Does digitalisation increase firm survival? Evidence from British SMEs during the Covid-19 crisis

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Abstract

We investigate whether pre-pandemic adoption of digital technologies helped small and medium enterprises (SME) survive during the pandemic, and whether this effect differs between urban and rural areas. The pandemic increased the reliance on digital tools, and as personal contact was restricted, led to expectations of the decline of cities. We combine the Longitudinal Small Business Survey with the Business Structure Database to build a panel of British SMEs from 2015 to 2022. Survival models show that use of different digital technologies increased survival, but the effect is concentrated in urban areas. In urban areas, this effect is comparable in size to that of government Covid subsidies, while in rural areas subsidies are significantly more effective at reducing business exit. In urban areas, increased survival from expanding SME's digitalisation would increase aggregate productivity, while in rural areas, digitalisation would help the least productive firms survive. The results show that the benefits of digitalisation are not evenly spread among SMEs and policy responses to crises should take these urban-rural differences into account.

1. Introduction

During the Covid-19 pandemic, many businesses and their employees relied on digital working practices, often working remotely and interacting with colleagues, customers and suppliers through digital platforms. Rural and remote areas were expected by some to be the winners of this trend (Knuepling *et al.,* 2024). Despite these adjustments and unprecedented government support programmes, the economy was deeply affected by the pandemic. According to the Insolvency Service, corporate insolvencies in England and Wales rose in 2023 to the highest level in thirty years.

The Schumpeterian theory of creative destruction posits that productive firms are more likely to survive (Schumpeter, 1939) and is widely supported empirically (Olley and Pakes, 1996; Frazer, 2005; Aga and Francis, 2017). However, to the best of our knowledge, the question whether digitalisation itself helps individual firms survive remains empirically unanswered. This is particularly important in the context of the disruption brought about by the Covid-19 pandemic, during which business continuity depended on existing digital inputs.

The agglomeration economies that make cities more productive were sharply reduced during the pandemic, ostensibly levelling the playing field with rural areas, potentially reducing stark urban-rural divides in the UK. Furthermore, urban areas were more affected by the pandemic as their density was amenable to spreading of the virus (Nathan, 2021). In England, the average number of weeks spent in strict lockdown was 50% higher in urban local authorities than in rural ones. However, as with previous episodes of technological change that heralded the death of distance, it is an open question whether businesses in rural areas benefitted to some extent from the pandemic, or whether the same inherent structural barriers, such as access to digital infrastructure and skills put them at a disadvantage. We therefore explore whether an urban-rural divide is at play among SMEs in the way in which digital tools translated into better survival chances.

In this paper, we investigate the differential impact of digitalisation on business survival during the pandemic in urban and rural areas. We focus on Small and Medium Entreprises (SME) in England and Wales. Because SMEs are less likely than larger firms to implement digital solutions in their business processes, those with digital inputs may have a particular edge over their competitors.[1] We use the Longitudinal Small Business Survey[2] (LSBS), a unique, detailed dataset that surveys individual SMEs and provides information at the firm level on whether they were using digital inputs, specifically online sales channels and digital record keeping software, in each year. Understanding the relationship between firm-level digitalisation and survival is of great policy relevance. If we know that firms that have already adopted specific digital inputs show greater resilience, promoting these inputs may reduce the need for government intervention during future crises similar to the Covid-19 pandemic.

The paper has three objectives. First, we test whether the use of digital technology *prior to 2020* reduced the probability of firm exit. Second, we test for differences in this impact across urban and rural areas. And third, we assess the potential impact of generalising the adoption of digital records and online sales to all firms, by providing counterfactual exit rates and productivity indices for SMEs for the 2020-2022 period.

Our findings show that pre-pandemic adoption of digital record keeping and online sales offered protection against exit for British SMEs when the crisis hit. The use of digital records prior to the pandemic reduces the probability of exit both pre- and post-2020, by 28% and 31% respectively. In contrast, pre-pandemic online sales are only associated with lower probability of exit post-2020. However, we find that the protection afforded by digital inputs was limited to urban areas. For urban firms, the impact of either type of digital input on survival is comparable in magnitude to that of receiving government Covid-19 support. For rural SMEs, government Covid-19 support was the key factor in survival.

Further, we find that universal early adoption of digital records and online sales has the potential to noticeably reduce the average exit rate, though again only for urban SMEs. Our approach follows the literature on productivity reallocation (Foster *et al.,* 2001; Foster *et al.,* 2016; Konings *et al.,* 2023). We find that for urban firms, the predicted exit rate drops from 4.6% to 2.5% with universal early adoption of digital inputs, whilst for

[1] Nightingale and Coad (2013) highlight that the positive performance of entrepreneurial firms is largely driven by a minority of high-performance businesses, rather than reflecting a mean effect.
[2] See Department for Business and Trade(2024).

the rural sample this remains unchanged at 5.1%. However, our findings reveal that SME aggregate productivity would in fact drop as digitalisation would help the least productive firms survive. In urban areas, aggregate productivity would increase, indicating positive reallocation there (Behrens and Robert-Nicoud, 2014; Combes *et al.,* 2012). Next, we compare our digitalisation counterfactuals to counterfactuals where all firms received Covid-19 support. In urban areas, universal Covid-19 support is comparable to the impact of universal digitalisation, but it would have a slightly negative effect on aggregate SME productivity. In rural areas, universal Covid support would more than halve the SME pandemic exit rate, from 5.1% to 1.9%, with no impact on productivity.

This paper contributes to the literature in several ways. First, to the best of our knowledge, it provides the first firm-level assessment of the impact of digitalisation on firm survival. While much of the empirical literature on determinants of firm survival has focused on the role of firm age and size (Dunne, Roberts and Samuelson, 1989) and productivity (Olley and Pakes, 1996) other firm-level factors have been explored, including participation in international trade (Bernard and Jensen, 2002; Georg and Spaliara, 2014), debt burden (Guariglia *et al*., 2016) and innovation (Cefis and Marsili, 2019; Helmers and Rogers, 2010).[3]

Second, we contribute to the literature on firm exit during the recent pandemic (Cros *et al,* 2021; Prashar *et al.,* 2020) with greater time perspective and a focus on the particularly vulnerable category of SMEs. This adds to evidence in Bartoloni *et al.* (2021), Guariglia *et al.* (2016) and Harris and Moffat (2016) among others that the determinants of exit can be different in times of crisis. Third, in the context of the recent pandemic, our analysis allows for a counterfactual comparison of the role of digital inputs with that of government support schemes. Previous empirical research has shown that the expected increase in "cleansing" in periods of crisis predicted in Caballero and Hammour (1994)'s creative destruction model, where the least productive firms become even less likely to survive, has often failed to materialise (Hallward-Driemeier and Rijkers, 2013; Foster *et al.,* 2016).

[3] See Cefis *et al.* (2022) for a survey of the literature on firm exit.

The paper proceeds as follows: Section 2 provides background on relevant literature. Section 3 introduces the data, with the empirical strategy discussed in section 4. Section 5 presents empirical results on the effect of digitalisation on business survival and section 6 presents implications for productivity reallocation. Section 7 concludes.

1. Relevant literature

The trend of increased digitalisation has transformed the way businesses work. The conventional wisdom is that digitalisation is an important factor for competitiveness. Digital technology is one of the sectors of focus in the UK's industrial strategy (Department for Business and Trade, 2025). For example, the government-funded Digital Catapult agency works to promote the adoption of advanced digital technologies by UK businesses. More recently, an SME Digital Adoption Taskforce was set up to improve the adoption of digital technologies by SMEs with a view to make them more productive. However, the adoption of digital technologies is far from universal (Massini *et al.,* 2025; Veugelers *et al.,* 2019). Across Europe and the US, small businesses are underrepresented among digitalised firms, as they often lack the skills and capital to invest in digital inputs.

There is empirical evidence that digitalisation is associated with higher productivity. However, findings are mixed, depending on the type of digital input, the size of firms and the sector (Anderton *et al.,* 2023; Borowiecki *et al.,* 2021; Coyle *et al.,* 2022; Gal *et al.,* 2019). In aggregate, new digital tools such as mobile technology and cloud computing have made no difference to productivity statistics (Van Ark, 2016). The direction of causality can also be reversed (Teruel *et al.*, 2024), and there is evidence that technology is used more productively in better managed firms (Bloom, Sadun and Van Reenen, 2012). Likewise, while digitalisation may reduce exit risk via higher productivity, sectors with more intensive use of digital technology are shown to be generally more dynamic, with both higher entry and exit rates (Calvino and Criscuolo, 2019). At the individual firm level, the presence of digital inputs requires both resources and capabilities that make firms more competitive and resilient.

Digital technologies allow businesses to communicate with anyone across the globe, but this has not resulted in a decline in agglomeration economies. Quite the opposite, face-to-face interaction remains as important as ever for more complex interactions that are based on trust and exchange of ideas (Leamer and Storper, 2017; Storper and Venables, 2004). This is even the case in highly digitalised industries and occupations such as software development (Goldbeck, 2025).

Further to this, cities also benefit from better digital infrastructure, with broadband and mobile connectivity in many rural areas remaining poor (Holl and Rama, 2024). However, there is also evidence that businesses in urban and rural areas adopt and use digital technology in different ways, with urban businesses benefiting more, *e.g.* from access to faster internet (DeStefano *et al.*, 2022). In addition to infrastructure, access to digital skills is an important driver of digital technology adoption (Berger & Frey, 2016; Gruber, 2019) but skills are regionally unequally distributed (Nguyen, 2020).

Unprecedented levels of government support for businesses and individuals were another defining feature of the economic environment during the pandemic. From 2020 until 2022, the British government implemented support schemes to help businesses survive through the crisis. Despite this, output fell substantially, with UK SMEs on average registering a sharper decline in turnover than larger businesses (Hurley *et al.*, 2021). This raised the question of whether firms that were not viable ended up surviving solely due to government support ("zombie firms"). Evidence suggests that the least productive firms benefitted most, dragging down aggregate productivity (Konings *et al.,* 2023; Cros *et al.*, 2021; Davies *et al.*, 2023; Meriküll and Paulus, 2024). Productivity reallocation between high and low productivity firms has been traditionally measured through predicted changes in firm employment (Foster *et al.,* 2001; Foster *et al.,* 2016), rather than reallocation that occurs through the change in each firm's predicted probability of survival.

This paper is most closely related to the literature on digitalisation as an important factor for business resilience, measured usually in terms of revenue or profit at times of crisis, such as a recession (Copestake *et al.,* 2024; Nose and Honda, 2023; Calza *et al.,* 2023; Abidi *et al.,* 2022). Our paper advances on these existing findings in several ways. First, we measure digitalisation at the firm level and prior to the start of the crisis, while much of the literature is restricted to industry-wide or ex-post measures that conflate crisis preparedness and response. Second, we focus on SMEs, that are both more vulnerable and exhibit more heterogeneity in digital technology adoption. And third, we investigate the role of the wider environment by studying differences between urban and rural areas, an aspect that to the best of our knowledge has not been considered by the literature.

2. Data

To estimate the effects of digital technologies on business survival, we combine data from the Longitudinal Small Business Survey (LSBS) with demographic events from the Business Structures Database (BSD) from 2015 to 2022. The LSBS is an annual survey of small and medium sized businesses with a limited panel aspect (Department for Business and Trade, 2024). The sample is stratified by registration status, employment size (with more weight given to medium-sized businesses), sector and geography (across the nations of the UK - England, Scotland, Wales and Northern Ireland). Businesses are re-surveyed every year and the sample is replenished to compensate for business exit and non-response.

For this study, we exploit questions on the use of digital technologies that were asked between 2015 and 2019[4]. Specifically, businesses were asked whether they used an online channel to sell to their customers, either on their own website, a third-party platform or social media, henceforth referred to as online or digital sales. They were also asked whether they used digital tools for record keeping, either an off-the-shelf or bespoke accounting software, henceforth digital records (see Appendix AI for the wording of survey questions). These particular digital tools are relevant to different industries and reflect different firm capabilities. Digital records are a productivity tool that reflects management capabilities while online sales were less prevalent before 2020 but had the potential to create new value for customers that helped with business

[4] Hence our indicators of digitalisation reflect early adoption and are independent of whether a firm has adopted digital inputs after 2020.

continuity during the pandemic. We record online sales and digital records as binary variables indicating whether a business used these digital technologies *prior to 2020*.

The survey also covers questions on access to finance and from 2020 asked whether the business accessed any public Covid-19 related benefits or support measures. From this, we derive a binary variable to indicate whether a business received any such support.

The LSBS is then linked to the BSD, which provides an annual snapshot of all businesses, allowing to derive demographic events. Businesses are registered when they first register for value added or pay-as-you-earn income tax. Birth has only been recorded in this way since 1973, which is the imputed birth year for older businesses. Hence, age is top-coded for the small number of older firms in the sample. As deaths are registered with a lag of one to two years, meaning that more recent death statistics are unreliable, we end the sample in 2022. Additionally, we recode businesses as dead if they record zero turnover for three or more years. In addition to demographic events, the BSD provides employment, turnover, industry and business location at the Lower Super Output Area (LSOA) level.[5] Turnover is deflated using industry deflators. We calculate labour productivity as deflated turnover divided by employment.

We limit the sample to businesses with at least one response on the LSBS and non-missing values for our two main variables of interest, online sales and digital records. We further limit the sample to single-plant firms, which make up the majority of businesses in the sample of small and medium sized firms. This restriction is required as turnover on the BSD is only recorded at the enterprise, rather than the individual plant level. The sample was further cleaned for rare instances of unusual events, for example a response to the LSBS after the business was recorded dead on the BSD.

During 2020 and 2021, local lockdowns were imposed. This established a regime of tiered restrictions on interpersonal contact and activities, including restrictions on operations of some businesses. The first period of local lockdowns, from 14 October 2020 established three tiers, ranging from Tier 1 – medium alert to Tier 3 – very high

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[5] LSOAs comprise between 400 and 1,200 households and have a usually resident population between 1,000 and 3,000 persons.

alert. This regime ended on 5 November 2020 when a stricter, national lockdown was put in place. From 2 December 2020, there were again tiered, local lockdowns, this time with four tiers and slight changes to the rules of the first local lockdowns. Tier 4 introduced a new alert level of 'Stay at Home'. The regulations stayed in place until 29 March 2021 but the tiered regime effectively ended on 6 January 2021 when all areas in England moved to Tier 4. Tiers were assigned at the local authority level (county council, combined or unitary authority, or borough council), meaning that there was substantial variation in the degree to which businesses were effectively exposed to Covid-19 regulations. To capture this variation, we define a variable indicating the number of weeks spent in the highest two lockdown tiers.

Due to data limitations, we focus on SMEs in England and Wales. Our sample for estimation has 10,766 observations from 1,992 firms, of which 1,282 are urban and 710 rural. Firms are defined as rural or urban at the Lower Super Output Area level according to the ONS 2011 Census definition, which is based on population and population density (Bibby & Brindley, 2013). 18% of observations belong to exiting firms.

Table 1 presents summary statistics of the variables, overall and separately for the urban and rural samples. The average exit rate in the sample is 4.3%. The prevalence of digital records is 70%, and of online sales 31%, with only slightly higher prevalence in the urban sample. The number of weeks spent in the two higher lockdown tiers is twice as high in the urban sample, at 4.27 on average compared to 2.05 weeks among rural observations. As expected, the urban and rural samples differ in their industrial composition. The two samples also differ greatly in their average broadband speeds.[6]

[6] Appendix Table A1 shows summary statistics for the underlying sample, before cleaning.

Table 1: Summary statistics

	Overall		Urban		Rural	
	Mean	SD	Mean	SD	Mean	SD
1 if firm dies in year	0.043	0.20	0.045	0.21	0.041	0.20
1 if firm exits at some point	0.18	0.38	0.18	0.38	0.18	0.38
Digital tech. used pre-Covid						
Record keeping	0.70	0.46	0.71	0.45	0.68	0.47
Online sales	0.31	0.46	0.32	0.47	0.28	0.45
Age brackets (years)						
. 0-5	0.094	0.29	0.10	0.31	0.076	0.26
. 6-10	0.28	0.45	0.30	0.46	0.23	0.42
. 11-20	0.41	0.49	0.40	0.49	0.41	0.49
. More than 20	0.22	0.42	0.19	0.39	0.28	0.45
Labour productivity (1,000)	95.8	152.3	95.5	158.2	96.3	141.1
Employment	7.45	17.5	7.58	17.8	7.23	17.0
Exporter	0.35	0.48	0.37	0.48	0.33	0.47
Importer	0.31	0.46	0.31	0.46	0.31	0.46
Weeks in two highest tiers	3.48	2.67	4.27	2.55	2.05	2.27
Government Covid support	0.070	0.26	0.069	0.25	0.073	0.26
Primary	0.060	0.24	0.0092	0.096	0.15	0.36
High & medium tech manuf.	0.046	0.21	0.053	0.22	0.034	0.18
Low-tech manufacturing	0.034	0.18	0.033	0.18	0.037	0.19
Utilities	0.0023	0.048				
Construction & real estate	0.084	0.28	0.091	0.29	0.072	0.26
Less KI services	0.35	0.48	0.35	0.48	0.34	0.47
KI services	0.43	0.49	0.46	0.50	0.37	0.48
Rural	0.36	0.48				
Urban	0.40	0.49	0.62	0.48		
Major urban	0.24	0.43	0.38	0.48		
Avg download speed (Mbits)	56.4	34.9	62.4	33.3	45.5	35.1
Number of Observations	10766		6937		3829	
Number of firms	1992		1282		710	

Note: Urban areas are defined as urban and major urban areas in the ONS Census definition, all others are rural. The table shows unweighted means. Urban/rural level statistics for Utilities firms censored to prevent disclosure.
Source: BSD and LSBS.

Descriptive evidence

Figure 1 documents exit rates by year, from 2016 to 2022, for firms with and without digital inputs prior to 2020.[7] Among the group of firms without digital record keeping or online sales pre-2020, some may have later adopted these technologies during the pandemic. The groups presented in Figure 1 therefore reflect pre-pandemic digitalisation status rather than the presence of digital inputs in general. It is striking that the exit rate for firms without digital inputs (dotted line), ranging between 6% and 9% over time, is consistently higher than for firms with digital inputs. Moreover, firms using digital technologies pre-2020 show a pronounced drop in their exit rates in 2020 and 2021.[8]

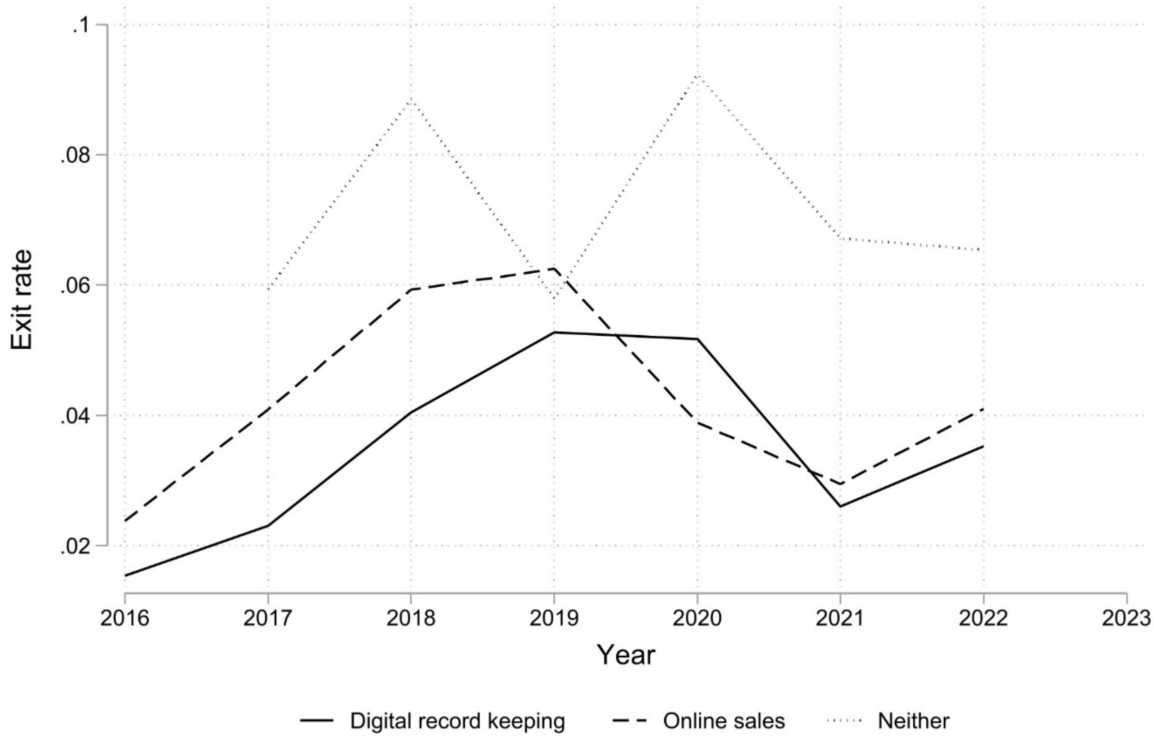

Figure 1: Exit rate by type of digital technology used

[7] The exit rate for firms without digital inputs in 2016 has been censured to prevent disclosure.

[8] The exit patterns in our SME sample do not exactly match the aggregate data based on all firms. First, some exiting firms dropped out of the sample during data cleaning. Second, we extract SMEs that answered the LSBS prior to 2020 and therefore do not include the numerous dying businesses born after 2019. This can explain why the spike in firm deaths in 2021 and 2022 in the aggregate statistics cannot be found in our sample.

The non-parametric Kaplan-Meier plot in Figure 2 shows the proportion of firms with (dashed line) versus without digital inputs (solid line) surviving, over time. Firms with digital inputs are more likely to survive than those without (from 2018) and the difference widens over time, particularly after the start of the Covid-19 pandemic in 2020. Because this estimates unconditional survival functions, we will turn in the next section to econometric analysis that takes into account determinants of survival that may shift the hazard function.

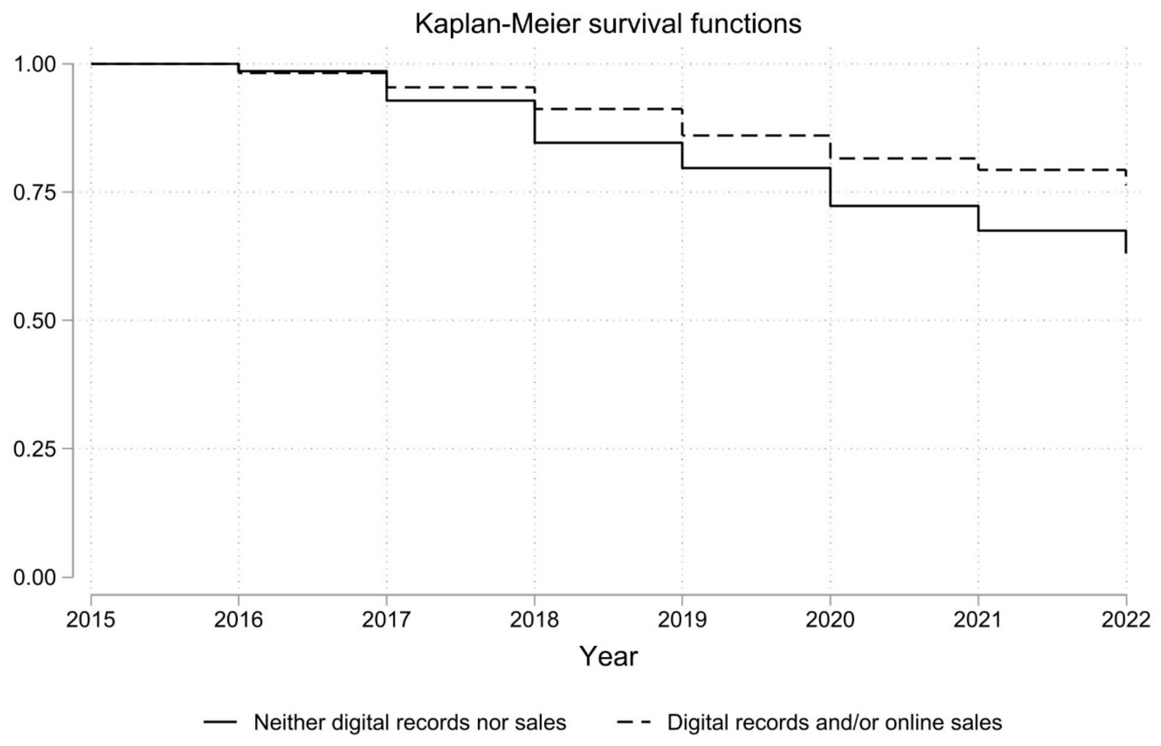

Figure 2: Kaplan-Meier plot by presence of digital inputs

The role of digital technologies becomes even more evident when considering differences between urban and rural areas in the evolution of exit rates. Figure 3 shows that in urban areas, while the exit rate for firms without digital inputs pre-2020 increased from 5.5% in the period 2016-2019 to 8.5% in the period 2020-2022, it remained about the same for firms with digital record keeping (about 3.5%) and decreased for firms with online sales from 5.1% to 2.8%. In contrast, in rural areas, exit rates increased in the pandemic period for all types of firms. In summary, SME exit rates increased during the pandemic for all types of firms except urban firms with prior online sales.

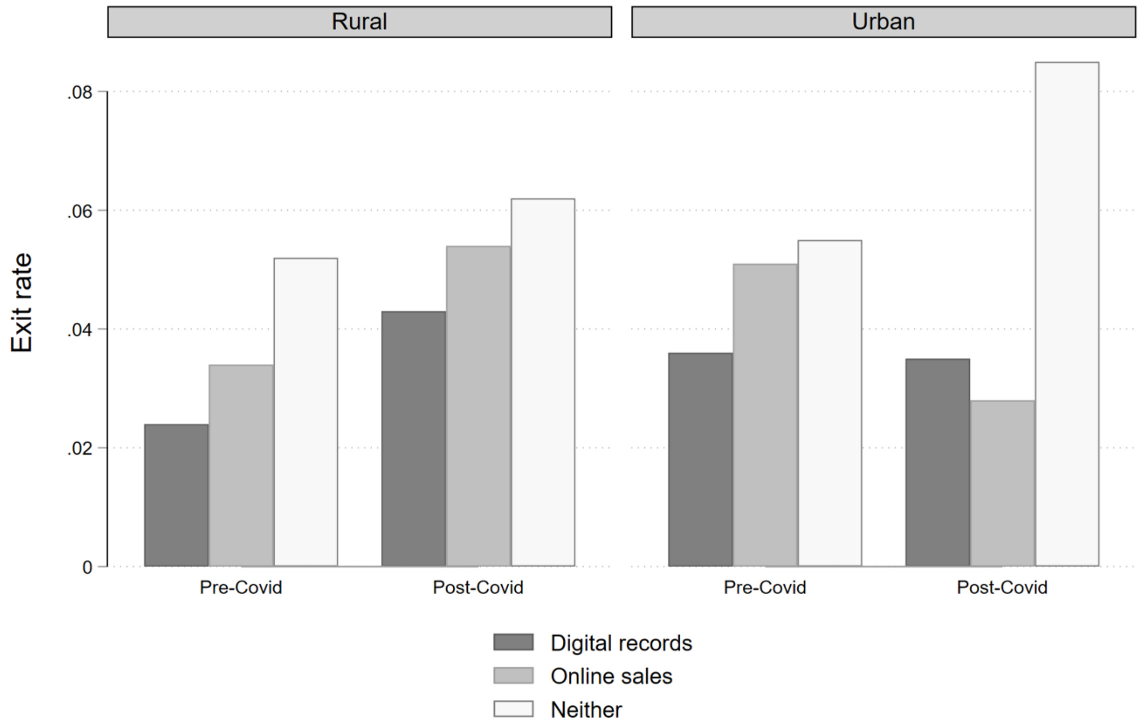

Figure 3: Exit rates by urban versus rural business location

Source: authors own elaboration from LSBS and BSD.

A key driver of firm survival and exit that has been evidenced in the theoretical and empirical literature is firm productivity. Figure 4 shows labour productivity trends over time for our sample of firms, by digital input use. Firms with prior digital record keeping are consistently the most productive. However, the productivity gap with the group of firms with prior online sales is narrowing over time. This may be because the least productive firms and sectors (such as retail) tended to adopt online sales prior to the pandemic, but were in turn in a better position to perform in later years thanks to their early adoption of these digital inputs.

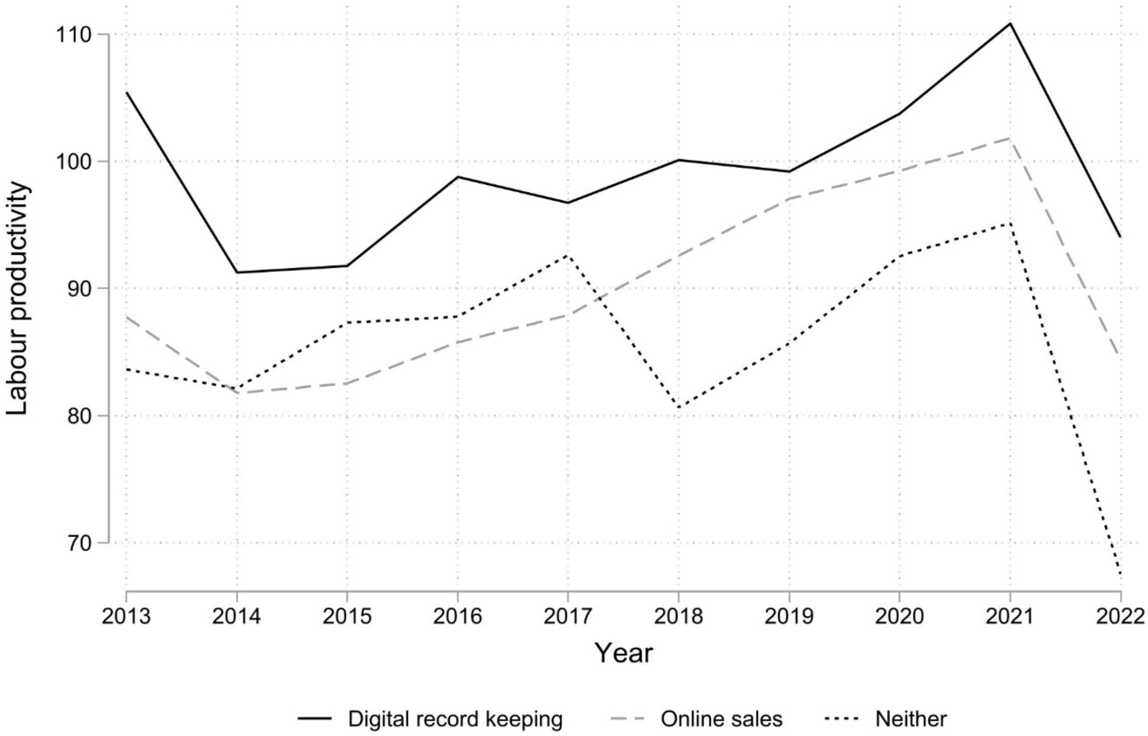

Figure 4: Labour productivity at firms with and without digital records pre-2020

Note: labour productivity is measured as deflated firm turnover divided by employment in £1000.

Again, the picture is different when we consider firms in urban and rural areas separately. In urban areas (Figure 5a), the gap in productivity between firms with digital record keeping and firms with online sales is narrower and reduces over time. Digitalised firms have a positive productivity trend since 2015. Firms that were not digitalised pre-2020 however, are lagging behind digitalised firms and exhibit a downward labour productivity trend since 2018. In rural areas (Figure 5b), the productivity gap between firms with digital record keeping and firms with online sales remains large and constant over time. Both non-digital firms pre-2020 and firms with online sales lag behind firms with digital record keeping in all years except 2021.[9]

[9] Appendix Figures A1-A3 show labour productivity for firms in the uncleaned sample.

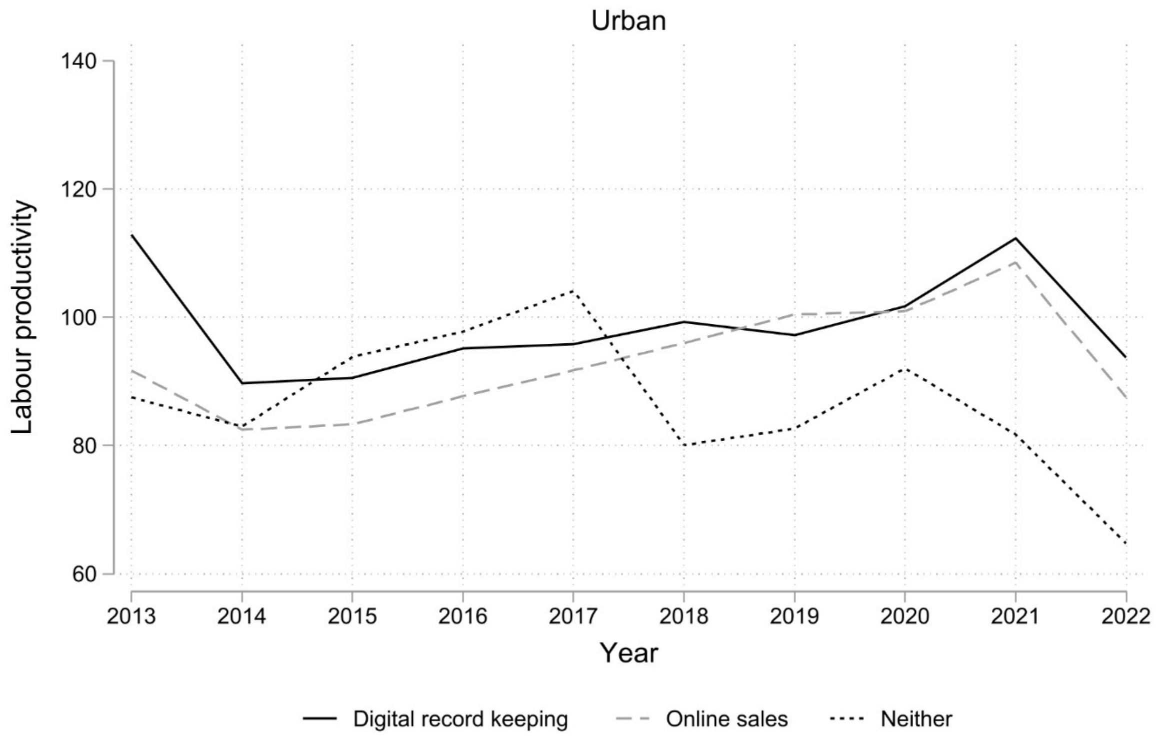

Figure 5a: Labour productivity at firms with and without online sales in urban areas pre-2020

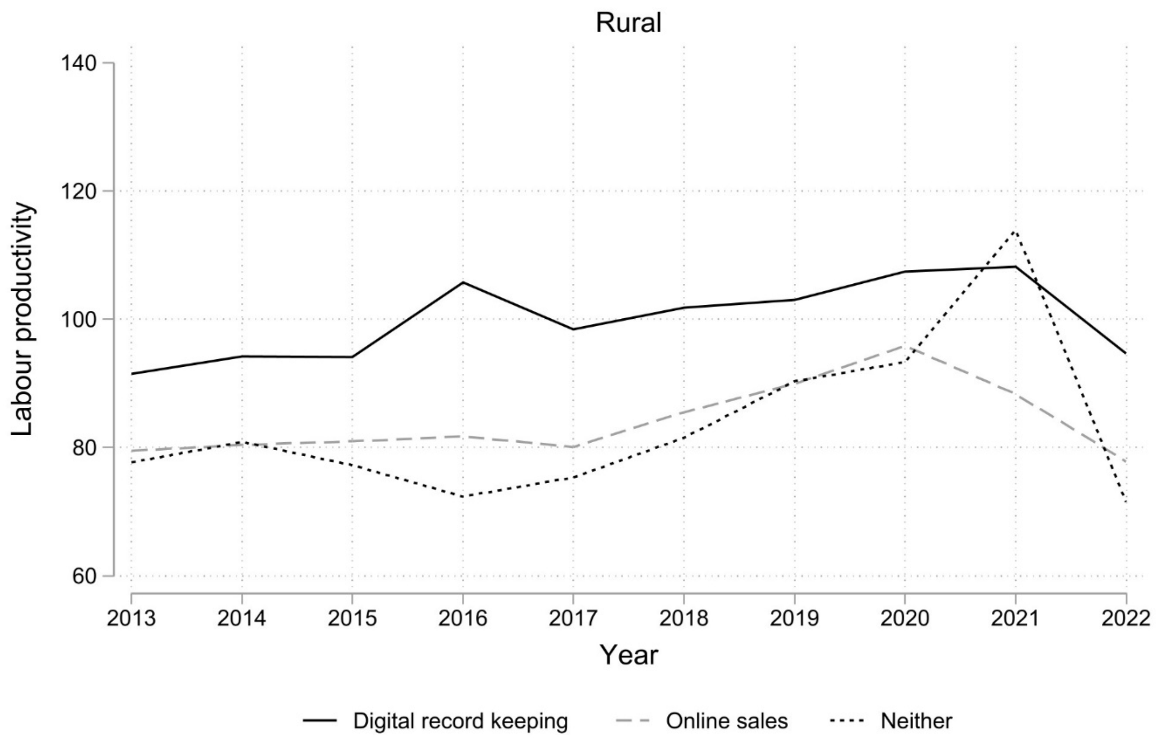

Figure 5b: Labour productivity at firms with and without online sales in rural areas pre-2020

3. Empirical strategy

Our aim is to assess the effect of digital technologies on business survival and the changing role of these during the Covid-19 pandemic. We estimate the probability of business exit in a given year as a function of digital technologies in use pre-2020, controlling for weeks spent in the two strictest lockdown tiers and receipt of government support. Our estimations also control for other factors influencing the probability of exit by including urban and major urban dummies, age ranges, indicators for whether the firm engages in import or export, labour productivity, employment to reflect the size of the firm, broad sector indicators derived from SIC 2007 sectors and year dummies.

We use the complementary log-log model, a discrete-time version of the Cox proportional hazard model. This model assumes that the hazard of exit depends only on time at risk and on explanatory variables that affect the risk independently of time. It is often preferred for the analysis of firm exit as it is particularly suitable for rare events (See Bandick and Georg (2010) and Guariglia *et al.* (2016)). We also implement Probit estimations and provide the results in the Appendix. In the baseline complementary log-log model, the proportional hazard is expressed as:

$$\mathrm{h}(j, X) = 1 - \exp\left[\exp\left(\mathrm{b}'X + y_j\right)\right] \quad (1)$$

Where $\mathrm{h}(j, X)$ is the hazard for the duration of the period of the j^{th} year of the firm, X is the set of variables that influence the hazard rate and b represents the effects of each variable on the hazard rate. y_j are time-specific effects on the hazard rate.

The use of digital technologies correlates strongly with other determinants of survival, such as other investment, workforce skills and managerial ability, making it challenging to clearly identify the causal impacts of digitalisation on business performance or survival. For example, firms with better quality of management are likely to be both more productive and to adopt digital inputs. However, the Covid-19 pandemic provides a context that sharply increased the importance of digital tools both for employees to communicate with each other as well as for businesses to communicate with customers and suppliers. To mitigate the risk of endogeneity and reverse causality between digitalisation, productivity and exit, we estimate the impact of digital technologies on survival both before and after the start of the pandemic to provide evidence of this changing role. We also use labour productivity lagged by two periods as a control variable.[10]

Claims have been made that Covid-19 would usher in the 'death of distance', with businesses and employees able to work from anywhere. Alternatively, businesses in urban areas may be at an advantage as they already benefit from access to better digital infrastructure and skills. To test for any such differential effects, we split the sample by rural and urban (including major-urban) areas, according to the Census definition.

We then perform a counterfactual exercise to estimate the effect of digitalisation on aggregate productivity among the population of SMEs. We build on the literature on productivity reallocation, particularly Foster *et al.* (2016)[11] to assess the contribution of digital inputs to a productivity index for SMEs. Unlike most of the literature, we do not consider employment reallocation but rather the reallocation that occurs via the survival channel, to isolate the effect of the change in predicted exit due to early digitalisation.

The base productivity index therefore takes into account the probability of survival in the previous period. It is computed for each year t from 2020, as:

$$P_t = \sum_i \theta_{it} \, P_{it} \, (1 - \hat{p}_{i,t-1})$$

θ_{it} is firm *i*'s employment share in year *t*,

P_{it} is firm *i*'s log labour productivity lp_{it} deviated from the industry-year mean $\overline{lp_{ijt}}$:

$P_{it} = \ln(\frac{lp_{it}}{\overline{lp_{ijt}}})$, where *j* is firm *i*'s industry

[10] Productivity values in the year of exit are abnormal, as firms tend to change how they deal with inventories. During the pandemic period, this can last more than a year as firms tend to survive for longer due to government support grants.

[11] See Syverson (2011) for a review of earlier literature.

and $\hat{p}_{i,t-1}$ is the predicted probability of exit in the previous year for firm *i* using the Probit model. Therefore $1 - \hat{p}_{i,t-1}$ is the predicted probability of survival of firm *i* between *t-1* and *t*.

Similarly, the counterfactual productivity index is computed as:

$$P_t^C = \sum_i \theta_{it} \, P_{it} \, (1 - \hat{p}_{i,t-1}^C)$$

$\hat{p}_{i,t-1}^C$ is the predicted probability of exit in the previous year for firm *i* obtained from applying the estimates from the model to data where we constrain both digital inputs variables to be set according to the counterfactual scenario. We explore four counterfactuals: the universal early adoption of both types of digital inputs (where both digital records and online sales variables are set to 1 for all firms), no digital inputs (where both variables are set to 0 for all firms), universal adoption of digital records (where online sales remain as in the original data) and universal adoption of online sales (where digital records remain as in the original data). The employment weight, θ_{it} is assumed unchanged in the counterfactual probability index.

The contribution of digital inputs to aggregate SME productivity via survival is measured as $P_t - P_t^C$.

$$P_t - P_t^C = \sum_i \theta_{it} \, P_{it} \, (\hat{p}_{i,t-1}^C - \hat{p}_{i,t-1})$$

Therefore, in the counterfactual scenario where all firms adopted both digital inputs prior to the pandemic, $P_t - P_t^C < 0$ if digital inputs facilitated the survival of firms that are above their industry productivity average and $P_t - P_t^C > 0$ if digital inputs facilitated the survival of firms that are below their industry productivity average.

4. Digitalisation and survival

The results of estimations of the effects of different factors on the probability of exit are reported in Appendix Table A2, using Probit (columns (1) and (2)), and using complementary log-log models (columns (3) and (4)).[12] Figure 6 plots the same complementary log-log coefficients reported in columns (3) and (4) of Appendix Table A2 with 95% confidence intervals.[13]

The results show that the use of digital records prior to the pandemic reduces the probability of exit both pre- and post-2020. The impact is not significantly different post-2020 compared to pre-2020 (28% versus 31% decrease in the probability of exit). In contrast, the use of online sales prior to the pandemic is associated with higher exit probability pre-2020, possibly reflecting the selection in digital input adoption highlighted in our descriptive analysis. Post-2020 however, firms with prior online sales are less likely to exit by 25.8%.

Turning to the control variables, as expected, firms in local authorities with greater time spent under strict lockdown are no more likely to exit pre-pandemic, but post-2020 an additional week spent under strict lockdown increases firms' probability of exit by 11.1%. Having been in receipt of Government Covid-19 support has a large and highly significant effect on the post-2020 probability of exit, reducing it by 55.7%.

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[12] Complementary log-log coefficients are reported in exponentiated form, meaning a coefficient greater than 1 indicates the variable increases the probability of exit. Results using a random effects complementary log-log estimation are reported in Appendix Table A3 as further robustness.
[13] Coefficients from the Probit estimations are plotted in Appendix Figure A4.

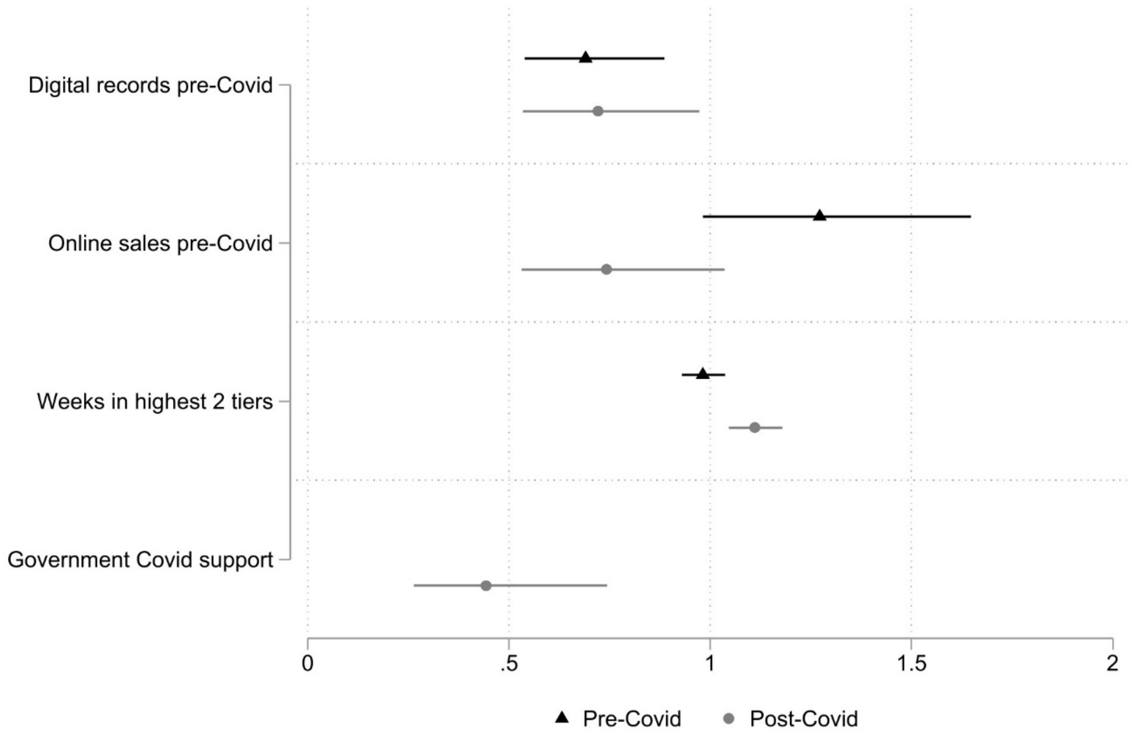

Figure 6: Coefficient plot from complementary log-log estimation

Note: binary dependent variable: exit, equal to 1 if the firm exits in year t, 0 otherwise. Complementary log-log coefficients in exponentiated form. Other controls not shown: Year, urban and major urban, industry, exporter, importer dummies, age brackets, labour productivity, employment.

As can be seen from the coefficients reported in Appendix Table A2, urban status is also related to the probability of exit, independently of local lockdown intensity. Consistent with the theorical prediction of greater churning in larger cities (Behrens and Robert-Nicoud, 2014; Combes *et al.,* 2012) and previous empirical evidence (D'Costa *et al.,* 2024), SME in major urban areas were 15.7% more likely to exit pre-2020 (column (1)), compared to those in rural areas. During the Covid-19 crisis however, they are 27.6% less likely to exit according to the Probit estimation and 42.4% less likely to exit according to the complementary log-log estimation. This is consistent with previous evidence that urban environments favour the resilience of firms during periods of economic crisis (Holl, 2018). The other explanatory variables have the expected effects. Start-ups under five years of age are more likely to exit, whilst more productive firms, larger firms and firms engaged in international trade are less likely to exit.

The above results indicate that firms belonging to urban and rural areas differ in their conditional probability of exiting and in their ability to survive the Covid-19 crisis. The descriptive evidence provided in Section III suggests that the role of digital inputs in firm survival also differs between rural and urban firms. Appendix Table A4 therefore reports the estimation results, separately for urban and rural firms, using complementary log-log estimation.[14] Figure 7 plots the key coefficients, with 95% confidence intervals.

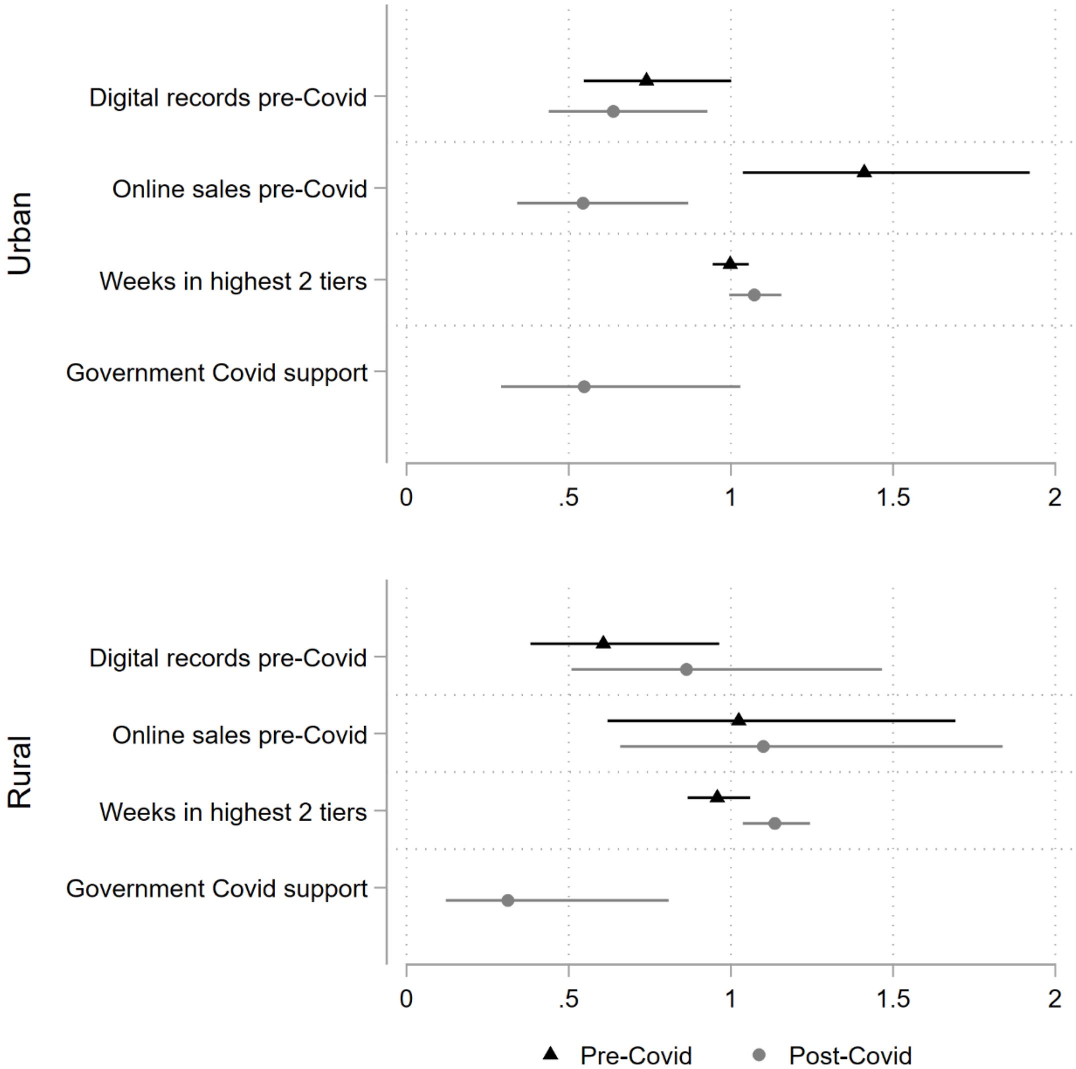

Figure 7: Coefficient plot from complementary log-log estimation

[14] The Probit results are reported in Appendix Table A5.

Note: binary dependent variable: exit, equal to 1 if the firm exits in year t, 0 otherwise. Complementary log-log coefficients in exponentiated form. Other controls not shown: Year, industry, exporter, importer dummies, age brackets, labour productivity, employment.

While pre-pandemic digital records inputs significantly reduce the probability of exit for urban firms in both periods (by 26% pre-2020 and 36% post-2020), for rural firms the effect is not significant during the pandemic period. Pre-pandemic online sales significantly increase the probability of exit for urban firms pre-2020, by 41%, and decreases it by 46% during the pandemic, but for rural firms the effect is small and insignificant in both periods. The results control for local-authority level average download speeds, as the quality of broadband may explain rural-urban differences in the effects of digitalisation on exit. However, controlling for broadband speeds does not affect any of the results in this paper.[15]

Turning to Government Covid-19 support schemes, these had a particularly large and significant effect in reducing exit in rural areas: firms in receipt of such support had a 69% lower probability of exit, compared to 45% in urban areas.

These results show that pre-pandemic adoption of digital record keeping and online sales offered some protection against exit for British SMEs when the crisis hit, though this protection was largely confined to urban areas. For rural SME, Government Covid-19 support was the key factor in survival. In Appendix Table A6, we investigate whether these results are driven by firms in London, by removing observations for London firms. The results for urban firms outside London are in a way stronger, as neither digital record keeping nor online sales significantly impacted firm exit prior to the pandemic, whilst both were negatively associated with exit post-2020 (at the 10% significance level).

[15] In results available upon request, we also find that various measures of broadband speed at local-authority level are not good predictors of digital input use.

5. Digitalisation and productivity reallocation

The previous results demonstrate that the role of digital technologies in the survival of British SMEs is dependent on the type of digital input used, whether the firm is located in an urban or rural local authority, and in the case of online sales, that this role has evolved during the pandemic. We now investigate what exit rates would have been during the crisis if none or all businesses had already been using digital technologies pre-2020. We then use predicted exit probabilities to compute counterfactuals of aggregate productivity and assess the extent of productivity reallocation through survival.

Figure 8 presents counterfactual exit rates for the whole sample and by urban status, for the 2020-2022 period. The first counterfactual, where no firms had adopted either type of digital inputs, predicts a higher pandemic exit rate of 6.2% versus the actual rate of 4.8%. The difference is much larger for urban firms, with 6.9% versus 4.6%, whilst it is minimal for rural firms (5.4% versus 5.1%). The second counterfactual imposes that all firms had adopted digital inputs pre-2020. The predicted exit rate drops to 3.4% for the whole sample and 2.5% for urban firms, whilst for the rural sample this remains unchanged. Finally, imposing that all firms had adopted one of either digital records or online sales, leaving the other input variable unchanged, produces predicted exit rates of 3.8% or 3.9% respectively, which is lower than the actual rates but still higher than the counterfactual with all firms having adopted both types of digital inputs.

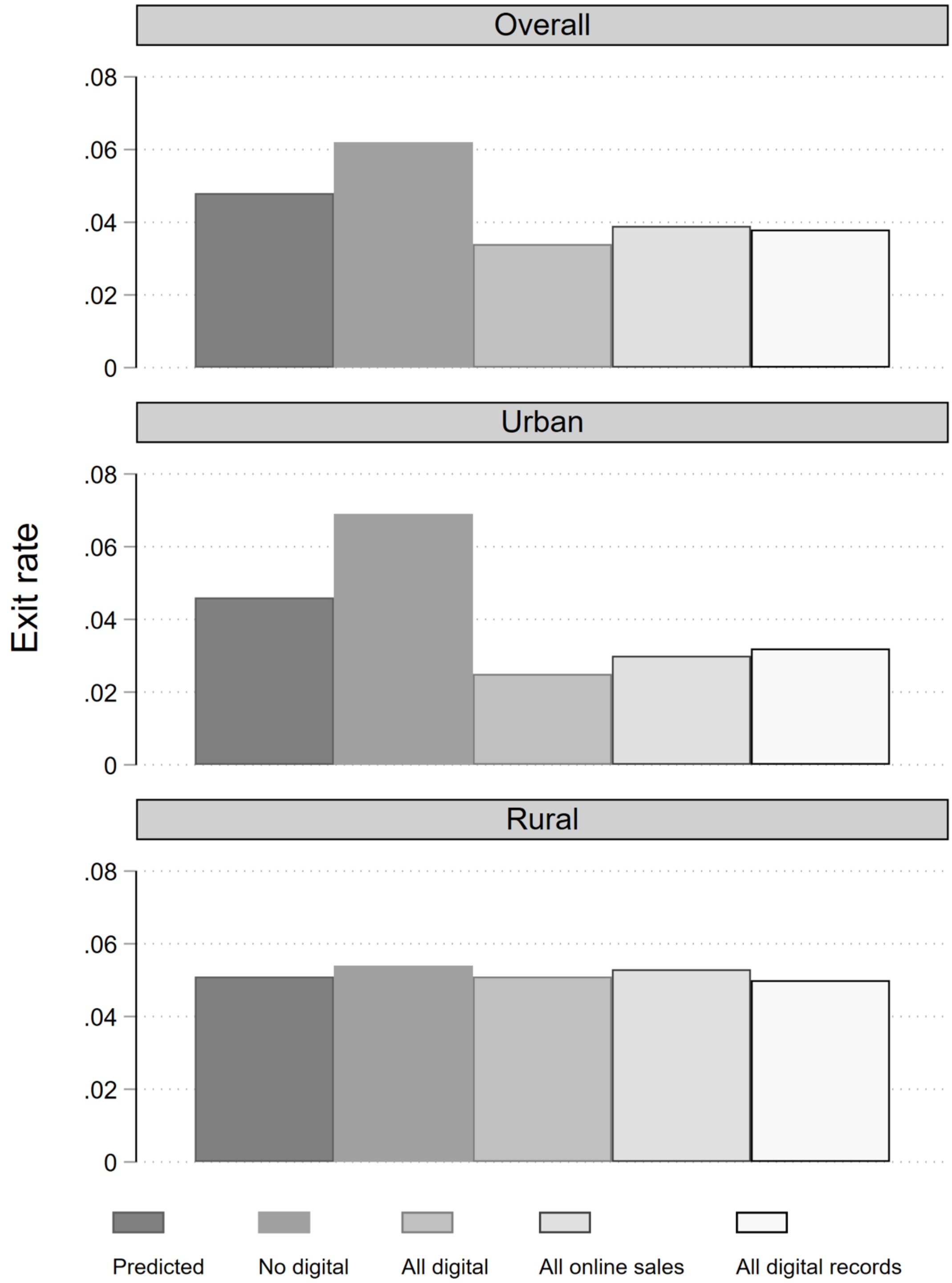

Figure 8: Counterfactual exit rates

These figures indicate that early adoption of digital records and online sales has the potential to noticeably reduce average exit rates, though mostly for urban SMEs.

However, if those firms that survive thanks to having digital inputs are relatively unproductive, this may have a negative effect on aggregate productivity. On the contrary, if digitalisation favours the survival of particularly productive firms during the crisis that may not have survived the Government-mandated lockdown restrictions otherwise, then there would be a positive impact on aggregate productivity. To assess this, we use predicted values for each counterfactual case to compute a corresponding counterfactual productivity index.

Figure 9 shows, for the whole sample and by urban status, survival probabilities derived from the predicted exit rates computed for each scenario and actual and counterfactual productivity indices for SMEs based on the mean divergence from a firm's industry average.[16] Changing survival probabilities by using a model where no firms had adopted either digital technology prior to the pandemic hardly changes the productivity index during the pandemic period. However, in the scenario where all SMEs had adopted both digital inputs, the counterfactual productivity index would in fact decrease from -0.028 to -0.035. This is due to reallocation through negative selection in rural areas, with productivity reducing from -0.019 to -0.096 there. In urban areas, this counterfactual brings positive reallocation, with the productivity index increasing. In urban areas, full digitalisation would have improved the survival of the relatively more productive firms and strengthened the "cleansing" role of urban areas.

The pattern of positive reallocation in urban and negative reallocation in rural areas is also found in scenarios where all firms adopt either online sales or digital records. Positive reallocation in urban areas is greatest with universal digital records, whereas negative reallocation in rural areas is greatest in the scenario with universal online sales.

[16] Note that the baseline productivity index is negative. As the productivity index is a weighted average of firms' log labour productivity relative to their industry mean, which can be positive or negative, weighted by their employment share and previous-period probability of survival, this suggests either that larger SMEs are less productive than their industry average, or that less productive firms are more likely to survive.

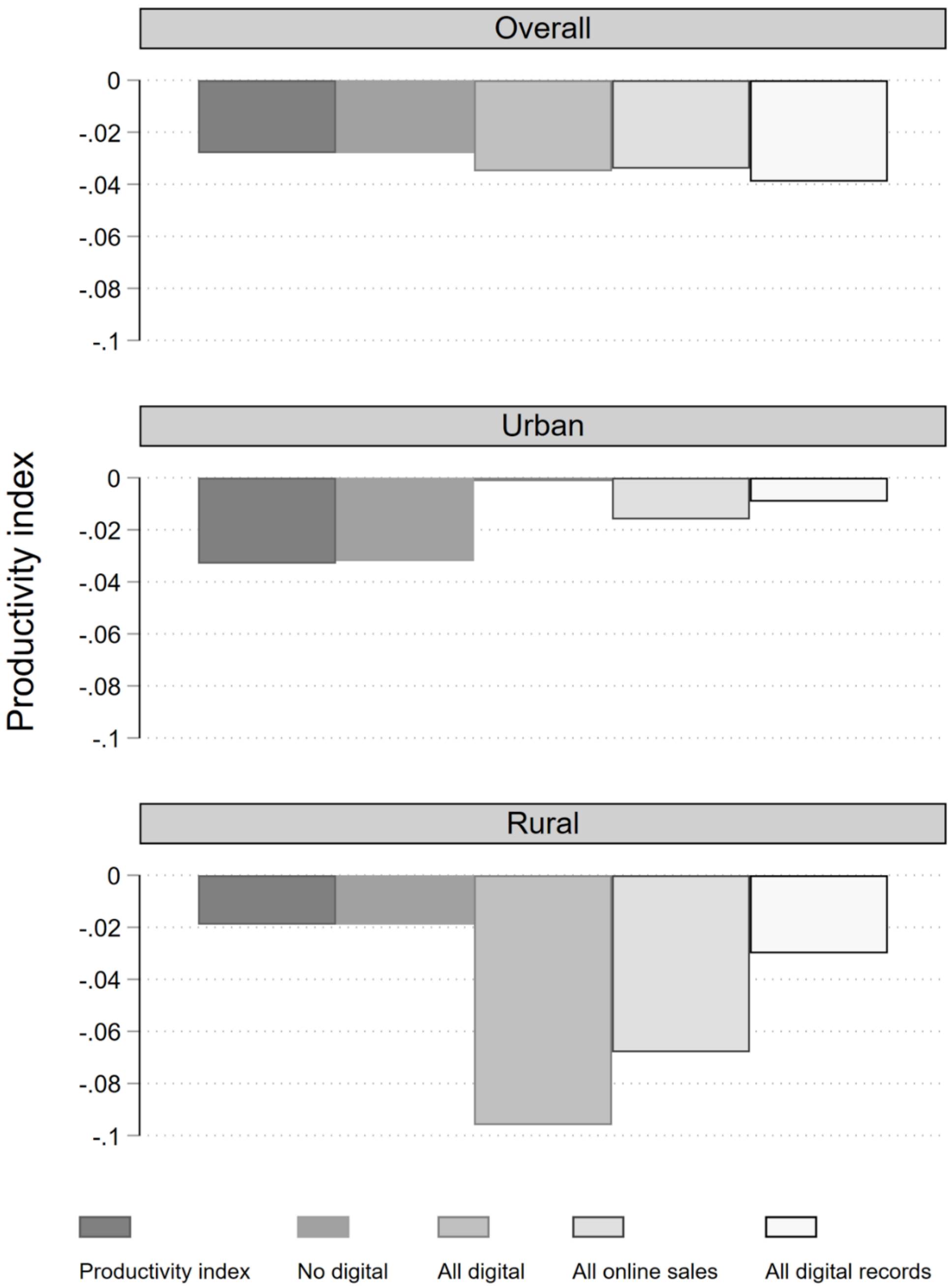

Figure 9: Productivity counterfactuals

Note: Counterfactual productivity indices based on counterfactual exit rates shown in Appendix Table A7. We develop the counterfactuals by imposing that all/no business uses digital technology, for either both digital sales and digital records, or only one of these variables, leaving the other unchanged. The counterfactuals are calculated for the post-Covid-19 period.

To benchmark the importance of digital technologies for survival during the crisis, we also compute counterfactual exit rates and productivity from the uptake of public Covid-support schemes. Panel A in Table 2 confirms the critical role of Covid-19 support schemes for SME survival in rural areas. From 5.1%, the exit rate would increase to 5.9% in the absence of Covid support and decrease to 1.9% if all firms benefited from such schemes. The effects in urban areas go in the same direction, though with much smaller magnitudes.

Panel B shows counterfactual productivity. Both counterfactuals, where no firms and all firms receive Covid-19 support, deliver minimal changes in the SME productivity index, in spite of large predicted changes in exit rates. With universal Covid support, the difference in productivity is positive, meaning that there would be negative reallocation, with the least productive firms surviving as a result of the policy. Though the magnitude of the effect is small, it is largest in rural areas.

The results in Table 2 suggest that in urban areas, the positive effect of digitalisation on survival is comparable to that of Government Covid-19 support, but in rural areas it is negligible while universal Covid support would more than halve the SME pandemic exit rate. In terms of productivity reallocation, in urban areas, universal adoption of digitalisation would come with positive productivity reallocation through the survival of the most productive firms, whilst universal Covid support would bring about some (though minimal) negative reallocation. In rural areas, contrary to the universal adoption of digital inputs, universal Covid support would have a minimal effect on reallocation whilst significantly improving survival.

Table 2: Counterfactuals with and without government Covid support

	(1) Whole sample	(2) Urban	(3) Rural
Panel A: Exit rates			
Actual exit rate	0.048	0.046	0.051
Predicted exit rate	0.048	0.046	0.051
Exit rate: no Covid support	0.053	0.049	0.059
Exit rate: universal Covid support	0.024	0.029	0.019
N	3934	2525	1409
Panel B: Productivity indices			
Productivity index	-0.028	-0.033	-0.019
Productivity index: no Covid support	-0.028	-0.033	-0.019
Productivity index: universal Covid support	-0.028	-0.033	-0.019
Difference: no Covid support	-0.000049	-0.000056	0.0000094
Difference: universal Covid support	0.00021	0.00016	0.00027
N	3858	2468	1390

Note: counterfactual exit rates in column (1) are based on the regression model shown in Appendix Table A2, column (2). Counterfactual exit rates in column (2) are based on Appendix Table A5, column (2), and in column (3) on Appendix Table A5, column (4). We develop the counterfactual by imposing that all/no business accessed Covid-19 support. The counterfactuals are calculated for the post-Covid-19 period.

6. Conclusion

We provide novel evidence at the firm level that early adoption of digital technologies improves crisis resilience of SMEs. The adoption of digital records prior to the pandemic reduces the probability of exit both pre- and post-2020, by 28% and 31% respectively. In contrast, though pre-pandemic adoption of online sales is associated with a 27% higher exit probability pre-2020, the role of online sales changes after 2020, as firms with prior online sales become less likely to exit by 26%.

However, we find that this protection was limited to urban areas. For rural SMEs, government Covid-19 support was the key factor in survival. Extrapolating from these results, we find that universal early adoption of digital records and online sales has the potential to noticeably reduce the average exit rate, though only for urban SMEs. For urban firms, the predicted exit rate in the pandemic period would drop from 4.6% to

2.5% if all firms had adopted digital inputs, whilst for the rural sample the exit rate remains unchanged at 5.1%.

Next, our counterfactual analysis shows that digital inputs have implications for SMEs' aggregate productivity via reallocation through survival. In urban areas, there is evidence of positive reallocation as universal pre-2020 digitalisation would have improved the survival of the relatively more productive firms.

We compare our digitalisation counterfactuals to counterfactuals where all firms received Covid-19 support. In urban areas, the positive impact of universal digitalisation on the average survival rate is comparable to that of universal Covid-19 support. In rural areas, the digitalisation impact is negligible while universal Covid-19 support would more than halve the SME pandemic exit rate, from 5.1% to 1.9%. Turning to productivity, in urban areas, whilst universal digitalisation would increase aggregate SME productivity, universal Covid support would very slightly reduce it. In rural areas however, universal Covid support is preferable, as it would leave the productivity index largely unchanged whilst significantly improving the survival rate, contrary to the universal adoption of digital inputs.

We therefore show that the adoption and familiarity with these tools prior to the pandemic was an important factor in helping businesses survive. Online sales became an essential digital tool for survival during the pandemic, while digital records, perhaps associated with management quality, had always favoured survival. Contrary to some expectations, digital inputs primarily benefitted businesses in urban areas, highlighting that geography still matters, even when physical mobility and contact are restricted.

While our data does not allow us to identify the sources of this urban advantage, several mechanisms could be at play. First, the share of high-skilled workers is highest in urban labour markets. Urban SMEs may therefore benefit from higher skilled employees that are better at using digital technologies and adapting their usage to pandemic requirements. Second, due to a greater concentration of firms in urban areas, urban SMEs interact with and learn from larger networks of other businesses who are likewise more apt at using digital tools. Third, rural areas in Britain suffer from a low supply of professional services, that might have helped local SMEs to use their digital tools effectively to weather the crisis. The latter mechanism seems the best candidate for policy action. As UK government is building a strategy to increase the digitalisation of SMEs, it should also provide training and advisory to ensure these new tools translate into better crisis resilience. Our results also suggest that government responses to crises may need to be flexible and spatially targeted, as emphasized in Bourdin and Levratto (2024).

This paper focuses on the Covid-19 pandemic, a health crisis where digital tools were particularly decisive in overcoming social distancing. The pandemic necessitated a rapid switch to digital technologies, with lasting effects for business practices.Many employees, particularly in white collar occupations continue to work from home at least some days of the week. Moreover, Copestake *et al.* (2024) also find that digitalisation improves resilience during economic crises more generally. Both these factors suggest that the results are generalisable to other types of economic crisis and can inform future policy.

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Appendix

A I. Construction of digitalisation variables

To construct the digitalisation variables, we combine different variables from the LSBS. For the digital record keeping, we rely on questions about record keeping for tax purposes. There are different questions for different taxes, and the question numbering varies from year to year, but the answer options have remained consistent:

F8/F8A: In which of these ways does your business keep records for VAT/tax purposes?

a) Record keeping software
b) Spreadsheets
c) Paper-based records only
d) Other
e) Don't know
f) Refused

We consider businesses choosing option a) for any tax purpose as adopting digital record keeping.

For digital sales, we rely on questions about the businesses' web presence as well as specific e-commerce related questions:

O8A: Ways in which website can be used: So that customers can order and pay for goods or services directly from your website

O8B: Ways in which websites can be used.: To take bookings or orders, without payment at the time

O9A: Ways in which 3rd party websites are used.: So that customers can order and pay for goods or services directly from the websites

O9A: Ways in which 3rd party websites are used.: To make bookings or orders, without payment at the time

O10: Are you using social media so customers can order or buy goods or services from you?

ECOMMA: Goods and services can be ordered directly from own website

ECOMMB: Goods and services can be ordered directly from own, 3rd party websites or social media

ECOMMC: Bookings or orders can be made without payment

ECOMMD: Any e-commerce

A II. Additional figures

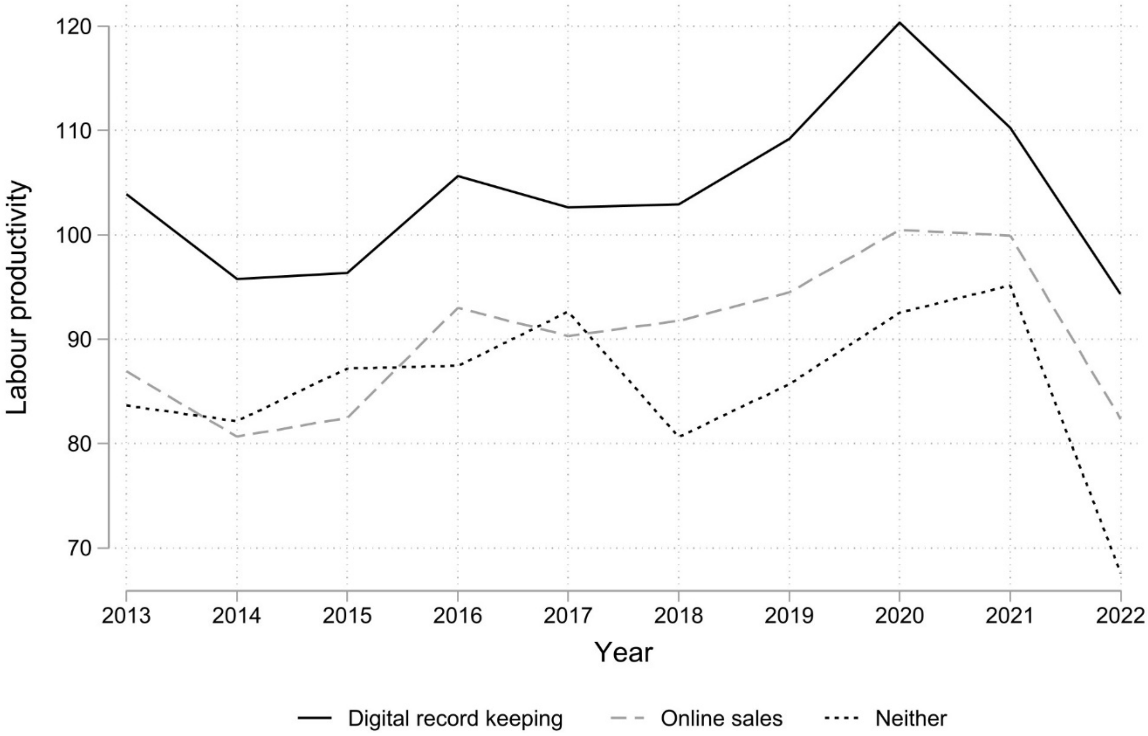

Figure A1: Labour productivity at firms with and without digital records, whole sample before cleaning

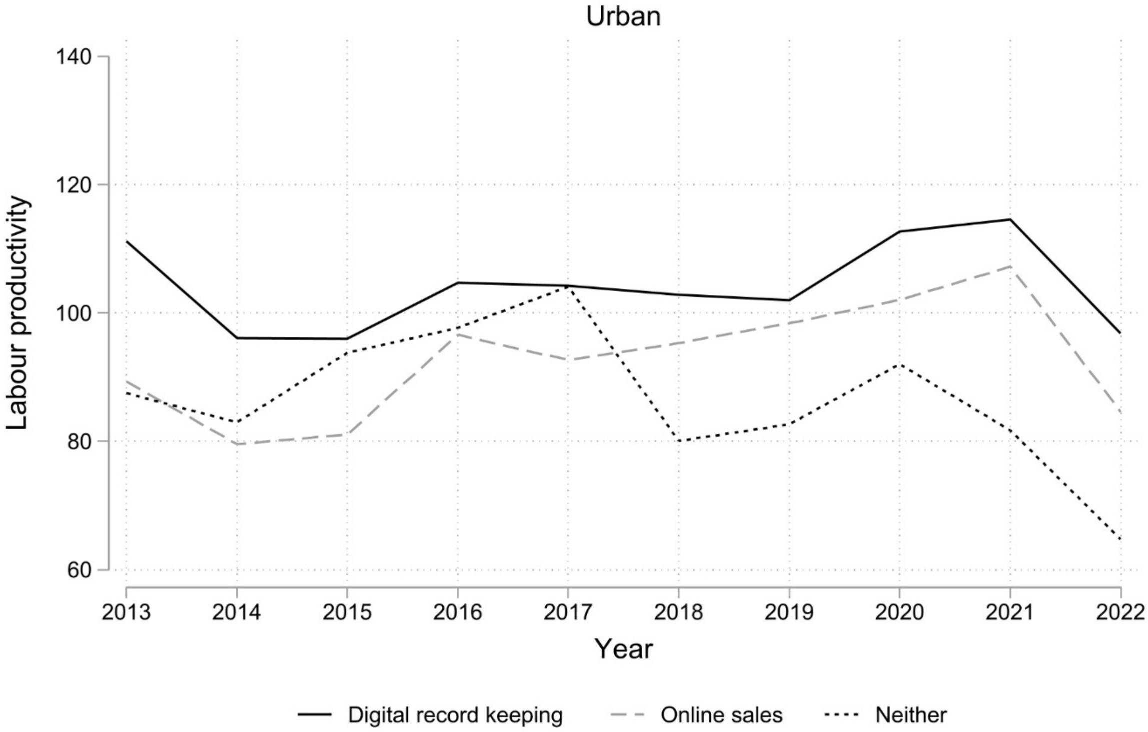

Figure A2: Labour productivity at firms with and without online sales in urban areas, whole sample before cleaning

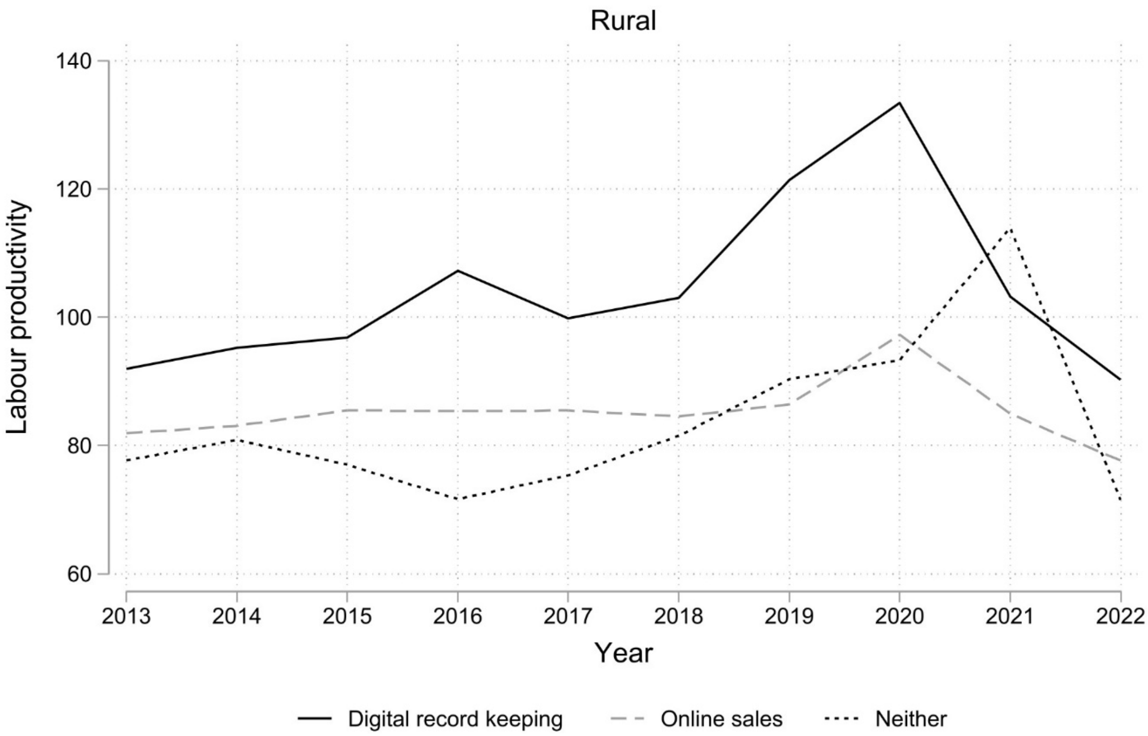

Figure A3: Labour productivity at firms with and without online sales in rural areas, whole sample before cleaning

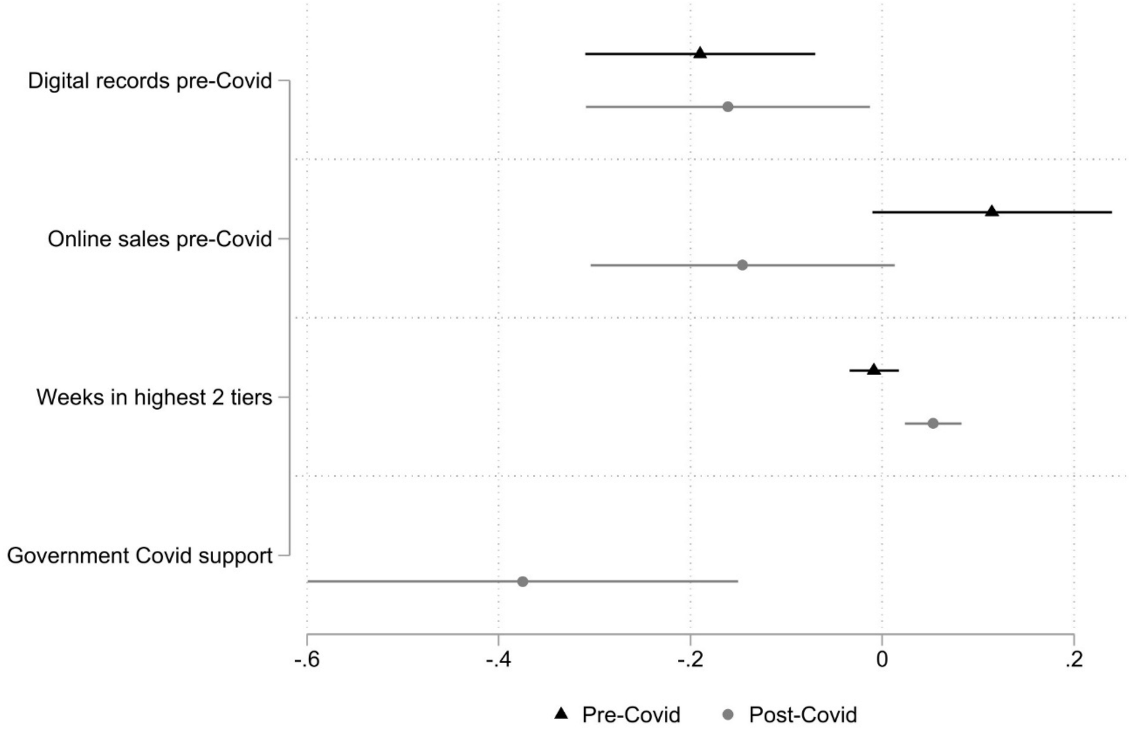

Figure A4: Coefficient plot from Probit estimation

Note: The chart plots the probit coefficients listed in table A2, with 95% confidence intervals.

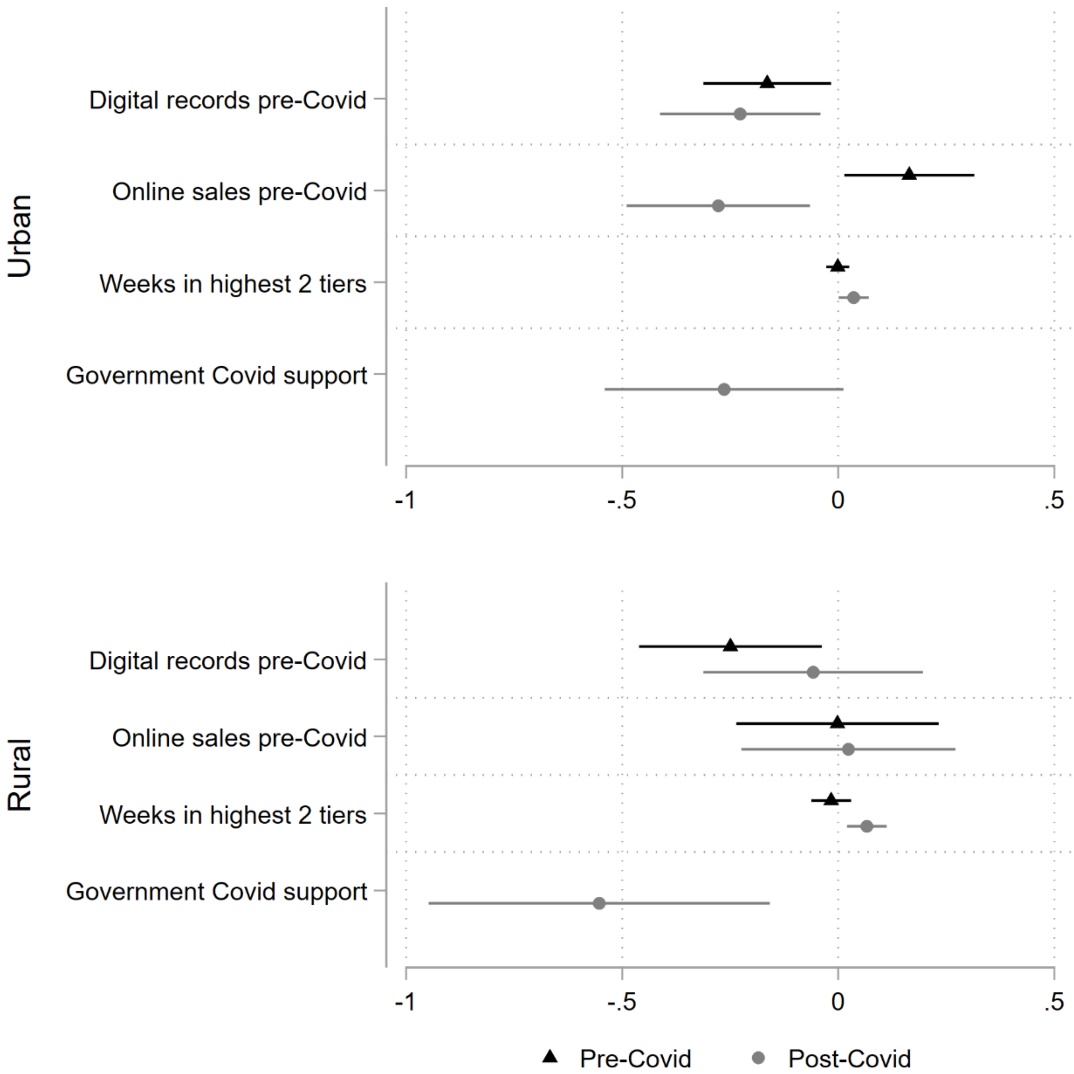

Figure A5: Coefficient plot from probit estimation

A III. Additional tables

Table A1: Summary statistics on the whole sample, before cleaning

	All		Urban		Rural	
	Mean	SD	Mean	SD	Mean	SD
1 if firm dies in year	0.033	0.18	0.035	0.18	0.031	0.17
1 if firm exits at some point	0.21	0.41	0.22	0.41	0.20	0.40
Digital technology used pre Covid						
. Record keeping	0.70	0.46	0.71	0.45	0.68	0.47
. Online sales	0.32	0.47	0.33	0.47	0.30	0.46
Age brackets (years)						
. 0-5	0.25	0.43	0.27	0.44	0.21	0.41
. 6-10	0.26	0.44	0.28	0.45	0.24	0.43
. 11-20	0.32	0.47	0.32	0.47	0.31	0.46
. More than 20	0.17	0.37	0.13	0.34	0.23	0.42
Labour productivity	99.8	222.3	101.7	211.6	96.5	240.3
Employment	7.45	16.1	7.73	15.7	6.94	16.8
Exporter	0.26	0.44	0.27	0.45	0.23	0.42
Importer	0.29	0.45	0.29	0.45	0.28	0.45
Weeks in two highest tiers	3.44	2.69	4.29	2.55	1.92	2.24
Government Covid support	0.044	0.20	0.041	0.20	0.048	0.21
Primary	0.058	0.23	0.0099	0.099	0.14	0.35
High & medium tech manufacturing	0.033	0.18	0.035	0.18	0.028	0.16
Low-tech manufacturing	0.028	0.17	0.029	0.17	0.027	0.16
Utilities	0.0051	0.071	0.0048	0.069	0.0054	0.073
Construction & real estate	0.11	0.31	0.11	0.32	0.094	0.29
Less knowledge-intensive services	0.41	0.49	0.41	0.49	0.41	0.49
Knowledge-intensive services	0.36	0.48	0.40	0.49	0.29	0.45
Rural	0.36	0.48				
Urban	0.39	0.49	0.60	0.49		
Major urban	0.26	0.44	0.40	0.49		
Avg download speed (Mbits)	48.8	34.6	53.9	33.7	39.5	34.3
N	79666		51110		28556	

Note: Urban areas are defined as urban and major urban areas in the ONS definition, all others are rural. The table shows unweighted means. The original whole sample has 10,882 firms, of which 6,991 urban and 3,891 rural.
Source: BSD and LSBS.

Table A2: Effects of pre-Covid digital inputs on the probability of exit

	(1) Probit Pre-2020	(2) Probit Post-2020	(3) Cloglog Pre-2020	(4) Cloglog Post-2020
Digital records pre-Covid	-0.190***	-0.161**	0.691***	0.721**
	(0.061)	(0.076)	(0.088)	(0.110)
Online sales pre-Covid	0.114*	-0.146*	1.272*	0.742*
	(0.064)	(0.081)	(0.168)	(0.126)
Weeks in highest 2 tiers	-0.009	0.053***	0.982	1.111***
	(0.013)	(0.015)	(0.028)	(0.034)
Government Covid support		-0.375***		0.443***
		(0.115)		(0.117)
Urban	0.092	-0.147*	1.189	0.768
	(0.070)	(0.086)	(0.175)	(0.136)
Major urban	0.157*	-0.276**	1.329	0.576**
	(0.093)	(0.112)	(0.261)	(0.131)
Age 0-4	0.233**		1.537**	
	(0.103)		(0.328)	
Age 5-9	0.026	0.078	1.032	1.076
	(0.091)	(0.104)	(0.196)	(0.235)
Age 10-19	-0.021	0.115	0.933	1.256
	(0.089)	(0.092)	(0.174)	(0.241)
Ln labour productivity (t-2)	-0.156***	-0.114***	0.740***	0.802***
	(0.029)	(0.038)	(0.043)	(0.058)
Exporter	-0.163**	-0.233***	0.713**	0.588***
	(0.072)	(0.085)	(0.113)	(0.106)
Importer	-0.140*	0.075	0.723*	1.160
	(0.076)	(0.084)	(0.121)	(0.203)
Employment	-0.044***	-0.043***	0.902***	0.898***
	(0.009)	(0.013)	(0.019)	(0.026)
High - med tech manuf	0.478*	0.573**	3.486*	3.743**
	(0.277)	(0.270)	(2.245)	(2.250)
Low tech manufacturing	0.596**	0.433	4.497**	2.364
	(0.272)	(0.302)	(2.809)	(1.565)
Utilities	0.920**		6.806**	
	(0.460)		(6.175)	
Construction & real estate	0.573**	0.199	4.144**	1.613
	(0.241)	(0.251)	(2.335)	(0.924)
Less KI services	0.602***	0.514**	4.476***	2.989**
	(0.225)	(0.217)	(2.373)	(1.496)
KI services	0.404*	0.329	2.872**	2.078
	(0.228)	(0.223)	(1.543)	(1.072)
Observations	6,832	3,934	6,832	3,934

Note: binary dependent variable: exit, equal to 1 if the firm exits in year t, 0 otherwise. Year dummies included. Cloglog coefficients in exponentiated form. Rural, urban and major urban are binary variables based on the Census classification. Age variables are indicators equal to 1 if the firm's age is within the given age bracket. Firms aged 20 years and over are the omitted category. Robust standard errors in parentheses. ***, **, *: significant at the 1%, 5% and 10% level respectively.

Table A3: Effects of pre-Covid digital inputs on the probability of exit, random effects complementary log-log estimation

Dependent variable: 1 if firm dies in year	Random effects cloglog Pre-2020	Random effects cloglog Post-2020
Digital records pre-Covid	0.535**	0.658**
	(0.137)	(0.138)
Online sales pre-Covid	1.448*	0.614**
	(0.309)	(0.130)
Weeks in highest 2 tiers	0.970	1.192***
	(0.031)	(0.076)
Government Covid support		0.268***
		(0.119)
Urban	1.420	0.724
	(0.359)	(0.208)
Major urban	1.671	0.445**
	(0.532)	(0.171)
Age 0-4		
Age 5-9	1.235	1.199
	(0.360)	(0.518)
Age 10-19	1.011	1.484
	(0.278)	(0.436)
Ln labour productivity (t-2)	0.629***	0.712***
	(0.078)	(0.089)
Exporter	0.590**	0.469***
	(0.141)	(0.136)
Importer	0.641*	1.228
	(0.157)	(0.311)
Employment	0.865***	0.862***
	(0.040)	(0.046)
High - med tech manufacturing	4.639	5.696
	(17.261)	(17.368)
Low tech manufacturing	7.240	3.289
	(26.340)	(10.139)
Utilities		
Construction and real estate	6.065	1.859
	(22.329)	(5.655)
Less KI services	6.879	4.789
	(25.347)	(13.973)
KI services	3.626	2.713
	(13.328)	(7.908)
Observations	6,832	3,934
Number of firms	1,893	1,421

Note: binary dependent variable: exit, equal to 1 if the firm exits in year t, 0 otherwise. Year dummies included. Cloglog coefficients in exponentiated form. Rural, urban and major urban are binary variables based on the Census classification. Age variables are indicators equal to 1 if the firm's age is within the given age bracket. Firms aged 20 years and over are the omitted category. Robust standard errors in parentheses. ***, **, *: significant at the 1%, 5% and 10% level respectively.

Table A4: Complementary log-log estimation results, by urban/rural location and time period

Dependent variable: 1 if firm dies in year	(1)	(2)	(3)	(4)
	Urban Pre-2020	Urban Post-2020	Rural Pre-2020	Rural Post-2020
Digital records pre-Covid	0.740*	0.638**	0.607**	0.863
	(0.114)	(0.122)	(0.143)	(0.233)
Online sales pre-Covid	1.411**	0.544**	1.024	1.100
	(0.222)	(0.130)	(0.262)	(0.288)
Weeks in highest 2 tiers	0.998	1.072*	0.958	1.135***
	(0.028)	(0.041)	(0.049)	(0.053)
Government Covid support		0.548*		0.312**
		(0.176)		(0.151)
Avg download speed (Mbits)	1.003	1.000	1.002	1.000
	(0.004)	(0.004)	(0.003)	(0.005)
Age 0-4	1.432		1.998*	
	(0.366)		(0.836)	
Age 5-9	1.071	1.023	0.873	1.044
	(0.240)	(0.272)	(0.335)	(0.427)
Age 10-19	0.842	1.365	1.215	1.060
	(0.191)	(0.316)	(0.412)	(0.368)
Ln labour productivity (t-2)	0.843**	0.762***	0.593***	0.901
	(0.061)	(0.063)	(0.057)	(0.133)
Exporter	0.760	0.602**	0.526*	0.519**
	(0.139)	(0.142)	(0.176)	(0.148)
Importer	0.745	1.267	0.638	1.079
	(0.148)	(0.299)	(0.202)	(0.303)
Employment	0.889***	0.901***	0.925***	0.899***
	(0.026)	(0.035)	(0.027)	(0.034)
Observations	4,412	2,525	2,416	1,409

Note: binary dependent variable: exit, equal to 1 if the firm exits in year t, 0 otherwise. Cloglog coefficients in exponentiated form. Other variables included: broad sector and year dummies. Age variables are indicators equal to 1 if the firm's age is within the given age bracket. Firms aged 20 years and over are the omitted category. Robust standard errors in parentheses. ***, **, *: significant at the 1%, 5% and 10% level respectively.

Table A5: Probit estimation results, by urban/rural location and time period

Dependent variable: 1 if firm dies	(1) Urban Pre-2020	(2) Urban Post-2020	(3) Rural Pre-2020	(4) Rural Post-2020
Digital records pre-Covid	-0.164**	-0.227**	-0.250**	-0.058
	(0.075)	(0.095)	(0.108)	(0.130)
Online sales pre-Covid	0.164**	-0.278**	-0.002	0.024
	(0.077)	(0.108)	(0.119)	(0.127)
Weeks in highest 2 tiers	-0.001	0.036**	-0.016	0.066***
	(0.014)	(0.018)	(0.024)	(0.023)
Government Covid support		-0.264*		-0.553***
		(0.141)		(0.201)
Avg download speed (Mbits)	0.001	-0.000	0.002	0.000
	(0.002)	(0.002)	(0.002)	(0.002)
Age 0-4	0.190		0.393**	
	(0.123)		(0.195)	
Age 5-9	0.031	0.052	0.019	0.057
	(0.107)	(0.125)	(0.175)	(0.190)
Age 10-19	-0.088	0.156	0.141	0.029
	(0.108)	(0.111)	(0.161)	(0.161)
Ln labour productivity (t-2)	-0.089**	-0.150***	-0.284***	-0.056
	(0.036)	(0.045)	(0.051)	(0.068)
Exporter	-0.133	-0.212*	-0.296**	-0.320**
	(0.085)	(0.110)	(0.146)	(0.136)
Importer	-0.127	0.100	-0.211	0.043
	(0.091)	(0.110)	(0.142)	(0.134)
Employment	-0.048***	-0.038**	-0.037***	-0.050***
	(0.012)	(0.016)	(0.012)	(0.017)
Observations	4,412	2,525	2,416	1,409

Note: binary dependent variable: exit, equal to 1 if the firm exits in year t, 0 otherwise. Other variables included: broad sector and year dummies. Age variables are indicators equal to 1 if the firm's age is within the given age bracket. Firms aged 20 years and over are the omitted category. Robust standard errors in parentheses. ***, **, *: significant at the 1%, 5% and 10% level respectively.

Table A6: Results without London firms, by urban/rural location and time period.

Dependent variable: 1 if firm dies in year	(1) Urban Pre-2020	(2) Urban Post-2020	(3) Rural Pre-2020	(4) Rural Post-2020
Digital records pre-Covid	0.779	0.691*	0.607**	0.863
	(0.133)	(0.144)	(0.143)	(0.233)
Online sales pre-Covid	1.236	0.608*	1.024	1.100
	(0.222)	(0.156)	(0.262)	(0.288)
Weeks in highest 2 tiers	0.998	1.067*	0.958	1.135***
	(0.030)	(0.040)	(0.049)	(0.053)
Government Covid support		0.583		0.312**
		(0.196)		(0.151)
Avg download speed (Mbits)	1.003	1.000	1.002	1.000
	(0.004)	(0.004)	(0.003)	(0.005)
Age 0-4	1.431		1.998*	
	(0.408)		(0.836)	
Age 5-9	1.024	0.820	0.873	1.044
	(0.253)	(0.238)	(0.335)	(0.427)
Age 10-19	0.725	1.270	1.215	1.060
	(0.187)	(0.301)	(0.412)	(0.368)
Ln labour productivity (t-2)	0.803***	0.724***	0.593***	0.901
	(0.064)	(0.063)	(0.057)	(0.133)
Exporter	0.816	0.591**	0.526*	0.519**
	(0.169)	(0.153)	(0.176)	(0.148)
Importer	0.812	1.175	0.638	1.079
	(0.178)	(0.309)	(0.202)	(0.303)
Employment	0.876***	0.849***	0.925***	0.899***
	(0.025)	(0.031)	(0.027)	(0.034)
Observations	3,637	2,089	2,416	1,409

Note: binary dependent variable: exit, equal to 1 if the firm exits in year t, 0 otherwise. Cloglog coefficients in exponentiated form. Other variables included: broad sector and year dummies. Age variables are indicators equal to 1 if the firm's age is within the given age bracket. Firms aged 20 years and over are the omitted category. Robust standard errors in parentheses. ***, **, *: significant at the 1%, 5% and 10% level respectively.

Table A7: Counterfactual exit rates

	(1) Whole sample	(2) Urban	(3) Rural
Actual exit rate	0.048	0.046	0.051
Exit rate predicted by model	0.048	0.046	0.051
Counterfactual: no digital technologies	0.062	0.069	0.054
Counterfactual: all digital technologies	0.034	0.025	0.051
Counterfactual: all online sales, records unchanged	0.039	0.030	0.053
Counterfactual: all digital records, sales unchanged	0.038	0.032	0.050
N	3934	2525	1409

Note: counterfactual exit rates in column (1) are based on the regression model shown in Table A2, column (2). Counterfactual exit rates in column (2) are based on Table A5, column (2), and in column (3) on Table A5, column (4). We compute predicted exit rates as the fitted values from this model. We develop the counterfactual by imposing that all/no business uses digital technology, for either both digital sales and digital records, or only one of these variables, leaving the other unchanged. The counterfactuals are calculated for the post-Covid-19 period.