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Relative Productivity and SME Closure During COVID-19: Exploring Optimal Productivity Levels for Firm Resilience

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Abstract

Firm failures have far-reaching consequences for employees, investors, communities, and the broader economy. Less productive firms are generally more likely to fail. However, high productivity may come at a cost that hampers survival, especially during sudden, unforeseen crises such as COVID-19. Using data from the World Bank Enterprise Survey for small and medium-sized enterprises (SMEs) in 20 European countries, this study tests whether there was a nonlinear association between productivity and survival during the COVID-19 pandemic. The findings suggest that SMEs with below-average productivity relative to their industry were more likely to shut down, whereas firms with exceptionally high productivity do not experience additional survival advantages. These results, while not causal, also hold across alternative SME definitions, underscoring the robustness of the results.

JEL classification

D24, L25, G33, O30

Keywords

firm closure, COVID-19, relative productivity

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Introduction

All businesses, regardless of size, are susceptible to failure, and such failures can have far-reaching consequences for employees, investors, communities, and the broader economy. Thus, it is important for all parties to understand the factors associated with firm failure. The COVID-19 crisis constituted an exogenous shock that was unforeseen and unprecedented, providing a rare opportunity to study firm failure. The failure rate for small businesses, in particular, skyrocketed (Adian et al. 2020; World Bank 2022b). This paper examines how, controlling for a myriad of other factors, a small firm's pre-COVID productivity relative to other firms within its industry relates to that firm's survival. Unlike previous studies, this relation is permitted to be nonlinear in recognition that more productive firms likely have lower production costs making them more competitive, but that very high labor productivity may come at a cost that could hamper survival during crises like the pandemic.

The small and medium-sized enterprise (SME) sector is a crucial contributor to national economies, serving as the backbone of economic activities and employment in most countries.[1] SMEs account for about 90% of businesses and 50% of employees worldwide; the contribution of SMEs to national Gross Domestic Product (GDP) is more than 40% in emerging economies (World Bank 2022a). Studies have further demonstrated that the small business sector disproportionately contributes to job creation and has the potential to absorb a significant number of workers (Kobe and Schwinn 2018; Storey 1994). With the global labor force projected to

[1] In this paper, the terms SMEs, small firms, and small businesses are used interchangeably to refer to firms with fewer than 250 employees, in line with the definitions provided by the European Commission (2020) and SME Finance Forum (2019). Additionally, to ensure the validity of the results, an alternative sample based on the World Bank definition - firms with fewer than 100 employees - is also examined.

increase by 600 million by 2030 (World Bank 2022a), governments may look to SMEs to create jobs and curb unemployment.

Small and medium-sized enterprises (SMEs), however, are more vulnerable to crises as compared to larger firms. Insufficient management competency, inadequate financial investment, limited access to skilled human resources, and low adoption of modern technology and marketing strategies likely all contribute to this vulnerability (Klein and Todesco 2021), as do more limited financing options and greater market competition than larger firms (Eggers 2020). Each of these factors acts to lowers profits, and economic theory tells us that firms with negative long-run profits will not survive. The COVID-19 crisis provides a rare opportunity to identify factors associated with firm failure.

COVID-19 had a differential impact across business sectors due to the nature of the crisis itself. For example, small firms in sectors heavily impacted by social distancing, such as barber shops and nail salons, faced elevated exit rates (Crane et al. 2022). In the hospitality sector, the failure rate increased by 50% compared to historical trends due to social distancing requirements (Kalemli-Ozcan et al. 2020; Muzi et al. 2022).

This research aims to evaluate the significance of firm-level productivity by using a matching model to examine how deviations from industry standards are associated with firm closure during extraordinary crises such as COVID-19. This study further contributes to the literature by testing for a nonlinear relation between productivity and firm failure. Firms with low labor productivity relative to their industry are hypothesized to be less competitive and less likely to survive a crisis, but firms that have made substantial investments to raise their labor productivity well above industry norms may be more constrained in their ability to adjust to market shocks and experience diminishing returns. We employ a multivariate probit model and

data from the World Bank Enterprise Survey, COVID-19 follow-up surveys, and a dataset provided by the World Bank that reports estimates of firm-level labor productivity to model SME firm failure.

The paper is organized into five main sections. The second section presents a review of the relevant literature, both theoretical and empirical, relating productivity to survival. The third section describes the data sources and construction, the empirical strategy, and the specification. The fourth section reports the main findings, with a particular focus on the nonlinear relation between relative productivity and firm closure. We close with concluding remarks.

Theoretical Framework and Literature Review

Theory linking productivity to firm survival

In general, standard economic theory assumes that firms act to maximize profits and survive so long as they are able to achieve a non-negative economic profit. More productive firms have lower costs and so, ceteris paribus, higher profits (van den Berg et al. 2018; Syverson 2011). Schumpeter's theory of creative destruction, also known as Schumpeterian growth theory (Schumpeter 2010; Aghion et al. 2015), is also widely cited to support this relation. Schumpeter argued that as technology and products evolve, less efficient firms that are unable to adapt face increasing competitive pressure within their market and are more likely to exit. Natural selection continually reshapes the industrial landscape from within by replacing outdated goods, firms, and systems with innovative alternatives (McCraw 2007; Uwe et al. 2005). The evolutionary economics literature (Jovanovic 1982; Hopenhayn 1992), too, emphasizes the underlying importance of productivity in driving firm survival.

During an economic crisis, competition often intensifies, making productivity differences even more critical in driving firm survival. COVID-19, a sudden, unforeseen, and substantial shock, created such a crisis. Social distancing whether officially mandated or unofficially practiced wreaked havoc. Demand in the hotel and restaurant sector plummeted as customers disappeared. Supply in many sectors fell as it could be difficult to accommodate social distancing in the workplace. This in turn caused supply chain disruptions even in firms that were able to continue operations. More productive firms likely had an advantage as they are generally more profitable and that profit could provide a cushion in the face of COVID-19 disruptions. One possible issue with some highly productive firms, however, is that they may be over-specialized and less able to adapt. Some firms with higher labor productivity may have more capital equipment in place which could have been more difficult to support financially during COVID-19 and could also have limited their ability to respond to changes in demand. Other highly productive firms could have invested in more educated workers who were better able to adapt to market changes. Hence the impact of labor productivity on firm failure may still be positive, but not increasing in magnitude.

The following section reviews previous research findings on the relation between productivity and small business failure, with a specific focus on studies conducted during times of crisis.

Evidence linking productivity to firm survival

Productivity is typically defined as the ratio of output to input, measuring how efficiently production inputs such as labor, capital, energy, or intermediates are combined to generate goods or services (OECD 2001). A firm's productivity is viewed as critical in determining its survival because it offers important information about its efficiency and profitability (Muzi et al. 2022).

As discussed in the theoretical section, less productive firms likely have higher costs and less profit with which to survive a shock. Studies have demonstrated that productivity differentials are a primary cause of firm failure (He and Yang 2016; Shiferaw 2009). Using labor productivity indicators in particular, Aga & Francis (2017) and Muzi et al. (2022) found that firms with higher productivity measures had lower probabilities of exit.

While some scholars doubt whether the relation holds in crises (Kozeniauskas et al. 2022)**,** numerous studies have concluded that the Schumpeterian cleansing effect occurs during recessions and when similar shocks arise (Aga and Francis 2017; Brata et al. 2018; Caballero and Hammour 1994; Muzi et al. 2022). Brata et al. (2018), for example, investigated the working of natural selection and the cleansing effect on Indonesian manufacturing firms after the 2006 Yogyakarta earthquake. Their findings supported the theory; firms that were more productive before the earthquake had a higher chance of surviving the shock.

The existing literature does not, however, sufficiently explore the association between firm and industry-level productivity differentials and business survival. In particular, the role of relative productivity, the gap between a small firm's productivity and the industry average, and its association with firm closure has received little attention, highlighting the need for further investigation. The possibility that this relation follows a nonlinear pattern also deserves consideration.

Data, Empirical Strategy, and Specification

Data

The data sources for this paper include the World Bank Enterprise Survey for 2019 (ES-2019)[2], the COVID-19-ES Follow-up Survey (COV-ES), and World Bank firm-level productivity estimates. The World Bank Enterprise dataset includes firms of all sizes; however, this study focuses exclusively on small and medium enterprises (SMEs). Samples from large firms, those with more than 249 employees according to the European Commission definition, are excluded. To ensure robustness, an alternative sample is also tested using the World Bank definition of SMEs, which includes only firms with fewer than 100 employees. The analysis is limited to European countries where the Enterprise Surveys were conducted just before the onset of the COVID-19 crisis (late 2018 to early 2020). After COVID-19 hit businesses worldwide, the World Bank Enterprise Analysis unit collected information to measure the pandemic's impact on the firms in the Bank's database (World Bank Enterprise Survey, n.d.). Data from the COV-ES survey is coded as time *t,* while baseline data (ES-2019) is coded as *t-1*.

The third dataset provides information on the productivity of individual firms. Both labor productivity and total factor productivity (TFP) are frequently employed as productivity indicators (Muzi et al. 2022; Aga and Francis 2017). Labor productivity is defined as the sales in the baseline year (in USD 2009) divided by the total number of permanent full-time employees. TFP takes into account not just the labor input but the capital inputs as well. The World Bank Enterprise Analysis unit provides firm-level estimates of these values, but due to substantial missing values in the TFPR dataset, caused by non-responses and outliers, the labor productivity

[2] Detailed information on the Enterprise Survey methodology can be found at https://www.enterprisesurveys.org/en/methodology. We would like to thank World Bank, Enterprise Unit for providing data for this research paper.

measure is used here. This measure likely captures some elements of process innovation but also employee and managerial skills.

The sample is restricted to 20 European countries that have enterprise survey data, participated in at least three waves of the COVID follow-up surveys, and have labor productivity data. These countries are Armenia, Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Georgia, Greece, Hungary, Italy, Latvia, Lithuania, Macedonia, FYR, Malta, Moldova, Poland, Portugal, Romania, the Slovak Republic, and Slovenia.

During the data cleaning process, 1,533 firms were excluded due to non-responses or outlier values. The majority, 1,171 cases, were dropped due to missing labor productivity data, which is the study's primary variable of interest. The next most common missing variable was managerial experience (246 cases), followed by the firm's age (64 cases). An additional 52 firms were excluded due to missing values in one of the four other variables. The final sample consists of 9,040 SMEs as defined by the European Commission and 7,740 SMEs as defined by the World Bank.

Empirical Strategy

A nonlinear regression model, specifically a probit model, is employed to analyze the data. The dependent variable is derived from the survey question about the 'operating status of the firm.' There are four possible responses to this question: 'permanently closed', 'temporarily closed', 'open', and 'could not be contacted'. 'Permanently closed' and 'open' have clear definitions. Firms that could not be contacted are likely actually closed. While some researchers treat 'temporarily closed' firms as closed (Grover and Karplus 2021; Liu et al. 2021), this may lead to misclassification, as some of these closures were mandated by authorities. Therefore, this

paper classifies only firms that are 'permanently closed' or 'could not be contacted' at time t as '*closed*', following the approach used by Muzi et al. (2022).

The standard functional specification of the probit model is as follows:

$$P(Y=1|X) = \Phi(\beta_0+\beta_1X_1+\beta_2X_2+\ldots.\beta_kX_k)$$

where,

P(Y=1|X) is the probability that Y=1 given the vector of explanatory variables X.

Φ(..) is the cumulative distribution function (CDF) of the standard normal distribution, which takes on values strictly between zero and one.

This study applies the matching concept proposed by Cragg (2009), which was used in an educational context to model the probability of student dropout. Instead of simply adding independent controls for student and institutional characteristics, Cragg included measures indicating the degree to which student and institutional characteristics differed. Here we study how the match between a firm and its industry's productivity is associated with the probability of firm failure. Since the small firms in our sample are drawn from a variety of industries, using a matching model helps isolate industry-specific performance and characteristics. In this sense, the matching model helps to 'normalize' the data. This model also captures the fact that in a competitive free-market economy, firms do not operate in isolation. Their existence and performance depend not only on their own actions but also on how they perform relative to other similar firms. Manufacturing firms do not compete with food service firms for customers, and lenders/investors generally decide in which firms to invest based on how those firms are performing relative to their peers. Therefore, evaluating firms relative to other firms in their industry with a matching model provides a more meaningful assessment of their performance

and probability of survival. To this end we recognize nineteen different industries. See Appendix Table B for the industry breakdown.

Our key explanatory variable, relative productivity, is constructed by subtracting industry average productivity from firm level productivity using data collected prior to the advent of COVID-19, i.e. period t-1. We then recode this continuous variable into a categorical variable (*productivity_match*) taking on one of four possible values using the standard deviation technique. Specifically, firms with productivity levels of more than one industry-specific standard deviation below the industry average are classified as having 'Poor' productivity. Those within one standard deviation below the mean are designated as having 'Average' productivity, while those within one standard deviation above the mean are deemed to have 'Good' productivity, and firms exceeding one standard deviation above the mean are categorized as having 'High' productivity. We expect that firms classified as having 'Poor' productivity will be more likely to close than those with 'Average' productivity and that those with 'Good' and 'High' productivity will be less likely to close than those with 'Average' productivity, but recognize that those with 'High' relative productivity may not fare much better than those with 'Good' or perhaps even 'Average' productivity.

Specification

The following specification is used to answer the research questions and test the proposed hypotheses:

$$closed_{it} = \propto + (productivity\_match)_{it-1}\beta + controls_{it-1}\delta + \varepsilon_{it}$$

where *i* identifies the firm; *t* data from the COV-ES or pandemic time period; *t-1* data from the pre-pandemic baseline; and *productivity_match* is the measure of the firm's relative productivity. The controls are discussed below.

Controls

Estimates of the association between a firm's relative productivity and a firm's probability of closing will suffer from omitted variable bias unless one controls for other factors influencing firm closure. To that end we include an array of control variables related research has linked to firm failure. These include entrepreneurial activities as well as firm and entrepreneur characteristics. As government funding was often offered during the COVID-19 pandemic, a control for government funding was also incorporated.

Entrepreneurial Activities

Entrepreneurial activities that improve a firm's performance are important explanatory variables in research on firm failure (Ireland et al. 2023). The entrepreneurial activities examined in this study are based on the definitions provided by Ahmad and Hoffmann (2008) and the availability of these measures from the World Bank Enterprise Survey. They include indicators of innovation, web technology, access to financial resources, and the ability to tap export markets.

Innovative entrepreneurs earn higher profits at the expense of other less innovative firms (Howitt 2026). Zhang & Mohnen (2022) found product innovation to be effective in the survival of manufacturing firms in China. Work by Sidorkin & Srholec (2014) found a positive association between pre-crisis innovation and survival in countries in Eastern and Southern Europe facing continued recession. In the case of COVID-19, innovative firms might modify their product or introduce a new product to better meet demand during the pandemic. To capture innovation, we use a dummy variable (*Innovative*) to identify firms that prior to COVID-19 introduced a new or improved product in the last three years.

The use of technology was seen as a pivotal part of continuing business operations in the COVID-19 crisis. In a technology-driven world, technical competence is vital in analyzing a

firm's success (Poudel et al. 2019; Prashantham and Floyd 2012). Due to mobility restrictions and mandatory social distancing during the COVID-19 pandemic, firms that shifted to online or digital transactions and distance working continued to thrive. Thus, digital presence and business exit were negatively associated during the COVID-19 pandemic (Muzi et al. 2022). To capture this factor, we include a dummy variable (*Web Savvy*) identifying firms that have a web site.

Additionally, many firms faced a cash flow crisis during the COVID crisis. Cash flow is vital for small firms' survival. Firms with access to bank financing were found to have reduced failure rates in China (He and Yang 2016) and in the U.K. (Saridakis et al. 2008). We create a dummy variable (*access_to_credit*) that takes a value of one for firms that have a line of credit or loan from a financial institution.

Finally, firms can reduce risk by diversifying into markets with different business cycles, allowing them to shift sales away from domestic markets affected by demand shocks (Hirsch and Lev 1971; Wagner 2013). Exporting firms then may have more opportunities to survive than non-exporting firms (Westhead et al. 2001). As COVID-19 caused a worldwide crisis, the impact of pre-crisis exports may be ambiguous. However, while COVID-19 was widespread, countries were affected in different ways and degrees, so firms with experience in the export market may still have had an advantage. If direct exports constitute 10% or more of a firm’s sales revenue, the variable *Exports* takes a value of one.

Including innovation, website presence, access to credit, and exports captures key aspects of a firm’s entrepreneurial activities: its ability to adapt through product development, engage digitally, maintain financial flexibility, and expand market reach, all essential for growth and resilience.

Firm Characteristics

Research has also linked a variety of firm characteristics to failure rates. Storey (1994) believed that a firm's age, size, and ownership would influence small firms' performance. Older firms are more likely to have developed internal systems, established networks, and experience in handling market shocks, which contributes to greater resilience during crises (Aga and Francis 2017; Crane et al. 2022; Ericson and Pakes 1995). Research on the relation between firm age and performance reveals mixed findings. Some studies suggest that older firms are more resilient and have lower failure rates (Kalleberg and Leicht 1991; Muzi et al. 2022; Fackler et al. 2013; Disney et al. 2003). Others argue that aging firms may accumulate structural and strategic liabilities, potentially leading to an inverted U-shaped relationship between firm age and success (Coad et al. 2018; He and Yang 2016; Mueller 1972). Following this literature, we include firm age in years as a control variable (*firm_age*).

Smaller firms are often more vulnerable due to limited financial, technological, and human resources, though they may possess some adaptive advantages (Becker 2005; Varum and Rocha 2012; Venkataraman et al. 1990). Larger firms tend to invest more in R&D than smaller ones, and profitable innovation drives growth and increases resiliency (Nelson and Winter 2002). Studies generally demonstrate that the mortality rate decreases as the firm's size increases, supporting the liability of smallness (Carreira and Teixeira 2011; Fackler et al. 2013; Jovanovic 1982; Shiferaw 2009). We use the number of employees to proxy for firm size (*firm_size*).

Entrepreneur Characteristics

Prior research highlights that firms' success often depends on the owner/manager's ability to understand their environment and adapt strategies (Maliranta and Nurmi 2019; Williams and Ramdani 2018). As experienced managers are better equipped to navigate uncertainty and

leverage past learning to adapt to crises (Kim and Miner 2009; Starbuck et al. 2008)**,** more managerial experience is expected to be negatively associated with firm closure. To control for managerial experience, we include the manager's years of work experience (*managerial_experience*).

Studies show that female entrepreneurs often face disadvantages such as limited access to capital, fewer opportunities for experience, and lower levels of startup and human capital, which hinder business outcomes (Brush 1992; Carter and Rosa 1998). Partly due to increased caregiving burdens, limited access to capital, and existing gender disparities in entrepreneurship, prior research suggests that female-led SMEs faced a higher likelihood of closure during COVID-19 (GEM 2021; Justo et al. 2015; Vasilić et al. 2020)**.** During COVID-19, women-owned firms were disproportionately affected, especially in North America and Europe, where 79% reported negative impacts and 11% closed (Torres et al. 2023; Koltai et al. 2020). This was partly due to women's greater concentration in personal service sectors, which were hit hardest by restrictions requiring physical proximity (Graeber et al. 2021; UNCTAD 2020). As a result, female entrepreneurs experienced higher closure rates (GEM 2021). To control for managerial gender, we include a dummy variable (*female*) coded as '1' if the firm is headed by a woman or if women own more than 50% of the firm.

Government Intervention

Government subsidies and access to formal credit played a significant role in SME survival during the crisis, particularly for small and young firms that entered the pandemic with limited financial buffers (Kozeniauskas et al. 2022; Srhoj et al. 2021). Many governments around the world introduced financial relief packages, including a moratorium on loan repayment from financial institutions, to support small and medium-sized enterprises. Most research indicates a

positive relationship between government support and firm survival (Doruk 2022; Zhang and Xu 2019; Najib et al. 2021). A dummy variable (*government_support*) is included to identify firms that received government assistance to support operations during COVID-19.

Other Controls

Finally, sector and country-specific controls are included. COVID-19 affected various sectors differently. Service sectors were badly impacted due to the necessity of physical proximity. Hotels and restaurants, too, experienced substantial negative demand shocks. In addition, some industries are likely more sensitive to supply chain issues than others and smaller countries may need to import more and thus have greater supply chain issues. Controls for country and industry should at least partially control for such concerns. To capture these differences, categorical variables identifying each firm's ISIC industrial sector and country of operation are included in the model. The World Bank survey categorizes firms' into 28 distinct sectors based on ISIC classification. However, due to the small number of firms in some of these groups, we combined some sectors, which yielded 19 distinct industrial classifications (*sectorind*). As described earlier, there are 20 distinct countries (*country*).

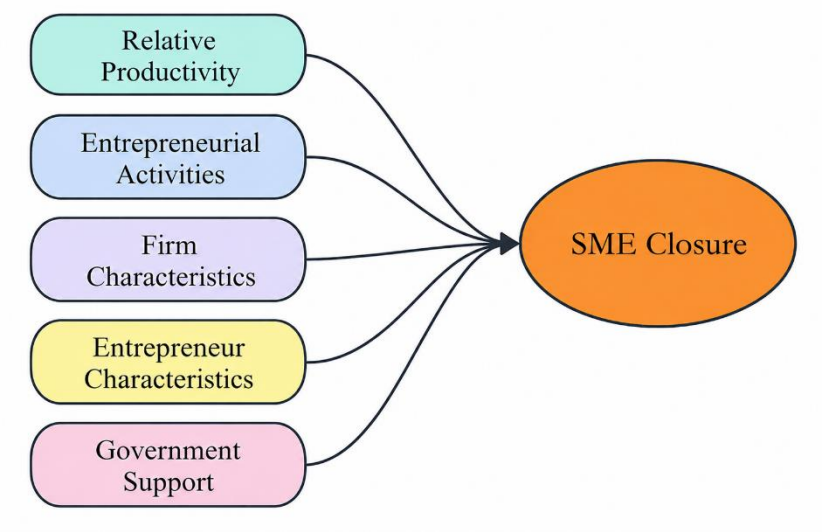
The Final Specification

The complete model has the following form:

$$closed_{it} = \beta_0 + productiviy\_match_{it-1}\beta_1 + \beta_{21} innovative_{it-1} + \beta_{22} websavvy_{it-1} + \beta_{23} accessto\_loan_{it-1} + \beta_{24} exports_{it-1} + \beta_{31} managerial\_experience_{it-1} + \beta_{32} firm\_age_{it-1} + \beta_{33} firm\_size_{it-1} + \beta_{34} female_{it-1} + \beta_4 government\_support_{it-1} + sectorind_i\gamma + country_i\delta + \epsilon_{it}$$

where, *i* identifies the firm and *t* and t-1 the time period. Figure 1 below illustrates the conceptual framework.

Figure 1 Empirical Model Framework (Path Diagram)



Results and Findings

Descriptive Statistics and Bivariate Correlations

Table 1 presents sample statistics. Totals are reported in the first column, followed by separate statistics for 'Open' and 'Closed' firms. The final column reports the p-values for two-sample t-tests of the difference in means (Denis 2021) between 'Open' and 'Closed' firms for the non-categorical variables and the p-value from a chi-squared test for the *Productivity_match* variable. The statistics show that the average productivity gap of open firms is higher than that of closed firms, and this difference is statistically significant at the 1% level. The table also reveals that the share of open firms with 'Good' productivity is higher than that of closed firms in the same category. However, the share of closed firms is higher for those with 'Poor,' 'Average,' and 'High' productivity levels. Means of all the other variables, with the exception of the share of female-managed firms, are higher among open as compared to closed firms.

Table 1 Descriptive Statistics

	Firm Operating Status			
	Total	Open	Close	Test (p-value)
Productivity Gap	0.109	0.131	0.050	
	(1.190)	(1.154)	(1.276)	0.004
Productivity Match				
Poor	0.143	0.131	0.172	
	(0.350)	(0.338)	(0.377)	<0.001
Average	0.342	0.338	0.352	
	(0.474)	(0.473)	(0.478)	
Good	0.385	0.402	0.340	
	(0.487)	(0.490)	(0.474)	
High	0.131	0.129	0.136	
	(0.337)	(0.335)	(0.343)	
Entrepreneurial Ability				
Innovative	0.299	0.309	0.275	0.002
	(0.458)	(0.462)	(0.447)	
Web savvy	0.692	0.714	0.636	<0.001
	(0.461)	(0.452)	(0.481)	
Access to credit	0.459	0.471	0.428	<0.001
	(0.498)	(0.499)	(0.495)	
Exports	0.250	0.259	0.226	0.002
	(0.433)	(0.438)	(0.419)	
Other Controls				
Firm age (yrs)	22.336	22.944	20.759	
	(15.144)	(15.470)	(14.144)	<0.001
Firm size (# employees)	41.225	41.922	39.414	
	(51.643)	(52.189)	(50.164)	0.039
Managerial experience (yrs)	22.564	23.203	20.908	
	(11.669)	(11.827)	(11.082)	<0.001
Female owner/manager	0.226	0.220	0.243	0.018
	(0.418)	(0.414)	(0.429)	
Government support	0.190	0.234	0.076	<0.001
	(0.392)	(0.423)	(0.265)	
Number of Observations	9,040	6,526	2,514	
	100%	72.2%	27.8%	

Standard deviations reported in parentheses.

Correlation and Possibility of Multicollinearity

The correlation matrix of the predictors can provide insights into potential multicollinearity issues among the variables. Typically, low to moderate correlation coefficients

do not cause multicollinearity problems (Cohen et al. 2003; Kim and Miner 2009). However, higher correlation coefficients can lead to less efficient parameter estimates by inflating standard errors, which reduces the likelihood of achieving statistically significant results. A general rule of thumb is that if any correlations exceed a value of 0.70, there may be a multicollinearity problem (Tabachnick et al. 2013). Given that the highest correlation in our sample is 0.4 (arising between f*irm_age* and *managerial_experience*), the likelihood of multicollinearity is minimal.

Results

Table 2 presents the empirical results with the average marginal effects reported in the final column.

Table 2 Empirical Results with Average Marginal Effects

Closed	Coefficient	Std. Err.	z	P-Value	Marginal Effect
Productivity Match					
Poor	0.000	(base)			
Average	-0.044	0.047	-0.94	0.348	-0.014
Good	-0.137	0.051	-2.70	0.007	-0.042
High	-0.104	0.064	-1.64	0.102	-0.032
Entrepreneurial Activities					
Innovative	-0.109	0.035	-3.13	0.002	-0.033
Web savvy	-0.062	0.034	-1.80	0.072	-0.019
Access to credit	0.021	0.031	0.67	0.505	0.006
Exports	-0.016	0.039	-0.41	0.679	-0.005
Other Controls					
Firm age	-0.004	0.001	-3.40	0.001	-0.001
Firm size	0.000	0.000	0.02	0.983	0.000
Managerial experience	-0.006	0.001	-3.88	0.000	-0.002
Female owner/manager	0.017	0.036	0.47	0.641	0.005
Government support	-0.767	0.046	-16.55	0.000	-0.199
Constant	-0.289	0.089	-3.24	0.001	
Pseudo R-squared	0.0932				

Note: Results for industrial sectors and countries are provided in Appendix D.

Goodness of Fit

To assess the overall fit of the model, a Pearson chi-square test was initially considered; however, given that the number of covariate patterns nearly equals the number of observations, its application becomes less reliable (Wooldridge 2000). Instead, the Hosmer–Lemeshow test was used by grouping observations into ten deciles based on predicted probabilities. This test produced a chi-square value of 5.84 (df = 8) with a p-value of 0.66, indicating no statistically significant difference between observed and predicted probabilities of firm closure. This result shows that the model effectively reflects the underlying patterns in the data.

Additionally, we employed the likelihood ratio (LR) version of the standard F test to assess the model's overall fit. The null hypothesis assumes that all explanatory variable coefficients (except the intercept) are jointly equal to zero. This test yielded a chi-square statistic of 995.62, which far exceeds the critical value of 66.34 at 49 degrees of freedom, allowing us to reject the null hypothesis (Tiku 2004; Wooldridge 2000).

We also conducted a test to examine whether the assumption of homoskedasticity, that is constant variance of the error term across all observations, was violated. We applied the Variance-Covariance Estimator (VCE) robust to assess the presence of heteroskedasticity. The standard errors are almost unchanged, suggesting that the assumption of constant error variance is reasonable.

Results of Research Hypotheses

The findings highlight the effects of relative productivity, along with firm and entrepreneurial characteristics, on the likelihood of SME closure. Focusing first on productivity, we find that firms with higher relative productivity levels are less likely to close compared to those with relatively 'Poor' productivity, the reference category. This relation is, however,

nonlinear. Specifically, only firms in the 'Good' productivity match group, defined as a productivity gap between the industry mean and up to one standard deviation above the mean, exhibit a significantly lower risk of firm closure. While the coefficients identifying firms with 'Average' and 'High' relative productivity are not found to be individually statistically significant at the 10% level (the coefficient to 'High' comes quite close at 10.2%), a joint test of the three productivity measures is significant. The relevant chi-square value is 9.28 with a p-value of 0.026. These results support the hypothesis that relative productivity has a strong association with firm resilience, particularly when firms operate slightly above the industry average.

We further investigate whether 'Good' and 'High' levels of productivity have significantly different associations with firm failure. Our results indicate that they do not (p-value 0.513). Overall, these findings suggest that there are diminishing returns to higher productivity. To confirm this finding, we re-estimate the model including a quadratic measure of the productivity gap. These results (available upon request) indicate that the probability of firm survival is highest when firms have a productivity gap in the 'Good' range and that the probability of firm survival is still higher for firms with the highest productivity than it is for firms with the lowest productivity relative to their industry.

As regards entrepreneurial activities, three of the four measures included here are found to have a negative association with firm closure. Innovative firms in particular are consistently and significantly less likely to close at the 1% significance level, affirming the importance of sustained innovative activity in enhancing crisis resilience. This finding supports the research hypothesis and aligns with the existing literature, which emphasizes the role of innovation in fostering adaptability and opportunity recognition. Firms with experience introducing new products might have been better able to pivot and meet changing market demands during

COVID-19. Having a website, used as a proxy for digital engagement, is also significantly positively associated with a reduced risk of closure, albeit only at the 10% level. Being able to stay in touch with consumers and suppliers without physical contact was likely an advantage during COVID-19. In contrast, while export experience was found to be negatively associated with firm closure, that relation was not statistically significant. Broader market access might be an advantage when a demand shock is localized, but COVID-19 was a global shock. The insignificant association between access to finance with firm survival appears inconsistent with the widespread liquidity constraints firms faced during COVID-19 and is less easily explained. Perhaps the fact that COVID-19 was not a sector specific shock but a market-wide phenomenon explains this finding. Several of the other control variables were also found to be associated with firm closure. Older firms and those led by more experienced managers demonstrate greater resilience, both significant at the 1% level. Receipt of government support was also found to be associated with a significantly lower probability of closing. Firm size and female leadership were not, however, found to be significant.

Simulated Marginal Effects

Unlike a linear model, interpreting coefficients from a probit regression model can be challenging due to the nonlinear nature of the specification (Breen et al. 2013; Karlson et al. 2012; Kuha and Mills 2020; Wooldridge 2000). The discussion above focused on the direction of the effect of explanatory variables. However, to better understand the magnitude of these effects, we present the simulated marginal effects of each variable in the final column of Table 2. These marginal effects represent the sample average change in the probability of closure resulting from a small change in each independent variable (Wooldridge 2000). To assess the economic significance, note that the overall sample average probability of closure is 27.8%.

In the case of the relative productivity measures, the results indicate that firms with 'Good' productivity levels had a 4.2 percentage point, or 15% lower probability of closure as compared to those with 'Poor' productivity. Thus, having 'Good' productivity is associated with an economically important closure differential. The differentials for firms with 'Average' and 'High' productivity, while not statistically significant, are also substantial at 1.4 and 3.2 percentage points, respectively.

Innovative firms have a 3.3 percentage point lower likelihood of closure compared to non-innovative firms, an almost 12% lower probability. Similarly, firms with websites have a marginally significant, 1.9 percentage point reduction in closure risk, compared to firms without a website. Firm age and managerial experience both demonstrate small but statistically significant negative associations with closure probability. Each additional year of firm age or manager experience is associated with a slightly lower likelihood of closure, highlighting the protective effect of more experience both at the firm and managerial levels. Finally, government support stands out with the largest effect: firms that received support have a 20.0 percentage point lower probability of closure compared to those that did not receive government assistance.

Robustness and Sensitivity

As mentioned earlier, we also re-estimate the model using the World Bank's definition of SMEs, firms with fewer than 100 employees. This approach allows us to test the consistency and generalizability of the findings across different SME classifications. Table 3 below presents the results under both definitions.

The empirical results show consistent findings across nearly all variables. Having a 'Good' productivity match is significant at the conventional level of 5% in both samples. A 'High' productivity level is not significant at the 10% level in either sample. Other variables,

such as the indicators of innovativeness and website use as well as firm age, managerial experience, and government support, remain consistently significant across both models, reinforcing the robustness of the findings regardless of the SME definition used.

Table 3: Results from Both EU and WB Definitions

Variable	EU250	WB100
Productivity match		
Average	-0.044	-0.041
Good	-0.137***	-0.138**
High	-0.104	-0.099
Entrepreneurial Activities		
Innovative	-0.109***	-0.115***
Web savvy	-0.062*	-0.062*
Access to credit	0.021	0.042
Exports	-0.016	0.016
Other Controls		
Firm age	-0.004***	-0.005***
Firm size	0.000	-0.001
Managerial experience	-0.006***	-0.006***
Female owner/manager	0.017	0.017
Government support	-0.767***	-0.749***
Constant	-0.289***	-0.283***
N	9040	7740
Pseudo R-squared	0.093	0.095

* indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Discussion & Conclusion

The COVID-19 pandemic brought about a severe crisis for small and medium-sized enterprises (SMEs). This research employs a matching model to examine the association between relative productivity and SME failure during the crisis. A novel contribution is the introduction of a nonlinear relative productivity effect, allowing for the possibility that substantial investments in labor productivity may have diminishing returns because of their cost and because

that investment may leave them so specialized that they have more difficulty adapting to changing market conditions.

Using deviations from the industry mean, firm productivity is classified as 'Poor' when more than one standard deviation below the mean, 'Average' when within one standard deviation below the mean, 'Good' when within one standard deviation above the mean, and 'High' when more than one standard deviation above the mean. Results indicate that productivity was generally negatively associated with firm exit. 'Good' firms in particular had a 4.2 percentage point or 15% lower probability of being closed relative to 'Poor' firms, an association that is significant at the 1% level. 'High' productivity firms also had lower exit probabilities, though the effect was not quite statistically significant ($p = 0.102$) and certainly not larger than that for 'Good' firms ($p = 0.513$). This result, supported by a specification using a quadratic measure of relative productivity and robust to an alternative definition of SME, suggests that while firms that are more productive relative to their industry are on average more likely to survive, substantial investments in labor productivity do not confer additional survival benefits.

Additional controls were included to capture entrepreneurial ability, firm and managerial characteristics, and government support. Experience introducing new products to market and having a web presence were found to have a significant negative association with firm closure. Firms that could meet changing market demands and do so with less physical interaction likely had comparative advantages during the COVID-19 crisis. Access to foreign markets and to credit might generally be associated with greater market resiliency in the face of local or sector specific shocks, but were not in the case of COVID-19's sector-wide and global shock.

Firm age and managerial experience were found to be statistically significantly associated with a lower probability of firm closure. Both measures are likely indicative of more established

customer bases and supplier relations, as well as more experience dealing with the ups and downs of business enterprises. Firm size was not statistically significant. This implies that size alone, absent complementary factors such as productivity or experience, may not sufficiently buffer firms against crisis-related shocks. Female management/ownership was also found to have no statistically significant association once additional controls were included. If female-managed businesses are more likely to fail due to differential entrepreneurial ability and/or differential choice of business sector, the controls here for entrepreneurial activities and industry sector may have captured any association between managerial gender and firm failure. Government support was found to have a large (20 percentage point) and significant association with firm survival. This finding underscores the critical role of timely policy interventions in bolstering SME resilience when internal capabilities alone may be insufficient. The provision of government support and the suspension of insolvency filings (Dörr et al. 2022), may have disrupted the cleansing effect brought on by COVID-19, but the fact that other factors were found to have a significant association suggests that the effect was not erased altogether.

Overall, a crucial insight from this research is that SMEs can significantly enhance their likelihood of surviving in severe crises by maintaining their productivity level close to or slightly higher than their industry average. Exceeding this positive gap by more than one standard deviation above the mean, however, may not lead to additional benefits. These findings are particularly pertinent for small business owners, managers, policymakers, and business incubators seeking to allocate limited resources effectively.

Future Research

These findings reflect real-world phenomena and provide actionable insights for policymakers and practitioners. Future research should utilize longitudinal data to track firm

dynamics over time. Such research would aid in identifying causal relations and enable an analysis of the impact of crisis-specific and structural factors on firm survival. Additionally, incorporating alternative productivity measures such as Total Factor Productivity (TFP) and including richer managerial and market-level variables would enhance analytical depth. Managerial education and firm concentration levels might be of particular interest. More detailed information regarding worker education, output quality, and customer satisfaction would also be useful. Ultimately, future studies should explore tailored support strategies that address SME-specific challenges, reinforcing firm-level productivity, fostering entrepreneurship, and expanding gender- and experience-sensitive policy interventions.

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APPENDICES

Appendix A: Firm Operating Status by Country

Country	Currently is this establishment open, temporarily closed, or permanently closed?				
	Permanently closed	Temporarily closed	Open	No Contact	Total
Georgia	29	16	335	79	459
	6.32	3.49	72.98	17.21	100.00
Poland	10	26	415	164	615
	1.63	4.23	67.48	26.67	100.00
Romania	21	4	424	208	657
	3.20	0.61	64.54	31.66	100.00
Moldova	8	7	205	90	310
	2.58	2.26	66.13	29.03	100.00
Macedonia, FYR	4	6	154	115	279
	1.43	2.15	55.20	41.22	100.00
Armenia	10	6	273	111	400
	2.50	1.50	68.25	27.75	100.00
Estonia	4	1	243	91	339
	1.18	0.29	71.68	26.84	100.00
Czech Republic	10	4	382	48	444
	2.25	0.90	86.04	10.81	100.00
Hungary	9	6	609	114	738
	1.22	0.81	82.52	15.45	100.00
Latvia	3	1	140	140	284
	1.06	0.35	49.30	49.30	100.00
Lithuania	14	1	206	98	319
	4.39	0.31	64.58	30.72	100.00
Slovak Republic	13	2	295	86	396
	3.28	0.51	74.49	21.72	100.00
Slovenia	0	4	199	162	365
	0.00	1.10	54.52	44.38	100.00
Bulgaria	33	9	383	169	594
	5.56	1.52	64.48	28.45	100.00
Croatia	12	6	285	56	359
	3.34	1.67	79.39	15.60	100.00
Greece	0	27	487	47	561
	0.00	4.81	86.81	8.38	100.00
Portugal	36	7	699	133	875
	4.11	0.80	79.89	15.20	100.00
Cyprus	3	9	139	41	192
	1.56	4.69	72.40	21.35	100.00
Italy	47	4	342	246	639
	7.36	0.63	53.52	38.50	100.00
Malta	5	0	165	45	215
	2.33	0.00	76.74	20.93	100.00
Total	271	146	6,380	2,243	9,040
	3.00	1.62	70.58	24.81	100.00

First row has *frequencies* and second row has *row percentages*

Appendix B: Tabulation of Industrial Sector

SN	Industrial sector based on ISIC	Freq.	Percent	Cumulative
1	Food	1160	12.83	12.83
2	Textiles	127	1.40	14.24
3	Garments	365	4.04	18.27
4	Wood	184	2.04	20.31
5	Publishing, printing, and recorded media	211	2.33	22.64
6	Chemicals	115	1.27	23.92
7	Plastics & rubber	247	2.73	26.65
8	Nonmetallic mineral products	180	1.99	28.64
9	Fabricated metal products	893	9.88	38.52
10	Machinery and equipment	687	7.60	46.12
11	Electronics	164	1.81	47.93
12	Furniture	240	2.65	50.59
13	Construction	700	7.74	58.33
14	Services of motor vehicles	279	3.09	61.42
15	Wholesale	598	6.62	68.03
16	Retail	1798	19.89	87.92
17	Hotel and restaurants	525	5.81	93.73
18	Transport	402	4.45	98.17
19	IT	165	1.83	100.00
	Total	9040	100.00	

Note: Some sectors are merged into the nearest sector due to the very low frequency

Appendix C: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Closed	1.000										
(2) Productivity gap	-0.041	1.000									
(3) Innovative	-0.033	0.026	1.000								
(4) Web Savvy	-0.076	0.199	0.141	1.000							
(5) Access to Credit	-0.039	0.082	0.124	0.146	1.000						
(6) Export	-0.033	0.157	0.111	0.174	0.120	1.000					
(7) Firm age	-0.065	0.187	0.033	0.168	0.053	0.108	1.000				
(8) Firm size	-0.022	0.134	0.079	0.176	0.132	0.277	0.132	1.000			
(9) Managerial experience	-0.088	0.144	0.004	0.120	0.029	0.059	0.029	0.120	1.000		
(10) Female owner/manager	0.025	-0.055	0.027	0.051	0.077	-0.043	-0.055	-0.077	-0.051	-1.000	
(11) Government support	-0.180	0.066	0.009	0.028	0.072	0.018	0.027	0.072	0.028	0.015	1.000

Appendix D: Empirical Results with Average Marginal Effects (Industry and Country)

close	Coefficient	Std. Err.	z	P-Value	Marginal Effects
Industrial Sector					
Food	0.000	(base)			
Textiles	0.018	0.131	0.14	0.892	0.005
Garments	0.129	0.085	1.51	0.131	0.040
Wood	-0.062	0.111	-0.56	0.574	-0.019
Publishing and Recorded Media	-0.068	0.108	-0.63	0.532	-0.020
Chemicals	-0.262	0.148	-1.77	0.076	-0.074
Plastics & Rubber	-0.059	0.101	-0.58	0.559	-0.018
Non metallic Mineral	-0.127	0.116	-1.10	0.272	-0.037
Fabricated Metal Products	-0.062	0.065	-0.95	0.343	-0.018
Machinery and Equipment	-0.125	0.071	-1.76	0.078	-0.037
Electronics	-0.097	0.120	-0.81	0.418	-0.029
Furniture	-0.062	0.100	-0.61	0.539	-0.018
Construction	-0.021	0.068	-0.31	0.754	-0.006
Services of Motor Vehicles	-0.035	0.094	-0.37	0.712	-0.010
Wholesale	0.029	0.072	0.40	0.686	0.009
Retail	0.035	0.055	0.63	0.527	0.011
Hotel and Restaurants	0.184	0.076	2.43	0.015	0.058
Transport	0.095	0.080	1.19	0.235	0.030
IT	0.074	0.115	0.64	0.522	0.023
Country					
Georgia	0.000	(base)			
Poland	0.196	0.090	2.18	0.029	0.060
Romania	0.281	0.086	3.26	0.001	0.088
Moldova	0.109	0.101	1.07	0.283	0.032
Macedonia, FYR	0.545	0.103	5.31	0.000	0.181
Armenia	0.030	0.095	0.32	0.751	0.009
Estonia	0.102	0.103	0.99	0.323	0.030
Czech Republic	-0.288	0.106	-2.71	0.007	-0.074
Hungary	-0.237	0.091	-2.59	0.009	-0.062
Latvia	0.755	0.103	7.31	0.000	0.260
Lithuania	0.312	0.102	3.07	0.002	0.098
Slovak Republic	0.124	0.101	1.23	0.220	0.037
Slovenia	0.710	0.100	7.08	0.000	0.243
Bulgaria	0.257	0.087	2.94	0.003	0.080
Croatia	-0.082	0.106	-0.77	0.441	-0.023
Greece	-0.413	0.107	-3.86	0.000	-0.100
Portugal	-0.091	0.090	-1.01	0.311	-0.025
Cyprus	0.087	0.127	0.69	0.493	0.026
Italy	0.812	0.093	8.77	0.000	0.281
Malta	0.314	0.124	2.53	0.011	0.099

Appendix E: Goodness-of-fit test of the Study Model

Hosmer-Lemeshow test (Pearson chi2 test with grouping 10)

Description	**Statistics**
Number of observations	**9,040**
Number of groups	**10**
Hosmer–Lemeshow chi2(8)	**5.84**
Prob > chi2	0.665

Appendix F: Default and Variance-Covariance Estimator (VCE) Results

Variable	normal	robust	Bootstrap
Productivity match			
Average	-0.044	-0.044	-0.044
	(0.047)	(0.047)	(0.044)
Good	-0.137	-0.137	-0.137
	(0.051)	(0.051)	(0.051)
High	-0.104	-0.104	-0.104
	(0.064)	(0.063)	(0.059)
Innovative	-0.109	-0.109	-0.109
	(0.035)	(0.035)	(0.034)
Web savvy	-0.062	-0.062	-0.062
	(0.034)	(0.035)	(0.037)
Access to credit	0.021	0.021	0.021
	(0.031)	(0.031)	(0.032)
Export	-0.016	-0.016	-0.016
	(0.039)	(0.040)	(0.040)
Firm age	-0.004	-0.004	-0.004
	(0.001)	(0.001)	(0.001)
Firm size	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Managerial experience	-0.006	-0.006	-0.006
	(0.001)	(0.001)	(0.001)
Female owner/manager	0.017	0.017	0.017
	(0.036)	(0.036)	(0.031)
Government support	-0.767	-0.767	-0.767
	(0.046)	(0.046)	(0.043)
_cons	-0.289	-0.289	-0.289
	(0.089)	(0.089)	(0.088)
N	9040	9040	9040
Pseudo R-squared	0.093	0.093	0.093