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ABSTRACT

Productivity is a key determinant of the sustainability of the public finances. While the initial impact of Covid-19 on labor productivity growth shows a surprisingly positive impact, the impact on total factor productivity (TFP) is less clear. We evaluate this with new survey data on labor and capital inputs, outputs and prices from a UK firm panel survey. We find that Covid-19 reduced private sector TFP by up to 4% during the pandemic, with a projected 1% reduction over the medium term. These numbers comprise a large reduction in 'within-firm' productivity as intermediate costs increased due to measures like protective equipment, screens, hand sanitizer and lower capacity utilization. This was partly offset, however, by a positive 'between-firm' effects as less productive sectors, and less productive firms within them, contracted. This highlights how the Covid-19 shock has had large, but offsetting, within and between firm impacts on aggregate TFP.

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Introduction

The global spread of Covid-19 has led to a widespread economic contraction and reorganization, with significant effects on standards of living and the public finances. The impacts on productivity, however, are more complex but equally important. Before the pandemic US, UK and EU productivity growth rates had been declining[1], registering average growth rates of less than 1% in the decade *pre-pandemic*. Given this low starting level the pandemic could potentially drive productivity growth into zero or negative territory, lowering living standards and placing a huge strain on the public finances.

Looking at the official statistics, the situation is complex. The initial impact of Covid-19 on US *labor* productivity growth – defined as value-added per hour worked – has actually been positive. Over the year to 2021Q1, US labor productivity per hour grew by 3.2% compared to the year to 2020Q1. Moreover, this represented the fastest four quarters of labor productivity growth in the US since 2010.[2] The UK business sector also recorded a similarly buoyant *labor* productivity growth, of 2.5% over the same period.[3] The reason is, perhaps surprisingly, that hours worked over the pandemic fell faster and recovered more slowly than measured value-added, so value-added per hour worked increased.

In contrast *total-factor* productivity – value-added normalized by a combination of capital and labor inputs – fell in the UK by 4.5% over this period (with US data not yet available). The main reason is while labor inputs fell during the pandemic, capital inputs were roughly flat as the pandemic-period fall in investment flows had a relatively small impact on the capital stock.

This paper evaluates and unpacks these macro aggregates using unique firm-level survey data from the Decision Maker Panel (DMP), a large and representative monthly panel survey of UK firms. Over 5,000 firm panel members were asked about the impact of Covid-19 on the main components of productivity, covering labor and capital inputs, outputs and prices.

Our new survey data shows that these reported impacts account for much of the realised changes in the firm-level data. Using both labor productivity and total factor productivity (TFP) we decompose the aggregate impacts into 'within-firm' and 'between-firm' effects (hereafter within and between effects) using the accounting framework of Baily et al. (1992). We do this for the period during the Covid pandemic and we assess the possible longer-term impacts.

Our estimates suggest that Covid-19 lowered *total factor productivity* in UK private sector by up to 4% during the pandemic, consistent with the fall in TFP in official data (Table 1). The main driver was businesses reporting a large reduction in productivity within firms. This was mainly because measures to contain Covid-19, like protective equipment, screens, hand sanitizer and lower capacity utilization led to higher intermediate costs.

The negative within-firm effect is partially offset by a positive 'between' effect from two channels – low-productivity sectors shrank, and the least productive firms within these sectors suffered most (Figure 1). The sector result arises because the lowest productivity sectors tend

[1] On the continuing decline in productivity growth see for example Jones (2009), Cowen (2011), Gordon (2016), and Bloom et al. (2020)).

[2] Quarter-on-quarter US hourly labor productivity growth in 2020 Q2 was also the highest since 1971 (see https://fred.stlouisfed.org/series/OPHNFB#0).

[3] UK hourly labor productivity data are available at: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/timeseries/gyy7/prdy

to involve more face-to-face activity – travel, leisure, retail etc – and so contracted as a share of value-added. The firm result arises because the pandemic appears to more severely affected lower productivity firms within sectors, possibly because they struggled to deal with the need for rapid pandemic re-organization. This positive between effect on productivity, however, is not the usual Schumpeterian process of *creative destruction*, whereby lower productivity firms are replaced by higher productivity firms. Instead, much of this is simply *destruction* of low productivity sectors. So, while this increases productivity it will reduce total economic output.

In contrast, the overall effects of Covid-19 on hourly *labor productivity* are estimated to have been positive during the acute phase of the crisis, again consistent with official data.[4] Hours worked – the only input controlled for when estimating labor productivity – dropped by around 40% in 2020Q2, with only a partial recovery after that. This drop was similar in magnitude to the fall in value-added, although increased intermediate costs meant that there was a negative within firm impact. But that was more than offset by the positive between-firm effects, such that we find a positive overall impact on labor productivity.

To gauge the effects over the medium term we take a different approach, which is made possible by the unique nature of our survey of business leaders. We ask managers about the expected impacts of Covid-19 on factor inputs, outputs and prices in 2022+. We estimate that the pandemic will reduce TFP and labor productivity by about 1% over the medium term (a combined result of within- and between-firm effects), equivalent to more than one year of pre-pandemic productivity growth. The implications of this is for public policy are important, implying tighter future fiscal policy and more challenging trade-offs for monetary policy in balancing demand and supply factors.

This paper draws together four strands of literature, on the link between productivity in the aggregate and (1) the firm level and (2) the business cycle, on business surveys, and on the economic impact of Covid-19.

First, the literature on using micro-data to analyse the drivers of macro productivity. Baily et al. (1992) developed the formula to decompose productivity changes into 'within' and 'between' which we employ in this study. Their decomposition has been extensively used in the productivity literature (see, e.g. Foster, Haltiwanger and Syversson (2001) or Syversson (2011)). Bartelsman et al. (2013) show that differences in the covariance between size and productivity drive productivity differences across countries, while Hsieh and Klenow (2009) highlight the importance of misallocation for productivity.

Second, there is a literature on the link between productivity growth and business cycles, of which the Covid-19 induced recession is an extreme, albeit idiosyncratic, example. Fernald and Wang (2016) show that TFP has been roughly acyclical in the US since the mid-1980s. In contrast, Ball (2014) shows that the recession of 2008-9 had persistent negative effects on output among a sample of 23 OECD countries, and Cerra and Saxena (2008) show that output does not return to trend following recessions in a broader sample of countries and time periods.

[4] The effects on labor productivity *per job* are estimated to be negative throughout, particularly in 2020 Q2 and Q3 (-27% and -11% respectively), as the number of jobs has fallen by much less than hours worked due to workers being put on furlough under the Government Coronavirus Job Retention Scheme (jobs on furlough are assumed to remain but at zero hours). We focus on the more economically meaningful measures in this context of hourly labor productivity and TFP.

Third, we contribute to the literature on using business surveys to evaluate the impact of major shocks (see Altig et al. 2020b and Bhandari et al 2020). The use of these large, high-frequency forward-looking firm surveys to measure the productivity impact of shocks – both the within and between elements – is novel and highlights the value of large-scale, representative firm surveys for analysing the impact of major economic shocks.

Lastly, our paper is one of many in a rapidly growing literature on the economic impact of Covid-19, which are already too numerous to cite and many of which are surveyed in Brodeur et al. (2020). Some examples include Alekseev et al. (2020), Bartik et al. (2020a and 2020b), Brynjolfsson et al. (2020), Buffington et al. (2020), Bloom, Fletcher and Yeh (2020), Gourinchas et al. (2020), and Papanikolaou and Schmidt (2020) who show pervasive impacts on firms. Baqaee and Farhi (2020) show that negative sectoral supply shocks can be stagflationary and can be amplified by complementarities in production, Chetty et al. (2020), Forsythe et al. (2020) and Cajner et al. (2020) show large and heterogeneous labor market impacts of Covid-19, Adams-Prassl et al. (2020), Alon et al. (2020) and Mongey et al. (2020) and show the gender impact of the pandemic, Guerrieri et al. (2020) show that supply shocks can cause demand shortages, and Jorda et al. (2020) examine the longer-run consequences of past pandemics. Productivity growth is already low, our paper assesses the additional impact of Covid-19. Most recently, Andrews et al. (2021) have found evidence of a positive reallocation effect from Covid among small businesses in Australia, New Zealand and the UK.

Section 2: The Decision Maker Panel (DMP)

Survey methodology

The DMP is a large and representative online survey of Chief Financial Officers in UK businesses.[5] It is similar in style to the Survey of Business Uncertainty run in the United States by the Federal Reserve Bank of Atlanta (Altig et al. (2019)). The survey asks about recent developments and expectations for the year ahead on sales, prices, employment and investment. An important advantage of the DMP survey relative to many other business surveys is the quantitative nature of the data that it collects.

The sampling frame for the DMP is the population of UK businesses with 10 or more employees in the Bureau van Dijk FAME database.[6] The DMP it has averaged just under 3,000 responses a month since 2019, covering around 10% of total UK employment. Covid-19 has not had a large impact on the DMP response rate.[7] DMP data match up well with the corresponding audited information from company accounts for variables such as sales and employment. Businesses report relatively accurate predictions about their future sales, employment and prices and, to a lesser extent, investment.

The survey data that we use in this paper were collected between July 2020 and August 2021. For each firm we use the most recently available data point for each question. Around 2,900

[5] See Bloom et al. (2019) for analysis of the impact of Brexit on UK businesses using data from the DMP.
[6] FAME is provided by Bureau Van Dijk (BVD) using data on the population of UK firms from the UK Companies House. FAME itself is part of the global AMADEUS database.
[7] Figure A1 in the Appendix shows the number of monthly responses and the response rate. Table A1 presents some regressions showing that changes in response rates during the Covid pandemic have not been larger in sectors more affected by Covid and have not been correlated with firm-level productivity. See Bloom et al. (2020c) for further details.

firms in the DMP survey have answered all of the relevant questions at least once during this period and have all the accounting data necessary to calculate pre-Covid-19 labor productivity and TFP.[8]

Section 3: Analytical framework

Our goal is to measure and decompose the aggregate impact of Covid-19 on both labor productivity and total factor productivity. To this end, we measure productivity at the firm level in the pre-Covid period using accounts data, and then use the DMP to estimate the impact relative to this baseline, inferring this impact from reported effects on inputs and outputs among the DMP respondents.

Measuring the impact of Covid-19 on inputs and outputs using the DMP

Since April 2020, the DMP survey has included questions about the expected impact of Covid-19 on respondents' sales, employment, and investment. The questions are of the form: '*Relative to what would have otherwise happened, what is your best estimate for the impact of the spread of coronavirus (Covid-19) on the sales/employment/investment of your business in the following quarters?*' These questions ask about the impact in the current quarter and about expectations for the following three quarters and 2022+. Respondents provide numerical responses to these questions. This direct approach to gauging the impact effects of a shock is different to other studies that estimate the productivity impact of shocks using before-after comparisons or some natural experiment with treatment-control comparison.

To estimate the impact of Covid-19 on total hours worked, we use data on the impact of Covid-19 on employment, the average hours worked of employees who remain active, and data on the percentage of employees on furlough.[9] Since June 2020, businesses have also been asked about the impact of measures to contain Covid-19 on their unit costs.[10] To assess the impact of Covid-19 on the capital stock, we cumulate the reported effects of Covid-19 on investment at the firm level and assume an annual depreciation rate of 4% and no additional capital scrapping.[11] For prices, the DMP asks firms about changes in output prices over the past year and about expectations for the next year.[12] Here we assume that the change in output price inflation, relative to 2019, was the effect of Covid-19. We calculate price effects at the 1-digit industry level rather than firm level. Overall, we find that the effects of Covid-19 on both capital and prices are small (see Figure 2), so neither of these assumptions have large impacts on our productivity calculations.[13]

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[8] Our analysis covers 8 different time periods. All firms must have answered questions for at least 4 of those time periods to be included in the sample. Where data for a variable is not available for any time period it is imputed using responses for that firm for the nearest available time period. This imputation is done by industry.

[9] Workers being furloughed and working no hours accounts for most of the initial fall in hours worked in 2020 Q2, but by 2021 Q4 most of the reduction in hours worked is expected to be via lower employment.

[10] The wording of this question is 'Relative to what would otherwise have happened, what is your best estimate for the impact of measures to contain coronavirus (social distancing, hand washing, masks and other measures) on the average unit costs of your business in each of the following periods?'

[11] Annual investment approximates to 6% of the capital stock in the UK. The depreciation assumption is consistent with aggregate UK data. The assumption of no additional capital scrapping poses some downside risk to our capital estimates.

[12] For detailed list of all questions please visit: https://decisionmakerpanel.co.uk/wp-content/uploads/2021/05/List-of-questions-up-until-May-2021.pdf

[13] We assume that the impact on prices does not persist over the medium term (2022+).

Firm-level productivity

We use 2017-2019 accounting data from Bureau van Dijk's FAME dataset to calculate each measure of productivity in the pre-Covid period for all firms in the survey.[14] Labor productivity is calculated as real value-added (operating profits plus total labor costs divided by the aggregate GDP deflator) per employee using accounting data. TFP is calculated as the residual from a production function, $ln(VA_{it}) = (2/3)ln(L_{it}) + (1/3)ln(K_{it})$, where VA_{it} is real value-added of firm i in year t, L is labor input which we measure as total remuneration (wage bill) and K is capital, measured as total real fixed assets.[15] Nominal values from accounting data are deflated using the GDP deflator. The elasticities of output with respect to capital and labor are assumed to be 1/3 and 2/3 respectively, to align with their economy-wide factor shares.

We measure the proportional impact of Covid-19 at the firm level on real final sales dy and infer the impact on value added dv in a manner analogous to the national accounts:

$$dv = (dy - s_M dm)/(1 - s_M)$$

where dm is the impact on intermediates and s_M is the share of materials in final sales. We define the impact of Covid on value-added total factor productivity da as the impact on value-added less the impact on elasticity-weighted inputs:

$$da = dv - \alpha dk - \beta dl$$

where dk and dl are the proportional impacts on the firm-level capital stock and labor input respectively, measured in heads or hours, and α and β are the corresponding elasticities of value-added. Three important things to note about our definition of da are that (1) we are measuring differentials dx with respect to the impact of Covid-19, not time or any other variable, (2) we measure the capital stock rather than capital services, and (3) we do not quality-adjust labor input other than by using the wage bill rather than employment in heads or hours.

In order to map this into our survey questions, we define unit costs, M_u=M/Y, as the volume of intermediates per unit of real final sales, such that the change in intermediates dm is $dm_u + dy$. We then have:

$$\begin{aligned} da &= dv - \alpha dk - \beta dl \\ &= (dy - s_M dm)/(1 - s_M) - \alpha dk - \beta dl \\ &= \big(dy - s_M(dm_u + dy)\big)/(1 - s_M) - \alpha dk - \beta dl \\ &= dy - \frac{s_M dm_u}{(1 - s_M)} - \alpha dk - \beta dl \end{aligned} \qquad (2)$$

[14] Figure A2 in the Appendix shows that these measures of labor productivity constructed from accounting data correlate well with official data at the industry level.

[15] Usually TFP would be normalized at the industry level. We do not do this because we require differences in the level of productivity between industries to consider the effects of reallocation between industries on aggregate productivity.

We measure firm-level changes in value-added TFP with this equation.[16]

Decomposing productivity into within and between effects

In order produce an estimate of the impact of Covid-19 on aggregate productivity in the UK, we follow Baily *et al.* (1992):

$$\Delta\Pi_t = \sum_{\mathrm{i}\in\mathrm{Surv}} \bar{\varphi}_i \Delta\pi_{\mathrm{i,t}} \quad \text{… within firms} \tag{7}$$

$$+ \sum_{i\in Surv} \Delta\varphi_{i,t}(\bar{\pi}_i - \bar{\Pi}) \quad \text{… reallocation between surviving firms} \tag{8}$$

$$+ \sum_{i\in\Delta Entry} \varphi_{i,t}(\bar{\pi}_i - \bar{\Pi}) \quad \text{…. reallocation to new firms} \tag{9}$$

$$- \sum_{i\in\Delta Exit} \Delta\varphi_{i,t-1}\left(\pi_{i,t-1} - \bar{\Pi}\right) \quad \text{…. reallocation from exiting firms} \tag{10}$$

Here $\pi_{i,t}$ is GVA per head/hour in firm *i* at time *t,* Π_t is aggregate GVA per head/hour at time *t,* $\varphi_{i,t}$ is the employment/hours share of firm *i* at time *t* and a bar over a variable indicates the average of the variables across times *t*-1 and *t*. Δ is with respect to Covid-19, not time. Δ*Entry* and Δ*Exit* denote firms that entered or exited due to Covid-19.

The within effect measures the contribution of changes in firm-level productivity for a given allocation of labor across firms. The between effect is the impact on total productivity of a reallocation of inputs towards firms with lower or higher levels of productivity. Productivity levels are measured as an average of periods *t* and *t*-1. There is an additional between effect arising from the birth or death of firms which depends on both the rate of entry and exit and whether firms that are born or die have productivity levels different to the average.

Section 4: Results

Here we first describe the within effects and then the between effects before combining them and summarising the overall impact.

Within-firm effects

Businesses, on average, estimated that Covid-19 led to a very sharp fall in sales of just over 30% in 2020Q2 (on an employment-weighted basis), relative to what otherwise would have happened (Figure 2 Panel A).[17] This masks large dispersion between industries in 2020Q2. For example, in the worst affected industries – accommodation and food and recreational services – estimated sales were almost 80% lower than they would have been, compared to around 15%

[16] One can show that $dtfp = \frac{1}{\alpha+\beta} d\widetilde{tfp}$.

[17] Using sales weights the fall in sales in 2020 Q2 is estimated to have been smaller at 28%. This fall in sales is smaller because sales weights give less weight to lower productivity sectors than employment weights.

lower in the least affected industries such other production (which includes agriculture, mining and utilities) and information and communication. Sales were still thought to be around 5% lower than they would have been by 2021Q3. Over the medium term (2022+), the effects on sales were expected to be small at around -1%. Total hours worked were estimated to have fallen by more than sales in 2020Q2 and 2020Q3, but with the effect converging on the impact on sales in later quarters.

Panel B of Figure 2 summarises the contributions of both real sales per hour and intermediate costs to aggregate within-firm labor productivity per hour. Increased costs associated with measures to contain Covid-19 have reduced productivity within firms. These additional unit costs could reflect two channels: (i) new costs, for example associated with businesses having to buy hand sanitizers, protective screens or other protective equipment, purchase extra signage etc.; and (ii) increased unit costs that arise from a reduction in capacity due to social distancing e.g. fewer tables at restaurants, spacing between workstations etc. These higher intermediate inputs will accordingly push down on value-added relative to sales, such that labor productivity within firms will be lower. Firms estimated that Covid-19 increased average unit costs by around 7-8% in 2020Q2 and 2020Q3 (as shown on Figure 2 Panel A). The unit cost impact of Covid-19 was then expected to taper off to around 4% by 2021Q3. A smaller, but still significant impact on costs of around 2% was expected to persist into 2022 and beyond.

The effects of Covid-19 on within-firm labor productivity per hour are estimated to be negative through the period from 2020Q2 to 2021Q4 (see Table 1 and Figure 2 Panel B). The average within effect over this period is around -3%. A smaller negative effect of around -1% is also expected over the medium term. The contributions from real sales per employee are, on average, positive. But the overall within effect is negative throughout because of persistent negative contributions from higher intermediate costs.

The impact on TFP, relative to hourly labor productivity, will depend on whether the impact on the capital stock is anticipated to be larger or smaller than on hours worked. Figure 2 Panel A shows that investment was reported to have been more negatively affected than sales in 2020, although the differences narrow in 2021. However, quarterly investment is equal to only about 1.5% of the capital stock on average, so that Covid-19 is anticipated to only reduce the capital stock by around 2% by 2021Q4. This means that elasticity-weighted inputs are expected to fall by less than labor inputs, such that within-firm TFP is expected to perform worse than labor productivity over the short run. Between 2020 Q2 and 2021 Q4, Covid-19 is expected to have lowered within-firm TFP by around 5%, on average (see Table 1). As with labor productivity, the within-firm effects become less negative in later quarters as the additional cost pressures start to ease. Over the medium term, for 2022+, within-firm TFP is estimated to be around 1.5% lower than it would have been without the Covid-19 pandemic.

This analysis of the within-firm effects on productivity described above is a measurement exercise. Data from other questions in the DMP survey can help to shed light on the potential channels (see Figure 3). For example, DMP members estimated that R&D investment in 2020 was around 14% lower than it otherwise would have been. Reduced investment in R&D and innovation would be likely to lower within productivity, although the effects of this might be largest over the longer term. And DMP respondents indicated that their CEO's have spent large amounts of time managing the effects of Covid-19 on their business over second half of 2020 – around 12 hours a week on average, which has diverted them from other activities. Bloom et al. (2019) show how time spent preparing for Brexit was associated with lower productivity among UK firms, indicating that this channel is potentially important. Senior managers are

critical for developing new products and processes, and if they are absorbed in dealing with the pandemic this type of long-run productivity enhancing activity will suffer.

Between-firm effects

The impact of Covid-19 varied a great deal across sectors and across firms within those sectors. This section describes the associated potential reallocation effects in more detail, first by discussing reallocation effects between surviving firms and then considering the effects of firm entry and exit.

At the firm level, the blue dots on Figure 4 show that there was a strong positive correlation between pre-Covid labor productivity and the impact of Covid-19 on hours worked in 2020Q2.[18] The chart implies that the least productive firms saw a fall of around 50%, on average, in total hours worked, compared to around 20% for the most productive firms, relative to what would have otherwise happened. As we input-weight productivity in our calculations it is this relationship that is a key determinant of the extent of the reallocation effects. The data for 2020Q2 shows that higher productivity firms shrank less and therefore saw their overall weight increase, while low productivity firms shrank more and saw their weight fall. The red diamonds on Figure 4 show that by 2021Q2, a smaller but still positive relationship remained between pre-Covid labor productivity and the impact of Covid-19 on hours worked. Table A2 in the Appendix also shows these relationships in regression form.

At the 1 digit industry level, the falls in hours worked in 2020Q2 were reported to have been largest in recreational services and in accommodation and food, which are also the two lowest productivity industries that we consider. These are both industries where a large proportion of spending involves face-to-face contact and/or social activity and where it is particularly difficult for these services to be provided from home.

Our between-firm calculations separate out the effects of inter industry (effects across 1 digit industries) from intra industry effects (reallocation effects within industries). The inter industry effects account for the majority of the overall reallocation effect, perhaps reflecting the nature of the shock being concentrated in lower-productivity industries On average, inter-industry reallocation between industries accounts for almost 80% of the total between effects on hourly labor productivity (Figure 5). For TFP, the inter-industry component accounts for more like 60% of the positive effect in 2020 and 2021. See Table 1 for a breakdown of these figures for each quarter.

Importantly, it is worth highlighting that this positive between-industries impact of Covid on productivity is not entirely the usual Schumpeterian process of *creative destruction*. Instead much of this is simply *destruction* of low productivity industries like accommodation and food or recreational services without substantial creation in other industries (as evidenced by the large reduction in overall employment). So, while this may increase *average* productivity it will reduce total economic output, and potentially reduce overall welfare.

Our analysis focuses on reallocation effects between surviving firms, but firm entry and exit can contribute too. Firm entry typically falls and exit increases in recessions. However, changes in entry and exit during Covid have been modest in the UK, and net firm entry has been similar

[18] We do not have historic data on hours worked at the firm level but rather only on the number of employees. Consequently, we use labor productivity per job in this analysis as our measure of pre-Covid-19 productivity. This implicitly assumes that average hours worked per employee are the same across all firms.

to in 2019 (Figure 6). Reallocation effects associated with entry and exit are therefore unlikely to have had any meaningful effect on productivity during the pandemic and our estimates assume that the effect was zero. However, below we provide some discussion of what any firm entry and exit effect would depend on and present some sensitivity analysis.

The key determinants of how Covid-19 will affect productivity through firm entry and exit will be: (i) how Covid-19 affects the number of jobs lost/created at the extensive margin; and (ii) what is the average productivity of firms that die versus the average productivity of new firms that are born, in both cases relative to what would have otherwise happened without Covid-19.

Firms that are newly born and those that die tend to be less productive than average. That implies lower births and higher deaths will typically raise average productivity in the short run, since there are fewer low-productivity firms in the economy than there would otherwise have been. Using labor productivity data derived from company accounts for the DMP sampling frame, businesses incorporated since 2016 have, on average, been 19% less productive than the average firm in their first year. Businesses that have failed over this period have been 15% less productive than average in the year before they died, although this could be higher during Covid because the shock has been particularly concentrated in lower-productivity sectors.

The presence of Government support schemes and delays in processing insolvencies caused by lockdown restrictions (such as reduced operation of courts) might help to explain why firm deaths have not risen during the pandemic. Exits could rise once support measures are removed. If the employment weighted firm death rate rose by 1 percentage point, similar to the increase the financial crisis around 2008-09, that could raise aggregate productivity by around 0.2% if the firms that exit were around 20% less productive than average (similar to historical experience), although the effect could be larger if nature of the Covid shock meant that failed firms were lower productivity than normal (if they were 30% less productive, the effect of a 1% reduction in employment from firm failures would be 0.3%, for example). Similarly, if the employment weighted firm birth rate fell by 1 percentage point that would also add about 0.2% to aggregate productivity if then entering firms were 20% less productive than average, as they have been in the past.

This sensitivity analysis shows how Covid-19 could raise average productivity if firm entry were to fall/exits were to increase materially in the future. But the numbers are relatively small, and given what has happened during the pandemic so far, large changes in entry and exit do not appear to be the most likely outcome.

Overall impact

Bringing all of the different channels together, we estimate that Covid-19 has lowered TFP during the pandemic (Table 1). Although between-firm effects have pushed up on TFP, our estimates suggest that has been more than offset by lower within-firm TFP, partly associated with an increase in intermediate costs (Figure 1). Between 2020Q2 and 2021Q4, TFP is estimated to have been around 2.5% lower, on average, than otherwise because of Covid-19, with a peak impact of -4%. However, in the earlier part of the pandemic the magnitude of the offsetting positive between and negative within effects was much larger (see Figure 1). Our estimates imply that TFP will be around 1% lower over the medium term (2022+).

The effects of Covid-19 on hourly labor productivity are estimated to have been less negative than those on TFP because hours worked fell by more than elasticity-weighted capital and labor

inputs. In 2020Q2, hourly labor productivity is estimated to have increased markedly. Those effects fell back after 2020Q2 before a second spike in 2021Q1 that was associated with a second national lockdown. By 2021Q3, the effects on hourly labor were estimated to have turned negative. A small negative effect of around -1% is implied over the medium term. The effects on labor productivity per job (shown in Figure A3 of the Appendix) are estimated to have been negative throughout, particularly in 2020Q2 and Q3 as the number of jobs fell by much less than hours worked.

Section 6: Conclusions

Covid is a global phenomenon that has reduced GDP and has important implications for productivity. Understanding these implications is imperative for public policymakers. Over the last decade US, UK and EU productivity growth rates have fallen below 1% a year, and the major impact from Covid-19 could push it into negative growth. This paper presents a micro-data analysis of the impact of Covid-19 on productivity in the UK, but it also gives an indication of the likely direction of the impact of Covid-19 in the US and other advanced European countries given the similar nature of the pandemic impact. Our results suggest that Covid-19 has lowered TFP in the UK private sector by up to 4% with a small negative effect expected to persist into 2022 and beyond. That reflects a large reduction in productivity within firms, partly because measures to contain Covid-19 increased intermediate costs. The negative within-firm effect is estimated to have been partially offset by a positive between-firm effect as low productivity sectors, and the least productive firms within them, were disproportionately affected and thus made a smaller contribution to the economy.

The dynamics of the Covid-19 effect are also very notable. In earlier quarters these offsetting negative within and positive between firm effects are both estimated to have been larger. The effects of Covid-19 on hourly labor productivity are estimated to have been positive during the pandemic because hours worked fall by more than elasticity-weighted capital and inputs, although a small negative effect is expected in the medium term.

In the longer run, Covid-19 will have further effects on productivity that may not be fully captured in our estimates because it has led to material reductions in R&D expenditure by firms and altered the efficacy of this R&D under lockdown if scientists and engineers cannot physically access equipment (see Eberly et al. 2021). As we report, Covid-19 has also diverted senior managers, with CEOs spending about a third of their time directly dealing with the pandemic, which is time that has presumably been taken away in part from other longer-run productivity enhancing activities. To some extent these channels may be factored in to businesses' longer-term expectations and may help to explain why TFP is expected to be around 1% lower over the medium term. But it may also take time for these effects to become apparent and there may potentially be some additional longer run negative effect on productivity from diminished innovation and intangible investment by firms.

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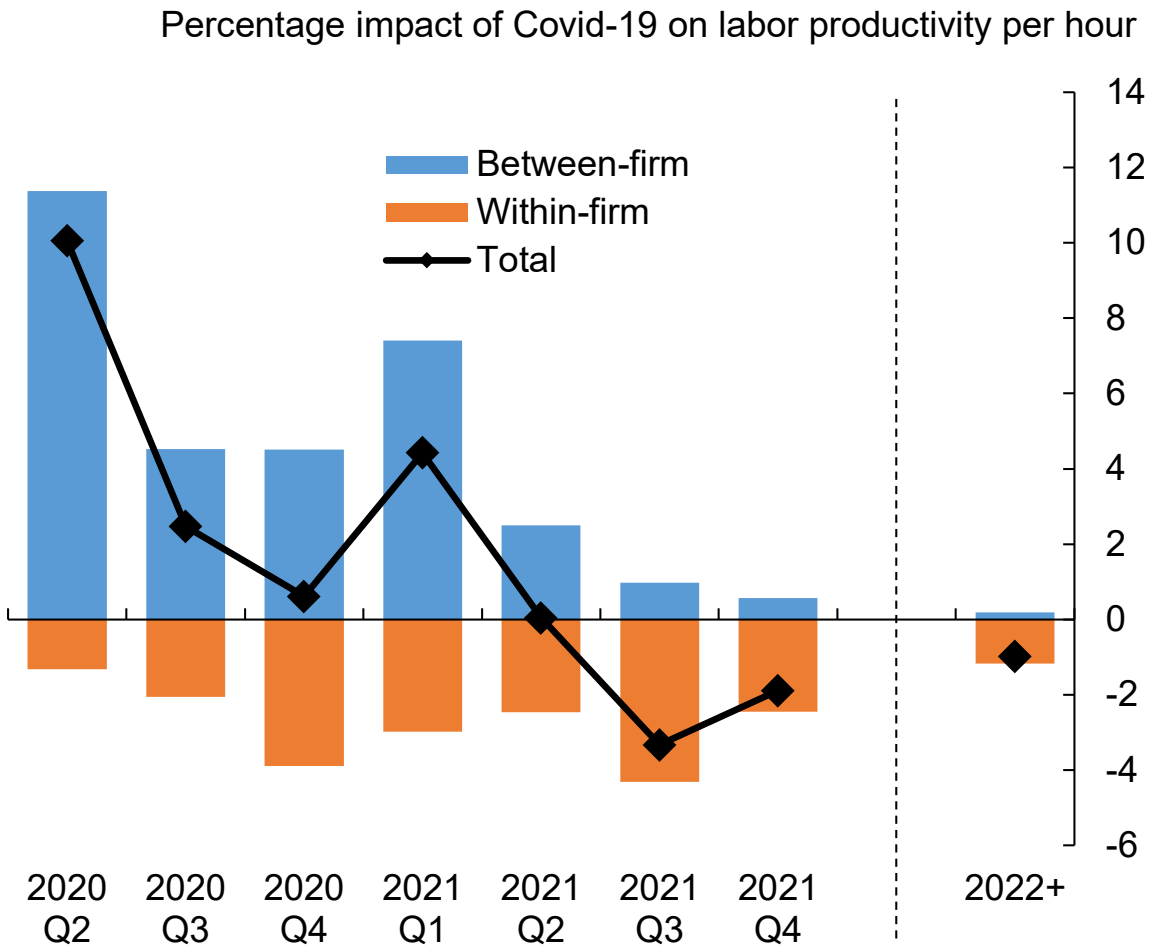
Table 1: Summary of estimated impact of Covid-19 on productivity

	2020 Q2	2020 Q3	2020 Q4	2021 Q1	2021 Q2	2021 Q3	2021 Q4	2022+
Labor Productivity per hour								
Within Firms	-1.3	-2.1	-3.9	-3.0	-2.5	-4.3	-2.5	-1.2
Between Continuing Firms	11.4	4.5	4.5	7.4	2.5	1.0	0.6	0.2
o/w inter industry effects	*7.6*	*3.1*	*3.0*	*4.5*	*2.3*	*0.7*	*0.7*	*0.5*
o/w intra industry effects	*3.7*	*1.4*	*1.6*	*2.9*	*0.1*	*0.2*	*-0.1*	*-0.3*
Total	10.1	2.5	0.6	4.4	0.0	-3.3	-1.9	-1.0
Total Factor Productivity								
Within Firms	-9.3	-5.7	-6.3	-5.7	-3.8	-4.0	-2.8	-1.5
Between Continuing Firms	7.3	1.6	2.1	3.8	2.7	0.5	0.5	0.5
o/w inter industry effects	*2.9*	*1.6*	*1.4*	*2.2*	*1.5*	*0.3*	*0.4*	*0.4*
o/w intra industry effects	*4.3*	*0.1*	*0.7*	*1.6*	*1.1*	*0.2*	*0.2*	*0.2*
Total	-2.1	-4.1	-4.2	-1.8	-1.1	-3.5	-2.3	-1.0

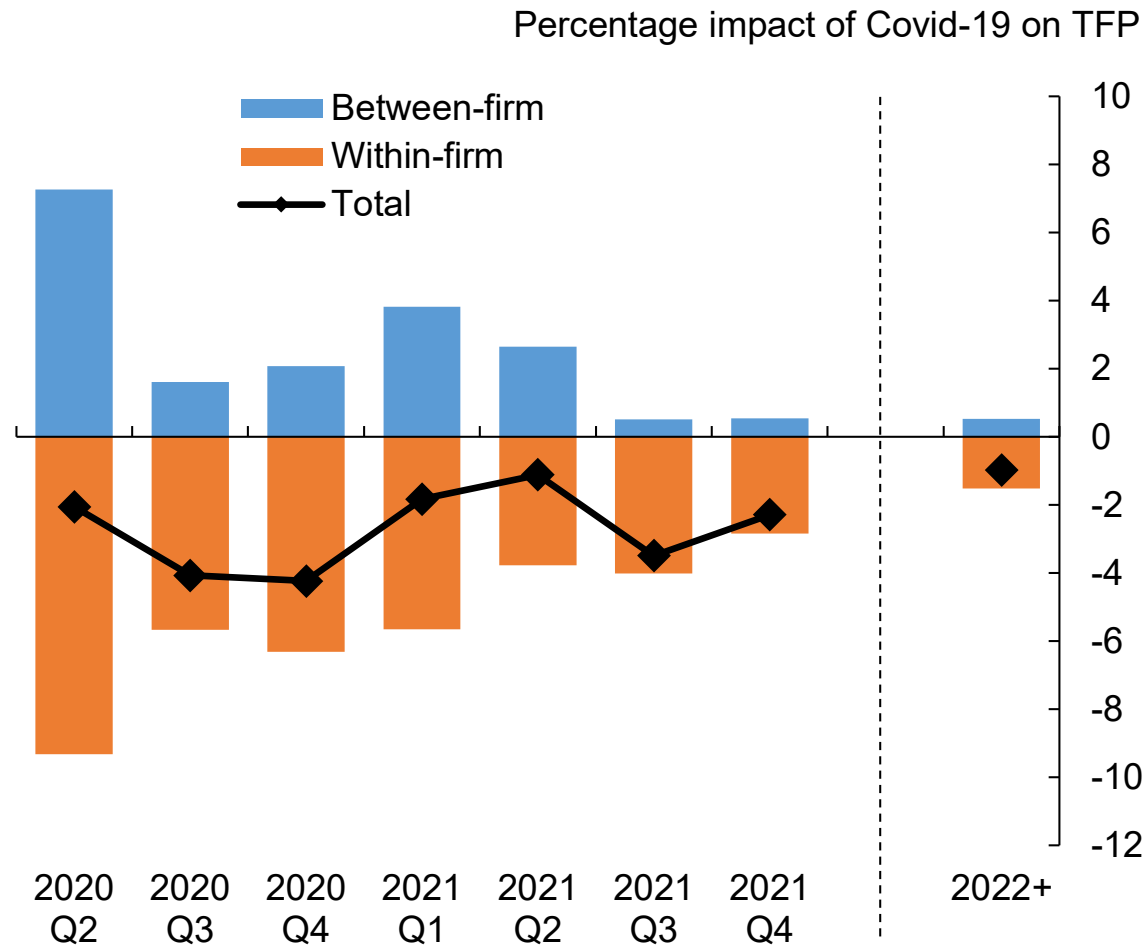
Notes: See notes to Figure 1 for further details on these calculations. Inter and intra industry effects are for 1 digit industries.

Figure 1: Contributions to impact of Covid-19 on productivity

Panel A: Labor productivity per hour



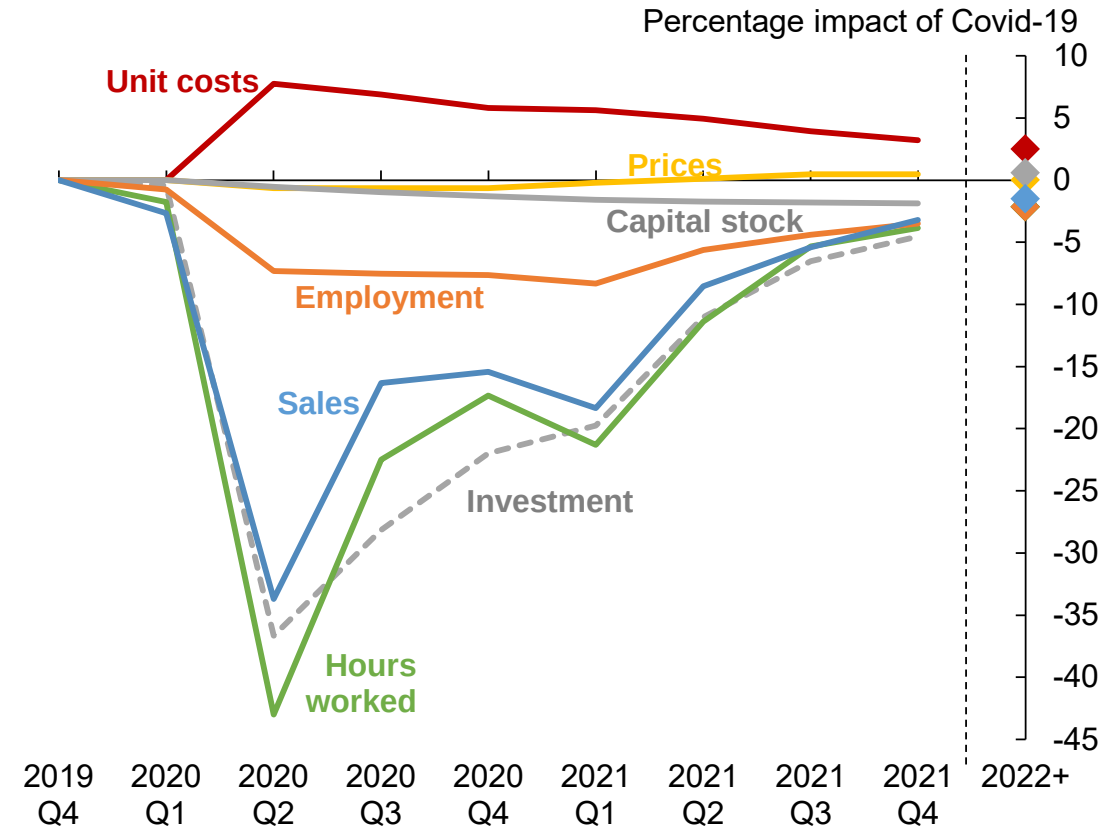
Panel B: TFP



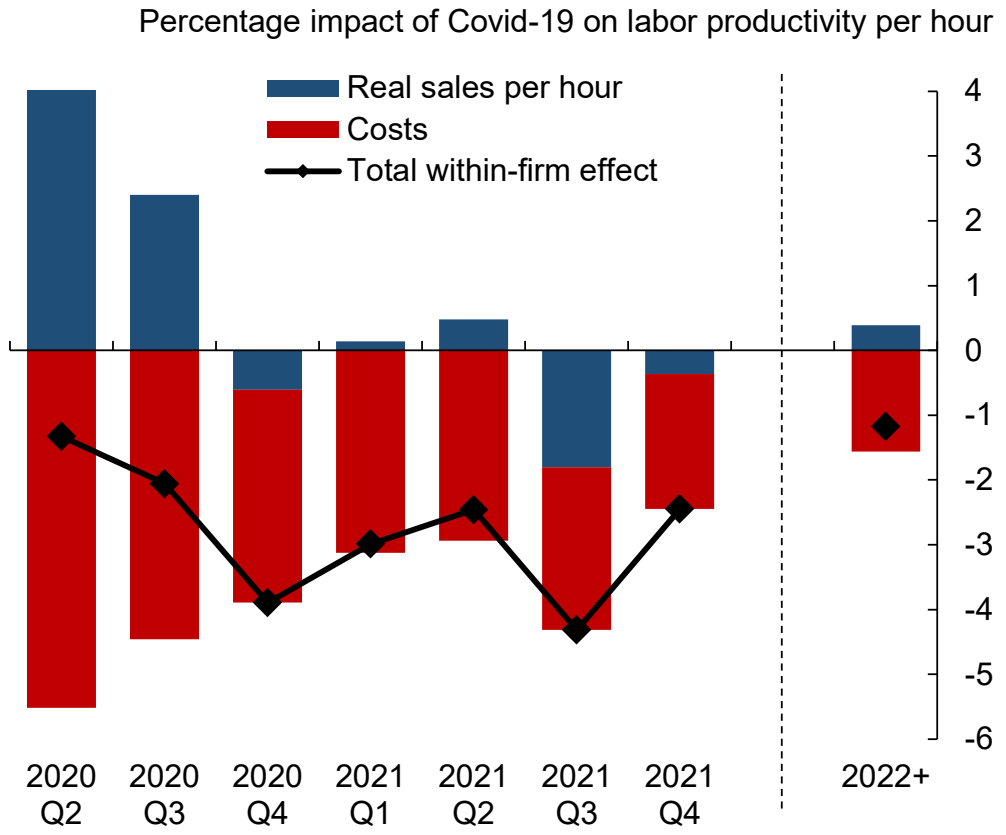
Notes: Impacts on productivity are estimated as $\Delta\Pi_t = \sum_{i\in Surv}\bar{\varphi}_i\Delta\pi_{i,t} + \sum_{i\in Surv}\Delta\varphi_{i,t}(\overline{\pi_t} - \bar{\Pi})$ where $\pi_{i,t}$ is productivity in firm i at time t, Π_t is productivity at time t, $\varphi_{i,t}$ is the labor input share of firm i at time t and a bar over a variable indicates the average of the variables across times t-1 and t. Changes between t and t-1 are changes due to Covid-19 only. The first term represents the within-firm effects. The second term represents between-firm effects. The impact of Covid-19 on labor productivity for each firm is calculated as $\frac{dLP}{LP}=\frac{dY}{Y}-\frac{dP}{P}-\frac{dL}{L}-\frac{dM}{M}$ $where\frac{dM}{M}=\frac{M}{Y-M}\frac{dM^U}{M^U}$. The impact of Covid-19 on TFP for each firm is calculated as $\frac{dTFP}{TFP}=\frac{dY}{Y}-\frac{dP}{P}-\beta\frac{dL}{L}-\alpha\frac{dK}{K}-\frac{dM}{M}$. LP is labor productivity, TFP is total factor productivity, Y is nominal sales, P is the price level, L is labor input, M are non-labor intermediate costs, M^U are intermediate unit costs and K is capital input.

Figure 2: Impact of Covid-19 on within-firm productivity

Panel A: Impact of Covid-19 on businesses



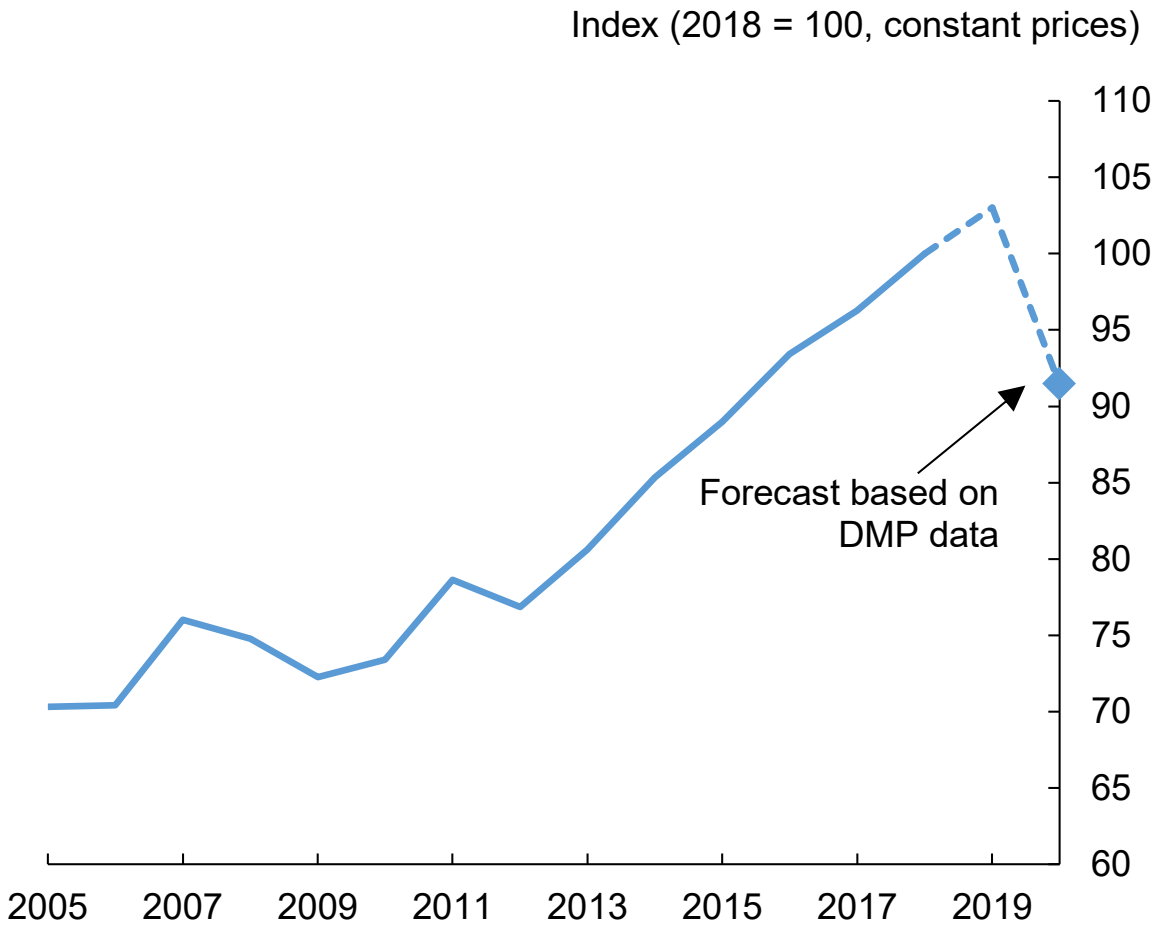
Panel B: Contributions to impact of Covid-19 on within-firm labor productivity per hour



Notes: The results are based on the questions: 'Relative to what would otherwise have happened, what is your best estimate for the impact of the spread of Covid-19 on the sales/employment/average hours worked per active employee/capital expenditure of your business in each of the following periods?'; 'Relative to what would otherwise have happened, what is your best estimate for the impact of measures to contain coronavirus (social distancing, hand washing, masks and other measures) on the average unit costs of your business in each of the following periods?'; and 'Approximately what percentage of your employees fall into the following categories in each of the following periods? (i) Still employed but not required to work any hours (eg 'on furlough'), (ii) Unable to work (eg due to sickness, self-isolation, childcare etc.), (iii) Continuing to work on business premises, (iv) Continuing to work from home'. Data are the most recent observation per firm for each period collected between July 2020 and August 2021. Data on the impact of Covid-19 in 2020Q1 have not been collected in the DMP. Data shown for 2020Q1 are absolute changes in aggregate ONS data for private sector output, business investment, private sector employment and hours worked between 2019Q4 and 2020Q1. The impact on unit costs is assumed to be zero in 2020Q1. Effects on the capital stock are estimated using by cumulating the investment impacts. The effects on the price level are estimated using data from DMP questions on actual price inflation and expected year-ahead price inflation: the impact of Covid-19 is estimated as the difference relative to 2019 at the 1-digit industry level. See notes to Figure 1 for details on how the impact of Covid-19 on within-firm productivity is calculated.

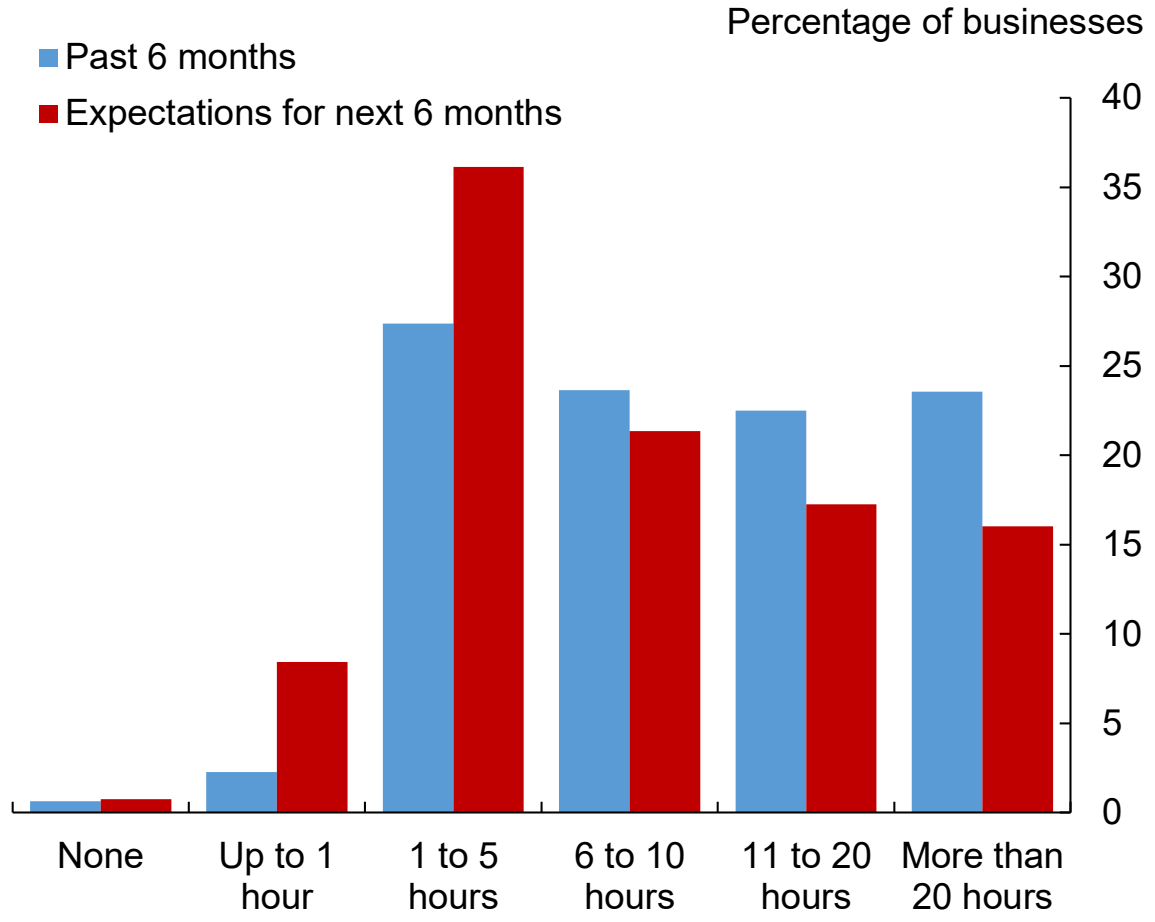
Figure 3: Covid-related influences on longer-term productivity

Panel A: Aggregate R&D investment



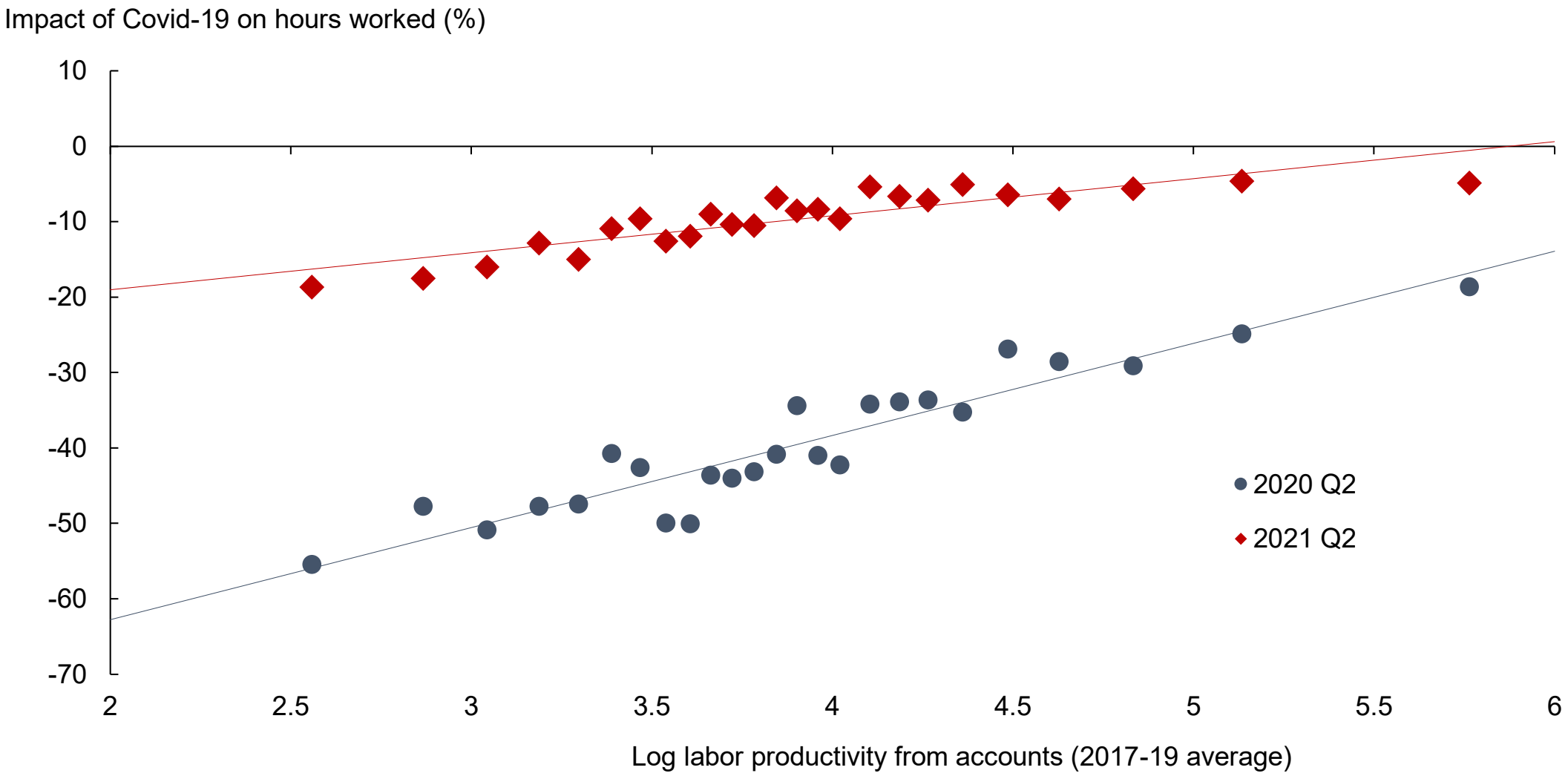
Notes: The solid line is real business sector R&D expenditure from the UK National Accounts. For 2019, for which we do not have data, we extrapolate an average growth between 2005 and 2018. For 2020, we extrapolate again and then adjust according to the response to the following DMP question: 'Relative to what would otherwise have happened, what is your best estimate for the impact of the spread of coronavirus (Covid-19) on spending on research and development of your business in 2020?'. DMP data were collected between August and October 2020.

Panel B: Average hours per week spent by CEOs managing effects of Covid-19



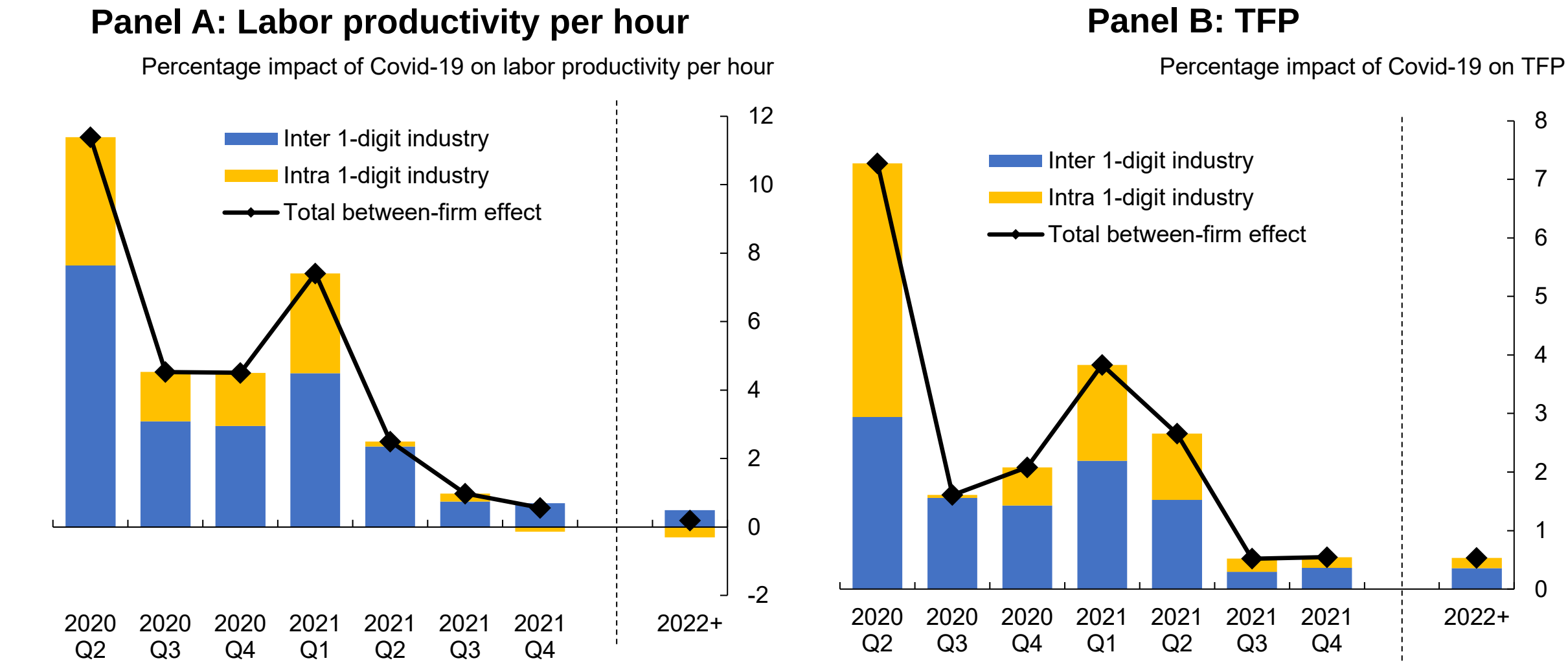
Notes: Based on the question 'Approximately how many hours a week has the CEO of your business spent managing the effects of Covid-19 on your business over the past six months? And how many hours a week do you expect them to spend on this over the next six months?'. Data were collected between November 2020 and January 2021.

Figure 4: Impact of Covid-19 on hours worked and pre-Covid labor productivity



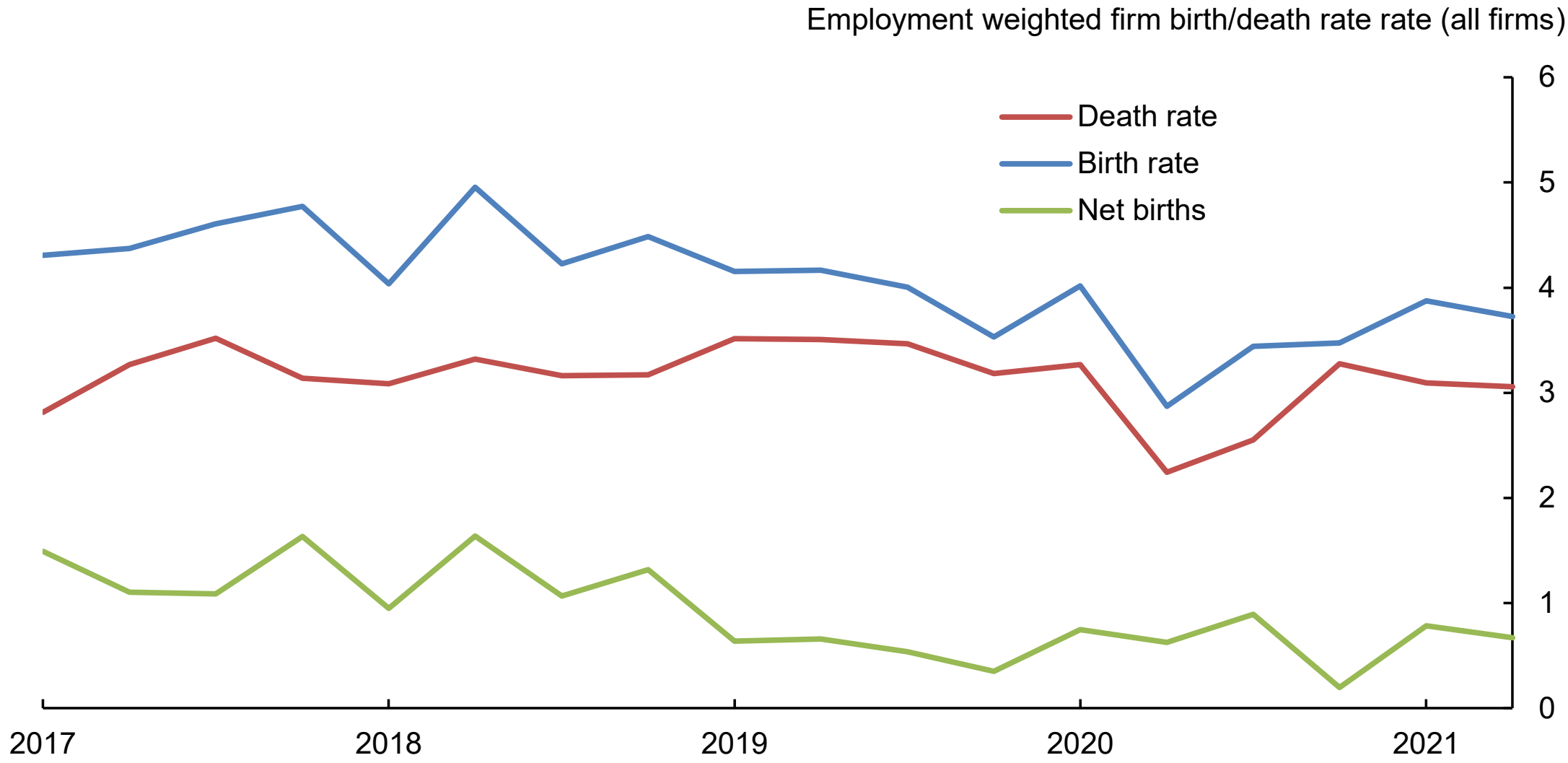
Notes: See notes to Figure 2 for details on how impact of Covid-19 on hours worked is calculated. Labor productivity is defined as real value-added (operating profits plus total labor costs divided by the aggregate GDP deflator) per employee using accounting data from Bureau van Dijk.

Figure 5: Contributions to impact of Covid-19 on between-firm productivity of continuing firms



Notes: Labor productivity is defined as real value-added (operating profits plus total labor costs divided by the aggregate GDP deflator) per employee using accounting data from Bureau van Dijk. Between-firm impacts are estimated as $\sum_{i\in Surv}\Delta\varphi_{i,t}(\overline{\pi_t}-\overline{\Pi})=\sum_{\mathrm{j\in Sectors}}\ \sum_{\mathrm{i\in Surv}}D_i^j\bar{\rho}_j\Delta\bar{\theta}_{i,t}(\overline{\pi_i}-\overline{\pi_j})+\sum_{\mathrm{j\in Sectors}}\ \Delta\rho_{j,t}(\overline{\pi_i}-\overline{\Pi})$ where $\pi_{\mathrm{i,t}}$ is productivity in firm i at time t, Π_t is productivity at time t, $\varphi_{i,t}$ is the labor input share of firm i at time t, is sector j's share of labor input at time t, $\rho_{j,t}$ is the share of firm i's labor input in it sector at time j, $\theta_{\mathrm{i,t}}$ is the share of firm i's labor input among surviving firms in its sector at time t, $\pi_{\mathrm{j,t}}$ is productivity of firms in sector j at time t, D_i^j is a dummy variable that takes the value of 1 when firm i is located in sector j, and a bar over a variable indicates the average of the variables across times t-1 and t. Changes between t and t-1 are changes due to Covid-19 only. The first term on the right hand side represents reallocation effects within industry – intra industry effects. The second term on the right hand side represents reallocation effects between industries – inter industry effects.

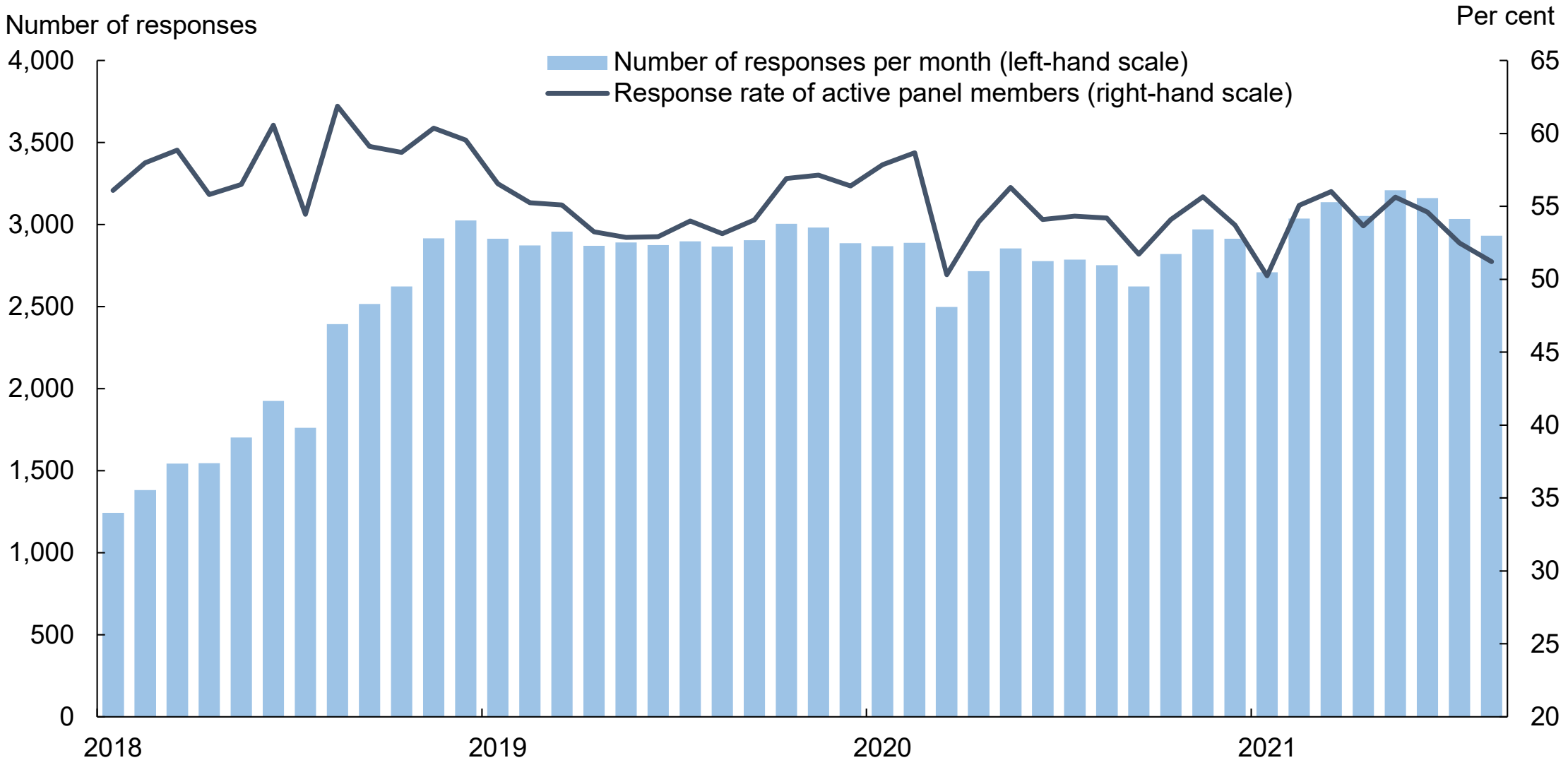
Figure 6: Firm entry and exit



Notes: Firm birth and death rate data are from the Office for National Statistics. These data have been seasonally adjusted by the authors.

Appendix

Figure A1: DMP response rate



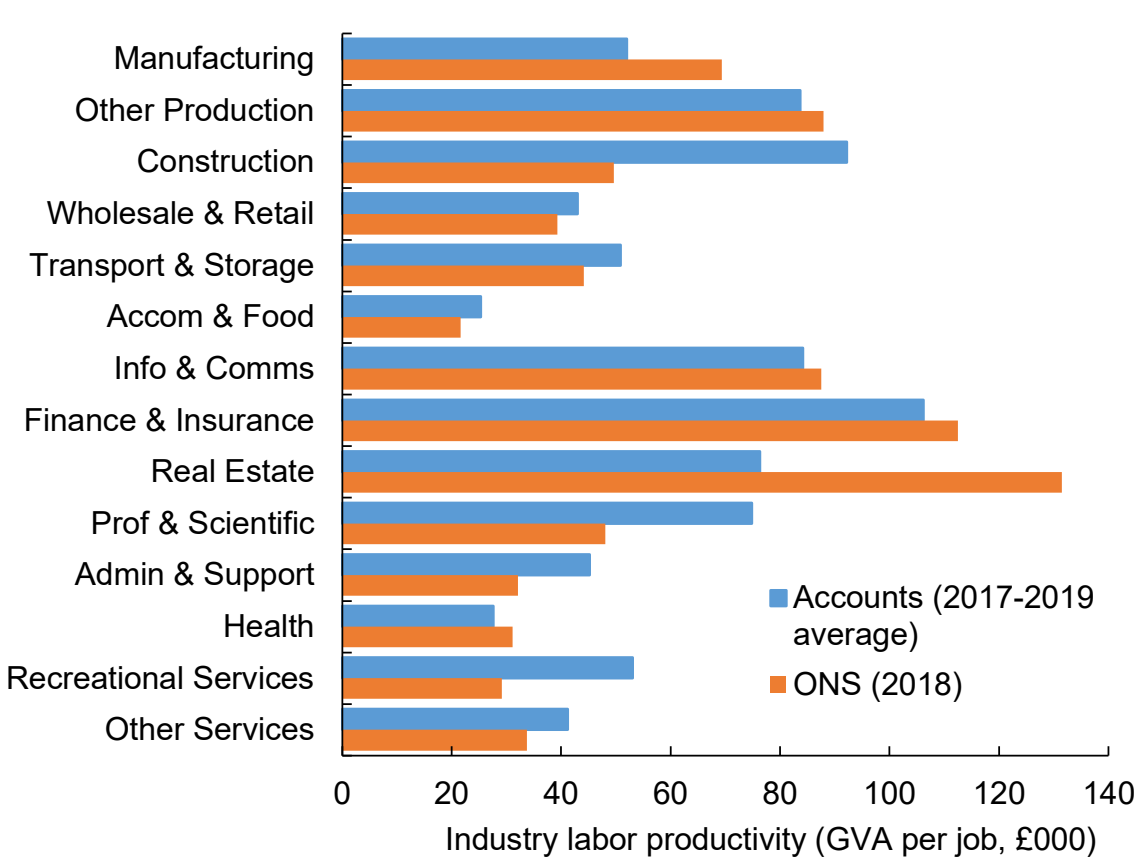
Notes: The response rate of active panel members is calculated as the percentage of panel members who had completed at least one survey over the last twelve months who responded to the survey in a given month.

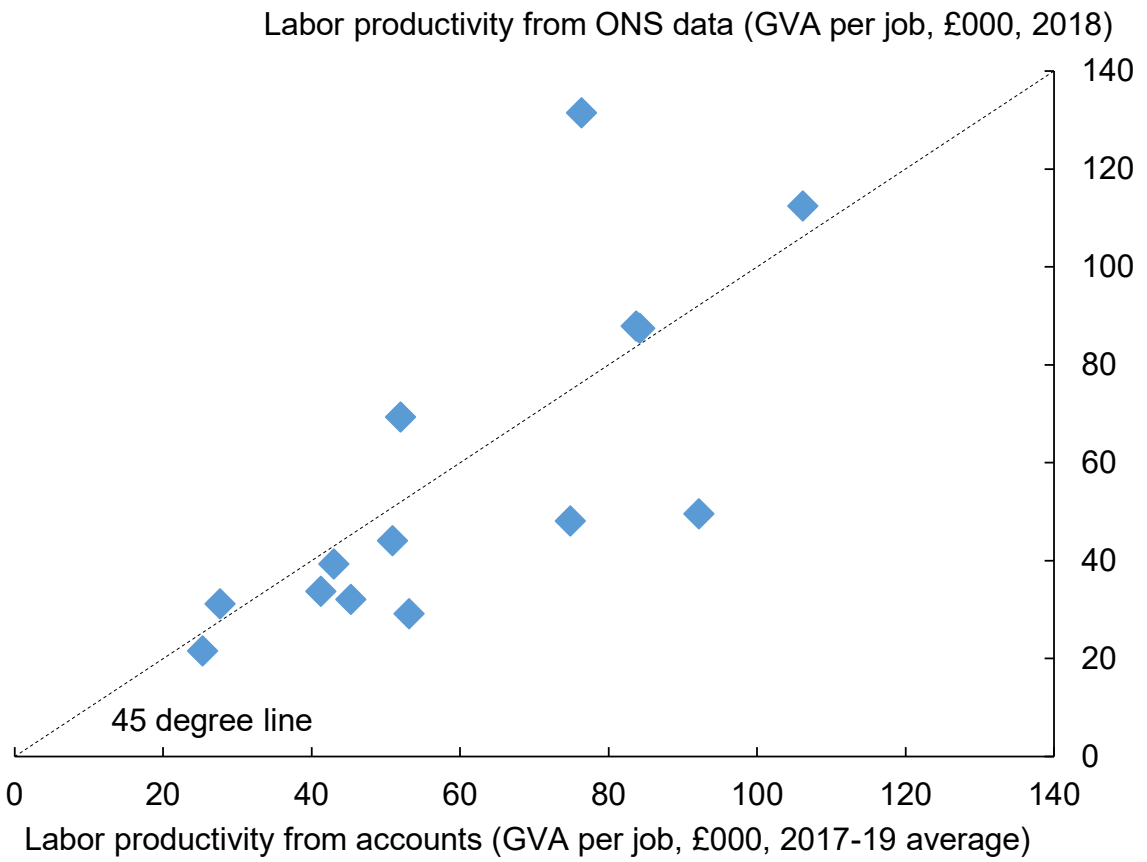
Table A1: Linear probability models for propensity to respond to the DMP

Sample period	Mar20 - Aug21	Jan19 - Aug21	
	(1)	(2)	(3)
Industry impact of Covid on sales in 2020 Q2	0.000		
	(0.003)		
Ln(Pre-Covid labor productivity)			0.513***
			(0.042)
Industry impact of Covid on sales in 2020 Q2 interacted with Covid period dummy variable		0.000	
		(0.003)	
Ln(Pre-Covid labor productivity) interacted with Covid period dummy variable			-0.053
			(0.055)
Survey wave dummies	Yes	Yes	Yes
1 digit industry dummies	No	Yes	Yes
Individual firm fixed effects	No	No	No
Observations	797,654	1,114,973	1,114,973
R-squared	0.006	0.008	0.008

Notes: Linear probability model for whether a firm in the sampling frame responds to the DMP survey in each month between January 2019 and August 2021 (1=responded to DMP, 0=Not responded). Firm characteristics are averages of 2017 to 2019 accounts data from Bureau Van Dijk FAME database. Labor productivity is defined as real value-added (operating profits plus total labor costs divided by the aggregate GDP deflator) per employee using accounting data. Regressions only includes firms who were part of the sampling frame in January 2019. Equations 2 and 3 are restricted to firms who have productivity data available from company accounts. Covid period dummy variable takes the value of one for March 2020 to August 2021. All equations are estimated by OLS. Standard errors are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Figure A2: Different measures of industry-level labor productivity





Notes: Labor productivity from company accounts is defined as real value-added (operating profits plus total labor costs divided by the aggregate GDP deflator) per employee using accounting data from Bureau Van Dijk FAME database.

Table A2: Impact of Covid-19 on total hours and pre-Covid labor productivity

Dependent variable: Impact of Covid-19 on total hours worked	2020 Q2		2021 Q2		2020 Q2		2021 Q2	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log labor productivity per job (2017-2019 average)	14.363***	7.040***	5.100***	0.070				
	(0.867)	(0.847)	(0.637)	(0.681)				
Log TFP (2017-2019 average)					0.578***	0.238*	0.299**	0.112
					(0.173)	(0.141)	(0.123)	(0.112)
Constant	-96.115***	-69.407***	-30.246***	-8.744***	-43.998***	-42.734***	-11.901***	-8.625***
	(3.259)	(3.550)	(2.398)	(2.851)	(0.689)	(1.456)	(0.490)	(1.156)
1 digit industry dummies	No	Yes	No	Yes	No	Yes	No	Yes
Weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,904	2,904	2,904	2,904	2,904	2,904	2,904	2,904
R-squared	0.086	0.366	0.022	0.190	0.004	0.351	0.002	0.190

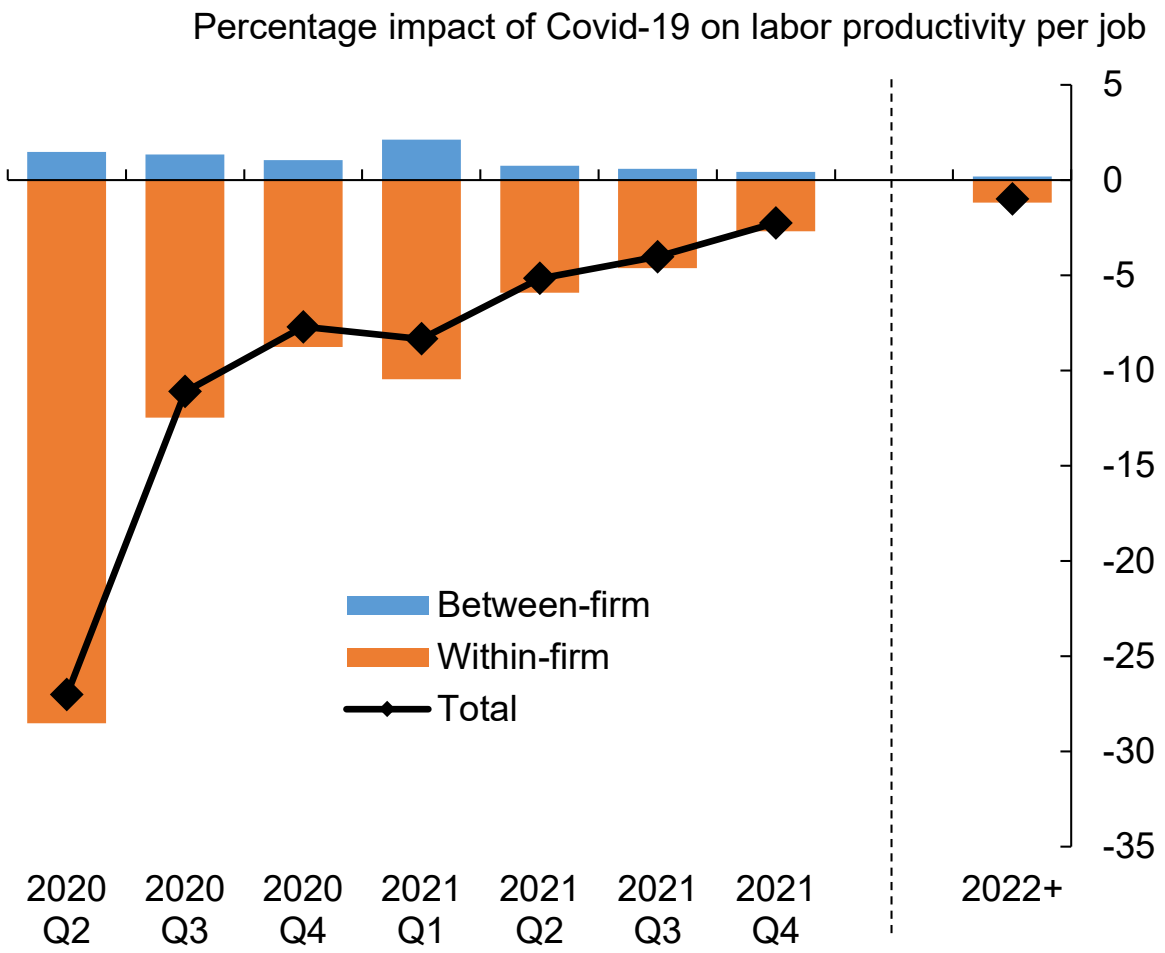
Memo: Explanatory variable means: Log labor productivity per job = 3.70 , Log TFP = 1.72

Explanatory variable standard deviations: Log labor productivity per job = 0.69, Log TFP = 3.59

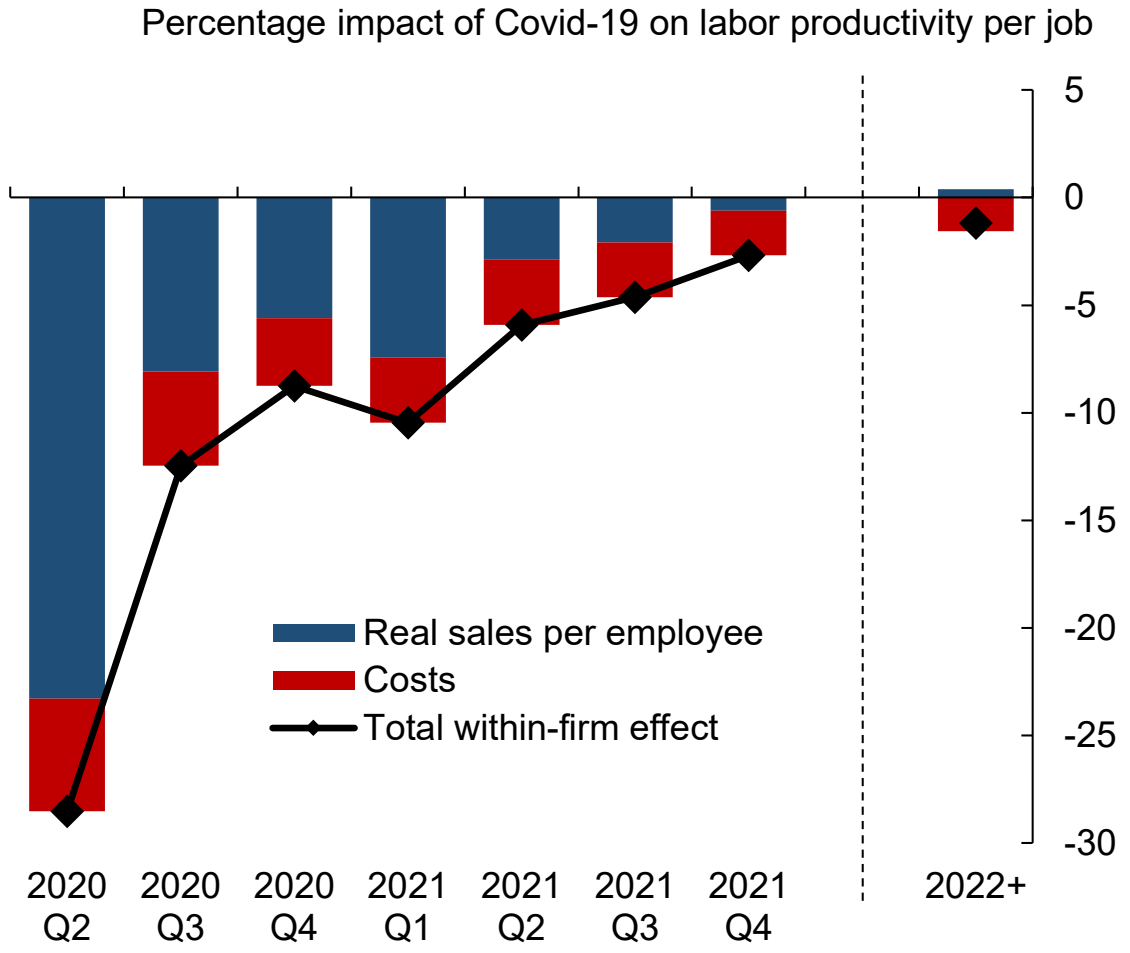
Notes: All regressions are weighted using employment data. Labor productivity is defined as real value-added (operating profits plus total labor costs divided by the aggregate GDP deflator) per employee using accounting data from Bureau Van Dijk FAME database. TFP is calculated as the residual from a production function $\ln(Y_{it}) = (2/3)\ln(L_{it})+(1/3)\ln(K_{it})$ where Y_{it} is real value-added of firm i in year t, L is labor input (total real labor costs) and K is capital (total real fixed assets), nominal values from accounting data are deflated using the GDP deflator. *** p<0.01, ** p<0.05, * p<0.1.

Figure A3: Contributions to impact of Covid-19 on labor productivity per job

Panel A: Overall impact



Panel B: Contributions to within-firm effect



Notes: Impacts on productivity are estimated as $\Delta\Pi_t = \sum_{i\in Surv} \bar{\varphi}_i \Delta\pi_{i,t} + \sum_{i\in Surv} \Delta\varphi_{i,t}(\overline{\pi_t} - \overline{\Pi})$ where $\pi_{i,t}$ is productivity in firm i at time t, Π_t is productivity at time t, $\varphi_{i,t}$ is the labor input share of firm i at time t and a bar over a variable indicates the average of the variables across times t-1 and t. Changes between t and t-1 are changes due to Covid-19 only. The first term represents the within-firm effects. The second term represents between-firm effects. The impact of Covid-19 on labor productivity for each firm is calculated as $\frac{dLP}{LP} = \frac{dY}{Y} - \frac{dP}{P} - \frac{dL}{L} - \frac{dM}{M}$ $where \frac{dM}{M} = \frac{M}{Y-M}\frac{dM^U}{M^U}$. LP is labor productivity, Y is nominal sales, P is the price level, L is labor input, M are non-labor intermediate costs and M^U are intermediate unit costs.