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Natural selection or strategic adaptation? Entrepreneurial digital technologies and survival of the species

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Abstract
Research on firm survival has primarily focused on input and outcomes. We shift the conversation by performing a systematic analysis of moderating role of firm size in the relationship between firm survival and strategic adaptation. After establishing a theoretical framework, we empirically assess the impact of strategic adaptation through digital transformation and public financial aid on the likelihood of firm survival. We find that smart working helped small firms, while home delivery and e-commerce had no effect on their survival. In contrast, liquidity support from the government and deferral of credit benefited micro firms. Our study emphasizes the importance of analyzing survival probabilities by differentiating firms by size, with the ultimate goal of exploring how selection or strategic adaptation processes may variably impact them.

Keywords Strategic adaptation · Digital transformation · Survival · Entrepreneurship · Financial aid

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1 Introduction

The economic effects of the COVID-19 pandemic on entrepreneurship and small businesses have drawn the attention of business and policymakers around the world (Giones et al., 2020; Kuckertz et al., 2020). The pandemic has resulted in economic instability, altered consumer preferences and habits, and affected market dynamics, in particular market entry and exit (Bartik et al., 2020b). Entrepreneurial exits only sometimes are successful, e.g. exits via IPO or acquisition (see Pahnke et al., 2023), in most cases firms that are not prompted to strategically adapt to market shocks are naturally selected out of market (Cefis et al., 2022; Cestino Castilla et al., 2023; Coad et al., 2016; Meeus & Oerlemans, 2000). The Covid-19 pandemic has become a perfect natural experiment to study how entrepreneurial firms of different sizes adapt and evolve when exposed to the exogeneous shock to survive (Andries et al., 2020; Warner & Wäger, 2019).

While we know that pandemic pushed firms towards 'creative destruction', shifting from traditional office-based models to online commerce platforms and remote working (Belitski et al., 2022), there is a paucity of knowledge on theories which can explain the strategic adaptation of entrepreneurial firms to withstand and recover from crisis. Smaller firms, despite their limited resources, that adopted digital technologies and increased employees' mobility have better adapted to the shock. As animals adapt and evolve over time, do entrepreneurial firms adapt to the environment and exogeneous shock or they are selected out of the market. Firm size is important for entrepreneurial survival as the animal size in the Darwin theory of evolution plays a crucial role in the process of adaptation and evolution (Ruse, 1975). However, it is essential to remember that the advantageousness of being a small or large firm may also be context-dependent and influenced by numerous ecological factors (Ruse, 1975). For example, being large might be advantageous in a stable environment with abundant resources and few predators according to Darwin's theory (Bateson et al., 2014), while being small might be advantageous in an environment with scarce resources, such as economic shocks and natural disasters, or frequent disturbances. To date, there is a paucity of research which theorizes on the role of strategic adaptation in entrepreneurship and the boundary condition of a firm size that explains the ability to withstand the shock by choosing a specific adaptation strategy. This study fills this gap by developing a theoretical argument that strategic adaptation enables to withstand a shock and facilitates survival of entrepreneurial firms in a way as survival of species.

Along with the shift to a "new normal", entrepreneurial firms embrace digital transformation which includes working remotely as a core component (Aksoy et al., 2023; Bloom et al., 2015), as well as online commerce and home delivery (Zhang et al., 2022).

We define digital transformation as "the use of new digital technologies, such as mobile, artificial intelligence, cloud, blockchain, and the Internet of Things (IoT) technologies, to enable significant business improvements to enhance customer experience, streamline operations, or create new business models" (Warner & Wäger, 2019: 26). Smart working, e-commerce, and home delivery have surfaced as crucial strategic adaptation of digital tools during the pandemic and in the post-COVID era (Digitally Driven, 2020; Li et al., 2018; Yang et al., 2023; Zhang et al., 2022). In addition, firms had access to governments financial aid, such as the deferral of credit payments, additional liquidity, and wage subsidies. A substantial variation in access to such support was due to firm size (Aksoy et al., 2023; Block et al., 2022a).

Despite substantial and robust research on digital transformation during the 2010s (Warner & Wäger, 2019) and during the COVID-19 pandemic (Digitally Driven, 2021),

it remains unknown to what extent strategic adaptation via digital transformation facilitate firm resilience, avoiding selection processes that result in market exit, and how this relationship varies with firm size.

Drawing on the World Bank's Enterprise Surveys (ES) Italian COVID-19 data on digitization strategies and government financial aid to entrepreneurial firms, this study theorizes and empirically examines the effect of strategic adaptation on firm survival for micro, small and medium size companies. The objective in this study is to examine whether the propensity of entrepreneurial firms of different sizes to survive is increased by adapting to the new context through (a) digital transformation via smart working, e-commerce and adjustments in product delivery and/or (b) government financial aid providing support in terms of deferral of credit payments, additional liquidity and wage subsidies. In doing so we argue that this relationship depends on firm size. Our study extends prior research on strategic adaptation (Carr et al., 2010) and the role of adaptability during the pandemic (Ferrigno & Cucino, 2021; Roper & Turner, 2020).

This study contributes to the existing literature in the following ways. Firstly, we examine the impact of smart working, e-commerce, and home delivery—three adaptation strategies implemented by firms—on the propensity of companies of varying sizes to either stay in or exit the market during the COVID-19 pandemic. This expands our understanding of the heterogeneity of digital responses to extreme events such as the COVID-19 pandemic (Ramadani et al., 2022). Secondly, the paper discusses the role of different types of government financial aid, alongside digital transformation, in enabling strategic adaptation of micro, small, and medium enterprises through a propensity to survive (or not) in the market.

Our findings indicate that government financial support significantly reduced the propensity of micro firms to exit the market, in conjunction with other forms of government aid such as deferral of credit. The effect is more pronounced for micro entrepreneurial firms compared to larger firms. We also demonstrated that smart working is the most efficient type of digital adaptation and transformation, with micro and small-sized firms benefiting most compared to medium-sized firms. This finding contrasts with prior pre-pandemic research, which argued that smaller firms are less likely to utilize smart working (Bartz & Winkler, 2016; Bloom et al., 2015), showing that COVID-19, as an extreme event, enforced strategic adaptation in entrepreneurial firms. Their digital transformation represents a new entrepreneurial opportunity expedited by the pandemic; it may also symbolize a turning point for global entrepreneurship (Audretsch & Moog, 2022; Haltiwanger, 2022). Similarly, if the distribution of funding for digitalization to small businesses is positively correlated with their survival and growth, this policy tool could be utilized to mitigate the impact of future exogenous shocks, including financial ones (Block et al., 2022a).

2 Theoretical framework

2.1 Digital transformation and survival probability

The COVID-19 pandemic significantly impacted smaller firms, particularly in the United States (Bartik et al., 2020a) and Europe (Juergensen et al., 2020; Teruel et al., 2022), pushing many to decide between exiting the market (selection) or implementing organizational changes to survive (strategic adaptation). Existing literature suggests that smaller firms typically face a lower likelihood of survival compared to their larger counterparts, except

during mature stages of the product life cycle and for diversified companies (Agarwal & Audretsch, 2001). Specifically, early pandemic survey results indicated the financial vulnerability of SMEs (Bartik et al., 2020b), which may hinder them from implementing necessary organizational changes, potentially leading to their market exit (Meeus & Oerlemans, 2000). For instance, while lockdowns necessitated smart working for all firms, larger ones adapted more easily due to existing digital tools and resources. In contrast, small and micro firms used digital tools less frequently and were more vulnerable. Only 42% of European SMEs adopted over 6 digital tools crucial for their business models (Digitally Driven, 2021), and digital gaps in the United States resulted in approximately 43% of surveyed small businesses temporarily closing operations (Bartik et al., 2020a). Micro and small businesses typically lack the resources needed to build a robust smart working infrastructure (Vilhelmson & Thulin, 2016) or the capital or reputation to withstand fragility (Bartz & Winkler, 2016).

On the contrary, some studies have found that smaller firms demonstrate relatively better growth performance in times of crisis (Moscarini & Postel-Vinay, 2012) due to their adaptability (Bartz & Winkler, 2016). Bartz and Winkler (2016) found young firms exhibit stronger growth during stable periods but are significantly negatively affected by crises. Simultaneously, small and micro firms show a relative growth advantage compared to medium and large firms, both during stable times and in crises, often attributed to their flexibility. Such an advantage derives from dynamic capabilities that allow small businesses to quickly and efficiently adapt to external shocks. Dealing with COVID-19 relates to digitalization (Priyono et al., 2020). Indeed, firms were urged to undergo strategic adaptation, including introducing new digital technologies and tools such as e-commerce, home delivery, and smart working, from the onset of the COVID-19 pandemic. Micro and small firms, particularly those reluctant to expand their online presence and e-commerce, had to adapt swiftly to avoid market exit (Bartik et al., 2020a). This necessitated additional investment in digital infrastructure and skills (Li et al., 2016), which often exceeded what micro firms and the self-employed could afford, pushing many to exit the market or contemplate doing so (Bloom et al., 2021). Despite the efficiency and cost-reducing benefits of rapid ICT development (Byrne et al., 2017), for micro firms with limited liquidity, adopting new digital tools and learning how to use them remained an expensive option (Andries et al., 2020). Small firms (10–49 employees) were better prepared for smart working and could even expand (Belitski et al., 2022; Fairlie & Fossen, 2022). Still, they had to find resources to finance the adoption of digital tools, often resorting to bootstrap finance measures such as delaying payments or cutting expenses to overcome financial constraints (Block et al., 2022a).

The improved performance and relatively low cost of new digital tools made them more accessible, enabling small firms to implement various digital transformation strategies (Khurana et al., 2022) previously unexplored in research, such as smart working, e-commerce, and home delivery. Smart working became a necessity during lockdowns, and under constant restrictions, firms urgently adapted to it. According to Businesswire (2021), OnPay's State of Small Business 2020 survey revealed that 44% of small businesses had a smart working policy before the pandemic, and 50% of employers plan to retain smart working post-pandemic. This aligns with Zhang et al.'s (2022) finding of an increased trend towards working from home among small businesses after lockdown, considering local pandemic, socioeconomic, and policy conditions.

In the United States, three-quarters of businesses have transitioned at least some of their employees to remote work, and only 11% of those businesses plan to mandate all employees to work on-site post-pandemic. Many employees reported positive outcomes from this

shift, with 45% asserting that working from home simplified their lives (Businesswire, 2021). This was especially relevant for married, self-employed women with children, who stated that remote work mitigated the negative economic effects of COVID-19 (Kalenkoski & Pabilonia, 2022).

Schumpeter (1934) might have regarded the COVID-19 crisis as a period of "creative destruction". In such scenarios, micro and small firms, as compared to medium-sized firms not yet constrained by conventional working methods, would pursue "improvisational processes" (Naldi & Davidsson, 2014) and strive to discover new opportunities and modes of digital transformation, especially in the areas of e-commerce, home delivery, and smart working.

Smart working can render small firms less vulnerable (Belitski et al., 2022; Gertler & Gilchrist, 1994). Therefore, the adoption of smart working is likely to assist firms in retaining customers and maintaining sales, according to evidence from the United States (Digitally Driven, 2020) and Europe (Digitally Driven, 2021; Teruel et al., 2022) on the adoption of digital technologies and firm resilience.

Less risk-averse small firms drew on Schumpeterian (1934) viewpoint, leading to improvisation and enhanced resilience and growth during crises. Due to their flexibility, small firms have had better success in adapting and implementing various types of digital transformation than their larger counterparts. This is attributed to their heightened ability to respond to sudden changes and keen awareness of emerging entrepreneurial opportunities (Gimenez-Fernandez et al., 2020), including transitioning to new markets and industries (Weiergraeber, 2022). The resource limitations induced by the COVID-19 pandemic posed a particular threat to micro and small firms, as they typically depend more on equity finance sources to sustain their operations than medium-sized firms (Cumming et al., 2021).

Although strategic adaptation has been found to substantially enhance firm resilience and positively impact firm performance during crises (Teruel et al., 2022), other studies also demonstrated the efficiency of digital tools (Adomako & Nguyen, 2023; Bartik et al., 2020a). The positive relationship between smart working and firm survival during the COVID-19 pandemic could differ among firms of various sizes, as well as with respect to e-commerce and home delivery.

Digital transformation via smart working can provide higher revenue-to-cost ratios by decreasing expenses related to heating, space, food, hotels, and travel for workers, thus resulting in higher net revenue and particularly increasing the survival likelihood for micro and small-sized companies. However, home delivery and e-commerce may necessitate additional investment in web design, cybersecurity, and digital skill development, which require both time and additional financial resources. Smart working and online commerce have reduced costs, enabling some businesses that couldn't remain in the market due to operational costs and employee numbers to compete with firms that already had cost advantages pre-pandemic. Therefore, despite existing literature suggesting that medium and large companies are more likely to withstand exogenous shocks, we challenge these findings by arguing that small firms are more likely to survive and remain in the market due to their superior adaptability to changing external environments. Specifically, strategic adaptation in a digital era (Li et al., 2016) includes adopting new digital tools, reconfiguring production methods, product and service delivery, and workforce organization—may particularly benefit micro and small firms rather than medium-sized ones (Digitally Driven, 2020, 2021). The smaller the firm size, the greater the advantage of digital transformation via smart working, e-commerce, and home delivery compared to larger SMEs. This implies a marginal

revenue advantage for micro and small versus medium-sized SMEs that adopt smart working. Based on the above discussion, we hypothesize:

H1 Strategic adaptation via smart working, e-commerce and home delivery increases the survival propensity in micro and small size rather than in medium size firms.

2.2 Government aid and entrepreneurial survival.

Different sized firms responded in varied ways to the COVID-19 pandemic. In particular, small firms, which were resource-constrained and faced a decline in customer numbers, had to apply for and demonstrate their eligibility for public financial aid (Block et al., 2022a). The attainment of public financial aid became a critical factor for many firms to stay operational in the market and maintain their employees during the toughest times. Micro firms and the self-employed, who typically have particularly limited finances compared to small- and medium-sized firms, may find government support crucial. Using monthly panel data from the Current Population Survey in the USA, Kalenkoski and Pabilonia (2022) studied the initial impact of COVID-19 on the employment and hours of unincorporated self-employed workers. They found that the self-employed were the most impacted, with self-employed women being especially vulnerable. Furthermore, it was found that remote work and employment in essential industries helped mitigate some of the adverse effects on employment and hours worked, as did government aid to businesses.

Government financial aid may directly and indirectly facilitate firm survival, offering support such as a wage supplement scheme or a moratorium on account credit lines, financing instalments, and rent payments for firms in financial distress (Hoang et al., 2022). The pandemic induced a massive shock to aggregate supply as businesses were unable to produce goods and services due to safety concerns for their workforce, necessitating continuous financing of fixed costs, such as salaries, which small and micro firms struggled to manage (Cajner et al., 2020). Supply chain disruptions caused by COVID-19 could be mitigated with remote work and online sales commerce, albeit requiring substantial digital transformation and "emergency funding" to facilitate such changes. Hubbard and Strain (2020) found that the Paycheck Protection Program (PPP) significantly boosted the employment, financial health, and survival of small businesses. They also suggest that the effect of PPP on small business outcomes will likely increase over time, but the authors did not distinguish between the impacts of PPP across SMEs of different sizes. We concur with Hubbard and Strain (2020) that smaller firms are more likely to benefit from the PPP, as we provide evidence that small firms (a) lack digital skills, which was evident both before and during the pandemic in the US and Europe (Digitally Driven, 2020, 2021), and (b) rely more heavily on external non-debt and non-equity funding than larger firms do (Block et al., 2018). Prior research also indicated that smaller firms were particularly affected during the crisis as they had to continue paying rent and wages while having no or limited sales, significantly endangering their survival (Bartik et al., 2020a, b). For micro firms, the situation could be even more precarious due to their limited resources and capacity to identify relevant digital technologies and select platforms, requiring liquidity to invest in technologies and be able to use these technologies to adapt to the shock. Based on the above discussion, we hypothesize:

H2 Strategic adaptation via securing government financial aid increases the survival of micro and small size firms to a greater extent than medium size firms.

3 The government response to COVID-19 crisis in Italy

Italy's first reported COVID-19 case emerged in the northern part of the country towards the end of February 2020. Since the onset of the pandemic, the country has reported more than 23 million cumulative cases and 179,101 fatalities, rendering it one of the most severely affected nations globally. The virus's swift proliferation compelled the Italian government to enforce rigorous containment measures. These measures, including lockdowns and the halt of numerous economic activities across diverse sectors, had a profound impact on Italy's socio-economic fabric, leading to the exit of many firms from the market. Consequently, the country's GDP plummeted by 8.9% in 2020, and employment contracted by 4% (Orlando & Rodano, 2022).

In Italy, government support during the pandemic incorporated several mechanisms, such as digital transformation programs, wage payments, and credit deferrals. The Italian government, for instance, implemented three major interventions to combat the economic impact of the COVID-19 emergency: the Cura Italia Decree,[1] the Liquidity Decree, and the Relaunch Decree. These provisions allocated resources for wage supplement mechanisms and ensured businesses, particularly micro firms, had access to necessary liquidity via guaranteed or non-refundable loans. The Cura Italia Decree, introduced in March 2020, was the first Italian legislation aiming to alleviate the economic repercussions of the crisis, offering liquidity support particularly to micro and small enterprises.

Other European countries enacted similar measures, acknowledging the economic contribution of micro and small enterprises in terms of job creation and value addition, and hence, the importance of maintaining their liquidity and workforce. In Germany, for example, measures included a crisis-related law for short-time work compensation, enabling companies to retain their workforce as the Federal Employment Office would pay workers at least 60% of their basic income (Taylor & Schwartz, 2020). Germany also introduced a €750 billion economic aid package, with €50 billion targeted at only entrepreneurs and microenterprises, further emphasizing the difficulties micro firms might face in surviving this crisis (Nienaber, 2020).

In the US, to aid small and micro firms during the pandemic, the Paycheck Protection Program (PPP) and the Economic Injury Disaster Loan (EIDL) program furnished funds to small businesses. In Italy, the August Decree, the Relaunch Decree, and the Cure Italy Decree collectively designated approximately 35 billion euros to assist workers. This aid incorporated wage supplement schemes and indemnities for seasonal, occasional, and intermittent workers. Businesses, on the other hand, were relieved from contribution payments, while companies in peripheral areas received non-refundable grants and concessions (MEF, 2020).

The Italian government implemented several mechanisms to maintain household incomes and provide liquidity to businesses, mitigating the economic repercussions of the crisis and preserving the nation's industrial structure. For instance, an exceptional fund, the "Cassa integrazione in deroga", was bolstered with 4 billion euros to supplement earnings for a maximum of 9 weeks, subsequently extended to 18 weeks under the August Decree.[2] This fund targeted all economic sectors and businesses of all sizes. A single 600-euro bonus was disbursed to self-employed and professional workers who had to curtail or

[1] Gazzetta Ufficiale law publication https://www.gazzettaufficiale.it/eli/id/2020/03/17/20G00034/sg Accessed last time May 2, 2023.

[2] Gazzetta Ufficiale law publications https://www.gazzettaufficiale.it/eli/id/2020/08/14/20G00122/sg. Accessed last time in October 25, 2022.

temporarily cease their activities due to the lockdowns. Among other fiscal measures were the abolition of tax payments (4 billion euros reserved for this purpose), a fiscal bonus for adapting workplaces, sanitation, disinfection, and the distribution of personal protective equipment. Other financial measures aimed at preserving business liquidity included a moratorium on loans available to micro, small, and medium-sized enterprises (SMEs), professionals, and self-employed workers, guaranteed loans (200 billion euros earmarked for this purpose), and 6.2 billion euros dedicated to providing non-refundable grants to self-employed workers and businesses whose revenues did not exceed 5 million euros and who had experienced a 33% decline in turnover relative to the pre-pandemic year.

These measures were prolonged and reinforced by the Liquidity Decree,[3] which allocated 750 billion euros to ensure that businesses had access to more finance through guaranteed loans. In addition, the Relaunch Decree[4] allocated approximately 16 billion euros to extending the wage supplement scheme, cancelling some taxation payments, providing tax credit, and providing non-refundable grants to businesses.

The Italian National Institute of Statistics (ISTAT, 2022) found in the "Business situation and outlook after the COVID-19 health emergency" survey that fewer Italian microenterprises used wage supplement schemes than large (21%), medium (17.3%) and small firms (16.9%). Similar results emerge for smart working. Indeed, only 4.4% of micro firms adopted this measure, and the data shows that microenterprises were more likely to ask for guaranteed public loans to cover fixed costs (66.2%), pay debts (62.1%) and run the business (87.8%).

ISTAT (2022) surveyed about 1 million Italian firms and found that 7.1% interrupted their business permanently or temporarily. This effect is very asymmetric by firm size. Micro businesses have suffered more from a lack of liquidity and business strategy, and this is reflected in the higher risk of market exit (ISTAT, 2022). In 2021, ISTAT recorded an increase in the turnover of Italian firms, but with important differences between micro businesses (+18.9%) and large firms (+36.4%). In general, the resilience of micro businesses seems to be strongly anchored to public liquidity support, while larger firms may benefit from endogenous forms of resilience (e.g., smart working and new business strategies) (Teruel et al., 2022).

This data demonstrates how it is interesting to deeply focus on the heterogeneity by firm size of the main internal and external factors helping firms to survive this exogenous shock.

4 Methodology

4.1 Data

Our analysis exploits longitudinal data on a sample of Italian firms sourced by the World Bank (WB). The sample was obtained by merging the 2019 standardized Enterprise Survey (ES) with three ES COVID-19 follow-ups carried out in May 2020, December 2020, and April 2021. These periods correspond to the most severe lockdowns in Italy. The random sample, stratified at the sectoral and regional level, includes 112 micro firms, 218 small firms and 158 medium firms, for a total of 488 Italian firms. We exclude large-sized firms

[3] https://www.mef.gov.it/en/inevidenza/Liquidity-Decree-over-400-billion-in-guarantees/.

[4] https://www.mef.gov.it/en/inevidenza/Relaunch-Decree-155-billion-for-Phase-two-of-the-Economy-00001/.

(more than 249 employees) since their survival probability to the pandemic shock is very high[5] (see Fig. 4 in "Appendix"), probably due to their stable financial structure and greater availability of resources. Including them in a survival analysis would thus not make sense. This reasoning would not apply whether the impact of the shock is evaluated in terms of sales as most empirical works so far have done (see Belitski et al., 2022). However, this is not the aim of this work.

As discussed above, the sampled units are observed at four time points: one before (2019) the pandemic, and three after the COVID-19 outbreak. In particular, the analysis observes firms that operated in 2019 and were alive until the first follow-up (May 2020). In this way, the effects of the pandemic shock on their survival probability are examined between the end of the first lockdown (May 2020) and April 2021. This time horizon allows us to evaluate the survival of firms immediately after the shock (i.e., the first lockdown that ended in May 2020) and also their ability to remain in the market over a longer period when public economic support started to become less intense (i.e., from December 2020 to April 2021). Table 1 reports the list of variables employed in the empirical analysis with the mean, standard deviation, minimum and maximum values.

Table 2 includes other information about the sample, including various firm characteristics, region, size and sector.

Our data is based on nationally representative surveys for a developed country—Italy, and can be replicated for other developed countries in Europe and North America.

4.2 Measures

4.2.1 Dependent variables

Our research hypotheses are evaluated through a two-stage empirical investigation. Initially, we conduct a mortality analysis, categorizing the studied phenomenon as binary (firms being either defunct or active). We construct a dummy variable (death) that is assigned the value 1 if a firm exited the market following the first lockdown (post-May 2020), and 0 if a firm persisted in the market until April 2021 (the final observation period). Subsequently, we undertake a survival analysis, considering how many lockdowns a firm survived while remaining operational. Our dependent variable equals one at the beginning (May 2020), two for firms still operating in December 2020, and three for firms continuing to operate in April 2021. A firm is deemed to have exited the market if it permanently shuts down during this timeframe, and it is considered to remain in the market if it never closes or only temporarily ceases operations.

Table 3 reveals that from an initial sample of 488 firms (May 2020), 35 permanently closed post the first lockdown (May-December 2020), while 77 permanently closed following the second lockdown (December 2020–April 2021). A preliminary survival analysis based on the non-parametric method by Kaplan and Maier (1985) indicates that a firm had a 92.8% probability of surviving the first lockdown, which reduced to 77% post the second lockdown. These initial findings suggest that public support to private businesses mitigated the impact of the pandemic shock on firm survival, particularly during the first lockdown, when the likelihood of remaining in the market only decreased by 7.2%. After the second lockdown, this probability dramatically declined by an additional 15.8%.

[5] Large sized firms account for only 37 observations in our sample.

Table 1 Variables and definitions with the summary statistics

Dependent variable	Definition	Mean	Min	Max
Death	Dummy variable equals to 1 if the firm exits the market after the first lockdown (May 2020) and 0 if the firm remains in the market until April 2021	0.2295	0	1
Survival	The variable assumes value equals to 1 at the starting time (May 2020), equals to 2 if the firm remains in the market until December 2020 and equals to 3 if it remains until April 2021	–	1	3
Smart working	Dummy variable equals to 1 if the firm has started or increased remote work arrangements in response to COVID-19 outbreak	0.4651	0	1
Online activities	Dummy variable equals to 1 if the firm has started or increased online activities in response to COVID-19 outbreak	0.2274	0	1
Delivery	Dummy variable equals to 1 if the firm has started or increased delivery of goods and services in response to COVID-19 outbreak	0.1659	0	1
Government liquidity	Dummy variable equals to 1 if the firm benefited of cash transfers or access to new credit for digital transformation, and 0 otherwise	0.4590	0	1
Deferral payments	Dummy variable equals to 1 if the firm benefited of deferral of credit payments, rent or mortgage, suspension of interest payments, or rollover of debt, and 0 otherwise	0.2233	0	1
Wage subsidies	Dummy variable equals to 1 if the firm benefited of wage subsidies and 0 otherwise	0.3688	0	1
Product innovation	Dummy variable taking value 1 if the establishment has introduced new or improved products or services over the last 3 fiscal yrs and 0 otherwise	0.1147	0	1
Process innovation	Dummy variable taking value 1 if the establishment has introduced new or improved processes over the last 3 fiscal yrs and 0 otherwise	0.0860	0	1
Exporting	Dummy variable equals to 1 if the establishment operates in international markets, 0 otherwise	0.3524	0	1
NUTS1 region	Categorical variables indicating firm's NUTS 1 location, i.e., North-West, North-East, Centre, South and Island	–	1	5
Sector	Categorical variable equals to 0 if the firm belongs to the manufacturing sector, 1 if it operates in the food sector, 3 if it operates in the service sector	–	0	2
Size	Categorical variable indicating firm's dimension: Micro (less than 10 employees); Small ($10 \leq$ Num. of employees < 49); Medium ($49 \leq$ Num. of employees < 250)	–	0	2
Age	Logarithm of firm age computed as the difference between the survey year and the year the establishment starts operation	3.1131	0.6931	4.934
Female ownership	Dummy variable equals to 1 if among the owners of the firm there are females, 0 otherwise	0.2090	0	1

Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

Figure 1 displays the survival curves by firm size (Kaplan & Maier, 1985). The survival probability is plotted on the Y-axis, with observed times on the X-axis. It is apparent that after the first lockdown, the survival curve for micro firms lies noticeably below that of small and medium firms (the first step in the graph). Following the second lockdown, the three curves diverge (the second step in the graph), with micro firms' survival probability falling below 75%, while small and medium firms remain above this threshold. The Log-Rank test indicates significant statistical differences in the observed curves over the entire duration (Peto et al., 1977).

4.2.2 Independent variables

The independent variables pertain to the two sets of tools firms can utilize to manage the exogenous pandemic shock. The first set encompasses three adaptation strategies, referred to as 'internal tools': such as working from home—smart working, launching e-commerce webpage, and home delivery. These are represented by three dummy variables equating to 1 if the firm initiated or amplified smart working, e-commerce, and delivery in response to the pandemic, and 0 otherwise. Table 2 shows that 47% of the firms sampled adopted or amplified smart working due to the pandemic crisis, while 23% adopted or increased e-commerce, and only 16% adopted or increased delivery. Figure 2 demonstrates that firms adapting through the application of smart working, e-commerce, and delivery have higher survival probabilities, although the difference between adopters and non-adopters is only statistically significant for smart working, as the Log-Rank test suggests.

Table 4 reveals that a significant portion of medium-sized firms adopted smart working (73.42%), while only 25.89% of micro firms and 37.61% of small firms did so. About 24% of small firms, 23% of medium firms, and only 17.8% of micro firms adopted e-commerce. Finally, more micro firms (27%) embraced delivery than small (14%) and medium (12%) firms.

The second set of tools, external tools such as government aid, allow us to assess Hypothesis 2. We consider three dummy variables: Government Liquidity, Deferral Payment, and Wage Subsidies. These are assigned the value 1 if the firm secured public aid liquidity, was able to defer credit, rent, or mortgage payments, or received wage subsidies during the pandemic, and 0 otherwise.

In Table 5, we note that 57.1%, 49.5%, and 32.9% of micro, small, and medium firms respectively received public aid in the form of liquidity support. Regarding payment deferral, 26.7%, 25.2%, and 15.1% of micro, small, and medium firms respectively benefited. Lastly, approximately 40% of micro, 36.7% of small, and 34.8% of medium firms received wage subsidies.

4.2.3 Control variables

The analysis also accounts for firm characteristics, gauged in the pre-pandemic period (2019) to prevent causality problems. These characteristics encompass female ownership, product and process innovations, exporting activities, firm age, NUTS-1 region, and sector.

Table 3 indicates that only 21% of sampled firms have female ownership; 11% and 9% of firms introduced product and process innovations respectively in the three years prior to the interview; 33% of firms operate in foreign markets (exporting); firms have an average age of 30 years; and 50%, 17%, and 33% of firms operate in the manufacturing,

Table 2 Sample distribution across the various characteristics of firms in the sample, including location, size and sector

Variables	Obs	Yes—a firm complies with the characteristic (%)
Smart working	488	47
E-commerce	488	23
Delivery	488	16
Government liquidity	488	46
Deferral payments	488	22
Wage subsidies	488	37
Female ownership	488	21
Product innovation	488	11
Process innovation	488	9
Exporting	488	35
Region		
North-West	112	23
North-East	103	21
Centre	175	36
South and Islands	98	20
Firm size		
Micro	112	23
Small	218	45
Medium	158	32
Sector		
Manufacturing	245	50
Food	81	17
Services	162	33

Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

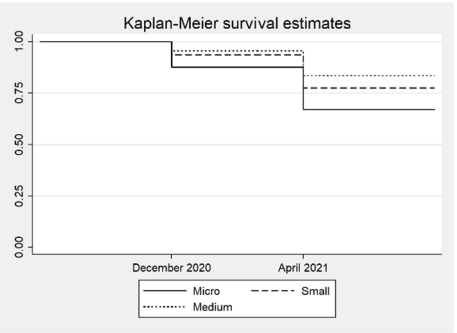
Table 3 Survival probabilities

Time	Number of subject alive at the beginning	Firm exits	Survivor function	Std. error	95% lower CI	95% upper CI
May 2020	488	–	–	–	–	–
December 2020	453	35	0.9283	0.0117	0.9015	0.9480
April 2021	376	77	0.7705	0.0190	0.7306	0.8053

Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

food, and services industries respectively. Finally, firms are geographically distributed as follows: 23% in North-West Italy, 21% in North-East Italy, 36% in Central Italy, and 20% in Southern Italy and the islands.

The literature suggests that innovators recover better from the pandemic shock than non-innovators (Doerr et al., 2021; Ferrigno & Cucino, 2021). Younger firms seem to



Log Rank test X^2=10.94 p-value=0.0042

Fig. 1 Kaplan–Meier survival curves by firm size. Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

be more affected by exogenous shocks, while male entrepreneurs suffered fewer consequences from the pandemic than female entrepreneurs (see Belitski et al., 2022; Block et al., 2022a; Kalenkoski & Pabilonia, 2022). However, the existing evidence has primarily examined the impact of the pandemic shock on sales, with few studies in the economic and business literature focusing on firm survival.

In Fig. 3 in the "Appendix", we compare survival curves for each control variable. We don't observe any difference between female and male ownership. Younger firms have significantly lower survival probabilities than older ones. While product and process innovators have higher survival probabilities compared to non-innovators, these differences aren't statistically significant. A similar result is obtained when comparing exporters and non-exporters, even if the difference here is slightly significant in statistical terms. Even if we do not find statistically significant differences in the case of geographical location (NUTS-1 region) and sector of activity, we can note that firms located in the North-East have higher survival probabilities while those operating in the services industry have a higher risk of exit.

4.3 Estimation method

4.3.1 Mortality analysis

A probit regression model allows us to explore in the simplest way the impact of some determinants on the probability a firm will exit the market after the first lockdown of May 2020. The equation may be specified as follow:

$$Prob(Death = 1) = f(\beta X) \tag{1}$$

where *Death* assumes value equal to 1 if a firm exits the market after the first lockdown (May 2020), and 0 if a firm remains in the market until April 2021. X is the matrix of our independent and control variables (covariates), and β is a vector of unknown parameters to be estimated. Since we are interested in the impact of digital transformation and government aids on the likelihood of the death of firms of different sizes, this equation is also estimated separately for the micro, small- and medium-sized business groups. The Count R^2 has been used to evaluate the predictive ability of the model and thus its goodness of fit.

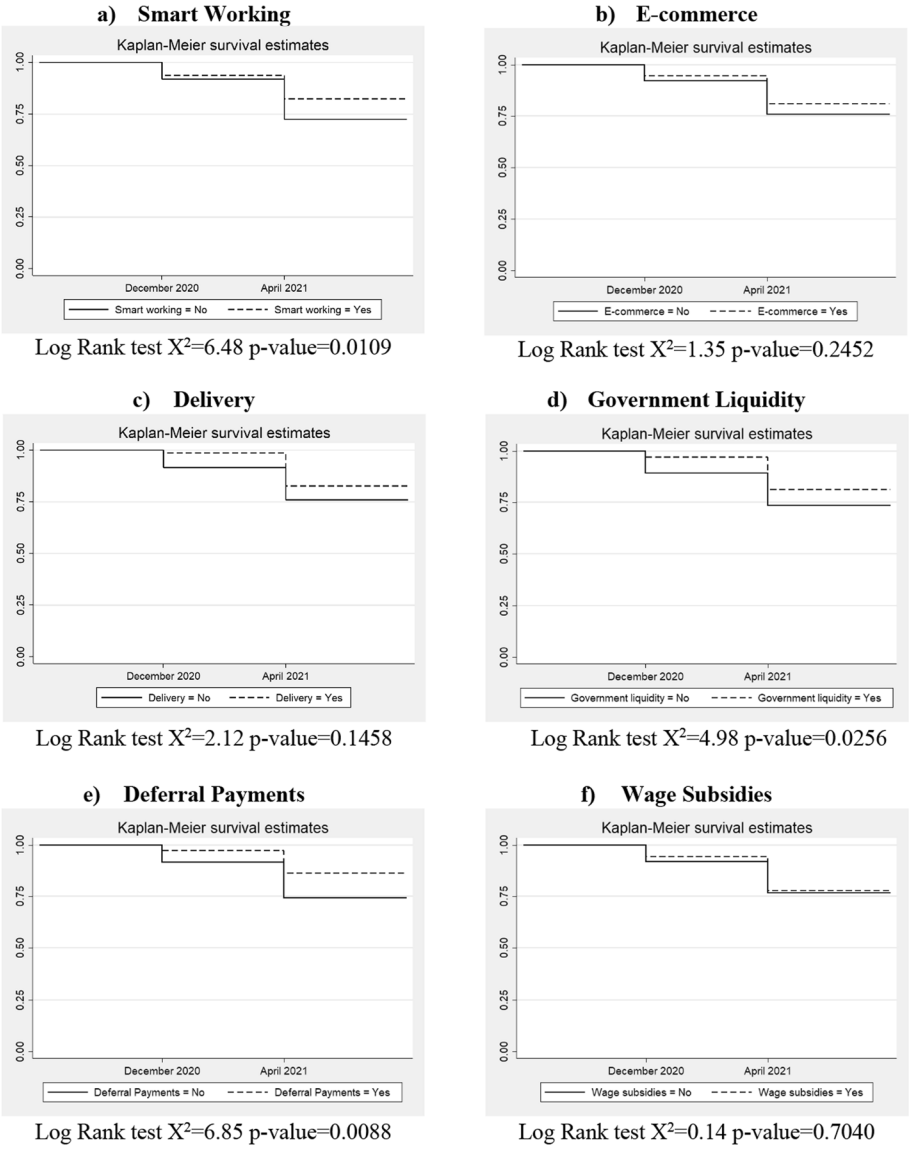


Fig. 2 Kaplan–Meier survival curves by independent variables. Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

4.3.2 Survival analysis

In a more accurate framework, we can account for the number of lockdowns a firm overcomes remaining in the market. To this end, we can exploit the Cox proportional hazard model (Cox, 1972) that allows the impact of covariates on the risk to exit to be evaluated, i.e., the inverse of survival probability. This model accounts for the presence of censored observations, since the survival time under investigation may be shorter than the time

Table 4 Smart working, e-commerce and delivery as digital strategies split by firm size

	Smart Working		E-commerce		Delivery		Totals
	No	Yes	No	Yes	No	Yes	
Micro	83	29	92	20	82	30	
	74.11	25.89	82.14	17.86	73.21	26.79	100
	31.80	12.78	24.40	18.02	20.15	37.04	
Small	136	82	164	54	187	31	
	62.39	37.61	75.23	24.77	85.78	14.22	100
	52.11	36.12	43.50	48.65	45.95	38.27	
Medium	42	116	121	37	138	20	
	26.58	73.42	76.58	23.42	87.34	12.66	100
	16.09	51.10	32.10	33.33	33.91	24.69	

First row has frequencies; second row has row percentages and third row has column percentages

Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

Table 5 Government aids by firm size

	Government liquidity		Deferral payments		Wage subsidies		Totals
	No	Yes	No	Yes	No	Yes	
Micro	48	64	82	30	67	45	
	42.86	57.14	73.21	26.79	59.82	40.18	100
	18.18	28.57	21.64	27.52	21.75	25.00	
Small	110	108	163	55	138	80	
	50.46	49.54	74.77	25.23	63.30	36.70	100
	41.67	48.21	43.01	50.46	44.81	44.44	
Medium	106	52	134	24	103	55	
	67.09	32.91	84.81	15.19	65.19	34.81	100
	40.15	23.21	35.36	22.02	33.44	30.56	

First row has frequencies; second row has row percentages and third row has column percentages

Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

needed to observe the exit or deaths of some statistical units (firms in our case). The model can be specified in a semi-parametric framework as follows:

$$\lambda_i(t) = \lambda_0(t)\exp(\beta X) \tag{2}$$

where, $\lambda_i(t)$ is the hazard function that measures the probability of exit for a firm I at a time t, $\lambda_0(t)$ is the baseline hazard, $\boldsymbol{X}$ is the matrix of our independent and control variables (covariates), and β is a vector of unknown parameters to be estimated.

Given the semi-parametric nature of the model, it does not make assumptions on the distribution of the baseline hazards; however, it requires the hazards to be proportional that is the relative risk to exit the market should be constant in all the survival intervals under

investigation. This is known as the Proportional Hazard assumption (PH) and can be validated by the Grambsch–Therneau test (Grambsch & Therneau, 1994). This test uses the Schoenfeld partial residuals (Schoenfeld, 1980) to evaluate the null hypothesis of constant hazard function over time. If the test is significant, it means that the assumption is violated and a potential impact of covariates is thus not independent of time, so that the significant coefficients do not have a straightforward interpretation.

5 Empirical results

Table 6 presents the average marginal effects derived from the probit model in Eq. 1. The model was initially run on a comprehensive sample comprising micro, small, and medium-sized firms. Subsequently, firms were differentiated by size to account for potential heterogeneous effects and to test our hypotheses: firm size as a boundary condition that influences the benefits derived from strategic adaptation. We deliberately refrained from incorporating interaction terms in the specification due to our sample's limited size, and to obtain more precise estimates for firms of different sizes.

Inparticular, Column 1 includes firm size, represented by a set of dummy variables, with micro firms as the reference group. This column indicates that both digital transformation (measured in terms of smart working adoption) and government aid (expressed as liquidity support) reduce the likelihood of firm mortality during the COVID-19 pandemic. Specifically, adapting through smart working and government liquidity each reduce the likelihood of firm mortality by about 7.6% and 10.5%, respectively (Specification 1, Table 6).

Furthermore, we observe that the likelihood of firm mortality decreases with increasing firm size in SMEs, with reductions of 11% for small firms and 15% for medium firms compared to micro firms. Firms engaged in product innovation are 3.6% less likely to cease operations compared to firms that do not innovate. Importantly, we find that firms located in North-East Italy have a 13.6% lower likelihood of closure than firms in other regions.

Columns 2 to 4 present results for micro, small, and medium enterprises. Notably, smart working only influences small firms, reducing the likelihood of firm closure by 11.9%. Government liquidity consistently lowers the probability of firm death, with the effect being more significant for micro firms (− 18.9%). Lastly, the Count R2 ranges between 0.70 and 0.83, underscoring the satisfactory goodness of fit of the models.

Table 7 provides the estimates of the Cox proportional hazard model defined in Eq. 2. Similar to the probit model estimation, the Cox model was initially run on the full sample, followed by separate runs for firms of different sizes. Negative values imply a reduction in the risk of exit, translating to an increased propensity to survive.

Consistent with the mortalityanalysis, we find that firms in North-East Italy have, on average, a higher likelihood of survival than firms in other Italian regions. Our results suggest that primarily small and medium firms, not micro firms, improve their survival likelihood. This finding is enlightening, as it reveals an unexpected gap between North-West and North-East Italy, even though a North–South divide was anticipated. This discrepancy might be attributable to regional governments' varied management strategies during the pandemic crisis.

The survival curves across different firm sizes also corroborate these results, as depicted in Fig. 1. We offer partial support for Hypothesis 1, which proposes that adapting via smart working enhances survival in micro and small firms relative to medium firms. Furthermore,

we support Hypothesis 2, which asserts that government liquidity aid mitigates selection processes, i.e., the exit of smaller SMEs.

Columns 2–4 of Table 7 each have the same specification, dividing the sample among micro, small, and medium-sized firms. The Proportional Hazard (PH) assumption test is also provided for each specification in Table 7. The PH test evaluates the Cox model's independence from time. If a covariate significantly influences survival, this effect is independent of time. In essence, this means that the impact of a covariate is not clouded by time. If the PH test wasn't conducted, interpreting the significant covariates in a straightforward manner would not be feasible.

We discover that digital transformation measures such as transitioning to smart working, e-commerce, and home delivery are not associated with the propensity of micro firms to survive. This is indicated by the insignificance of the coefficients (refer to column 2, Table 7). Hypothesis 1 (H1) is only substantiated for smart working in small firms ($\beta = -0.602$, $p < 0.05$). In economic terms, this suggests that strategic adapting to smart working can reduce the relative risk of exiting the market by 60.2 percent for small firms. Our findings highlight that while small firms have been most impacted by the pandemic, their flexible labor structures enable quicker strategic adaptation via smart working and the creation of a digital safety net compared to micro firms, which lack resources, or larger firms, which tend to be less flexible and more risk-averse (Belitski et al., 2022).

Our second hypothesis (H2), which posits that strategic adaptation via government financial aid improves survival propensity in micro firms, is confirmed. We find a statistically significant coefficient for micro firms in the Government Liquidity for digital transformation ($\beta = -0.670$, $p < 0.05$) and Deferral Payments ($\beta = -0.983$, $p < 0.05$) categories, but not for small- or medium-sized firms. Economically, these results indicate that access to government liquidity for digital transformation and deferral of payments can reduce the relative risk of market exit by 67.0 and 98.3% respectively. Interestingly, not only micro firms but also small firms benefit from Deferral Payments ($\beta = -0.539$, $p < 0.05$) as they face more significant resource constraints during the COVID-19 crisis compared to medium-sized firms.

These findings extend previous discussions in management and entrepreneurship literature regarding the role of government financial aid for digitalization and credit for micro and small firms due to their resource constraints relative to medium firms (Belitski et al., 2022; Block et al., 2022b). We provide evidence that government aid for digital transformation can build dynamic capabilities for digital transformation (Warner & Wäger, 2019).

Existing literature suggests that small firms are more dependent on external resources, particularly non-debt and non-equity, and are more likely to be affected by crises than medium and large firms expanding what we know from Branicki et al. (2018). This is because they lack formal, long-term crisis planning, have less bargaining power (Smallbone et al., 2012), and lack the resources and structure needed to consistently monitor external shocks (Schwaiger et al., 2021). While our data supports this argument, we also illustrate there are multiples strategies of adaptation required to survive a crisis.

Cross-industry comparisons yield interesting results. There's a reduction in the likelihood of market exit for small and medium-sized firms that innovate their products by 40.4 and 61.4% respectively. Medium-sized firms in the manufacturing sector, which was significantly affected by the COVID-19 pandemic in Italy, are less likely to survive (refer to column 4, Table 7).

Government aid plays a significant role in micro firms' survival, and the ability to defer payments helps these firms continue to meet their liabilities. This provides an increase to their working capital, enabling them to cover fixed and variable costs, pay suppliers,

Table 6 Mortality analysis (probit regression model)

Variables	(1) Death Full sample	(2) Death Micro-firms	(3) Death Small-firms	(4) Death Medium-firms
Smart working	− 0.0769**	− 0.102	− 0.119**	− 0.0229
	(0.0329)	(0.106)	(0.0529)	(0.0691)
E-commerce	0.0165	− 0.00248	0.0173	0.0770
	(0.0504)	(0.126)	(0.0775)	(0.0835)
Delivery	− 0.0843	− 0.0965	− 0.0607	− 0.210
	(0.0595)	(0.108)	(0.0958)	(0.144)
Government liquidity	− 0.105***	− 0.189***	− 0.107**	− 0.00641
	(0.0399)	(0.0765)	(0.0521)	(0.0682)
Deferral payments	0.00374	0.0364	− 0.0183	− 0.00680
	(0.0405)	(0.0935)	(0.0625)	(0.0612)
Micro	*Reference*			
Small	− 0.116**			
	(0.0539)			
Medium	− 0.153**			
	(0.0624)			
Female owner	− 0.0187	− 0.121	0.0805	− 0.0754
	(0.0480)	(0.0980)	(0.0718)	(0.0967)
Product innovation	− 0.0360**	0.0698	− 0.0695**	− 0.0875**
	(0.0143)	(0.146)	(0.0317)	(0.0455)
Process innovation	0.0297	− 0.125	0.154	0.00290
	(0.0820)	(0.163)	(0.143)	(0.119)
Exporting	0.00837	0.145	− 0.0751	0.00511
	(0.0471)	(0.160)	(0.0646)	(0.0685)
Age	− 0.0258**	− 0.0308**	0.0103	− 0.0356***
	(0.0130)	(0.0194)	(0.0364)	(0.0189)
North-West	*Reference*	*Reference*	*Reference*	*Reference*
North-East	− 0.136**	− 0.0399	− 0.141**	− 0.202**
	(0.0551)	(0.115)	(0.0789)	(0.0938)
Centre	−0.0388	0.139	− 0.0909	− 0.144**
	(0.0531)	(0.115)	(0.0825)	(0.0770)
South	− 0.0492	0.132	− 0.0663	− 0.139
	(0.0610)	(0.148)	(0.0890)	(0.117)
Food	*Reference*	*Reference*	*Reference*	*Reference*
Manufacturing	0.0277	− 0.00824	− 0.0971	0.128**
	(0.0532)	(0.135)	(0.0914)	(0.0639)
Service	0.0453	0.135	− 0.0835**	0.0757
	(0.0586)	(0.134)	(0.0489)	(0.0877)
Count R2	0.77	0.696	0.775	0.835
Observations	488	112	218	158

The reported coefficients are the Average Marginal Effects; standard errors in parenthesis;
*10% significant level; **5% significant level; ***1% significant level

Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

and potentially outsource some digital capabilities (Li et al., 2016). Unlike medium firms, micro firms received a significant survival boost as they were able to cover costs and invest in new digital tools to reconfigure their product and service creation and sales during the pandemic (Block et al., 2022a; Dörr et al., 2022; Nienaber, 2020).

6 Discussion

While many studies have recently emerged offering different pathways of strategic adaptation (Carr et al., 2010), including the most recent related to the COVID-19 pandemic such as working from home and social distancing (Zhang et al., 2022), government support to retain labour and for investing in digital tools and capabilities (Fairlie, 2020), this study is the first to theoretically and empirically examine the effects of strategic adaptation on firm survival with firm size moderating this relationship. We drew on firm-level data of Italian micro, small, and medium firms during COVID-19. The study constructs a theoretical framework of firm selection versus strategic adaptation and firm resilience, along with the role of government support programs in enabling adaptation strategies through digital transformation (Aksoy et al., 2023; Bloom et al., 2015) and distinguishing between the effects on micro, small, and medium-sized firms. In doing so, this study responds to two key research calls regarding entrepreneurship and the COVID-19 pandemic (Hubbard & Strain, 2020; Block et al., 2022a, 2022b) for a better understanding of the role of government support schemes during COVID-19 and the ability of differently sized firms to adapt their dynamic capabilities and adopt digital technologies. Firstly, it answers whether employing strategic adaptation that involve digital technologies and government financial aid increased the survival chances differently with firm size. Secondly, we showed what adaptation strategies are most effective in reducing the likelihood of exit. By using the advanced method of analysis to account for survival length our results of two separate estimation methods were consistent.

Entrepreneurial strategic adaptation via starting to digital working practices helped small firms increase their survival chances more than micro and medium-sized firms, changing how firms operated during the pandemic and extending what we know from Belzunegui-Eraso and Erro-Garcés (2020) and more recently Teruel et al. (2022). This was particularly interesting since our findings show that off-site digital work not only contributes to firm growth and productivity, as found in prior research (Bailey & Kurland, 2002; Bloom et al., 2015),[6] but also decreases the likelihood of closure and increases survival duration following a significant shock. Our findings extend the conversation on the ability of small, flexible, and agile businesses (Belitski et al. 2022) to shift from traditional work methods and organizational structures.

During the COVID-19 pandemic, an urgent need arose for Schumpeter's concept of "creative destruction"—shifting from physical shops and offices to online commerce platforms and remote work. While this shift is consistent with Schumpeter's (1934) "creative destruction," it posed challenges for Italian firms traditionally dependent on office-based models. Our analysis notes that smaller firms do not necessarily perform worse if they can adapt their organizations through digital transformation and offer flexible working arrangements.

[6] The importance of digital technologies has been recognized also in other studies highlighting the positive role of digital tools in favouring, for example, circular economy transition (see Soriano-Pinar et al. 2023) and entrepreneurial activities at the national level (see Zhang et al., 2023).

Table 7 Survival analysis (Cox proportional hazard model)

Variables	(1) Survival Full sample	(2) Survival Micro-firms	(3) Survival Small-firms	(4) Survival Medium-firms
Smart working	− 0.330**	− 0.382	− 0.602***	− 0.106
	(0.176)	(0.468)	(0.263)	(0.523)
E-commerce	0.0964	− 0.111	0.121	0.455
	(0.267)	(0.551)	(0.427)	(0.565)
Delivery	− 0.523	− 0.473	− 0.425	− 1.366
	(0.325)	(0.478)	(0.535)	(1.149)
Government liquidity	− 0.425**	− 0.670***	− 0.428	0.0889
	(0.201)	(0.290)	(0.352)	(0.488)
Deferral payments	− 0.622**	− 0.983**	− 0.539**	− 0.583
	(0.303)	(0.467)	(0.252)	(0.728)
Wage support	0.130	0.445	− 0.009	− 0.0238
	(0.216)	(0.411)	(0.344)	(0.424)
Micro	*Reference*			
Small	− 0.515**			
	(0.232)			
Medium	− 0.766**			
	(0.302)			
Female owner	− 0.119	− 0.555	0.366	− 0.549
	(0.253)	(0.429)	(0.376)	(0.788)
Product innovation	− 0.214**	0.237	− 0.404**	− 0.614**
	(0.118)	(0.559)	(0.223)	(0.333)
Process innovation	0.247	− 0.222	0.613	0.239
	(0.424)	(0.851)	(0.637)	(0.889)
Exporting	− 0.002	0.698	− 0.399	0.0283
	(0.251)	(0.609)	(0.380)	(0.483)
Age	− 0.152	− 0.179	0.0261	− 0.231*
	(0.116)	(0.196)	(0.189)	(0.141)
North-West	*Reference*	*Reference*	*Reference*	*Reference*
North-East	− 0.597**	− 0.178	− 0.562**	− 1.175***
	(0.246)	(0.591)	(0.251)	(0.612)
Centre	0.0145	0.611	− 0.200	− 0.663
	(0.245)	(0.475)	(0.403)	(0.469)
South	− 0.0667	0.743	− 0.187	− 0.617
	(0.289)	(0.615)	(0.418)	(0.745)
Food	*Reference*	*Reference*	*Reference*	*Reference*
Manufacturing	0.185*	0.153	− 0.307	1.130**
	(0.102)	(0.634)	(0.426)	(0.503)
Service	0.269	0.592	− 0.199	0.890
	(0.316)	(0.608)	(0.443)	(0.947)
PH test (χ^2)	24.60	12.55	17.78	35.06**
Observations	488	112	218	158

Standard errors in parenthesis; *10% significant level; **5% significant level; ***1% significant level

Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

Our findings reveal a non-linear relationship between smart working, government financial aid, and the survival chances of differently sized firms. This is because digital transformation, including e-commerce, home delivery, and, most importantly, smart working, requires investment in control and organization systems for remote work (Khurana et al., 2022). This could be difficult for micro firms and undesirable for medium firms due to significant infrastructure dependence and the potential loss of team cohesion. During the COVID-19 pandemic, team working was limited to online meetings.

Many firms, particularly micro and small ones, temporarily closed at the beginning of the pandemic and during the first lockdown in summer 2020 (Bartik et al., 2020a). These firms, particularly micro ones, relied heavily on immediate public aid to pay employees and support their families throughout the pandemic. However, these employees were then revitalized and reintegrated through smart working more successfully by small firms than micro firms.

Prior research has demonstrated that supply chain disruptions caused serious challenges during the COVID-19 pandemic (Siche, 2020). As such, there was a surge in demand for online platforms that allowed firms to work (e.g., Zoom, Teams, Webex) and manage personnel effectively (e.g., Monday.com). Our findings contrast with Levenburg's (2005) assertion that internet usage is crucial for both larger and smaller firms. Instead, we found that it was small and micro firms that benefited most from the digitalization transition, not medium-sized firms.

While micro firms traditionally rely on informal sources of finance (Nofsinger & Wang, 2011), these sources were limited during the pandemic due to restrictions on face-to-face contact and equity fundraising campaigns. Firms that were unable to secure finance were financially challenged and prompted to apply for public funds support. Our findings confirm Moscarini and Postel-Vinay's (2012) result that smaller firms had better growth performance during times of crisis if they secured more funding.

On the one hand, micro and small firms, compared to medium-sized ones, are generally more flexible and often find it easier to break from convention and adapt to the new environment (Naldi & Davidsson, 2014). On the other hand, micro and small firms, due to their limited resources have been more vulnerable than medium-sized firms during times of economic crisis, which may prevent them from making necessary changes, resulting in environmental selection with limited empirical evidence existed before our study (Agarwal & Audretsch, 2001; Kolasa et al., 2010; Meeus & Oerlemans, 2000; Teruel et al., 2022). On the contrary, larger multinational firms have exhibited greater resilience during the COVID-19 pandemic (Juergensen et al., 2020), the crisis has resulted in a substantial decline in both young and small businesses, even in innovative-intense sectors (Didier et al., 2021). This raises the question of the extent to which the strategic adaptation related to use of digital tools and procurement enables resilience and growth.

7 Conclusion

7.1 Theoretical contribution

Applying the adaptation perspective in evolution (Thagard & Findlay, 2010), this study explores a firm's strategic choice between selection or adaptation using the COVID-19 pandemic as a springboard for such exercise, where digitization and government aid were used to survive.

During the COVID-19 pandemic, strategic adaptation using digital tools (Digitally Driven, 2021) emerged as a key strategy for entrepreneurial firms of varying sizes, facilitating survival. Small and medium businesses, often organized around a few individuals, enjoy greater decision-making autonomy, and can adapt more readily, despite potential liquidity challenges and skill shortages.

Like Darwin's theory of evolution by natural selection, which emphasizes the essential role of beneficial characteristics for survival and reproduction (Thagard & Findlay, 2010), firms also acquire characteristics crucial for survival. We posit that this process is central to both natural and strategic adaptation throughout firm and market evolution. Firm size, akin to the size of an organism, can significantly influence survival, and subsequently, evolution. However, whether the selection favors larger or smaller sizes often depends on specific ecological, or business conditions and threats faced (Ellis et al., 2009). Large organisms, or firms, typically require more resources and might be more affected by environmental changes. Conversely, smaller species and firms could be more flexible in their habitat or business ecosystem and resource usage, potentially offering them greater opportunities for adaptation and evolution (Ellis et al., 2009). Within this ecosystem, remote work or "smart working" emerged as a prevalent strategic adaptation move for both small and large firms, with smaller entities gaining more benefits. However, the efficacy of applying for government support, another strategy adopted by small firms, is debatable given the multitude of programs and eligibility criteria.

Overall, the COVID-19 pandemic has accelerated digital transformation, which has proven more successful in smaller firms, alongside government financial aid, enabling firms to adapt their business models to the evolving environment.

Our findings build upon the literature on entrepreneurship and firm selection versus adaptation strategy (Meeus et al., 2000), incorporating the theoretical perspectives of digital transformation and government support (Khurana et al., 2022). Previous research on firm survival during the COVID-19 pandemic has employed various theoretical lenses such as dynamic capabilities, relational capital, and organizational learning (Carmine et al., 2021; Fairlie, 2020; Kalenkoski & Pabilonia, 2022; Münch & Hartmann, 2023). However, no research exists on firm adaptation or selection, potentially limiting policy responses to shocks.

7.2 Policy and managerial implications

Micro and small firms account for the largest share of total employment globally (Kok & Berrios, 2019), and are often the pillar of regional competitiveness and economic growth (Audretsch et al., 2015), but their ability for digital transformation remains underexplored.

Primarily, our study found that compared to medium-sized firms, micro and small firms had broader and more efficient labour arrangements, providing an advantage over traditional office settings. Nonetheless, our results indicate that the benefits of dedicated working hours and wage savings depend on firm size. This was reflected in our empirical analysis; the advantages of smart working only became evident when we separated the sample into three size categories, not when we analysed all entrepreneurial firms together in the survival analysis.

Secondly, our study reveals that smart working aids small firms' survival but is less beneficial for medium-sized firms.

Thirdly, our study commenced at the early stages of the pandemic, shortly after the first lockdown. With the transition from traditional offices to smart working still in its infancy, the benefits of the latter became increasingly significant. Hybrid workplaces, which adopted new digitization strategies blending smart working and traditional offices during the COVID-19 lockdown, blurred the distinction between the two, thus highlighting the advantages of smart working, as detailed by Zhang et al. (2022).

Fourth, micro firms with limited resources were less prepared for the COVID-19 pandemic compared to their small and medium-sized counterparts and therefore heavily relied on cash availability and public funds. Evidence from pre-pandemic Sweden supports this claim (Vilhelmson & Thulin, 2016). Identifying mechanisms to enhance their performance, resilience, and reduce the risk of exit is vital for those designing entrepreneurship support and recovery policies (Teruel et al., 2022). Therefore, policies will differ for firms of varying sizes. For instance, providing government financial support exclusively to micro firms and granting credit deferrals to both micro and small firms can help retain customers and ensure survival.

Fifth, while digitization strategies are crucial, not all tools prove beneficial. For example, e-commerce and home delivery did not significantly enhance firms' survival propensity. Moreover, not all types of government aid were important—only liquidity aid mattered for micro firms, assisting them in maintaining operations and retaining labour. The primary cost-saving advantage was the reduction in commercial rental costs through remote working and cash payments for rent or wages, enhancing firm survival.

Finally, our findings stress the need to cater to firms' specific needs rather than adopting a one-size-fits-all approach. Directing additional liquidity aid to all firms would be wasteful. This aid should primarily target micro enterprises lacking the financial resources to counter the negative economic impacts of the crisis. On the other hand, governments should encourage digital literacy training for small firms reluctant to adopt digitalisation, particularly smart working. This can be achieved by developing high-quality infrastructure and a regulatory framework that enforces digital security and data protection (OECD, 2021). This tailored approach is particularly crucial for Italy and other European countries, where micro and small firms constitute the majority of productive units (ISTAT, 2022; Kok & Berrios, 2019).

7.3 Future research

As the first investigation into the effects of the digital transformation of entrepreneurial firms of different sizes and government aid on survival probability during the pandemic, this study has a number of limitations. Firstly, our limited sample size hinders our ability to examine finer spatial scales accurately and account for the impacts of disparate regional policies and potential spatial spillovers (Fazio & Piacentino, 2010). Future research could replicate this analysis in other countries and regions. Given the World Bank's publication of COVID-19 surveys for other European countries, constructing a unique dataset and rerunning the analysis for inter-country comparisons could provide intriguing insights into how digitalization and government aids influence the survival of firms operating in different nations.

Secondly, present data lacks information on employment size at industry level and in smaller regions such as cities. Future research will investigate further industry sector specifics and explore various types of entrepreneurial ecosystems. A possible future direction

could be to utilize a different dataset, once available, or compare with analogous data outside Italy.

Finally, as the pandemic and digitalization can be localized, another future study plan is to analyse the more nuanced spatial pattern of the digital transformation effects, and in particular the effects of smart working when it is implemented in proximity to offices and physical workplaces. Further data on government aid will be helpful in differentiating the long-term impact of financial aid on firm resilience across different employment size and regions.

Appendix

See Figs. 3 and 4.

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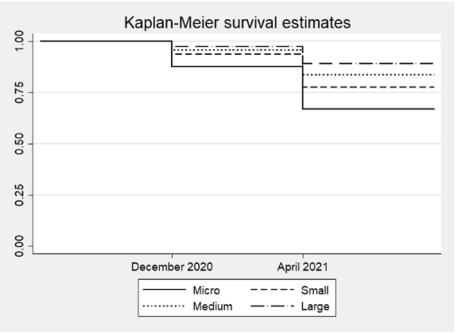

Fig. 3 Survival probabilities by size. Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

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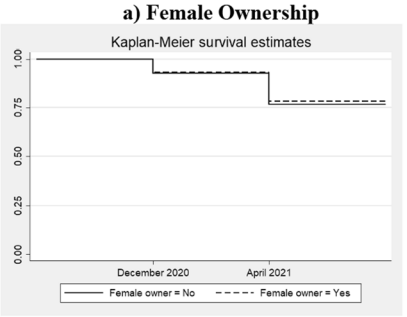
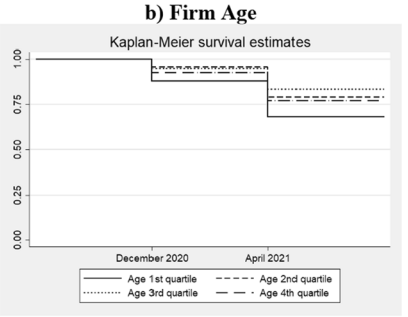
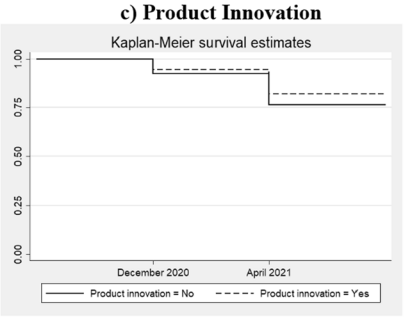


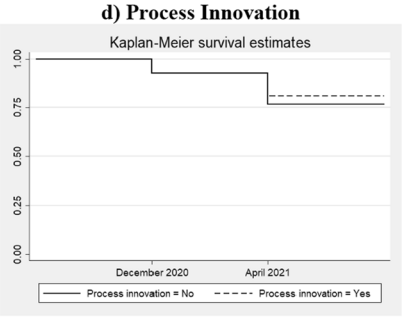
Log Rank test X^2=0.13 p-value=0.7144



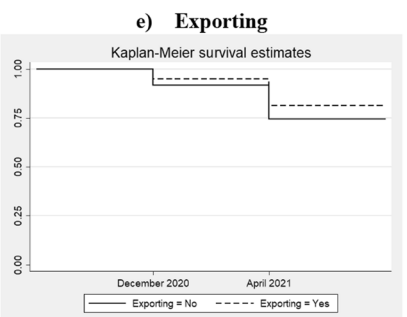
Log Rank test X^2=8.90 p-value=0.0306



Log Rank test X^2=0.92 p-value 0.3369



Log Rank test X^2=0.35 p-value 0.5516



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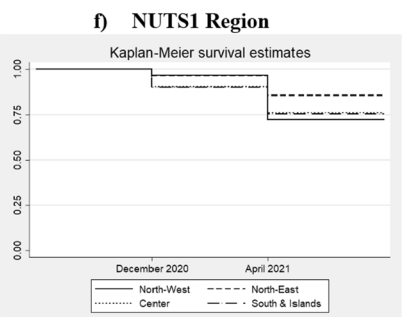
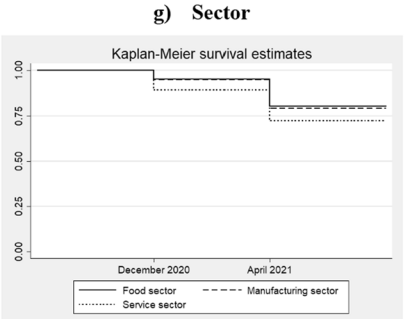


Log Rank test X2=5.41 p-value=0.1438



Log Rank test X^2=3.79 p-value=0.1500

Fig. 4 Kaplan–Meier survival by control variables. Source: World Bank Enterprise Survey for Italy in (2019, 2020a, b, 2021)

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