



Economic
and Social
Research Council



**URBAN-RURAL DIFFERENCES IN THE IMPACT OF
DIGITALISATION ON SME SURVIVAL ¹**

ERC Insight Paper

March 2026

Urban-rural differences in the impact of digitalisation on SME survival ¹

Sabine D'Costa

Westminster Business School, University of Westminster

s.dcosta@westminster.ac.uk

Carolyn Ioramashvili

Science Policy Research Unit, University of Sussex

Department of Geography & Environment, London School of Economics

c.ioramashvili@sussex.ac.uk

The Enterprise Research Centre (ERC) is an independent research centre based at Warwick Business School focusing on growth, innovation and productivity in small and medium-sized enterprises. The Centre is funded by the Economic and Social Research Council, The Department for Business and Trade, The Department for Science Innovation and Technology, Innovate UK, the British Business Bank and the Intellectual Property Office. The views expressed in this report are those of the authors and do not necessarily represent those of the funders.

¹ Copyright

© [Crown copyright](#). The use of these data is subject to the [UK Data Service End User Licence Agreement](#). Additional restrictions may also apply.

Disclaimer

Although all efforts are made to ensure the quality of the materials, neither the original data creators, depositors or copyright holders, the funders of the data collections, nor the UK Data Archive, nor the UK Data Service bear any responsibility for the accuracy or comprehensiveness of these materials.

CONTENTS

Urban-rural differences in the impact of digitalisation on SME survival	1
Contents.....	3
Abstract.....	4
Declaration of competing interests	4
1. Introduction.....	5
2. Relevant literature	7
2.1 Spatial disparities in digitalisation and Covid-19 impacts	7
2.2 Digitalisation and firm survival	8
3. Data	10
4. Empirical strategy.....	17
5. Digitalisation and survival	19
5.1 Baseline results.....	19
5.2 Robustness checks.....	22
6. Discussion	23
7. Conclusion.....	24
References	26
Appendix.....	30
A I. Construction of digitalisation variables.....	30
A II. Additional figures	31
A III. Additional tables	33

ABSTRACT

We investigate urban-rural differences in the role of pre-pandemic digitalisation in the survival of small and medium-sized enterprises (SME) through the pandemic. Survival analysis on a geocoded panel of British SMEs from 2015 to 2022 reveals that digital inputs increased survival, but the effect is restricted to urban areas. In urban areas, this effect is comparable in size to that of government Covid-19 subsidies, while in rural areas only subsidies were effective at reducing exit. The benefits of digitalisation are not evenly spread among SMEs and digital policy should take these urban-rural differences into account.

DECLARATION OF COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

No funding was received for the conducting of this study.

ACKNOWLEDGEMENTS

We are grateful to John Moffat, Jen-Chung Mei as well as participants at the Regional Studies Association (RSA) Winter Conference 2024, Regional Science Association International – British and Irish Section conferences 2024 and 2025, RSA annual conference 2025, the impact workshop on “Firm productivity and exit during economic crisis: does the urban environment foster resilience?” (University of Westminster, May 2025), the North American Urban Economics Association annual meeting and seminar audiences at the Enterprise Research Centre (University of Warwick), IfM Bonn, and the Centre for Advanced Spatial Analysis (University College London) for helpful discussions.

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. Despite these adjustments and unprecedented government support programmes, the economy was deeply affected. According to the Insolvency Service, corporate insolvencies in England and Wales in 2023 rose to the highest level in thirty years. This begs the question whether individual firms that were already more digitalised before the Covid-19 pandemic were more likely to survive, with wider lessons for digitalisation and resilience.

This question is inextricably linked to the urban-rural economic and digital divides observed in many countries. The agglomeration economies that make cities more productive were sharply reduced during the pandemic, ostensibly levelling the playing field with rural areas (Knuepling *et al.*, 2024). 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. Theoretical predictions on previous episodes of technological change expected the “death of distance” (Friedman, 2005). While we might expect a lesser impact of the pandemic on rural areas, urban areas have been the winners of successive waves of economic transformations, including the current digital transformation (Kemeny *et al.* 2025). 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. In this paper, we therefore explore whether an urban-rural divide is at play among SMEs in the way in which pre-existing digital tools translated into better survival chances.

We focus on Small and Medium Enterprises (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.² We use the Longitudinal Small Business Survey (LSBS), a unique, detailed dataset that surveys individual SMEs and provides information at the firm level on whether they were using

² 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.

digital inputs, specifically online sales channels and digital record keeping software, in each year (Department for Business and Trade, 2024). To accurately capture firm exit, as well as labour productivity and other firm characteristics, we link firms from the LSBS to administrative data from the Business Structure Database (BSD) (Office for National Statistics, 2024).

First, we test whether the use of digital technology – proxied by digital record keeping and online sales - *prior to 2020* reduced the probability of firm exit. 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.

Second, we test for differences in this impact across urban and rural areas. 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.

The paper adds to the literature on regional digital divides as well as regional crisis resilience. While much of the literature has focused on rural-urban divides in digital technology adoption or infrastructure (Holl and Rama, 2024; OECD, 2025), this paper contributes new evidence on spatial differences in how digital technology impacts businesses. It also links to research on regional capabilities to absorb such technologies (Corradini *et al.*, 2021) by exploring the urban-rural dimension. Finally, by showing that digital technology use has failed to improve the resilience of rural SMEs, the paper contributes to the debate on regional economic resilience (Reveiu *et al.*, 2023; Baumgartinger-Seiringer *et al.*, 2025).

Methodologically, the panel data used here allows building on previous contributions (including Copestake *et al.*, 2024; Muzi *et al.*, 2023) by measuring digitalisation at the firm rather than regional level and by measuring early adoption of digital tools rather than as crisis response. We also exploit the firm location information to control for locality-level exposure to Covid-19 using weeks spent in strict lockdown.

The results offer new evidence for policymaking. Since urban SMEs that have already adopted specific digital inputs show greater resilience, promoting these inputs may reduce the need for government intervention during future disruptions of a similar nature. Moreover, our results indicate that even outside a crisis, rural SMEs need further support beyond digital tools to improve their survival. Despite interventions for digital adoption,

including by SMEs (e.g. “Making tax digital”, SME Digitalisation Taskforce), a detailed assessment of the impact of digitalisation on SME performance has been lacking and a territorial approach has not been taken so far both in research for evidence or in policy design.

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. Results are discussed in Section 6, and Section 7 concludes.

2. RELEVANT LITERATURE

2.1 Spatial disparities in digitalisation and Covid-19 impacts

The trend of increased digitalisation has transformed the way businesses work. The conventional wisdom is that digitalisation, understood here broadly as the use by firms of digital tools, 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. 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 (Massini *et al.*, 2025; Veugelers *et al.*, 2019).

There are also strong spatial disparities in digitalisation. Corradini *et al.* (2021) document the uneven distribution across European regions of Industry 4.0 tools and establish a relation to regional absorptive capacity and to the cognitive proximity of a tool to the existing regional technological base. The regional digital divide is also present at the household and individual level and affects income inequality between workers (Crespo Cuaresma and Lutz, 2021; Capello *et al.*, 2025). This is important because the spatially uneven use of digital technologies can have long-lasting local economic impacts (Tranos *et al.*, 2021).

Particularly relevant to our paper, there is evidence that businesses in urban and rural areas adopt and use digital technology in different ways, with urban businesses benefiting more, for example from access to faster internet (DeStefano *et al.*, 2023). Cattani *et al.* (2025) find that European firms in urban areas are better able to use their digital tools to achieve eco-innovation, compared to rural firms. They attribute this to the particular

infrastructure and skills in urban areas that favour the creation of digital ecosystems that facilitate eco-innovation. For example, cities benefit from better digital infrastructure, with broadband and mobile connectivity in many rural areas remaining poor (Holl and Rama, 2024). 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).

As mentioned in the previous section, the impact of the Covid-19 crisis itself has been spatially uneven, with cities experiencing greater numbers of Covid-19 cases and being kept under government-mandated lockdowns for longer (Nathan, 2021). Leamer and Storper (2017), Rodriguez-Posé and Crescenzi (2008) and Storper and Venables (2004) argue that face-to-face interaction remains as important as ever for more complex interactions that are based on trust and exchange of ideas. Goldbeck (2025) shows that this is even the case in highly digitalised industries and occupations such as software development. The reduction in face-to-face interactions during the pandemic therefore might have led to a levelling of the playing field between rural and urban firms.

2.2 Digitalisation and firm survival

There exists a large empirical literature on the determinants of firm survival. The main firm-level factors that have been found to improve survival chances include firm age and size (Dunne, Roberts and Samuelson, 1989), productivity (Olley and Pakes, 1996), participation in international trade (Bernard and Jensen, 2002; Georg and Spaliara, 2014), innovation (Cefis and Marsili, 2019; Helmers and Rogers, 2010) and a low debt burden (Guariglia *et al.*, 2016).³

The research on the role of digitalisation in firm survival is more limited and does not include the spatial dimension. Much of the existing empirical research on digitalisation investigates its impact on 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.*, 2024; 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

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

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).

To our knowledge, three recent papers relate firm digitalisation to survival in the context of the Covid-19 crisis using cross-country data from the World Bank Enterprise Surveys (WBES). Audretsch *et al.* (2024) focus on digital transformation, defined as the use of new digital technologies to enable significant business improvements. Observing about 500 Italian SMEs from WBES between 2019 and May 2021, they explore the role of the adoption of working from home, e-commerce and home delivery during the Covid-19 crisis in firm survival during the period. Audretsch *et al.* (2025) focus on digital diversification. Using cross-country WBES data from the same period, they explore the role of the number of digital tools adopted and of government support schemes accessed during the crisis on firm survival. Also using a cross-country sample in the period 2019-2021, Muzi *et al.* (2023) find a negative relationship between digital presence – measured by whether a firm has its own website - and the likelihood of exiting the market. None of these papers measures the relationship between digitalisation and survival for a significant period prior to the onset of the pandemic. They are therefore not able to assess what the relationship between digitalisation and survival would have been in the absence of the Covid-19 crisis. Additionally, a known limitation of the WBES is the difficulty to capture firm exit, resulting in exit being assumed when businesses did not respond to the survey.

This paper is also related to the recent literature on digitalisation as an important factor for business resilience, measured usually in terms of revenue or profit, in times of crisis such as recessions. Based on a survey of small US firms in 2019 and 2020, Bloom *et al.* (2021) find that firms with greater shares of sales done online experienced lower drops in sales at the start of the Covid-19 crisis. Copestake *et al.* (2024), using cross-country balance sheet data over two decades, find that the negative impact of recessions on sales is mitigated for firms in more digitalised industries. The mitigation is stronger during the Covid-19 recession, likely due to the importance of remote working and online selling. Nose and Honda (2023) construct a firm-level digitalisation index from balance sheet data and find that digitalised firms were more resilient in terms of sales and profit margins in the aftermath of the Covid-19 shock. Calza *et al.* (2023) show that advanced digital production tools are also very relevant for industrial business resilience in emerging and developing economies. Abidi *et al.* (2022) find that firms in the Middle East and Central Asia regions that were already digitalised before the Covid-19 crisis experienced a lower decline in sales during the crisis.

There is a gap in the literature uniting the territorial study of firm digitalisation with the firm-level evidence on survival and resilience. Territorial differences in digitalisation are extensively studied, as discuss above, but the implications of digitalisation for businesses at the subnational level remain less understood. The present paper aims to fill this gap, while also contributing important methodological advances: First, we measure digitalisation at the firm level while much of the literature is restricted to industry-wide variables. Second, we measure SME digitalisation prior to the start of the crisis, rather than during the crisis which would conflate crisis preparedness and response. Third, by linking our survey data to administrative data from the BSD, we capture firm exit more accurately. And finally, we focus on SMEs, that are both more vulnerable and exhibit more heterogeneity in digital technology adoption.

3. DATA

To estimate the effects of adoption of digital tools 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 the only source of detailed information on technology use and business practices of small businesses in the UK. It 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 tools and technologies that were asked between 2015 and 2019. 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 A I for further details on the 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 continuity during the pandemic. We record online sales and digital records as time-invariant binary variables indicating whether a business used these digital technologies *prior to 2020*.

Many businesses invested in or intensified their use of digital tools in direct response to the pandemic. However, such strategies are likely to be correlated with other factors that relate to a firm's crisis resilience and resourcefulness during the pandemic. While adoption of digital tools has been shown to be driven by managerial capability, amongst other factors, our measure here is exogenous to an individual business's crisis response. We measure use of digital tools before the start of the pandemic, and do not record any changes in technology use over the course of the pandemic. As the pandemic came as an unexpected shock, our measure is therefore unaffected by the response to the crisis.

However, there are also limits to the indicators used here. Digital records and online sales are two specific tools that businesses may use to replace certain tasks and activities. Digital technology, by virtue of being a digital purpose technology, pervades all aspects of business activities, so the number of tools and technologies to consider is potentially unlimited. The two tools considered here are sufficiently general that they could be used by all businesses – any business needs sales channels as well as tools for book-keeping and filing taxes – and yet we see meaningful variation in businesses' adoption of these tools. Another limitation lies in the intensity with which businesses use these tools. Record keeping software could be used to prepare period accounts or as a sophisticated management accounting information system, and the share of online in total sales will vary across businesses. Unfortunately, the nature of the survey does not allow us to take any variation in usage into account.

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 enter the BSD when they first register for value added or pay-as-you-earn income tax. Entry 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. Businesses are considered as having died when they are registered as closed or struck off Companies House, the business register. However, there can be a lag of one to two years between a business ceasing operations and being registered as closed. Death is then backdated to the closing date. Additionally, we recode businesses as dead if they record zero turnover for three or more years, considering the first year where turnover was zero as the year of death. As more recent years are still unreliable, our samples includes the years up until and including 2022. In addition to demographic events, the BSD provides employment, turnover, industry and

businesses' location at the Lower Super Output Area (LSOA) level.⁴ 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 prior to 2020 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 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 total 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 and 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

⁴ LSOAs comprise between 400 and 1,200 households and have a usually resident population between 1,000 and 3,000 persons.

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. 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.

Figure 1 documents exit rates by year, from 2016 to 2022, for firms with and without digital inputs prior to 2020. 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 2021.⁵

⁵ 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 aggregate statistics cannot be found in our sample. numerous dying businesses born after 2019. This can explain why the spike in firm deaths in 2021 and 2022 in aggregate statistics cannot be found in our sample.

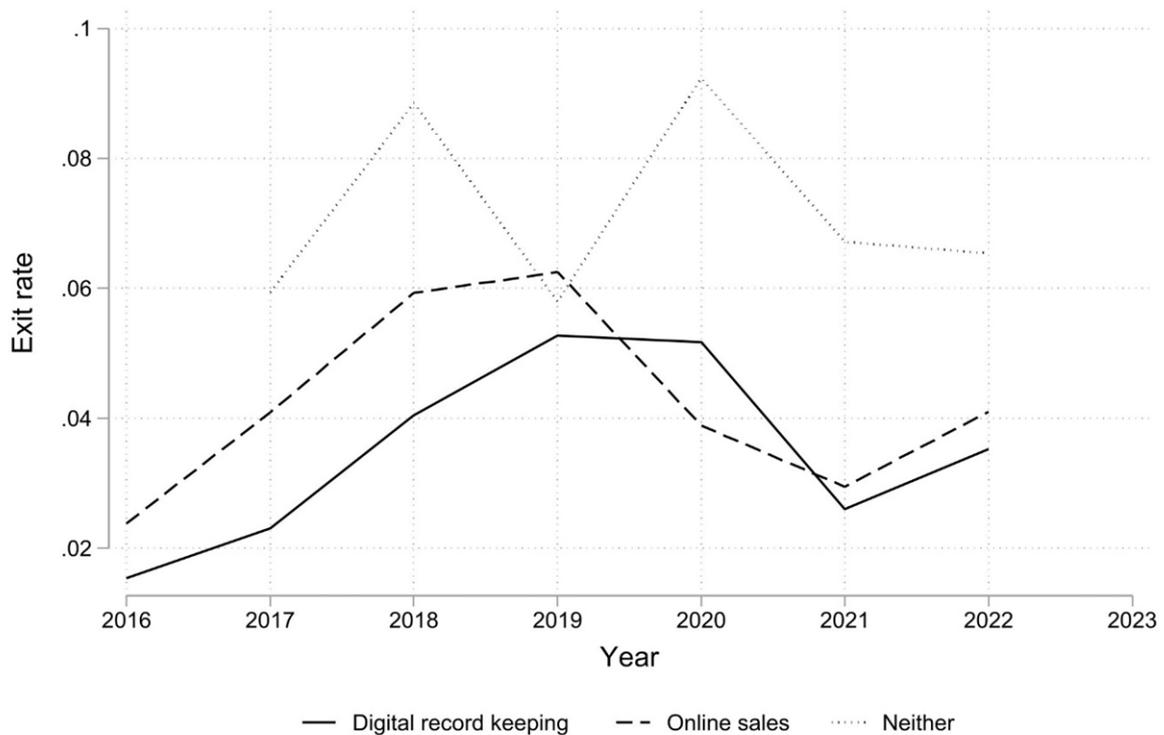


Figure 1: Exit rate by type of digital technology used

Note: The exit rate for firms without digital inputs in 2016 has been censored to prevent disclosure.

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.

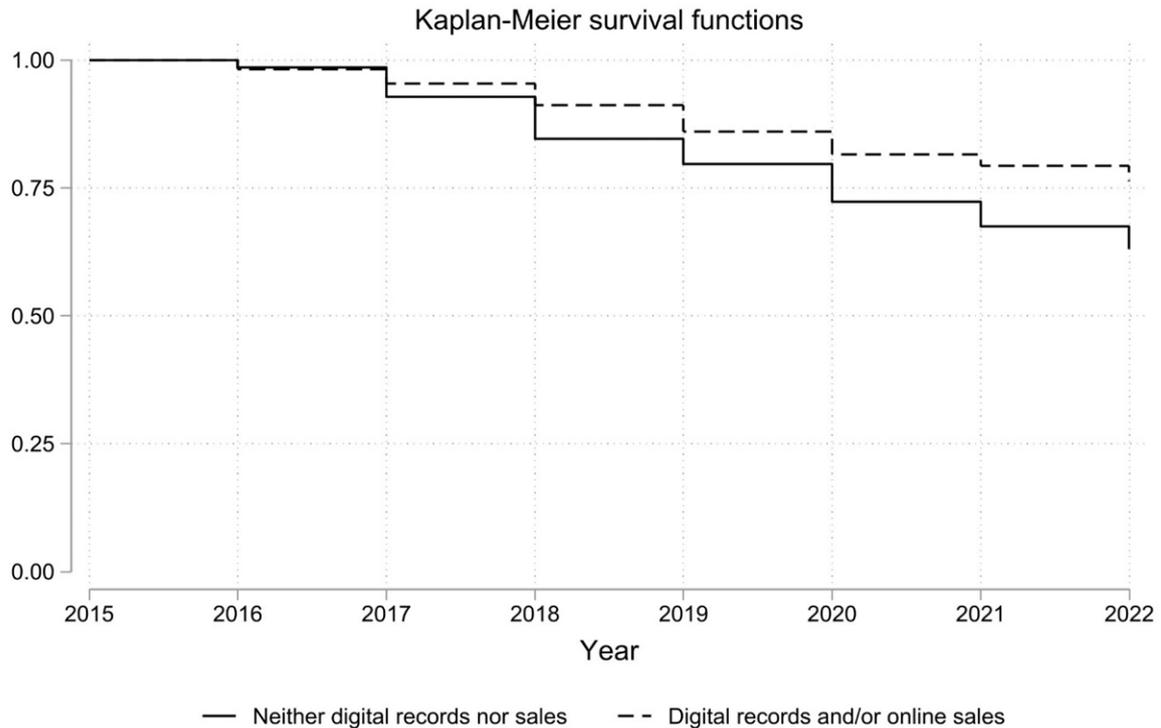


Figure 2: Kaplan-Meier plot by presence of digital inputs

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.

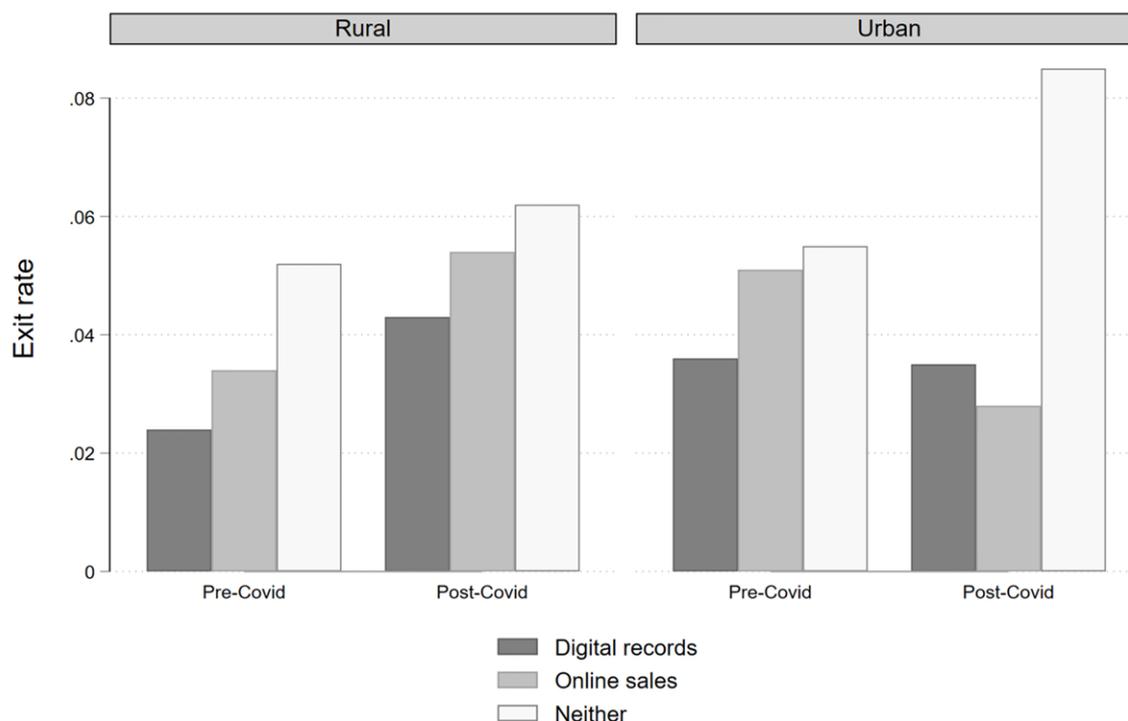


Figure 3: Exit rates by urban versus rural local authorities

4. 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:

$$h(j, X) = 1 - \exp[\exp(b'X + y_j)] \quad (1)$$

Where $h(j, X)$ 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.⁶

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.

⁶ 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.

5. DIGITALISATION AND SURVIVAL

5.1 Baseline results

Figure 4 plots the results of the complementary log-log regression, splitting the sample into pre-Covid (pre-2020) and post-Covid periods. Point estimates of coefficients are shown with 95% confidence intervals indicated as bars. Complementary log-log coefficients are reported in exponentiated form, meaning a coefficient greater than 1 indicates the variable increases the probability of exit.

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. 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%. Appendix Table A2 presents full regression results using Probit and complementary log-log estimation. Coefficients from Probit estimation are presented in Figure A1.

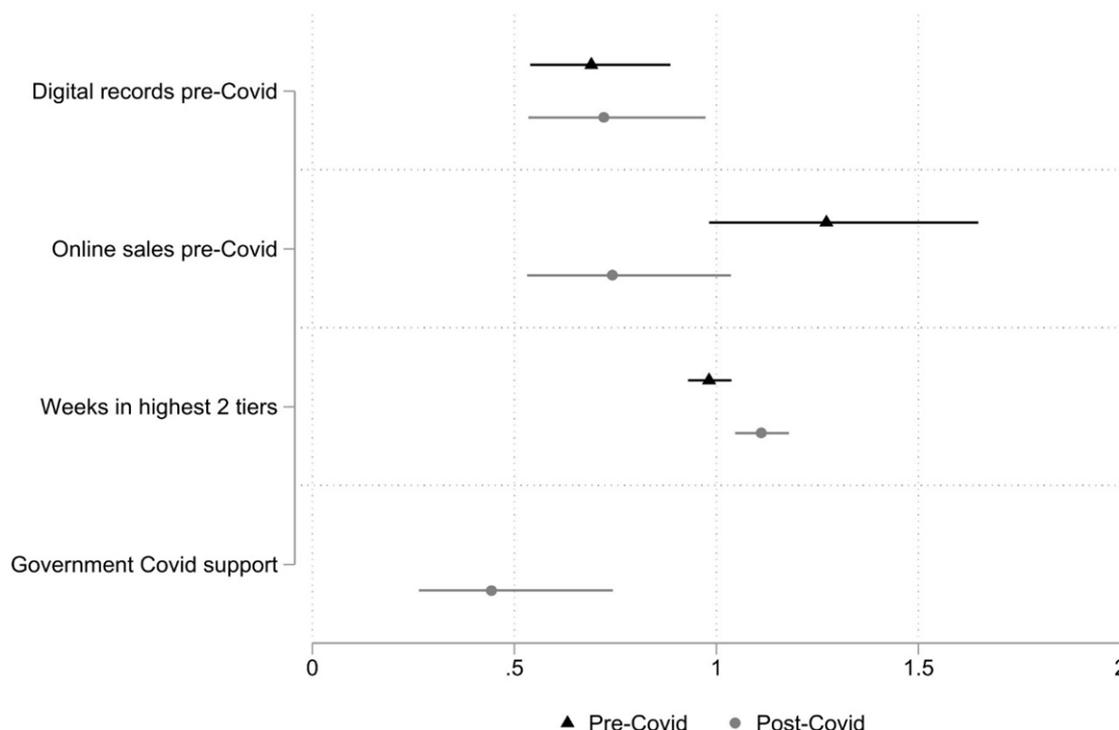


Figure 4: Coefficient plot from complementary log-log estimation

Note: Lines indicate 95% confidence intervals. 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 theoretical 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), SMEs 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. We repeat the analysis, splitting the sample between urban and rural firms. Figure 5 plots the key coefficients, with 95% confidence intervals. Full regression results are provided in Appendix Table A4 for the cloglog estimation and Table A5 for the Probit estimation.

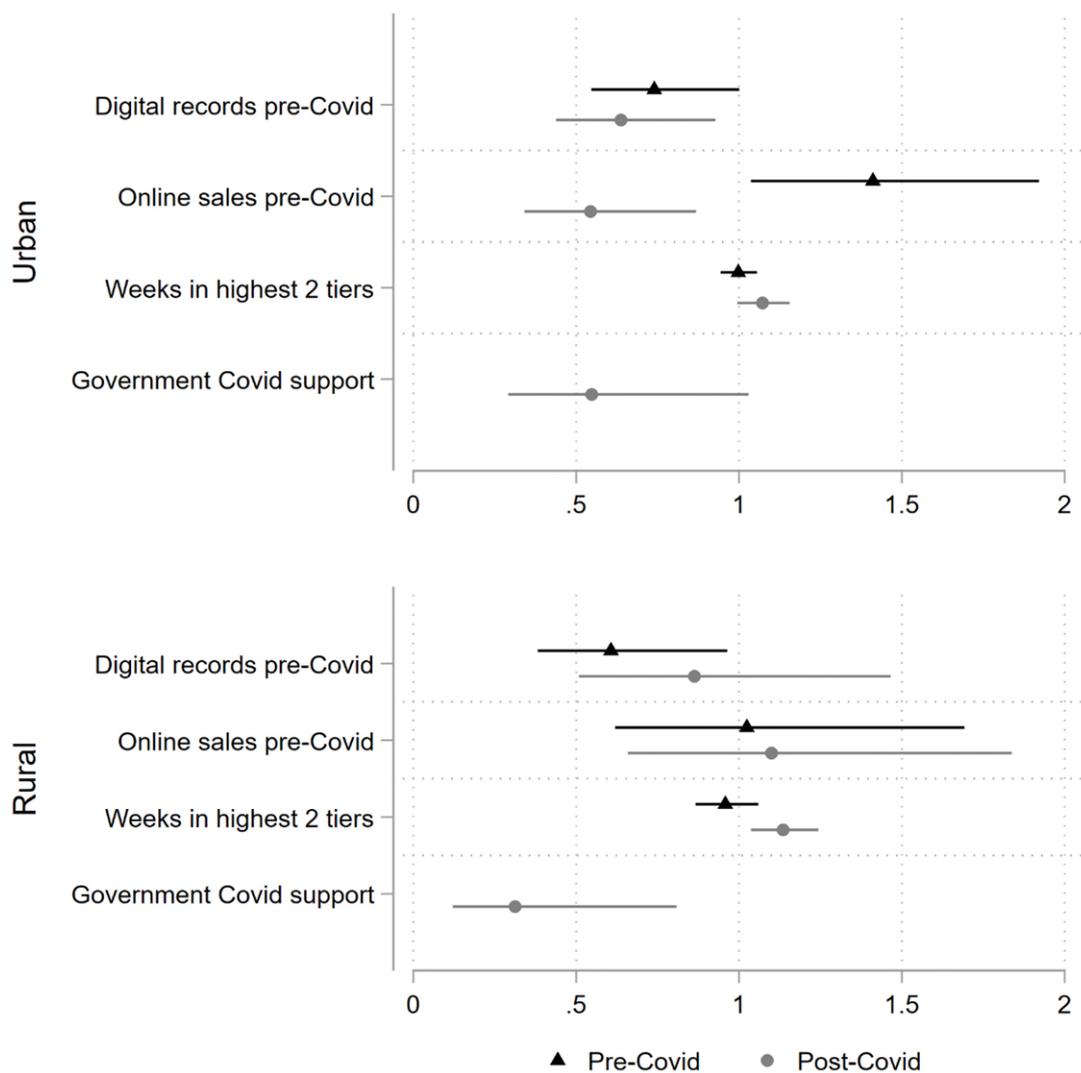


Figure 5: Coefficient plot from complementary log-log estimation

Note: Lines indicate 95% confidence intervals. 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. 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 SMEs, Government Covid-19 support was the key factor in survival.

5.2 Robustness checks

We provide two further sets of estimations to probe the robustness of our results. One factor that may affect the results is unobserved characteristics of businesses that affect both digitalisation status and resilience during the pandemic, such as management ability. To take into account unobserved heterogeneity without fixed effects, we use random effects complementary log-log estimation. Results are reported in Appendix Table A3. Despite controlling for individual random effects, the coefficients of interest change only immaterially, and our interpretation of the results remains unchanged.

In Appendix Table A6, we investigate whether these results are driven by firms in London, by removing observations for London firms. London contains the biggest agglomeration of businesses in the UK, with average productivity significantly above the national average. Given the large number of businesses from London in the urban sample, a ‘London effect’ may skew the results. However, removing businesses located in London only strengthens

our results. Neither digital record keeping nor online sales significantly impacted firm exit in urban areas prior to the pandemic, whilst both were negatively associated with exit post-2020 (at the 10% significance level). Post-2020, the results are qualitatively the same, but given the smaller sample size, coefficients are estimated less precisely, resulting in significance of the coefficients of interest at the 10% level only.

6. DISCUSSION

The Covid-19 pandemic significantly changed the way businesses organised their operations, and how they interacted with employees, customers, and suppliers. At the same time, the pandemic was a period of economic strife, with output contracting as people consumed less, businesses were forced to close temporarily or struggled to access inputs. Though economic geography theory might expect a declining importance of agglomeration economies as economic transactions became increasingly digital, accumulated capabilities in cities are also a strong factor of resilience (Florida *et al.*, 2021).

Our findings have implications for SME digitalisation policy, and regional policy in particular. First, when pooling all firms, we find that whilst digital records were negatively associated with firm exit before the pandemic, online sales were not. This is in line with the literature finding only a weak association between digitalisation and productivity at the firm, as well as macro level (Gal *et al.*, 2019; van Ark, 2016).

With the start of the Covid-19 pandemic, both indicators of digitalisation are associated with increased chances of survival. This can potentially be interpreted in two ways. In line with Copestake *et al.* (2024), digitalisation might support resilience. Not enough time has passed since the end of the crisis to study whether the effects of digitalisation return to the pre-crisis baseline. Alternatively, the Covid-19 pandemic and particularly the associated social-distancing policies could have led to a permanent shift in the importance of digitalisation and the way digital tools were used, in particular online sales.

When taking the regional perspective into account, it becomes obvious that the results are driven by businesses in urban areas. Though previous research shows higher adoption of digital tools in urban areas, this does not explain the results as we estimate effects of pre-pandemic adoption by both urban and rural firms. Local-authority level differences in broadband speed do not seem to explain the findings either.

Several factors may explain the differential effect of digital technology on firms in urban and rural areas. First, urban SMEs have access to more skilled workers while rural firms lacked the relevant skills. Second, there is a lack of professional services in rural areas to help SMEs adapt their digital tools for competitiveness during the crisis. Also relevant to

the conversion of existing tools, urban firms may have benefitted from better learning from larger networks during the crisis. Another possible explanation is that the infrastructure required for the distribution of online goods and services was more disrupted in rural areas than in cities during the pandemic. Finally, an important factor may be the heterogeneous demand for online goods and services, with urban customers being more favourable.

Our analysis also suggests that other factors are more important to aid crisis resilience in rural areas. Indeed, we find that for rural SMEs, government Covid support was a more important driver of survival than digital technology adoption. This may inform regional policy when choosing between different resilience interventions. It can also help design digital policy that takes into account the environment of the firms, as suggested by Bourdin and Levratto (2024). In rural areas, incentives to adopt digital technologies must be complemented by support to overcome the lack of in-house skills and local ancillary services, for example. This is an important blind spot for policy, which tends to focus on supporting development of new technology rather than diffusion and adoption (Rodríguez-Pose and Dijkstra, 2025). Digital policy is usually delivered as part of general business and SME support. With the English Devolution agenda, responsibility for business support in England will fall with Mayoral Strategic Authorities at the regional level (Ministry for Housing, Communities & Local Government, 2024), which our results suggest would be a promising approach. The European Union, however, is moving in the opposite direction with a more centralised policy approach to cohesion policy (Rodríguez-Pose, 2025), of which digitalisation has been an important component (European Commission, 2024).

7. CONCLUSION

We provide novel evidence at the firm level that early adoption of digital technologies improves crisis resilience of SMEs. Businesses that used digital sales and record keeping technologies before the start of the pandemic were significantly less likely to exit during the crisis. However, we find that this protection was limited to urban areas. For rural SMEs, government Covid-19 support was the key factor in survival.

Methodologically, we benefit from access to high-quality data at the firm-level that spans both the pre-and post-pandemic periods. Studies on the adoption of digital technologies often suffer from unobserved heterogeneity between firms that is correlated both with the probability of technology adoption as well as other factors that predict firm productivity and probability of survival. While we are not fully able to alleviate these concerns, we are able to exploit the Covid-19 pandemic as an unexpected shock. Businesses adopting digital technologies before 2020 would not have anticipated the pandemic, and while individual

survival chances may be correlated with adoption, the differential effect between urban and rural areas cannot be driven by such differences.

The paper advances the literature in several ways. Conceptually, we show that digitalisation as a driver of resilience varies across space and time. Heterogeneity in the effect of digitalisation across firms and with the external environment may explain why the literature has so far not established a clear link between digitalisation and productivity.

While research in regional studies and economic geography has drawn due attention to the struggles of rural and peripheral regions to adapt to the digital transition, including lagging adoption rates of digital technologies, we show that adoption is not sufficient for improved competitiveness. Rural businesses seem to draw less benefit, even from the technologies that they do adopt.

Our discussion suggests avenues for further research to understand the drivers of the differential effect of digital technology on firms in urban and rural areas. Rural SMEs may lack both the relevant in-house skills and access to professional services locally to adapt their digital tools for competitiveness during the crisis. Moreover, urban firms benefit from larger networks to share knowledge of these tools. The overall infrastructure required for the distribution of online goods and services was also more disrupted in rural areas during the pandemic. Finally, on the demand side, attitudes to online consumption may be less positive in rural areas.

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. However, many employees, particularly in white collar occupations continue to work from home at least some days of the week. Moreover, digitalisation improves resilience during economic crises more generally (Copestake *et al.*, 2024). Both these factors suggest that the results are generalisable to other types of economic crisis and can inform future policy.

REFERENCES

- Abidi, N., El Herradi, M., & Sakha, S. (2022). *Digitalization and resilience: firm-level evidence during the COVID-19 pandemic*. International Monetary Fund.
- Anderton, R., Botelho, V., & Reimers, P. (2023). *Digitalisation and productivity: gamechanger or sideshow?* European Central Bank Working Paper no. 2794.
- Audretsch, D. B., Aronica, M., Belitski, M., Caddemi, D., Piacentino, D. (2025). The impact of government financial aid and digital tools on firm survival during the COVID-19 pandemic. *Small Business Economics*, 1-24.
- Audretsch, D. B., Aronica, M., Belitski, M., Piacentino, D. (2024). Natural selection or strategic adaptation? Entrepreneurial digital technologies and survival of the species. *The Journal of Technology Transfer*, 49(5), 1631-1659.
- Bandick, R. and Görg, H. (2010). Foreign acquisition, plant survival, and employment growth. *Canadian Journal of Economics*, 43, 547–573.
- Bartoloni, E., Arrighetti, A., & Landini, F. (2021). Recession and firm survival: is selection based on cleansing or skill accumulation? *Small Business Economics*, 57(4), 1893-1914.
- Baumgartinger-Seiringer, S., Páger, B., & Trippl, M. (2025). Regions in Industrial Transitions: A Transformative Resilience Perspective on the Uneven Geographies of Vulnerability, Preparedness, and Responsiveness. *Economic Geography*, 101(4), 191–217. <https://doi.org/10.1080/00130095.2025.2542151>
- Behrens, K., & Robert-Nicoud, F. 2014. Survival of the fittest in cities: Urbanisation and inequality. *The Economic Journal*, 124(581), 1371-1400.
- Berger, T., & Frey, B. (2016). *Digitalisation, jobs and convergence in Europe: Strategies for closing the skills gap* (Vol. 50). Oxford: Oxford Martin School.
- Bernard, A. B., & Jensen, J. B. (2002). *The deaths of manufacturing plants*. NBER Working Paper no. W9026
- Bibby, P., & Brindley, P. (2013). *Urban and rural area definitions for policy purposes in England and Wales*. Office for National Statistics.
- Bloom, N., Fletcher, R. S., Yeh, E. (2021). *The impact of COVID-19 on US firms* (No. w28314). National Bureau of Economic Research.
- Bloom, N., Sadun, R., Van Reenen, J. (2012) Americans Do IT Better: US Multinationals and the Productivity Miracle. *American Economic Review*, 102 (1):167–201.
- Borowiecki, M., Pareliussen, J., Glocker, D., Kim, E.J., Polder, M., & Rud, I. (2021). *The impact of digitalisation on productivity: Firm-level evidence from the Netherlands*. OECD Economics Department Working Papers, No. 1680, OECD Publishing, Paris.
- Bourdin, S., & Levratto, N. (2024). The spatial footprint of COVID-19 and local policy answers. *Regional Studies*, 58(2), 255–262.
- Calvino, F., & Criscuolo, C. (2019). *Business dynamics and digitalisation*. OECD Science, Technology and Industry Policy Paper no. 62 <https://doi.org/10.1787/6e0b011a-en>.

- Calza, E., Lavopa, A., & Zagato, L. (2023). Advanced digitalisation and resilience during the COVID-19 pandemic: firm-level evidence from developing and emerging economies. *Industry and Innovation*, 30(7), 864–894.
- Capello, R., Lenzi, C., & Panzera, E. (2025). Cities as catalysts of wage inequalities from digitalisation. *Spatial Economic Analysis*, 1–23. <https://doi.org/10.1080/17421772.2025.2533478>
- Cattani, L., Montresor, S., Vezzani, A. (2025). Firms' eco-innovation and Industry 4.0 technologies in urban and rural areas. *Regional Studies*, 59(1).
- Cefis, E., & Marsili, O. (2019). Good times, bad times: innovation and survival over the business cycle. *Industrial and Corporate Change*, 28(3): 565-587.
- Cefis, E., Bettinelli, C., Coad, A., & Marsili, O. (2022). Understanding firm exit: a systematic literature review. *Small Business Economics*, 59(2), 423-446.
- Combes, P.-P., Duranton, G., Gobillon, L., Puga, D. & Roux, S. (2012). The Productivity Advantages of Large Cities: Distinguishing Agglomeration From Firm Selection. *Econometrica*, 80, 2543-2594.
- Copestake, A., Estefania-Flores, J., Furceri, D. (2024). Digitalization and resilience. *Research Policy*, 53 (3),104948.
- Corradini, C., Santini, E., & Vecciolini, C. (2021). The geography of Industry 4.0 technologies across European regions. *Regional Studies*, 55(10-11), 1667-1680.
- Coyle, D., Lind, K., Nguyen, D., Tong, M. (2024) *Digital transformation and firm productivity: Evidence from the UK*. ESCoE Discussion Paper No. 2022-06.
- Crespo Cuaresma, J., Lutz, S. U. (2021). Modelling and projecting digital trends in European regions: an econometric framework. *Regional Studies*, 55(10–11), 1696–1710.
- D'Costa, S., Holl, A., & Ribaud, D. (2024) Service sector firm death and productivity in urban and rural locations, *Economics Letters*, 235: 111560.
- Department for Business and Trade. (2024). *Longitudinal Small Business Survey, 2015-2022: Secure Access*. [data collection]. 8th Edition. UK Data Service. SN: 8261, [DOI: http://doi.org/10.5255/UKDA-SN-8261-8](http://doi.org/10.5255/UKDA-SN-8261-8)
- Department for Business and Trade (2025). *The UK's modern industrial strategy*.
- DeStefano, T., Kneller, R., Timmis, J. (2023) The (fuzzy) digital divide: the effect of universal broadband on firm performance. *Journal of Economic Geography*, 23: 139-177.
- Dunne, T., Roberts, M. J., & Samuelson, L. (1989). The growth and failure of US manufacturing plants. *The Quarterly Journal of Economics*, 104(4), 671-698.
- European Commission (2024). *Enhancing EU cohesion: The European Commission's 2021-2027 policy for a greener, digital future*. <https://transition->

pathways.europa.eu/tourism/policy/enhancing-eu-cohesion-european-commissions-2021-2027-policy-greener-digital-future

- Florida, R., Rodríguez-Pose, A., & Storper, M. (2021). Critical Commentary: Cities in a post-COVID world. *Urban Studies*, 60(8), 1509-1531.
- Gal, P., Nicoletti, G., Renault, T., Sorbe, S., & Timiliotis, C. (2019). *Digitalisation and productivity: In search of the holy grail—Firm-level empirical evidence from EU countries*. OECD Economics Department Working Papers No. 1533
- Goldbeck, M. (2025). Bit by bit: colocation and the death of distance in software developer networks. *Journal of Economic Geography*, IbaF002.
- Görg, H., and Spaliara, M. E. (2014). Financial health, exports and firm survival: Evidence from UK and French firms. *Economica*, 81(323): 419-444.
- Gruber, H. (2019). Proposals for a digital industrial policy for Europe. *Telecommunications Policy*, 43(2), 116-127.
- Guariglia, A., Spaliara, M. E., & Tsoukas, S. (2016). To what extent does the interest burden affect firm survival? Evidence from a panel of UK firms during the recent financial crisis. *Oxford Bulletin of Economics and Statistics*, 78(4): 576-594.
- Helmers, C., & Rogers, M. (2010) Innovation and the Survival of New Firms in the UK. *Review of Industrial Organization*, 36:227–248.
- Holl, A. (2018) Local employment growth patterns and the Great Recession: the case of Spain'. *Journal of Regional Science*, 58(4): 837-863.
- Holl, A., & Rama, R. (2024). Spatial patterns and drivers of SME digitalisation. *Journal of the Knowledge Economy*, 15(2), 5625-5649.
- Kemeny, T., Petralia, S., & Storper, M. (2025). Disruptive innovation and spatial inequality. *Regional Studies*, 59(1), 2076824. <https://doi.org/10.1080/00343404.2022.2076824>
- Knuepling, L., Sternberg, R., & Otto, A. (2025). Rural areas as winners of COVID-19, digitalization and remote working? Empirical evidence from recent internal migration in Germany. *Cambridge Journal of Regions, Economy and Society*, 18(1), 227-248.
- Leamer, E. E., & Storper, M. (2017). The economic geography of the internet age. In *Economy* (pp. 431-455). Routledge.
- Massini, S., Sanchez-Barrioluengo, M., Yu, X., Kim, M., Chen, P. & Velu, C. (2025). *Adoption of advanced digital technologies and platforms: Insights from a UK national survey*. Working Paper No. 049, The Productivity Institute.
- Ministry for Housing, Communities and Local Government (2024). *English Devolution White Paper*.
- Muzi, S., Jolevski, F., Ueda, K., Viganola, D. (2023). Productivity and firm exit during the COVID-19 crisis: Cross-country evidence. *Small Business Economics*, 60(4), 1719-1760.

- Nathan, M. (2021). Critical Commentary: The city and the virus. *Urban Studies*, 60(8): 1346-1364.
- Nguyen, D. (2020). *Failure to tackle digital skills divide will worsen regional inequality*. National Institute of Economic and Social Research.
- Nightingale, P., Coad, A. (2013). Muppets and gazelles: political and methodological biases in entrepreneurship research. *Industrial and Corporate Change*, 23(1): 113-143.
- Nose, M., & Honda, J. (2023). *Firm-Level Digitalization and Resilience to Shocks: Role of Fiscal Policy*. International Monetary Fund.
- OECD (2025). *Closing Broadband Connectivity Divides for All: From Evidence to Practice*. OECD Publishing, Paris.
- Office for National Statistics. (2024). *Business Structure Database, 1997-2023: Secure Access*. [data collection]. 16th Edition. UK Data Service. SN: 6697, [DOI: http://doi.org/10.5255/UKDA-SN-6697-16](http://doi.org/10.5255/UKDA-SN-6697-16)
- Olley, S., & Pakes, A. (1992). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, 64(6):1263–97.
- Reveiu, A., Vasilescu, M. D., & Banica, A. (2023). Digital divide across the European Union and labour market resilience. *Regional Studies*, 57(12), 2391–2405. <https://doi.org/10.1080/00343404.2022.2044465>
- Rodríguez-Pose, A. (2025). Forging a sustainable future together: Cohesion Policy at its defining moment. *Regional Studies*, 59(1). <https://doi.org/10.1080/00343404.2025.2552869>
- Rodríguez-Pose, A., & Crescenzi, R. (2008). Mountains in a flat world: why proximity still matters for the location of economic activity. *Cambridge Journal of Regions, Economy and Society*, 1(3), 371-388.
- Rodríguez-Pose, A., & Dijkstra, L. (2025). *The pursuit of competitiveness and the high stakes of territorial myopia* (No. JRC142460). Joint Research Centre.
- Storper, M., & Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. *Journal of Economic Geography*, 4(4), 351-370.
- Teruel, M., Bauer, P., Coad, A., Domnick, C., Harasztosi, P., Rückert, D., & Weiss, C. (2025). Digitalisation and high-growth enterprises in Europe. *Technology Analysis & Strategic Management*, 37(12), 3082–3095. <https://doi.org/10.1080/09537325.2024.2394771>
- Tranos, E., Kitsos, T., Ortega-Argilés, R. (2021). Digital economy in the UK: regional productivity effects of early adoption. *Regional Studies*, 55(12), 1924–1938.
- van Ark, B. (2016). The Productivity Paradox of the New Digital Economy. *International Productivity Monitor*, 31: 3-18.

Veugelers, R., Rückert, D., Weiss, C. (2019) Bridging the divide: New evidence about firms and digitalisation, *Bruegel Policy Contribution*, No. 2019/17.

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

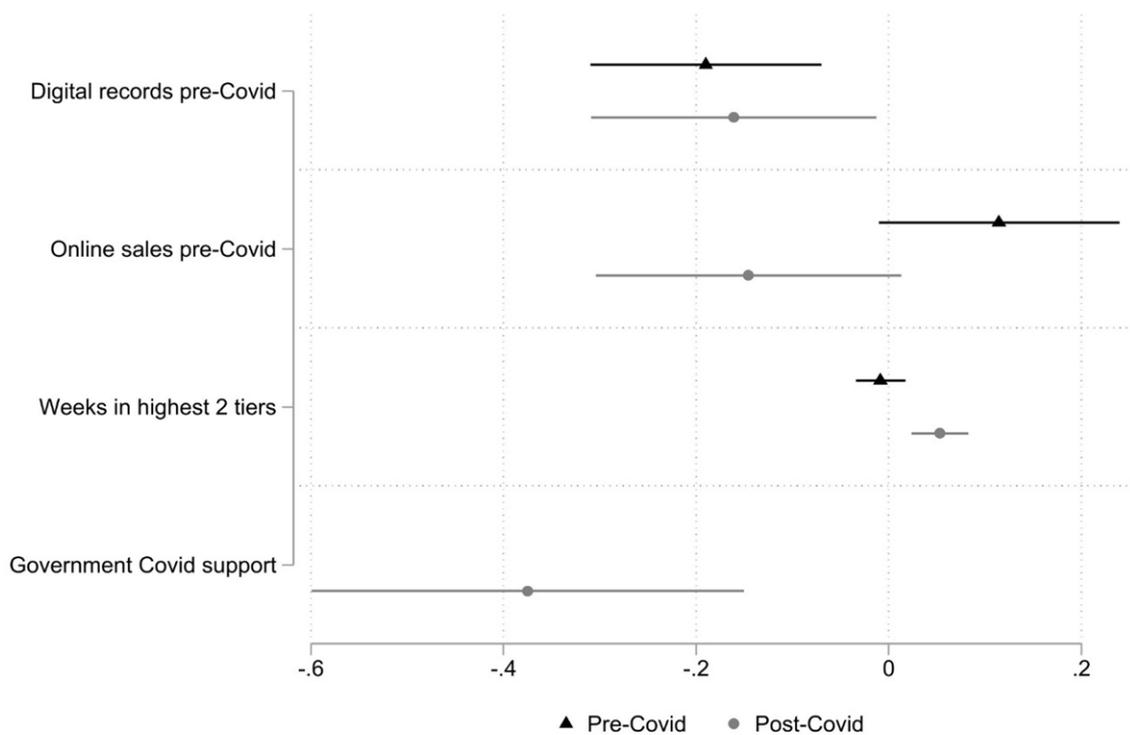


Figure A1: Coefficient plot from Probit estimation

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

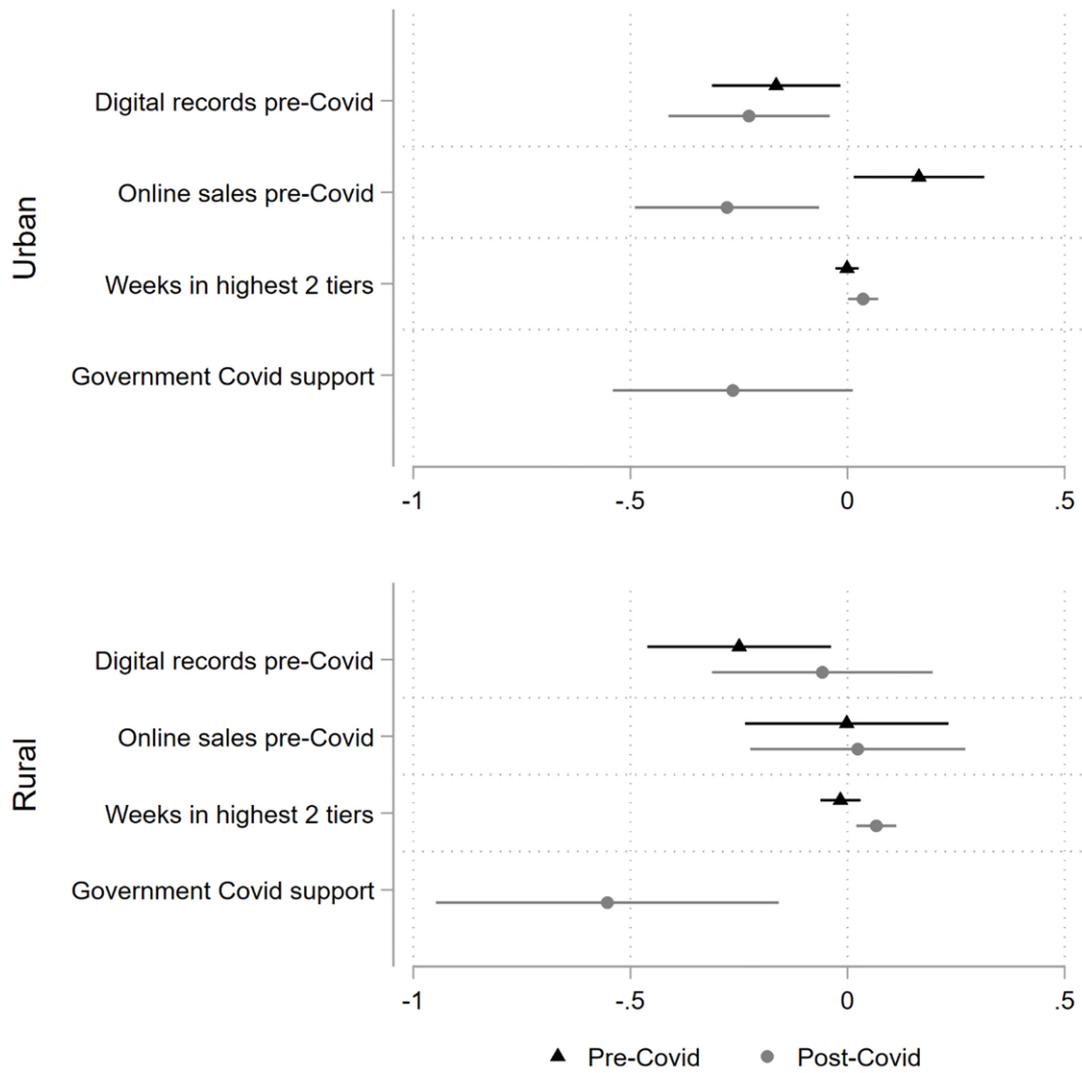


Figure A2: Coefficient plot from probit estimation

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)	(2)	(3)	(4)
	Probit Pre-2020	Probit Post-2020	Cloglog Pre-2020	Cloglog Post-2020
Digital records pre-Covid	-0.190*** (0.061)	-0.161** (0.076)	0.691*** (0.088)	0.721** (0.110)
Online sales pre-Covid	0.114* (0.064)	-0.146* (0.081)	1.272* (0.168)	0.742* (0.126)
Weeks in highest 2 tiers	-0.009 (0.013)	0.053*** (0.015)	0.982 (0.028)	1.111*** (0.034)
Government Covid support		-0.375*** (0.115)		0.443*** (0.117)
Urban	0.092 (0.070)	-0.147* (0.086)	1.189 (0.175)	0.768 (0.136)
Major urban	0.157* (0.093)	-0.276** (0.112)	1.329 (0.261)	0.576** (0.131)
Age 0-4	0.233** (0.103)		1.537** (0.328)	
Age 5-9	0.026 (0.091)	0.078 (0.104)	1.032 (0.196)	1.076 (0.235)
Age 10-19	-0.021 (0.089)	0.115 (0.092)	0.933 (0.174)	1.256 (0.241)
Ln labour productivity (t-2)	-0.156*** (0.029)	-0.114*** (0.038)	0.740*** (0.043)	0.802*** (0.058)
Exporter	-0.163** (0.072)	-0.233*** (0.085)	0.713** (0.113)	0.588*** (0.106)
Importer	-0.140* (0.076)	0.075 (0.084)	0.723* (0.121)	1.160 (0.203)
Employment	-0.044*** (0.009)	-0.043*** (0.013)	0.902*** (0.019)	0.898*** (0.026)
High - med tech manuf	0.478* (0.277)	0.573** (0.270)	3.486* (2.245)	3.743** (2.250)
Low tech manufacturing	0.596** (0.272)	0.433 (0.302)	4.497** (2.809)	2.364 (1.565)
Utilities	0.920** (0.460)		6.806** (6.175)	
Construction & real estate	0.573** (0.241)	0.199 (0.251)	4.144** (2.335)	1.613 (0.924)
Less KI services	0.602*** (0.225)	0.514** (0.217)	4.476*** (2.373)	2.989** (1.496)
KI services	0.404* (0.228)	0.329 (0.223)	2.872** (1.543)	2.078 (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 exits in year	Random effects cloglog Pre-2020	Random effects cloglog Post-2020
Digital records pre-Covid	0.535** (0.137)	0.658** (0.138)
Online sales pre-Covid	1.448* (0.309)	0.614** (0.130)
Weeks in highest 2 tiers	0.970 (0.031)	1.192*** (0.076)
Government Covid support		0.268*** (0.119)
Urban	1.420 (0.359)	0.724 (0.208)
Major urban	1.671 (0.532)	0.445** (0.171)
Age 0-4		
Age 5-9	1.235 (0.360)	1.199 (0.518)
Age 10-19	1.011 (0.278)	1.484 (0.436)
Ln labour productivity (t-2)	0.629*** (0.078)	0.712*** (0.089)
Exporter	0.590** (0.141)	0.469*** (0.136)
Importer	0.641* (0.157)	1.228 (0.311)
Employment	0.865*** (0.040)	0.862*** (0.046)
High - med tech manufacturing	4.639 (17.261)	5.696 (17.368)
Low tech manufacturing	7.240 (26.340)	3.289 (10.139)
Utilities		
Construction and real estate	6.065 (22.329)	1.859 (5.655)
Less KI services	6.879 (25.347)	4.789 (13.973)
KI services	3.626 (13.328)	2.713 (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* (0.114)	0.638** (0.122)	0.607** (0.143)	0.863 (0.233)
Online sales pre-Covid	1.411** (0.222)	0.544** (0.130)	1.024 (0.262)	1.100 (0.288)
Weeks in highest 2 tiers	0.998 (0.028)	1.072* (0.041)	0.958 (0.049)	1.135*** (0.053)
Government Covid support		0.548* (0.176)		0.312** (0.151)
Avg download speed (Mbits)	1.003 (0.004)	1.000 (0.004)	1.002 (0.003)	1.000 (0.005)
Age 0-4	1.432 (0.366)		1.998* (0.836)	
Age 5-9	1.071 (0.240)	1.023 (0.272)	0.873 (0.335)	1.044 (0.427)
Age 10-19	0.842 (0.191)	1.365 (0.316)	1.215 (0.412)	1.060 (0.368)
Ln labour productivity (t-2)	0.843** (0.061)	0.762*** (0.063)	0.593*** (0.057)	0.901 (0.133)
Exporter	0.760 (0.139)	0.602** (0.142)	0.526* (0.176)	0.519** (0.148)
Importer	0.745 (0.148)	1.267 (0.299)	0.638 (0.202)	1.079 (0.303)
Employment	0.889*** (0.026)	0.901*** (0.035)	0.925*** (0.027)	0.899*** (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** (0.075)	-0.227** (0.095)	-0.250** (0.108)	-0.058 (0.130)
Online sales pre-Covid	0.164** (0.077)	-0.278** (0.108)	-0.002 (0.119)	0.024 (0.127)
Weeks in highest 2 tiers	-0.001 (0.014)	0.036** (0.018)	-0.016 (0.024)	0.066*** (0.023)
Government Covid support		-0.264* (0.141)		-0.553*** (0.201)
Avg download speed (Mbits)	0.001 (0.002)	-0.000 (0.002)	0.002 (0.002)	0.000 (0.002)
Age 0-4	0.190 (0.123)		0.393** (0.195)	
Age 5-9	0.031 (0.107)	0.052 (0.125)	0.019 (0.175)	0.057 (0.190)
Age 10-19	-0.088 (0.108)	0.156 (0.111)	0.141 (0.161)	0.029 (0.161)
Ln labour productivity (t-2)	-0.089** (0.036)	-0.150*** (0.045)	-0.284*** (0.051)	-0.056 (0.068)
Exporter	-0.133 (0.085)	-0.212* (0.110)	-0.296** (0.146)	-0.320** (0.136)
Importer	-0.127 (0.091)	0.100 (0.110)	-0.211 (0.142)	0.043 (0.134)
Employment	-0.048*** (0.012)	-0.038** (0.016)	-0.037*** (0.012)	-0.050*** (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)	(2)	(3)	(4)
	Urban Pre-2020	Urban Post-2020	Rural Pre-2020	Rural Post-2020
Digital records pre-Covid	0.779 (0.133)	0.691* (0.144)	0.607** (0.143)	0.863 (0.233)
Online sales pre-Covid	1.236 (0.222)	0.608* (0.156)	1.024 (0.262)	1.100 (0.288)
Weeks in highest 2 tiers	0.998 (0.030)	1.067* (0.040)	0.958 (0.049)	1.135*** (0.053)
Government Covid support		0.583 (0.196)		0.312** (0.151)
Avg download speed (Mbits)	1.003 (0.004)	1.000 (0.004)	1.002 (0.003)	1.000 (0.005)
Age 0-4	1.431 (0.408)		1.998* (0.836)	
Age 5-9	1.024 (0.253)	0.820 (0.238)	0.873 (0.335)	1.044 (0.427)
Age 10-19	0.725 (0.187)	1.270 (0.301)	1.215 (0.412)	1.060 (0.368)
Ln labour productivity (t-2)	0.803*** (0.064)	0.724*** (0.063)	0.593*** (0.057)	0.901 (0.133)
Exporter	0.816 (0.169)	0.591** (0.153)	0.526* (0.176)	0.519** (0.148)
Importer	0.812 (0.178)	1.175 (0.309)	0.638 (0.202)	1.079 (0.303)
Employment	0.876*** (0.025)	0.849*** (0.031)	0.925*** (0.027)	0.899*** (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.



ERC



Enterprise Research Centre

Centre Manager
Enterprise Research Centre
Warwick Business School
Coventry, CV4 7AL
CentreManager@enterpriseresearch.ac.uk



Economic and Social Research Council



Innovate UK



BRITISH BUSINESS BANK

