such as the system-relevance designation that we find to significantly predict firms' revenue and profit growth. China's 2022 lockdowns may be considered an extreme case of such regulations. Our results are policy-relevant in that one can use them to identify firms that have tended to suffer or benefit from the COVID crisis, including the extent of this, and to either support them or even tax windfall profits ex post. They are also relevant in providing a first estimate of the costs of such restrictions policies on the firm side (which could be weighed against the benefits). Similar approaches to ours may be used to identify winners and losers from other crises and regulations.

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Appendix for Online Publication

A Descriptives and Validation of Bureau van Dijk Data

Table A1. Summary statistics

A: Full Sample	**Mean**	**Std. dev.**	P_5	P_{50}	P_{95}	**Obs.**
Revenues	22.43	146.92	0.77	2.90	88.66	150,620
Profits	2.73	13.15	0.00	0.50	10.62	24,128
Total Assets	13.67	95.69	0.33	1.40	52.39	150,620
Tangible Assets	2.82	16.70	0.01	0.18	11.12	150,620
Technical Assets	8.71	28.66	0.00	1.20	37.15	17,185
Employment	76.14	292.95	5.00	20.00	315.00	149,193
B: Means by year	**2017**	**2018**	**2019**	**2020**	**2020 — 2019**	**Obs.**
Revenues	21.46	22.63	23.11	22.52	–0.59	150,620
Profits	2.77	2.75	2.63	2.76	0.13	24,128
Total Assets	12.88	13.43	13.94	14.43	0.50	150,620
Tangible Assets	2.66	2.76	2.89	2.97	0.08	150,620
Technical Assets	8.19	8.59	8.83	9.22	0.39	17,185
Employment	75.16	75.81	76.74	76.85	0.12	149,193
C: Standard deviation by year	**2017**	**2018**	**2019**	**2020**	**2020 — 2019**	**Obs.**
Revenues	143.28	156.83	152.35	134.22	–18.13	150,620
Profits	13.31	12.94	13.68	12.64	–1.03	24,128
Total Assets	92.04	93.86	95.76	100.88	5.12	150,620
Tangible Assets	15.92	16.26	16.95	17.61	0.66	150,620
Technical Assets	27.16	28.08	28.75	30.52	1.77	17,185
Employment	358.43	265.55	266.92	271.27	4.34	149,193

Notes: The financial variables are measured annually and expressed in million of euros. Employment is in total headcounts. The sample is the balanced panel of firms during 2017–2020. Panel A present summary statistics of the full sample. Panel B reports the means for each of the years and the difference between 2020 and 2019. Panel C reports the standard deviations for each of the years and the difference between 2020 and 2019.

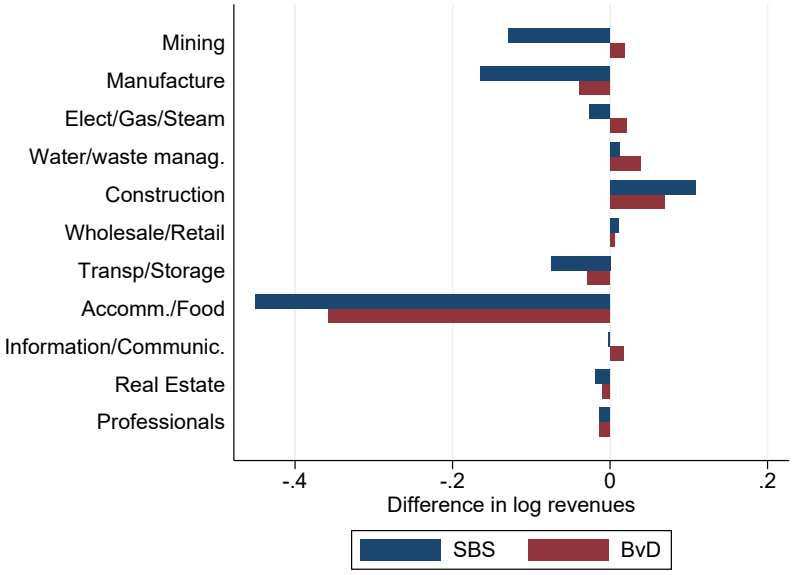

Figure A1. Difference in revenues before and after the pandemic – SBS vs BvD

Notes: The graph compares revenue growth 2019–2020 between SBS and BvD data for the sectors that SBS provides data on. Differently from BvD, SBS lacks data on, Agriculture, Administrative Support Services, Education, Health and Social Work, Financial Activities and Insurance Activities, Art and Entertainment and Other Services. For the BvD data the balanced panel for 2020 is used.

Table A2. Share of economic activity by firm size – comparison of BvD with SBS data

	$[0, 10)$	$[10, 20)$	$[20, 50)$	$[50, 250)$	≥ 250
BvD Data					
Share Employment	0.03	0.08	0.16	0.25	0.49
Share Firms	0.25	0.29	0.27	0.13	0.04
Share Revenues	0.05	0.06	0.13	0.30	0.45
SBS Data					
Share Employment	0.19	0.11	0.12	0.18	0.40
Share Firms	0.83	0.10	0.05	0.02	0.00
Share Revenues	0.10	0.06	0.08	0.17	0.58

Notes: BvD and SBS data are compared with respect to revenues, number of firms and employment for the five firm size categories (SBS definition). Comparison is performed using the balanced sample between 2017 and 2019.

Table A3. Share of economic activity by industry – comparison of BvD with SBS data

	BvD Data	SBS Data
Firm Share		
Mining	0.003	0.001
Manufacture	0.203	0.079
Electricity/Gas/Steam	0.009	0.018
Water/Waste Management	0.011	0.003
Construction	0.175	0.139
Wholesale/Retail	0.234	0.227
Transportation/Storage	0.050	0.042
Accommodation/Food	0.024	0.092
Information/Communication	0.045	0.051
Real Estate	0.018	0.063
Professionals	0.087	0.195
Employment Share		
Mining	0.001	0.002
Manufacture	0.254	0.257
Electricity/Gas/Steam	0.011	0.011
Water/Waste Management	0.008	0.009
Construction	0.072	0.080
Wholesale/Retail	0.169	0.211
Transportation/Storage	0.058	0.077
Accommodation/Food	0.025	0.080
Information/Communication	0.045	0.047
Real Estate	0.007	0.018
Professionals	0.065	0.090
Value Added Share		
Mining	0.005	0.003
Manufacture	0.285	0.345
Electricity/Gas/Steam	0.079	0.025
Water/Waste Management	0.007	0.013
Construction	0.045	0.066
Wholesale/Retail	0.343	0.174
Transportation/Storage	0.037	0.062
Accommodation/Food	0.006	0.027
Information/Communication	0.041	0.071
Real Estate	0.007	0.041
Professionals	0.055	0.094

Notes: BvD and SBS data are compared across industries with respect to firm, employment, and value added share. This is done using the balanced sample during 2017–2019 and across the 11 broad sectors for which we have data in both sources (see also Figure A1). Since we are not printing BvD sectors for which we do not have SBS data, and vice versa, the shares printed in the table do not sum to one.

Table A4. ANOVA decomposition of variation – 5-digit industries and LMRs for 2018 and 2019

	2-digit industries			5-digit industries		
Source	Partial SS	Share (%)	*F*	Partial SS	Share (%)	*F*
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: 2018						
Model	30.09	1.21	2.08	110.26	4.44	1.51
Industry	16.11	0.65	3.03	96.28	3.87	1.51
LMR	13.08	0.53	1.42	12.67	0.51	1.39
Residual	2455.24	98.79		2375.07	95.56	
Total	2485.33			2485.33		
Panel B: 2019						
Model	26.77	1.34	2.30	73.71	3.69	1.25
Industry	15.03	0.75	3.52	61.97	3.10	1.20
LMR	10.69	0.53	1.45	10.36	0.52	1.40
Residual	1972.79	98.66		1925.85	96.31	
Total	1999.56			1999.56		
Panel C: 2020						
Model	224.07	7.39	13.52	382.34	12.62	4.71
Industry	203.59	6.72	33.52	361.86	11.94	5.09
LMR	15.08	0.50	1.44	13.12	0.43	1.29
Residual	2806.54	92.61		2648.26	87.38	
Total	3030.61			3030.61		
Observations per year		37,655			37,655	

Notes: ANOVA is run on the balanced panel. Panel A presents the ANOVA results of the revenue growth in 2018, whereas Panel B presents the ANOVA for 2019 and Panel C the ANOVA for 2020. A cross-sectional version of the data set for 2018, 2019 and 2020 respectively, is used for the three panels. The first three columns show the results of an ANOVA run on two-digit industries (82 industries) and labor market regions (141 LMRs), whereas the three following columns report results of the ANOVA run on five-digit industries (976 industries) and labor market regions. The outcome variable is the revenue growth. Column (2) and (5) report the share of explained variation for the ANOVA on two-digit and five-digit industries, respectively. The critical *F*-statistic $F(140, 36692)$ for LMR is 1.30 for the 1% significance level. The critical *F*-statistic $F(81, 36751)$ for two-digit industries and 0.1 significance level is 1.64, whereas the critical *F*-statistic $F(975, 35857)$ for five-digit industries and 0.1 significance level is 1.22.

Table A5. Commonality in industry-level revenue growth between Germany and four other European countries during 2017–2020

	Revenue Growth DE (BvD)		Revenue Growth DE (SBS)	
	2017–2019	2019–2020	2017–2019	2019–2020
	(1)	(2)	(3)	(4)
Revenue growth SE	0.257***	0.712***	0.266**	0.845***
R-squared	0.002	0.042	0.079	0.649
Revenue growth NL	0.094***	0.611***	0.072*	0.586***
R-squared	0.000	0.028	0.008	0.466
Revenue growth AU	−0.007	0.613***	0.213***	0.939***
R-squared	0.000	0.035	0.109	0.656
Revenue growth FR	0.043***	0.686***	−0.080	1.025***
R-squared	0.000	0.037	0.014	0.717

Notes: Each entry in the table represents the point estimate from a regression of German revenue growth on a specific country revenue growth. Columns (1) and (2) present these results for the firm level data (BvD), whereas columns (3) and (4) report results for aggregated data (SBS). We use SCB data for Sweden. For the other countries we use two-digit industry data from SBS. The point estimate is presented for those industries for which there is data in SBS in each of the respective countries. Robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

One implication of industries playing such an important role in the COVID shock is that this should be true across countries. Table A5 indeed shows that the additional variation in industry-level performance has high commonality between Germany and Sweden plus the Netherlands, Austria, and France. The table reports coefficients from regressing German revenue growth (individual BvD firms in columns 1 and 2; two-digit SBS industry data in columns 3 and 4) onto two-digit industry revenue growth separately for the four other countries. While these coefficients in the preceding years are always small and only partially statistically significant, they are substantial (at least 0.6) and an order of magnitude larger in 2020. They are also statistically significant at the one percent level and R-squared rises at least sixfold. This clearly shows that the COVID shock has hit different industries across countries in the same way.

B Example of a Balance Sheet and Income Statement

We present an annual financial statement of a firm in our sample in order to illustrate the type of information used in the analysis. Searching by the name of the firm and year provided in BvD, one can download the particular financials from the Federal Gazette ("Bundesanzeiger").[45]

Not all firms have to submit an annual financial statement to the Federal Gazzette. Reporting depends on the legal form, type of operations, size, performance and whether they are a subsidiary or not. In particular, legal forms such as corporates (AGs or GmbHs), cooperatives, commercial partnerships (GmbH & Co. KGs, GmbH & Co. OHG with only corporations as partners) have to submit their accounts. Credit institutions, external capital management companies, pension funds and insurance companies have to submit the financial statement regardless of the legal form, performance, or size. Furthermore, all firms, regardless of their legal form, have to submit if they fulfill two out three of the following conditions: (1) total assets over €65 million, (2) revenues exceeding €130 million and (3) an average of at least 5000 employees. BvD is more inclusive than the Federal Gazzette as it draws the data from Crefo credit ratings agency, which in turns collect information from the Federal Gazzette but also financial statements that are directly sent by the firms. Last, subsidiaries can be exempted from the obligation to disclose.

Here we take the example of a large company in the manufacturing sector (chemicals industry) because such firms report on a broader set of entries. The level of detail in the financial statement depends on the size of the firm and the type of operations. For instance, not all firms own intangible assets and there is thus no need to report this entry in the annual accounts. We present the two most important statements of the financial accounts, the balance sheet statement and the income statement.

The balance sheet statement contains the Assets Statement (Aktiva in German) and the Equity and Liabilities Statement (Passiva). These balance each other out, hence the

[45] Bundesanzeiger is the official website where the financial statements of firms registered in Germany are published. These are publicly available data.

name. Figure B1 displays the Assets Statement of our example firm, which contains information on fixed assets (Anlagevermögen), tangible assets (Sachanlagen), financial assets (Finanzanlagen), or current assets (Umlaufvermögen). This is one side of the balance sheet. The other side is the Equity and Liabilities Statement, which is shown in Figure B2. This contains information on equity (Eigenkapital), liabilities (Verbindlichkeiten), as well as other relevant entries (e.g., accruals – Rückstellungen) to the company. In our analysis, we take the information on assets from the balance

Bilanz zum 31. Dezember 2020

Aktiva

	31.12.2020 EUR	Vorjahr EUR
A. Anlagevermögen		
I. Immaterielle Vermögensgegenstände		
1. Selbst geschaffene gewerbliche Schutzrechte und ähnliche Rechte und Werte	138.488,33	470.860,33
2. Entgeltlich erworbene Konzessionen, gewerbliche Schutzrechte und ähnliche Rechte und Werte sowie Lizenzen an solchen Rechten und Werten	420.920,05	411.634,10
3. Geleistete Anzahlungen und Anlagen im Bau	0,00	84.152,07
	559.408,38	966.646,50
II. Sachanlagen		
1. Grundstücke, grundstücksgleiche Rechte und Bauten einschließlich der Bauten auf fremden Grundstücken	13.887.315,02	15.745.377,36
2. Technische Anlagen und Maschinen	123.875.724,50	126.339.862,95
3. Andere Anlagen, Betriebs- und Geschäftsausstattung	1.013.077,07	1.232.433,53
4. Geleistete Anzahlungen und Anlagen im Bau	10.897.817,94	14.155.511,38
	149.673.934,53	157.473.185,22
III. Finanzanlagen		
1. Anteile an verbundenen Unternehmen	7.650,00	7.650,00
2. Beteiligungen	12.806.250,00	12.806.250,00
	12.813.900,00	12.813.900,00
	163.047.242,91	171.253.731,72
B. Umlaufvermögen		
I. Vorräte		
1. Roh-, Hilfs- und Betriebsstoffe	6.183.508,65	6.928.072,76
2. Fertige Erzeugnisse und Waren	17.690.711,26	34.950.530,28
	23.874.219,91	41.878.603,04
II. Forderungen und sonstige Vermögensgegenstände		
1. Forderungen aus Lieferungen und Leistungen	22.895.658,23	17.217.746,29
2. Forderungen gegen verbundene Unternehmen	4.372.209,07	18.596.182,98
3. Sonstige Vermögensgegenstände	37.116.872,33	47.336.670,03
	64.384.739,63	83.150.599,30
III. Guthaben bei Kreditinstituten	30.500.019,83	18.980.266,80
	118.758.979,37	144.009.469,14
C. Rechnungsabgrenzungsposten	311.808,07	292.109,71
	282.118.030,35	315.555.310,57

Figure B1. Balance sheet statement—Assets

Note: The figure shows the Assets side of the balance sheet statement (Aktiva in German).

Passiva

	31.12.2020 EUR	Vorjahr EUR
A. Eigenkapital		
I. Gezeichnetes Kapital	510.800,00	510.800,00
II. Kapitalrücklage	47.348.978,35	57.348.978,35
III. Gewinnrücklagen		
Andere Gewinnrücklagen	5.430.935,08	5.430.935,08
IV. Verlustvortrag	2.034.410,04	-
V. Jahresüberschuss	359.450,37	-
VI. Bilanzverlust	-	2.034.410,04
	51.615.753,76	61.256.303,39
B. Sonderposten für Zuschüsse zum Anlagevermögen	1.320.771,28	1.631.224,72
C. Rückstellungen		
1. Rückstellungen für Pensionen und ähnliche Verpflichtungen	70.948.974,00	67.189.948,00
2. Steuerrückstellungen	350.116,00	1.726.467,00
3. Sonstige Rückstellungen	13.051.953,54	33.048.992,97
	84.351.043,54	101.965.407,97
D. Verbindlichkeiten		
1. Verbindlichkeiten gegenüber Kreditinstituten	51.117.549,88	60.998.026,02
2. Erhaltene Anzahlungen auf Bestellungen	194.414,33	27.649,83
3. Verbindlichkeiten aus Lieferungen und Leistungen	46.060.924,50	52.740.671,78
4. Verbindlichkeiten gegenüber verbundenen Unternehmen	14.881.409,28	20.153.666,43
5. Verbindlichkeiten gegenüber Unternehmen, mit denen ein Beteiligungsverhältnis besteht	184.463,20	155.534,19
6. Sonstige Verbindlichkeiten	25.822.930,14	4.125.516,91
davon aus Steuern: TEUR 1.846 (Vorjahr: TEUR 2.231)		
	138.261.691,33	138.201.065,16
E. Rechnungsabgrenzungsposten	1.931.882,22	2.567.872,66
F. Passive latente Steuern	4.636.888,22	9.933.436,67
	282.118.030,35	315.555.310,57

Figure B2. Balance sheet statement—Equity and Liabilities

Note: The figure shows the Equity and Liabilities side of the balance sheet statement (Passiva in German).

sheet statement.[46]

The other key statement in the annual financial accounts is the income statement (Gewinn- und Verlustrechnung or GuV in German). The income statement of our example firm is presented in Figure B3. It contains information on revenues from sales (Umsatzerlöse), other operating revenues (sonstige betriebliche Erträge), net profits (Jahresüberschuss), and other relevant entries (e.g., taxes – Steuern) to the company. Revenues from sales are the "revenues" in our analysis and net profits is what we use

[46] E.g., for this particular case, we have verified that overall "Sachanlagen" of 150 million EUR in Figure B1 indeed equals the entry in our sample for tangible assets of this firm in 2020.

Gewinn- und Verlustrechnung für die Zeit vom 1. Januar bis 31. Dezember 2020

	2020 EUR	Vorjahr EUR
1. Umsatzerlöse	510.889.097,82	592.453.681,99
2. Herstellungskosten der zur Erzielung der Umsatzerlöse erbrachten Leistungen	421.354.462,04	493.552.190,60
3. Bruttoergebnis vom Umsatz	89.534.635,78	98.901.491,39
4. Vertriebskosten	57.064.685,90	57.030.152,70
5. Forschungs- und Entwicklungskosten	6.586.177,45	6.824.773,21
6. Allgemeine Verwaltungskosten	12.996.635,96	13.702.052,47
7. Sonstige betriebliche Erträge	4.722.047,91	6.543.982,26
davon aus Währungsumrechnung: TEUR 2.038 (Vorjahr: TEUR 1.126)		
8. Sonstige betriebliche Aufwendungen	10.349.066,22	32.845.448,85
davon aus Währungsumrechnung: TEUR 2.178 (Vorjahr: TEUR 1.629)		
9. Sonstige Zinsen und ähnliche Erträge	56.700,70	1.555.425,86
davon aus verbundenen Unternehmen: TEUR 35 (Vorjahr: TEUR 1.555)		
10. Zinsen und ähnliche Aufwendungen	6.803.408,00	7.672.218,02
davon aus Aufzinsung von Rückstellungen: TEUR 5.723 (Vorjahr: TEUR 6.422)		
11. Steuern vom Einkommen und vom Ertrag	-27.543,53	4.472.088,15
davon aus der Veränderung bilanzierter latenter Steuern: TEUR -5.297 (Vorjahr: TEUR -5.223)		
12. Ergebnis nach Steuern	540.954,39	-15.545.833,89
13. Sonstige Steuern	181.504,02	179.671,28
14. Jahresüberschuss (Vorjahr: Jahresfehlbetrag)	359.450,37	15.725.505,17
15. Gewinnvortrag aus dem Vorjahr		65.191.095,13
16. Ausschüttung aus dem Bilanzgewinn		-51.500.000,00
17. Bilanzverlust		2.034.410,04

Figure B3. Income statement

Note: The figure shows the income statement (Gewinn- und Verlustrechnung or GuV in German).

for "profits". The last important variable we use from the BvD data is employment, which is often reported (but not always) in the notes to the financial statement.

C Effect of COVID-19 Local Incidence Rate

This section studies the relationship between firms' revenue growth and an indicator of the COVID-19 shock that varies at the regional level, the *local incidence rate*. It is constructed using the 7-day average incidence rate, where the daily incidence rate is calculated as the number of infected individuals per one hundred thousands inhabitants. The 7-day incidence rate is then aggregated (i.e., averaged) at the yearly level to get a measure for 2020. This measure is a proxy of how labor market regions have been hit by the COVID-19 pandemic. In our regressions we use the log of the

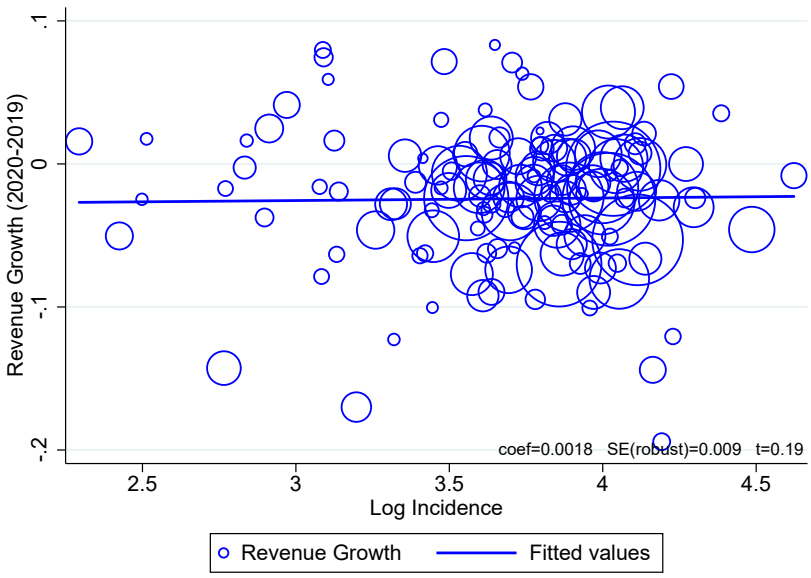

Figure C1. Relationship between revenue growth and incidence rate

Notes: Growth rate of revenues is the difference in log revenues between 2020 and 2019. Number of firms used to produce the graph is 37,655. Each circle represents one of the 141 labor market region, with circle sizes reflecting the number of workers in the initial year (2017) in that region (and the regression line weighed by this).

incidence rate to measure the elasticity of firm revenue growth with respect to it.[47]

Both of these data are retrieved from the official COVID-19 reporting database at the district level, which is maintained by the Robert-Koch-Institute (RKI). Following Kosfeld and Werner (2012) the districts are aggregated into 141 labor market regions covering both West and East Germany. Each district uniquely pertains to one and only one labor market region. We use variation across labor market regions and not districts to account for commuting across districts.

We start by studying the correlation between revenue growth in 2020 and incidence rate in the labor market region where the firm operates. Figure C1 plots the correlation between weighted regional values (by the number of workers in the initial year 2017) of revenue growth in 2020 and average 7-day incidence rate. Circles represent the

[47] An alternative we tried (with similar results) that captures the COVID-19 shock is the local death rate. This is measured as the number of casualties related to COVID-19 per ten thousand inhabitants in a specific district.

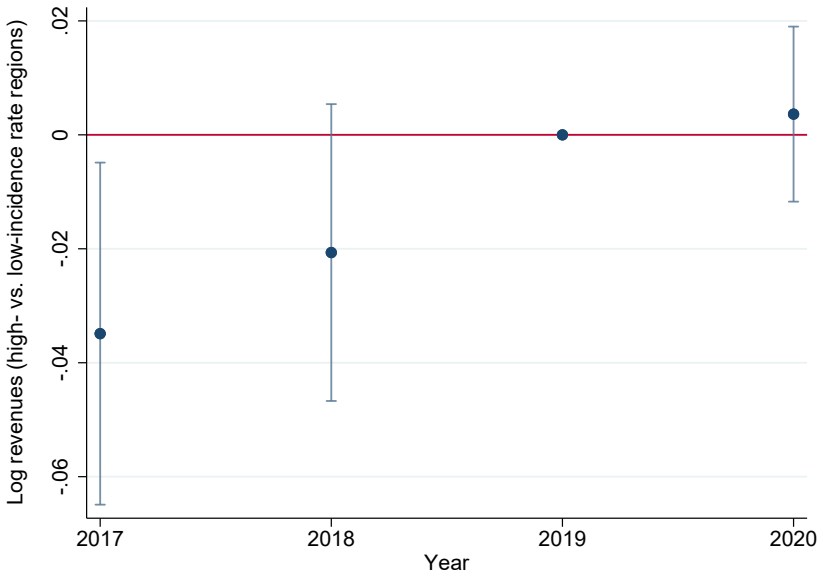

Figure C2. Relative firm revenues in high COVID-19 incidence regions over time

Notes: This graph shows an event study impact of the pandemic (year 2020) on relative log revenues of firms in high incidence rate regions. The event study regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the labor market region level and 95% confidence bounds drawn around the point estimates.

141 labor market regions and their size indicates the number of workers in the initial year in each labor market region. Locations which had a higher incidence rate are associated with a slightly larger increase in revenues. This first piece of evidence hence does not indicate that regions with a higher incidence rate were hindered in performing their economic activity (e.g., because they had to go through more severe closures).

We still want to study performance by incidence rate over a longer period, including any potential pre-trends. We follow the same empirical strategy as for the system relevance presented in Section 3.2. First, we look at whether revenues of high-incidence and low-incidence regions (splitting at the mean incidence rate) have exhibited parallel trends prior to the COVID-19 shock. Figure C2 indicates that revenues do not develop similarly during the pre-period, but instead they increased in high-incidence regions from 2017 to 2019 compared to low-incidence regions. Compared

Table C1. Firm log revenues and local COVID-19 incidence rates

	Log(Rev) (1)	Log(Rev) (2)	Log(Rev) (3)	Log(Rev) (4)	Log(Rev) (5)	Log(Rev) (6)
Post	0.0025	0.0025	−0.0606***	−0.0518	−0.0518	−0.0075
	(0.0072)	(0.0072)	(0.0066)	(0.0675)	(0.0675)	(0.0618)
High Incidence	0.1465	0.1152	−35.0907**			
	(0.1583)	(0.1344)	(15.3632)			
Post × High Incidence	0.0222**	0.0222**	−0.0127			
	(0.0110)	(0.0110)	(0.0111)			
Log Incidence				0.3172	0.2765	−32.9321
				(0.2090)	(0.1902)	(24.1246)
Post × Log Incidence				0.0173	0.0173	−0.0156
				(0.0179)	(0.0179)	(0.0166)
Linear Time Trend × Incidence	No	No	Yes	No	No	Yes
Firm FE	No	Yes	Yes	No	Yes	Yes
Observations	150,616	150,616	150,616	150,616	150,616	150,616
R-squared	0.001	0.002	0.002	0.003	0.003	0.003

Notes: Outcome variable is log revenues. High incidence rate is 1 for values above the mean of the average 7-day incidence rate in the firm's labor market region and 0 otherwise. Log incidence is the logarithm of the average 7-day incidence rate. The regressions are weighed by the number of workers in the initial year (2017). Standard errors are clustered at the labor market region. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

to this, the differences of relative log revenues in 2019 versus 2020 are tiny (they are generally small at about 0.2 percent). To account for the pretends, we include specifications with time trends across high and low incidence rate regions in our regressions that follow.

Table C1 presents the resulting estimates of the DiD model where the treatment is the high incidence rate dummy in specifications (1) to (3) and log incidence rate in specifications (4) to (6). High-incidence regions have statistically significantly higher revenues in 2020 – coefficient on post × high incidence is positive at more than two percentage points – in columns (1) and (2). However, when we account for the pre-trends – via a linear time trend specific to high- and low-incidence regions – in column

(3), this all goes away and the point estimate even turns negative though insignificant. Results using continuous log incidence rates (columns 4–6) are similar and never significant, neither statistically nor economically in either direction.

Overall, these results suggests that there is no detectable effect of local incidence rates on revenue growth. This is consistent with regional variation mattering little for the variance of revenue growth during the pandemic and contrary to the strong role of industry affiliation and system relevance that we found in the main text.

D Unbalanced Panel

Table D1. DiD estimation on retention of firms in the sample

	Retention	Retention	Retention
	(1)	(2)	(3)
System relevance	0.083***	0.082***	—
	(0.029)	(0.029)	
System relevance × Post	0.035*	0.025	0.015
	(0.019)	(0.021)	(0.021)
Year Dummy	Yes	Yes	Yes
Controls	No	Yes	Yes
Firm FE	No	No	Yes
Observations	589,764	589,764	589,760
R-squared	0.031	0.036	0.416

Notes: The outcome variable is a dummy, which equals 1 when the firm is present in the data set in any year between 2017 and 2020 and 0 otherwise. "Controls" include firm size category (of the initial year) and tangible assets (of the initial year) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the two-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table D2. DiD estimates on system relevance for the unbalanced panel

	Log(Rev)	Rev. Growth	Rev. Growth	Rev. Growth
	(1)	(2)	(3)	(4)
System relevance	—	0.000	0.006	—
		(0.005)	(0.004)	
System relevance × Post	0.074***	0.057***	0.056***	0.060***
	(0.019)	(0.018)	(0.015)	(0.015)
Year Dummy	Yes	Yes	Yes	Yes
Controls	Yes	No	Yes	Yes
Firm FE	Yes	No	No	Yes
Observations	329,273	220,832	220,832	187,196
R-squared	0.994	0.011	0.034	0.415

Notes: The first column is an estimation of equation (1), where the outcome variable is log revenues. The three following columns are from estimations of equation (3), where the outcome variable is the change of log revenues ("revenue growth"). "Controls" include firm size category following the SBS definition (of the initial year), labor market region (141 unique values) and tangible assets (of the initial year) interacted with year dummies. The unbalanced panel is used for these estimations. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the two-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

E Additional Tables on System Relevance

Table E1. System relevance and share of essential workers for the 2-digit industries

Industries	Share Sys.Rel	Share Essent-I	Share Essent-II	Ind. Cont. Index
Crop and animal production	1.00	0.038	0.073	0.0
Forestry and logging	0.00	0.065	0.065	0.0
Extraction of crude petroleum and natural gas	0.00	0.081	0.081	0.0
Other mining and quarring	0.00	0.182	0.182	0.0
Mining support service activities	0.00	0.084	0.094	0.0
Manufacture of food products	1.00	0.273	0.274	0.0
Manufacture of beverages	1.00	0.184	0.187	0.0
Manufacture of tobacco products	0.00	0.124	0.131	0.0
Manufacture of textiles	0.00	0.113	0.114	0.0
Manufacture of wearing apparel	0.00	0.139	0.141	0.0
Manufacture of leather and related products	0.00	0.107	0.107	0.0
Manufacture of wood and of products of wood and cork	0.00	0.072	0.074	0.0
Manufacture of paper and paper products	0.00	0.107	0.107	0.0
Printing and reproduction of recorded media	0.00	0.072	0.096	0.0
Manufacture of coke and refined petroleum products	1.00	0.104	0.106	0.0
Manufacture of chemicals and chemical products	0.00	0.107	0.110	0.0
Manufacture of basic pharmaceutical products	1.00	0.185	0.203	0.0
Manufacture of rubber and plastic products	0.00	0.083	0.085	0.0
Manufacture of other non-metallic mineral products	0.00	0.099	0.100	0.0
Manufacture of basic metals	0.00	0.071	0.073	0.0
Manufacture of fabricated metal products	0.00	0.061	0.063	0.0
Manufacture of computer, electronic and optical products	0.04	0.053	0.064	0.0
Manufacture of electrical equipment	0.00	0.063	0.068	0.0
Manufacture of machinery and equipment	0.00	0.062	0.067	0.0
Manufacture of motor vehicles, trailers & semi-trailers	0.00	0.075	0.079	0.0
Manufacture of other transport equipment	0.00	0.058	0.067	0.0
Manufacture of furniture	0.00	0.075	0.075	0.0
Other manufacturing	0.63	0.101	0.285	0.0
Repair and installation of machinery and equipment	0.00	0.068	0.075	0.0
Electricity, gas, steam and air conditioning supply	1.00	0.112	0.126	0.0
Water collection, treatment and supply	1.00	0.362	0.365	0.0
Sewerage	1.00	0.513	0.515	0.0
Waste collection, treatment and disposal activ.	0.36	0.572	0.574	0.0
Remediation activities and other waste management services	0.00	0.254	0.254	0.0
Construction of buildings	0.00	0.022	0.023	0.0
Civil engineering	0.00	0.081	0.082	0.0

Table E1—continued

Industries	Share Sys.Rel	Share Essent-I	Share Essent-II	Ind. Cont. Index
Specialised construction activ.	0.00	0.034	0.035	0.0
Wholesale and retail trade and repair of motor vehicles	0.00	0.107	0.109	2.3
Wholesale trade, except of motor vehicles and motorcycles	0.20	0.251	0.260	5.2
Retail trade, except of motor vehicles and motorcycles	0.22	0.235	0.275	5.3
Land transport and transport via pipelines	0.94	0.749	0.751	0.0
Water transport	1.00	0.251	0.257	0.0
Air transport	1.00	0.088	0.089	0.0
Warehousing and support activities for transport.	0.94	0.575	0.577	0.0
Postal and courier activities	1.00	0.840	0.842	0.0
Accommodation	0.00	0.042	0.043	7.1
Food and beverage service activ.	0.00	0.063	0.064	6.0
Publishing activities	0.00	0.042	0.342	0.0
Motion picture, video and tv production, music	0.00	0.030	0.181	0.0
Programming and broadcasting activities	1.00	0.034	0.341	0.0
Telecommunications	1.00	0.045	0.056	0.0
Computer programming, consultancy	0.08	0.075	0.098	0.0
Information service activ.	0.91	0.086	0.207	0.0
Financial service activities, wøinsurance & pension fund	1.00	0.025	0.779	0.0
Insurance, reinsurance and pension funding, wøsoc. sec.	1.00	0.031	0.692	0.0
Activities auxiliary to financial services and insurance activ.	1.00	0.025	0.553	0.0
Real estate activities	0.00	0.050	0.077	0.0
Legal and accounting activities	0.00	0.011	0.675	0.0
Activities of head offices; management consultancy activ.	0.00	0.109	0.155	0.0
Architectural & engineering activ.	0.00	0.059	0.066	0.0
Scientific research and development	0.00	0.093	0.129	0.0
Advertising and market research	0.00	0.031	0.105	0.0
Other professional, scientific and technical activ.	0.00	0.056	0.079	2.6
Veterinary activities	0.00	0.721	0.957	0.0
Rental and leasing activities	0.00	0.194	0.214	0.0
Employment activities	0.00	0.327	0.329	0.0
Travel agency, tour operator	0.00	0.081	0.090	7.1
Security and investigation activities	0.00	0.882	0.883	0.0
Services to buildings and landscape activities	0.00	0.364	0.366	0.0
Office administrative, office support	0.00	0.158	0.183	0.6
Education	0.00	0.372	0.537	0.0
Human health activities	0.94	0.794	0.813	0.0
Residential care activities	1.00	0.815	0.823	0.0
Social work activities without accommodation	0.56	0.771	0.781	0.0
Creative, arts and entertainment activities	0.00	0.045	0.057	6.2
Libraries, archives, museums and other cultural activ.	0.09	0.133	0.427	6.6

Table E1—continued

Industries	Share Sys.Rel	Share Essent-I	Share Essent-II	Ind. Cont. Index
Gambling and betting activities	0.00	0.501	0.505	7.4
Sports activities and amusement and recreation activ.	0.00	0.133	0.142	3.2
Activities of membership organisations	0.00	0.261	0.333	0.0
Repair of computers and personal and household goods	0.00	0.074	0.081	0.0
Other personal service activities	0.07	0.242	0.288	6.3

Notes: The table provides the share of system relevant firms and share of essential workers of the "first hour" (column 3) and "second hour" (column 4) for each one of the 82 two-digit industries.

Table E2. List of system-relevant 5-digit industries within non-fully system-relevant 2-digit industries

2-digit industries which are not fully system-relevant	**5-digit system-relevant industries**
Manufacture of computer, electronic and optical products	Manufacture of irradiation, electromedical and electrotherapeutic equipment
Other manufacturing	Manufacture of medico-technical instruments and supplies Manufacture of orthopaedic appliances Dental laboratories
Waste collection, treatment and disposal activities; materials recovery	Collection of non-hazardous waste Collection of hazardous waste
Wholesale trade, except of motor vehicles and motorcycles	Agents involved in the sale of agricultural raw materials, live animals, textile raw materials and semi-finished goods Agents involved in the sale of sugar, chocolate and sugar confectionery Agents involved in the sale of other food, beverages and tobacco Agents involved in the sale of pharmaceutical, medical and orthopaedic goods, laboratory equipment, physicians' and dental material and equipment, dentists' instruments, material and equipment for hospitals and for nursing care provided to old people Wholesale of live animals Wholesale of fruit and vegetables Wholesale of meat and meat products Wholesale of dairy products, eggs and edible oils and fats Wholesale of beverages Wholesale of sugar and chocolate and sugar confectionery Wholesale of coffee, tea, cocoa and spices Wholesale of fish, crustaceans and molluscs

Table E2—continued

2-digit industries which are not fully system-relevant	5-digit system-relevant industries
	Wholesale of flour and cereals products
	Wholesale of food n.e.c.
	Non-specialised wholesale of frozen food
	Non-specialised wholesale of other food, beverages and tobacco
	Wholesale of pharmaceutical goods
	Wholesale of medical and orthopaedic goods, dental and laboratory material and equipment
	Wholesale of solid fuels
	Wholesale of liquid and gaseous fuels and related products
Retail trade, except of motor vehicles and motorcycles	Retail sale of food, beverages or tobacco in non-specialised stores
	Other retail sale in non-specialised stores with food, beverages or tobacco predominating
	Retail sale of fruit and vegetables in specialised stores
	Retail sale of meat and meat products in specialised stores
	Retail sale of fish, crustaceans and molluscs in specialised stores
	Retail sale of bread, cakes, flour confectionery and sugar confectionery in specialised stores
	Retail sale of beverages in specialised stores
	Other retail sale of food in specialised stores
	Retail sale on behalf of others of automotive fuel in specialised stores (filling stations acting as agencies)
	Retail sale of private-brand automotive fuel in specialised stores (independent filling stations)
	Dispensing chemist in specialised stores
	Retail sale of medical and orthopaedic goods in specialised stores
	Retail sale via stalls and markets of food, beverages and tobacco products
	Retail sale of fuels from stock
Land transport and transport via pipelines	Passenger rail transport, interurban
	Freight rail transport
	Urban and suburban passenger land transport
	Scheduled long-distance passenger transport by motor bus
	Non-scheduled passenger transport by motor bus
	Land passenger transport n.e.c.
	Freight transport by road
Warehousing and support activities for transportation	Operation of car parks and garages
	Operation of road infrastructure
	Operation of railroad infrastructure
	Operation of terminal facilities for passenger transport, including bus stations

Table E2—continued

2-digit industries which are not fully system-relevant	5-digit system-relevant industries
	Operation of stations for the handling of goods carried by rail or road (except cargo handling)
	Service activities incidental to land transportation n.e.c.
	Operation of waterway infrastructure
	Operation of ports, harbours and piers
	Navigation, pilotage and berthing activities
	Service activities incidental to water transportation n.e.c.
	Operation of airports and airfields
	Service activities incidental to air transportation n.e.c.
	Cargo handling
	Freight forwarding
	Organisation of group consignments by sea
	Other transportation support activities n.e.c.
Computer programming, consultancy and related activities	Computer facilities management activities
Information service activities	Data processing, hosting and related activities
	News agency activities
	Other information service activities n.e.c.
Human health activities	Hospital activities (excluding university hospitals, preventive care and rehabilitation centres)
	Activities of university hospitals
	Activities of preventive care and rehabilitation centres
	Other own-account activities pertaining to human health
Social work activities without accommodation	Domestic social service activities
	Other social work activities without accommodation for the elderly and disabled
Libraries, archives, museums and other cultural activities	Operation of historical sites and buildings and similar visitor attractions
Other personal service activities	Activities of morticians
	Operation of cemeteries and crematoriums

Notes: This table lists all the 5-digit industries, which are system relevant within the 2-digit industries which are partially system-relevant.

Table E3. Difference-in-differences estimates including share of essential workers and industry-level containment measures

	Log(Rev) (1)	Log(Rev) (2)	Log(Rev) (3)	Log(Rev) (4)	Log(Rev) (5)	Log(Rev) (6)
Share essential workers-I	0.731	−0.980***				
	(0.544)	(0.173)				
Share essential workers-I × Post	0.114***	0.128***				
	(0.038)	(0.034)				
Share essential workers-II			0.714	−0.916***		
			(0.551)	(0.186)		
Share essential workers-II × Post			0.123***	0.139***		
			(0.037)	(0.034)		
Industry containment index					0.029	0.075**
					(0.058)	(0.033)
Industry containment index × Post					−0.007	−0.007
					(0.007)	(0.007)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes
Observations	150,620	150,620	150,620	150,620	150,620	150,620
R-squared	0.011	0.780	0.011	0.778	0.001	0.771

Notes: Column (1) and (2) estimate the relative effect of COVID-19 shock for the share of the essential workers of the "first hour". Column (3) and (4) estimate the relative effect of COVID-19 shock for the share of the essential workers of the "second hour". Column (5) and (6) estimate the effect of industry containment index. "Controls" include firm size category following the SBS definition (of the initial year), labor market region (141 unique values) and tangible assets (of the initial year) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the two-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table E4. DiD estimates on system relevance excluding mining and energy sectors (columns (1A) and (1B)), media and culture broad sector (columns (2A) and (2B)), health industries (columns (3A) and (3B)) and industries that suffered the most from closures and consumers' behavioral change (columns (4A) and (4B))

	Log(Rev) (1A)	Log(Rev) (1B)	Log(Rev) (2A)	Log(Rev) (2B)	Log(Rev) (3A)	Log(Rev) (3B)	Log(Rev) (4A)	Log(Rev) (4B)
System relevance	0.908***	–0.226	0.947***	–0.195	0.946***	0.116	0.919***	–0.210
	(0.244)	(0.166)	(0.237)	(0.165)	(0.258)	(0.107)	(0.242)	(0.165)
System relevance	0.077***	0.087***	0.076***	0.087***	0.061***	0.075***	0.065***	0.078***
× Post	(0.022)	(0.019)	(0.021)	(0.018)	(0.019)	(0.016)	(0.021)	(0.019)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	148,142	148,142	150,431	150,431	147,862	147,862	147,770	147,770
R-squared	0.046	0.771	0.050	0.768	0.038	0.782	0.048	0.771

Notes: Columns (1A) and (1B) estimate the equation (1) excluding the mining and energy sectors. Columns (2A) and (2B) excluding the broad sector of media and culture. Columns (3A) and (3B) exclude health industries, namely Human Health Activities and Residential Care Activities. Columns (4A) and (4B) exclude the industries that suffered the most from closures and consumers' behavioral change, namely Accommodation, Food and Beverages Services, Creative, Arts and Entertainment Activities, Travel Agency and Tour Operator, Gambling and Betting Activities and Sports Activities, Amusement and Recreation Activities. "Controls" include firm size category following the SBS definition (of the initial year), labor market region (141 unique values) and tangible assets (of the initial year) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the two-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table E5. DiD estimates excluding firms with up to ten workers in 2019

	Log(Rev)	Log(Rev)	Rev. Grth	Rev. Grth
	(1)	(2)	(3)	(4)
System relevance	0.923***	−0.197	0.001	0.010**
	(0.235)	(0.165)	(0.006)	(0.004)
System relevance × Post	0.096***	0.091***	0.072***	0.063***
	(0.022)	(0.018)	(0.018)	(0.014)
Year Dummy	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Observations	142,613	142,613	104,961	104,961
R-squared	0.050	0.766	0.032	0.079

Notes: The first two columns are from estimations (1), where the outcome variable is log revenues. The last three columns are from estimations (3), where the outcome variable is the change of log revenues ("revenue growth"). "Controls" include firm size category following the SBS definition (of the initial year), labor market region (141 unique values) and tangible assets (of the initial year) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the two-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table E6. Correlation between log revenues and key assets post COVID-19 shock

	Log(Rev) (1)	Log(Rev) (2)	Log(Rev) (3)	Log(Rev) (4)	Log(Rev) (5)	Log(Rev) (6)
Log(Lagged Total Assets)	0.776***			0.789***		
	(0.009)			(0.011)		
Log(Lagged Total Assets) × Post	0.010***			0.006		
	(0.003)			(0.004)		
Log(Lagged Fixed Assets)		0.466***			0.457***	
		(0.011)			(0.013)	
Log(Lagged Fixed Assets) × Post		0.011***			0.005	
		(0.003)			(0.004)	
Log(Lagged Tangible Assets)			0.439***			0.440***
			(0.012)			(0.014)
Log(Lagged Tangible Assets) × Post			0.008**			0.003
			(0.003)			(0.004)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry#Year	No	No	No	Yes	Yes	Yes
Observations	112,962	112,962	112,962	112,959	112,959	112,959
R-squared	0.909	0.790	0.768	0.925	0.830	0.817

Notes: Outcome variable is log revenues. "Controls" include firm size category following the SBS definition (of the initial year) and labor market region (141 unique values) interacted with year dummies. Columns (4) to (6) control in addition for the interaction term between two-digit industries and year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table E7. Difference-in-differences estimates: effects on tangible assets

	Log(Tangible Assets) (1)	Log(Tangible Assets) (2)	Log(Tangible Assets) (3)
System relevance	1.759***	1.015***	—
	(0.486)	(0.332)	
System relevance × Post	−0.010	0.006	0.009
	(0.027)	(0.018)	(0.018)
Year Dummy	Yes	Yes	Yes
Controls	No	Yes	Yes
Firm FE	No	No	Yes
Observations	150,618	150,618	150,618
R-squared	0.096	0.479	0.990

Notes: "Controls" include firm size category (of the initial year) and labor market region (141 unique values) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the 2-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

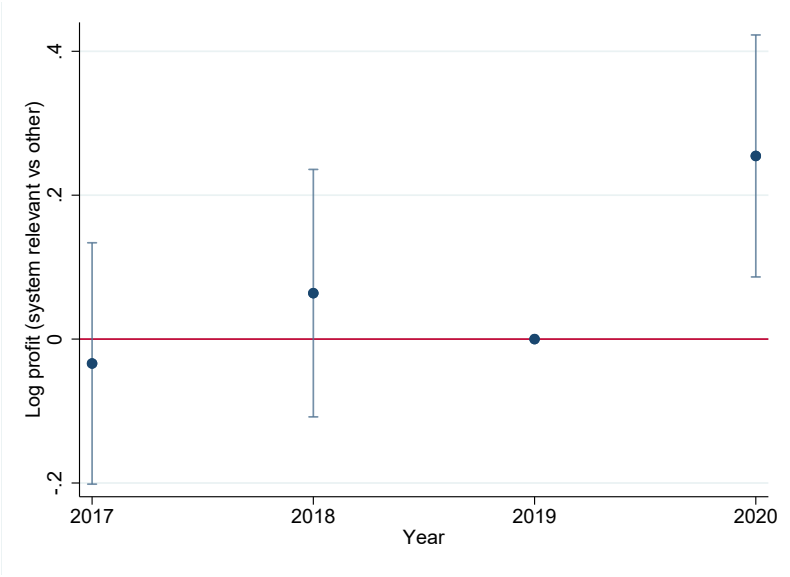

Figure E1. Impact of COVID-19 on system-relevant versus other firms' log profits

Notes: This graph plots the event study impact of the pandemic (year 2020) on system-relevant firms' relative log profits, for those firms that report positive profits. The event study regressions are weighted by number of workers in the initial year (2017). Standard errors clustered at the two-digit industry level and 95% confidence bounds drawn around the point estimates.

Table E8. Difference-in-differences effects on profits including zeros and negatives

	$\mathbf{1}[\text{Profit} > 0]$			Arc(Profit)		
	(1)	(2)	(3)	(4)	(5)	(6)
System relevance	0.077*	0.086**	—	−0.010	−0.145	—
	(0.041)	(0.040)		(0.134)	(0.137)	
System relevance × Post	0.079**	0.053*	0.054*	0.353***	0.296***	0.301***
	(0.040)	(0.029)	(0.030)	(0.122)	(0.094)	(0.094)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	No	Yes	Yes
Firm FE	No	No	Yes	No	No	Yes
Observations	24,126	24,122	24,118	24,126	24,122	24,118
R-squared	0.012	0.115	0.831	0.004	0.145	0.804

Notes: Columns (1) to (3) report the difference-in-difference estimates where the outcome is a dummy variable, which equals 1 for positive profits and 0 otherwise. Columns (4) to (6) report the results for the outcome Arc(Profit). In this case profits are transformed using the inverse hyperbolic sine, i.e. $\text{arcsinh}(x_i) = \log\left(x_i + \sqrt{x_j^2 + 1}\right)$. "Controls" include firm size category following the SBS definition (of the initial year), labor market region (141 unique values) and tangible assets (of the initial year) interacted with year dummies. The regressions are weighted by the number of workers in the initial year (2017). Standard errors are clustered at the 2-digit industry level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.