UP School of Economics
Discussion Papers

Discussion Paper No. 2025-06 September 2025

Survival strategies and the robustness and resilience of exporters amidst wild card COVID-19 shocks

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Abstract

Using a large firm-level dataset assembled from the World Bank Enterprise Surveys and COVID-19 Follow-up Surveys for 23 countries, this study examined the survival, robustness, and resilience of exporters amidst the economic hibernation induced by COVID-19 lockdowns. While the stylized facts suggest that "positive" ("negative") technology-intensive emergency innovations were positively (negatively) related with exporting, the Weibull and negative binomial regressions show that most of these strategic responses were either insignificant or negatively related with the ability of exporters to weather and recover from COVID-19 disruptions. With a limited window for learning, this implies that the documented emergency innovations were likely signs of distress and mainly used by exporters as last-ditch efforts to avoid exit. Another explanation is that the pandemic shocks crowded out the supposed positive effects of these emergency responses, with stringency and idiosyncratic negative supply and demand shocks significantly accelerating the failure time of exporters; while the duration of disruptions (proxied by vaccine delay) partly prolonged the expected speed of recovery. In the face of wild card COVID-19 shocks, superior pre-pandemic capabilities, especially labor productivity, mattered more for the survival, endurance, and recovery of exporters. Importing also allowed exporters to ease local supply chain constraints, indicating that firms with stronger international linkages had lower exit probabilities despite their greater exposure to global shocks. The preceding results favor the self-selection argument, while positive learning effects may have been muted by fast-evolving pandemic shocks. This highlights the importance of early investment in capabilities to future-proof firms against wild card crises.

Keywords: COVID-19, exporters, survival, robustness, resilience, wild card

JEL: D22, D24, F10, L21, L25, O33

1. Introduction

The COVID-19 crisis fits Petersen's (1997) description of a wild card, which is a low probability but high impact shock that has the potential to severely affect human conditions. The "Great Lockdown" implemented to contain the coronavirus led to an unprecedented albeit short-lived economic hibernation that halted production and consumption activities worldwide.[1] Mobility restrictions and supply chain disruptions forced many establishments to temporarily shut down operations while others exited the market permanently. This resulted in massive unemployment, loss of income, and cutbacks in consumption which further deepened the recession. Muzi et al. (2023) estimated that exit rates of businesses surpassed 20 percent in some countries (e.g., Italy and Mongolia) at the height of the pandemic in 2020. Business closures were mainly attributed to low productivity in the face of adverse global shocks, while cumbersome regulations exacerbated the risk of exit. The aggregate impact of COVID-19 disruptions was severe. World output contracted by 3.1 percent while the global unemployment rate jumped to 6.9 percent in 2020. Firms in the services sector suffered more than manufacturers due to social distancing and travel restrictions (Islam & Fatema, 2023). Compared to large firms, small and medium-sized enterprises (SMEs) were more vulnerable to negative input supply and sales shocks during the pandemic (Amin, Jolevski, & Islam, 2023).

[1] Didier et al. (2021) introduced the concept of economic hibernation as the deliberate slowing down of the economy by allowing only the essential activities to keep the economy functional as lockdowns were enforced to control the spread of COVID-19.

There is an emerging literature that documents the impact of the Great Lockdown on establishments worldwide, and how they adjusted operations in a bid to keep their businesses afloat amidst the pandemic-induced economic hibernation. The bulk of these analyses are based on the World Bank Enterprise Surveys (WBES) and the COVID-19 Follow-up Surveys (COV-ES) which collected useful data on the experiences of firms before and during the pandemic. Four major themes emerged from these studies: impact of the pandemic on firm performance, pre-pandemic characteristics that boosted survival probability during the lockdowns, strategic reaction of firms to the wild card disruptions, and the role of pandemic regulations and government support. Apedo-Amah et al. (2020), one of the earliest reports on the impact of COVID-19 on businesses worldwide, documented the following stylized facts based on firm-level data from 51 countries: the pandemic caused persistent negative effect on sales; employment adjusted more via reduction in working hours and leaves of absence rather than layoffs; small firms faced greater financial constraints; digitalization increased; and higher uncertainty lead to pessimistic business expectations. These results find broad support from succeeding studies that also used the WBES and COV-ES datasets. In terms of impact, Islam and Fatema (2023) confirmed that the pandemic reduced the survival probability of firms in 21 countries in Africa, Latin America, and Asia. Muzi et al. (2023) found evidence of a Schumpeterian cleansing; that is, less productive firms, especially SMEs, were permanently driven out of the market during the crisis. Janzen and Radulescu's (2022) analysis of 23 Southern and Eastern European countries also showed that small firms experienced a higher reduction in year-on-year sales growth due to an increase in lockdown stringency. Gendered analysis also suggests that female-led establishments were more adversely affected by the pandemic (Khan, 2023; Lashitew, 2023; Croucher et al., 2025).

A large chuck of studies investigated the idiosyncratic and aggregate factors that contributed to firm-level outcomes during the pandemic. Using data from 34 countries, Muzi et al. (2023) documented that permanent closure during the pandemic was partly averted by digital presence and innovativeness, while burdensome business environment increased the probability of exit. Wagner (2021) also found that pre-pandemic online presence reduced the likelihood of firm exit in 10 European countries. Wagner (2024) added that size, age, and pre-pandemic process innovation boosted the probability of firm survival in eight European countries. Similar evidence was documented for SMEs in eight African and 26 European countries (Croucher et al., 2025). In contrast, Nguyen et al. (2024) suggest that pre-pandemic innovation significantly contributed to resilience but not to the ability of firms to remain open during the lockdowns. Chit, Croucher, and Rizov (2022) also found that institutional connection and financial health improved the survival of SMEs in 25 European countries. Similarly, the results of Özşuca (2024) for agribusinesses in 42 countries and Khan (2022) for SMEs in 19 countries also highlight the relevance of financing constraints on firm performance during the pandemic. Previous banking crisis experience also seems to have helped SMEs in 39 countries cope with the pandemic (Lefebvre & Osei-Tutu, 2024). Grover and Karplus (2021) suggested that good pre-pandemic management practices also helped firms in 16 countries adjust to the disruptions, which partly eased the adverse impacts on sales and survival. On a macro level, Liu et al. (2021) concluded that firms had higher survival probabilities in countries with higher GDP per capita, less severe COVID-19 spread, less stringent containment policy, and a culture of future orientation.

In terms of firm-level response to lockdown-induced disruptions, Islam and Fatema (2023) found that business strategies during the pandemic helped boost survival probability. The fast-tracked shift to remote work arrangements and digitalization during the lockdowns particularly buoyed firms' productivity and reduced their probability of exit (Grover & Karplus, 2021; Boutros, Fakih, & Tarraf, 2023; Avalos et al., 2024). Chundakkadan and Sasidharan (2023) and Nguyen et al. (2024) both documented that e-commerce adoption and innovation, which boosted sales growth during the pandemic, benefitted from government support. This indicates that assistance from the government during the lockdowns likely played a role in the survival of firms, especially SMEs (Doruk, 2022). But Janzen and Radulescu (2022) argued that not all forms of government support were equally successful, with some (e.g., deferral of payments and wage subsidies) being more effective in curtailing job losses.

While the majority of existing studies have examined the impact of COVID-19 on business survival, especially of SMEs, very few have paid closer attention to exporters that were arguably more exposed to the wild card pandemic shocks. In addition to weak domestic consumption and local supply constraints, exporters were also affected by the slump in foreign demand, global supply chain disruptions, input shortages, stronger protectionist tendencies, reduced logistics and certification services, and cumbersome pandemic regulations—both locally and abroad (Mendoza, 2021; Borino et al., 2024). Globally-engaged firms also faced higher uncertainty due to the volatility of the global environment, exchange rate risks, default risks, liquidity problems, and financial market frictions (Constantinescu et al., 2022). The available studies on the experience of exporters during the pandemic are still very few and have mixed results. For instance, Wagner (2024) found that exporting reduced the exit probability of firms in eight European countries during the pandemic. Using the World Bank datasets, Doan (2024) also found that the positive effect of global value chains (GVC) participation on firms' productivity, bargaining power, and financial position boosted their survival probability during the pandemic. Moreover, Gopalan, Miroudot, and Reddy (2023) documented that the interaction of GVC participation and digitalization increased the survival probability of firms in 41 countries. Gopalan and Reddy (2025) added that simultaneous exporting and importing of firms in 33 countries is associated with robustness and resilient sales recovery. In contrast, Baltaji, Fakih, and Sayour (2023) found that non-exporting firms in Jordan and Morocco were significantly less likely to close down than exporters. Jordaan's (2023) analysis of firms from 43 developing, emerging, and advanced economies showed that MNCs with high import and export intensities experienced larger declines in sales, but involvement in production networks can dampen this effect. Constantinescu et al. (2022) also documented a similar pattern, with GVC firms enduring larger drops in exports and imports compared to non-GVC firms. Nevertheless, Constantinescu et al. (2022) noted that GVC firms also recovered faster. Benguria (2021) found a heterogenous effect of COVID-19 shocks on Columbian exporters. He noted that exporters of intermediate inputs and capital goods were more severely affected than exporters of final consumer goods. Moreover, the export decline was milder for multinational affiliates.

The Great Lockdown and the resulting economic hibernation were unprecedented situations that no firm could have adequately prepared for. The pandemic forcibly teleported firms to a new market environment with turbulent supply and demand conditions. Similar to the great trade collapse caused by the global financial crisis (GFC) in 2009, establishments experienced a sudden reduction in domestic and foreign demand due to income loss and credit constraints (Ruch & Taskin, 2023). But COVID-19 shocks were unique because firms also endured severe supply chain disruptions that halted production activities. The systemic nature of the pandemic shocks also destabilized the adjustment mechanisms in GVCs that could have eased the disruptions in some segments. This begs the question: how could firms have survived these harsh conditions? Did exporters fare differently during the lockdowns given the complex domestic and global shocks they faced? This study explores the combined WBES and COV-ES datasets that cover more than 10,000 firms from 23 countries to answer the following central question: In the presence of aggregate and idiosyncratic COVID-19 shocks, did pre-pandemic capabilities and emergency innovations effectively support exporters' survival, robustness, and resilience? This relates to the long-standing debate about the role of self-selection and learning on exporters' performance.

This study contributes to the literature in several ways. First, the results uncovered interesting stylized facts about exporters' survival experience during the wild card crisis. For instance, we documented an interesting pattern about the higher tendency of exporters to implement more technology-intensive "positive" emergency innovations during the pandemic. Second, our framework used elements of the self-selection hypothesis and the resource-based view of the firm to examine the survival strategies of exporters amidst aggregate and idiosyncratic demand and supply shocks induced by COVID-19 disruptions. The study found that most emergency innovations and business adjustments implemented during the lockdowns did not significantly help exporters weather COVID-19 shocks, while superior pre-pandemic capabilities, especially labor productivity, mattered more for survival, robustness, and resilience during the disruptions. This suggests that exporters' better survival prognosis was not due to exporting per se but the self-selection of superior firms into international markets. Nevertheless, importing partly allowed exporters to ease local supply chain constraints. This adds to the limited micro-level evidence that firms with stronger GVC linkages had lower exit probabilities despite their greater exposure to pandemic shocks. The results also reveal that stringency and simultaneous negative supply and demand shocks accelerated the exit time of exporters; while the duration of disruptions (as proxied by vaccine delay) seemed more relevant in the speed of recovery. More importantly, the results shed light on the crowding out effect of the severity and duration of pandemic shocks on the emergency responses of exporters and governments to the crisis. Third, the study empirically analyzed exporters' robustness and resilience, which are less explored topics in the literature. The results provide some evidence that superior pre-pandemic characteristics contribute to the strength and speedy post-crisis recovery of exporters, while emergency innovations were either insignificant or negatively related with robustness and resilience. With a limited window for learning, this implies that the documented emergency innovations and business adjustments were likely signs of distress and mainly used last-ditch efforts to avoid exit. Lastly, the results shed some light on the debate about relevant policy interventions during crisis periods. Methodologically, this study implemented Weibull and negative binomial regression models which are less commonly used methods in previous research on the topic.[2]

The rest of the paper is organized as follows. Section 2 developed the conceptual framework and research questions based on the surveyed literature. Section 3 describes the empirical strategy and data used in the study. Section 4 presents some stylized facts and discusses the empirical results. Section 5 summarizes the findings and offers some business and policy insights.

2. Conceptual Framework

Czakon, Hajdas, and Radomska's (2023) brief survey identified several important characteristics of wild cards. First, wild cards are low-probability but high-impact events that can potentially disrupt social and economic systems on a massive scale. Second, wild cards can trigger a chain of events that can be more severe than the original event. Third, this chain reaction tends to progress faster than what the system can process, giving people, businesses, and governments little time to adjust. Lastly, instead of being "unknown unknowns" or unpredictable surprises, some wild cards have an incubation period before progressing into a full-blown disruptive event. In the case of COVID-19, the prelude to the pandemic started with the detection of "mysterious pneumonia-like cases of unknown origin" in 2019 which quickly escalated into a global health emergency by March 2020. This triggered an unprecedented series of events that prevented firms from doing business as usual: national borders were closed to stop the global spread of the virus, disrupting cross-country movements of goods, inputs, and people; and lockdowns and social distancing were implemented, with factories, offices, establishments, and schools closed indefinitely to limit human mobility and interactions. Despite these extreme regulations that induced economic hibernation, COVID-19 infections and deaths still increased exponentially. Disrupted economic activities generated adverse domestic demand and supply shocks, especially in "non-essential" sectors; while stringent cross-border regulations restricted local access to foreign markets. These first-order shocks amplified through complex production and trade linkages that transcend national boundaries, suggesting that trade-oriented firms endured harsher conditions during the lockdowns.

We adopt the simple framework of Bernard and Jensen (1999) to analyze a firm's decision to persist or exit the export market within the context of wild card COVID-19 shocks that induced global economic hibernation. According to Equation 1, a firm j stays in the export market (i.e., $\hat{\pi}_{js} = 1$) in the current period s when $\hat{R}_{js}$ (i.e., sum of export sales and discounted future benefits from exporting versus not exporting) is higher than the sum of the variable costs (c_{js}) and the sunk entry cost incurred by first-time exporters (f):

$$\hat{\pi}_{js} = \begin{cases} 1 & \text{if } \hat{R}_{js} - c_{js} - f\left(1 - E_{js-1}\right) > 0 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where $E_{js} = 1$ if exporting at time t and 0 otherwise. On the revenue side, the hibernation of many economic activities during the early phase of the pandemic translated to the collapse of aggregate demand and forgone sales of firms. Moreover, prolonged lockdown-induced disruptions worsened the

[2] To our knowledge, only Islam and Fatema (2023) have previously performed formal survival analysis using the WBES and COV-ES datasets.

prospects from exporting which further dragged down $\hat{R}_{js}$. Equation 1 implies that firms with shorter lifespan or uncertain future revenues are more likely to exit since they do not expect that future gains can sufficiently offset current losses.[3] On the other hand, limited access to inputs affected total variable costs in two contrasting ways: higher input prices increased costs, while lower induced input demand reduced costs. Notwithstanding, firms continued to spend on labor costs, operating expenses, and other fixed costs despite the hibernation. Using the standard Dixit and Stiglitz (1977) model of a monopolistically competitive market, Melitz (2003) showed that a firm's revenue performance is largely driven by aggregate and sector-level conditions as well as its own inherent productivity. This implies that during the Great Lockdown, a firm's ability to survive was mainly determined by how it quickly employed efficiency-enhancing strategies to adjust variable costs given virtually zero revenues and limited alternative markets in the face of pandemic shocks.

According to Fabiani et al. (2015), a firm's optimal response to a negative shock depends on three factors: the nature (e.g., origin, duration, scope, and severity) of the shock, the firm-level conditions during the shock, and the broader market environment when the shock occurs. Assuming a firm does not exit, it can respond to demand-eroding shocks using various strategies such as cutbacks in production, prices, costs, market scope, and profit margins (Bricongne, et al., 2012; Fabiani et al., 2015). This implies corresponding adjustments in factor inputs which tend to follow a certain sequencing. For instance, Nadiri and Rosen (1969) suggested that when hit by demand shocks, firms instantaneously adjust labor utilization rates (i.e., changes in working hours, followed by changes in employment size); while capital stock is inflexible in the short run. Ardiyono and Patunru (2023) found supporting evidence from Indonesian big firms, with slow adjustments in employment slow, relatively faster adjustments in material inputs, and no short-run change in capital in the face of foreign demand shocks during the GFC. This is consistent with the strategic management literature, which identified ideal responses for different timeframes: retrenchment in the short run, perseverance or status quo preservation in the medium run, and innovation or exit in the long run (Wenzel, Stanske, & Lieberman, 2020). Adverse supply shocks may be dealt with by downscaling, shifting, or suspending production or by diversifying input sources to include some redundancies in the supply chain. Inventory management is also important, such as in the study of Lafrogne-Joussier, Martin, and Mejean (2023) which found that Chinese firms with higher levels of inventories were better able to absorb COVID-19 supply shocks. Firms may also rely on credit to stay afloat until the shocks subside (Didier et al., 2021). A firm that is not robust enough to endure negative shocks exits the market permanently. This is consistent with the Schumpeterian cleansing effect, in which inferior firms are driven out of business during disruptive crises (Dal Pont Legrand & Hagemann, 2017).

The foregoing discussion suggests the following hypotheses:

H1: Firms employ various emergency innovations and strategic business adjustments to respond to wild card crises.

H2: When the wild card crisis induces an economic hibernation that shrinks aggregate demand, firms will respond more using cost-adjusting rather than revenue-raising measures.

H3: When the wild card shock is massive, cost-reducing responses cannot boost a firm's survival, robustness and resilience. Moreover, a combination of fast evolving wild card shocks and firms' slow learning process renders delayed response ineffective.

H4: Firms facing simultaneous demand and supply shocks are less likely to survive during wild cards.

H5: Government interventions that cannot effectively address simultaneous demand and supply shocks during wild cards will not boost a firm's survival, robustness and resilience.

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[3] This is consistent with the model of optimal stopping time for exit during the pandemic developed by Miyakawa, Oikawa, and Ueda (2021) for Japanese firms. Their simulations show that exit rate is high when firms see the reduction in sales growth as permanent, while moderate when the reduction in sales is expected to be temporary.

These hypotheses imply that efficiency-enhancing adjustments will be more common during a wild card shock such as COVID-19 since these are faster to implement and directly impact the cost structure. On the other hand, revenue-raising product innovations and market expansions may not be as effective.

A firm's survival during a crisis is closely linked to robustness and business resilience in the face of disruptive shocks. Miroudot (2020) defined robustness as the ability to remain operational during disruptions, while resilience is the ability to return to normal operations after disruptions. Both robustness and resilience require superior capabilities needed to weather the shocks. According to Rose and Liao (2005) the inherent resilience of firms is founded on mechanisms already embedded in the firm's system (e.g., inventories, excess capacity, input substitution).[4] In addition, adaptive resilience arises from ingenuity and innovative changes in business operations amidst challenging situations. This is traced to the fact that innovative firms possess the agility to adapt and execute new ideas during periods of uncertainty (Gölgeci & Ponomarov, 2014).

According to the self-selection literature, these superior capabilities are more common among exporters that had to incur huge sunk costs in order to enter foreign markets (Roberts & Tybout, 1997; Melitz, 2003). As documented by Bernard and Jensen (1999, 2004), exporters are bigger and more productive than non-exporters, and these differences can be observed even before superior firms started exporting. These relate to the resource-based view (RBV) of the firm, which suggests that firms with better resources have better capabilities to develop and implement effective strategies (Safón, Iborra, & Escribá-Esteve, 2024). Esteve-Pérez and Mañez-Castillejo (2006) suggest that firms with unique capabilities built through research and development (R&D) have even better survival prognosis. Self-selection and RVB implies that the amount and quality of a firm's pre-existing resources and capabilities will significantly determine its ability to survive during an unprecedented and rapidly-evolving wild card, especially given that it takes time to develop strategic responses to a fast-mutating crisis. In Equation 1, $f(1 - E_{js-1}) = 0$ for incumbent exporters, which implies that experienced firms that have acquired exporting capabilities are more likely to weather wild card shocks.

The foregoing discussion suggests the following additional hypotheses:

H6. Pre-wild card resources and capabilities significantly boost a firm's survival, robustness, and resilience.

H7. Exporters are more likely to survive than non-exporters during wild cards due to their superior capabilities.

These capabilities consist of physical capital, skills, knowledge and technological resources, experiences (e.g., past innovative activities and exposure to crisis), and networks (including access to external resources such as credit and government support), among others. These capabilities may also manifest in a firm's superior size and productivity.

A number of studies particularly highlighted the role of innovation in firm-level outcomes during disruptions and crises. For instance, Gölgeci and Ponomarov (2013) found that firms adopt a higher magnitude of innovation when faced with more severe disruptions. Reinmoeller and Van Baardwijk (2005) also noted that pursuing multiple innovation strategies increases the chance of successful adjustment to shocks. This suggests that firms actively engage in innovative strategies to increase resilience amidst disruptions. As documented by Ozdemir et al. (2022), implementing new ideas and creative methods of operations amidst the COVID-19 lockdown significantly improved the pace of adaptation to disruptions in the UK perishable goods market. Pre-crisis innovations also keep firms afloat during crisis periods. For example, Gupta (2020) showed that innovative Spanish manufacturers were more resilient compared to non-innovative firms during the Great Recession. She added that this resilience was traced to product differentiation rather than marginal cost reductions due to process innovation. Comin et al. (2022) showed that pre-pandemic technological sophistication positively affected sales directly and indirectly by enabling firms to speed up the adoption of digital technologies

[4] Although Rose and Liao's (2005) definition of resilience is more aligned with Miroudot (2020)'s concept of robustness.

amidst the shocks. In the context of COVID-19 shocks, several studies using the WBES and COV-ES datasets found broad support for the positive impact of pre-pandemic innovativeness and sound business practices on survival (e.g., Grover & Karplus; 2021; Muzi et al., 2023; Chit, Croucher, & Rizov, 2022; Wagner; 2024; Croucher et al., 2025). However, some studies show mixed results such as Nguyen et al. (2024) which found that innovations contributed to resilience but not to firms' ability to stay open during the lockdowns. Lim and Morris (2023) also added that costly innovation projects undertaken before the pandemic might have added to the financial losses of firms that underperformed during the pandemic. This is consistent with Sidorkin and Srholec (2014) which documented that firms from East and Southern Europe with excessive innovations before the GFC were more likely to exit during the crisis.

The critical role of innovativeness in building robustness and resilience is consistent with the broader literature recognizing innovation as a key element of firms' long-term growth and survival. Earlier work by Agarwal and Gort (2002) showed that technological intensity significantly boosts firm survival. For example, Cefis and Marsili (2005) showed that innovation extends the life expectancy of firms in the Netherlands. Cefis and Marsili (2012), Helmers and Rogers (2010), Zhang et al. (2018), and Jitsutthiphakorn (2021) found similar evidence for Dutch, British, Chinese, and Southeast Asian firms, respectively. This may be partly explained by the self-selection of superior firms into innovation ventures given the high costs of entry to these activities (Costantini and Melitz, 2008). Schumpeterian-based models also predict that small and relatively less innovative firms in innovation-intensive industries will face high risks of exit due to the effect of competitive forces and creative destruction. On the other hand, survivors are expected to grow faster (Aghion et al., 2015). Sabahi and Parast's (2020) systematic survey of the literature showed that firms in a more innovative environment are more resilient because innovation helps them improve their risk management capability, knowledge sharing, agility, and adaptability. A recent review by Ugur and Vivarelli (2021) also confirmed this positive relationship between innovation and firm survival, although they observed a significant heterogeneity across industries, firm size, innovation type, and innovation intensity.

3. Methodology and Data

Since $\hat{\pi}_{js}$ in Equation 1 is unobservable, a firm's exit or survival can be modeled via the latent variable approach using the binary indicator Y_{js} defined as follows:

$$Y_{js} = \begin{cases} 1 \text{ if } \hat{\pi}_{js} \geq 0 \\ 0 \text{ if } \hat{\pi}_{js} < 0 \end{cases}. \tag{2}$$

Y_{js} is usually modelled as a function of a vector of covariates $\boldsymbol{X}$ and estimated using standard limited dependent variable regression. An alternative is to model a firm's exit or failure using duration or survival models. For instance, Agarwal and Gort (2002) model a firm's exit or hazard rate as follows:

$$h(t) = h_0(t)\psi(\boldsymbol{X}) \tag{3}$$

where t is the time to event or failure, $h_0(t)$ is the baseline hazard when all covariates in $\boldsymbol{X}$ are set to null. In the context of COVID-19, $\boldsymbol{X}$ may be partitioned into $\boldsymbol{X_F}$ for pre-crisis firm-specific attributes such as age, size, productivity, organizational capital, R&D investment, and foreign ownership; $\boldsymbol{X_E}$ for emergency innovations and business adjustments implemented by firms during the crisis; $\boldsymbol{X_W}$ for the aggregate and idiosyncratic wild card shocks; and $\boldsymbol{X_I}$ for industry-specific and country-specific variables. The function ψ relates the hazard rate to the covariates. Under certain conditions, Equation 3 can be estimated using the semi-parametric Cox proportional hazards (PH) model which assumes no particular distribution for $h(t)$ but uses a parametric distribution for ψ:

$$h(t) = h_0(t)\exp(\boldsymbol{X\beta}) \tag{4}$$

where the βs are the corresponding coefficients. Equation 4 implies that the relationship between $\ln[h(t)]$ and each X_k (as summarized by the coefficient β_k) is linear and constant over time.

Instead of estimating the Cox PH model, an alternative approach is to use a parametric survival model fit for the data, especially when the proportional hazard assumption is violated. Standard models for survival regressions widely use parametric distributions such as the generalized Gamma, Weibull, lognormal, and exponential models. In parametric survival regressions, the common approach is to model accelerated failure time (AFT) as a function of the covariates:

$$\ln t_j = \boldsymbol{x_j}\boldsymbol{\beta} + \varepsilon_j \tag{5}$$

where $\ln t_j$ is the natural logarithm of time to event of firm j and ε_j is the idiosyncratic error term. The regression model to be used (e.g., Weibull, lognormal, exponential) is based on the distributional assumption on the error. When β_k is positive (negative), covariate X_k extends (shortens) the expected waiting time for failure, other things equal. A particular advantage of the AFT specification is that the interpretation of the regression coefficients is not changed when shared frailty (i.e., the unobserved heterogeneity shared by individuals in the same group) is controlled for in the model (Gutierrez, 2002).

Letting s be measured in months, where $s = 1$ pertains to February 2020, then $t_j = \sum_{s=1}^{\infty} Y_{js}$ assuming no re-entry. This implies that t_j in Equation 5 will be extended by factors and shocks that improve $\hat{R}_{js}$ and reduce c_{js} in Equation 1. Moreover, the determinants of incumbency (i.e., $Y_{js-1} = 1$) also improve $\hat{\pi}_{js}$, Y_{js}, and t_j. In the firm survival literature, the usual regression covariates are age, firm size, productivity, capital intensity, R&D and innovation, exporting and importing experience, foreign ownership, managerial quality, access to credit, industry controls, and country-specific controls (Agarwal & Gort, 2002; Buddelmeyer et al., 2009; Cefis & Marsili, 2005; Ugur & Vivarelli, 2021). In the context of COVID-19, firm-level emergency responses, lockdown stringency, firm-specific demand and supply shocks, and government support can also affect t_j.

The foregoing discussion suggests that the analysis can be extended to examine whether the factors that boost survival can also support the endurance and recovery of exporters from COVID-19 disruptions. Miroudot's (2020) definitions of robustness and resilience imply that these are characteristics of firms that survived. In fact, Gopalan and Reddy (2025) equated robustness with survival, while resilience was defined in terms of avoiding sales reduction during the pandemic. This suggests that both robustness and resilience will be affected by similar factors that boost or reduce survival probabilities. For instance, Gölgeci and Ponomarov (2014) and Sabahi and Parast (2020) suggest that innovativeness improves robustness and resilience because it helps firms build risk management capability, the flexibility to adapt and adopt during periods of uncertainty, and the agility to execute new ideas and respond to shocks quickly. Intuitively, investment in R&D, ICT, and market surveillance capabilities may help improve the ability of firms to predict, identify, and manage potentially disruptive shocks. These options are naturally more accessible to larger, and more productive, experienced and innovative firms, which coincidentally have extensive networks and better access to technological, knowledge, and financial resources.

We combined two datasets to analyze firm-level survival, robustness, and resilience during the pandemic. The first set contains data from the WBES conducted before the pandemic hit in 2020. [5] This dataset provides the baseline pre-crisis information on firms' characteristics, innovation activities, performance, and experience. The second set pertains to the results of the COV-ES or the COVID-19 Follow-Up Surveys ran by the World Bank from 2020 to 2022.[6] The surveys, done in one to four rounds, cover a number of countries in Africa, Asia, Europe, and Latin America. The surveys explicitly tracked whether firms remained open, temporarily closed, or permanently exited during the first two years of the pandemic. The surveys also recorded the month and year of a firm's permanent closure. In addition, the COV-ES has questions that can capture a firm's robustness and resilience during the pandemic. In terms of emergency innovation responses to COVID-19 shocks, the surveys also inquired about various

[5] As described by (Muzi et al., 2023), the WBES is a nationally representative survey of formal firms with five or more employees. The surveys are comparable across countries given the standard survey instrument and a common stratified random sampling methodology. For each country, industry, firm size, and location were used as the stratification variables.
[6] The COV-ES adopted the main WBES sampling methodology, which makes it also comparable across countries.

coping strategies such as labor adjustments, loans, government support, and ad hoc innovations that establishments adopted to weather the crisis. In particular, firms were asked if they introduced, improved, converted or discontinued products or services amidst the lockdowns, furloughed or laid-off some workers, scaled down production, shifted to e-commerce, and implemented remote work arrangements.

While the entire COV-ES dataset covers 47 countries over several survey rounds, the initial sample used in this study only included more than 13,000 firms interviewed during the baseline pre-pandemic period (i.e., 2018 to 2019). The sample is assembled such that included firms were interviewed for the COV-ES at around the same period for each round; i.e., Quarters 2 to 3 of 2020 for the first round and Quarter 4 of 2020 to Quarter 1 of 2021 for the second round. The third and fourth rounds were excluded in the analysis due to the significantly reduced sample size. Narrowing down the analysis to the first two rounds also ensured that the period captures the hibernation phase and the dynamics of shocks faced by firms were mainly lockdown-induced and not yet confounded by massive vaccinations. Out of 13,564 observations with pre-pandemic information, COV-ES was able to follow-up 10,512 in the first round, of which 274 already exited prior to February 2020. Moreover, 181 firms lacked information on exporting activities. Given that first round information will be used in the empirical analysis, only the remaining 10,057 firms were included in the baseline cohort, whose failure status were tracked through the second follow-up interview. The distribution of this cohort by country and exporting status is summarized in Appendix 1. The table shows a wide variety of firms from high-income (e.g., Italy, Greece and Portugal), middle-income (e.g., Georgia, Jordan, and Morocco), and low-income (i.e., Zambia) countries. In addition to increasing the sample size, this diversity ensures that the sample adequately captures different combinations of COVID-19 shocks and firm-level responses in various country and industry settings. Previous studies using the WBES and COV-ES used similar samples, such as by Islam and Fatema (2023), Muzi et al. (2023), and Croucher et al. (2025). We note that although the surveys are based on nationally representative samples, the firms included in our baseline cohort may not fully capture the pandemic experiences of developing countries, especially in Asia and South America. Hence, generalizing the results must be done with caution.

We modified Islam and Fatema (2023) and Muzi et al. (2023) by combining information from the first and second follow-up survey rounds to have a more fine-tuned definition of failure status (see Table 1). This is partly informed by the well-known hysteresis in firm behavior where entry and exit decisions become history-dependent in the presence of sunk entry costs (Baldwin, 1989). The event (i.e., permanent exit) is defined for firms that permanently closed as of the second round. Firms that are still open as of the second interview were right-censored and considered as survivors. Temporarily closed firms for which the failure event was not observed by the second round were also right-censored. This includes firms that were open, temporarily closed, or could not be contacted during the first round but self-reported as temporarily closed during the second round. Given that the questionnaire explicitly asked whether a firm is temporarily or permanently closed, identifying as the former during the second interview indicates that they have not exited the market permanently. This classification suggests that closure does not automatically equate with permanent exit. This is true for establishments that were forced by government containment policies to pause operations during the lockdowns.[7] Muzi et al. (2023) also argued that some firms may have resorted to temporary closure as a strategic hibernation to survive the pandemic shocks. In fact, the data suggest that many firms that were temporarily closed as of the first round were able to reopen as of the second round, as they have possibly adjusted to the "new normal". Nevertheless, it is possible that some of the assumed survivors were already struggling at the date of censoring. The advantage of using proper duration or survival models is that firms that remain open are not explicitly tagged as survivors; instead, they are right-censored based on the assumption that the event (i.e., their eventual exit) did not happen during the observation period.

[7] The existing literature has not settled on a single definition of survival based on the COV-ES dataset, with studies like Chit, Croucher, and Risov (2022), Wagner (2021, 2024), Gopalan, Miroudot, and Reddy (2023), and Muzi et al. (2023) that do not explicitly group temporary and permanent exit together; while others such as Grover and Karplus (2021), Liu et al. (2021), and Islam and Fatema (2023) did not distinguish between the two.

An interesting case pertains to establishments for which all other means of contact were attempted during the second round but:

- o no reply after having called in different days of the week and in different business hours;
- o phone number does not exist, line out of order, or no tone; and
- o for self-administrated online survey: invitation email bounced back, no reply to the email, and survey initiated but never completed.

Table 1. Summary of Failure Classifications

<table>
<tr><th rowspan="2">Status as of Round 1</th><th colspan="5">Status as of Round 2</th></tr>
<tr><th>Open</th><th>Permanently Closed</th><th>Temporarily Closed</th><th>Unsuccessful contact</th><th>No information</th></tr>
<tr><td>Open</td><td rowspan="3">Right-censored as of Round 2</td><td rowspan="3">Confirmed exit as of Round 2</td><td>Right-censored as of Round 2</td><td>Assumed exit if closure date is reported; otherwise, right-censored as of Round 1</td><td>Assumed exit if closure date is reported; otherwise, right-censored as of Round 1</td></tr>
<tr><td>Permanently Closed</td><td>Assumed exit as of Round 1</td><td>Assumed exit as of Round 1</td><td>Assumed exit as of Round 1</td></tr>
<tr><td>Temporarily Closed</td><td>Right-censored as of Round 2</td><td>Assumed exit if closure date is reported; otherwise, right-censored as of Round 1</td><td>Assumed exit if closure date is reported; otherwise, right-censored as of Round 1</td></tr>
</table>

Islam and Fatema (2023) and Muzi et al. (2023) both assumed this group to have permanently exited. In survival analysis, these cases may be attributed to dropout or loss to follow-up instead of failure, which must be properly accounted for to minimize bias in the results. In this study, establishments that permanently closed during the first round and could no longer be contacted during the second round were assumed to have already exited. Establishments open or temporarily closed during the first survey round but could not be contacted during the second follow-up were also assumed to have already exited when there is available information on their date of permanent closure; otherwise, they were right-censored as of the first round.

Using the above definition, only 4.18 percent of the baseline cohort have permanently exited as of the second round of COV-ES, three-quarters of which are non-exporters.[8] The failure time was computed as the number of months from February 2020 up to the reported date of permanent closure or right-censoring as of the date of their last interview.[9] The average failure time of firms in the sample is 5.5 months which coincide with the last major wave of COVID-19 before the introduction of vaccines.

In terms of innovation strategies, the study adopts the following definitions based on the Oslo Manual (OECD, 2005):

- product innovation – a good or service that is new or significantly improved;
- process innovation – a new or significantly improved production or delivery method;
- marketing innovation – a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing; and

[8] A stricter definition which only includes confirmed open and permanently closed firms as of Round 2 yields an exit rate of 4.19 percent. This is slightly higher than Muzi et al.'s (2023) estimated average confirmed exit rate of 3.45 percent across 31 countries.

[9] February 2020 was chosen as the start of the analysis time since COVID-19 was declared as a Public Health Emergency of International Concern on January 30, 2020, and classified as a full-blown pandemic on March 11, 2020 (WHO, n.d.).

- organizational innovation – a new organizational method in business practices, workplace organization or external relations.

The first two are classified as technological innovations while the last two are considered non-technological innovations. This is consistent with the argument that not all innovations are R&D-related. While the traditional notion of innovation usually pertains to the technological kind, the broad sense of innovation also encompasses non-technological changes in organizational structure, strategies, and business environment. Based on these descriptions, introducing new products or services is considered product innovation. Discontinued products or services may be considered a negative product innovation. Converting a product line may be a result of combined product and process innovations. Shifting to a remote work setup may be considered process and organizational innovation. Adopting e-commerce may be a combination of process and marketing innovation. Changes in the size, composition, and types of employment may be considered a broad proxy for organizational adjustments.

The main variables used in the empirical analysis are described in Appendix 2. Pre-pandemic characteristics of establishments such as employment size, age, labor productivity, innovativeness, and foreign ownership were derived from the baseline WBES data collected from 2018 to 2019. Emergency innovations and business adjustments, mostly during the first months of the pandemic, were based on the first and second rounds of the COVID-19 Surveys (see Table 2). To reduce potential endogeneity, the key dependent variables such as failure status, failure time, robustness, and resilience are constructed using data from the second round of the COV-ES. The stringency index developed by Hale et al. (2021) was used to proxy for the aggregate COVID-19 shocks in a particular country. We used the main index instead of the sub-indices to fully account for the effects of COVID-19 disruptions on firms via all possible channels, not just via factory closures or mobility restrictions. Note that the first six months of the pandemic was characterized by widespread lockdowns, exponential increase in COVID-19 cases and deaths, and heightened uncertainty due to limited information about the disease and its treatment. Note as well that there were no widely available vaccines yet during the period. We measure the length of delay of the COVID-19 vaccine rollout in a country to capture the duration of the COVID-19 shocks. This is based on the fact that the speedy development of vaccines was a game changer that resulted in less stringent lockdowns and allowed many firms to return to business as usual.

4. Empirical Results

4.1. Stylized Facts

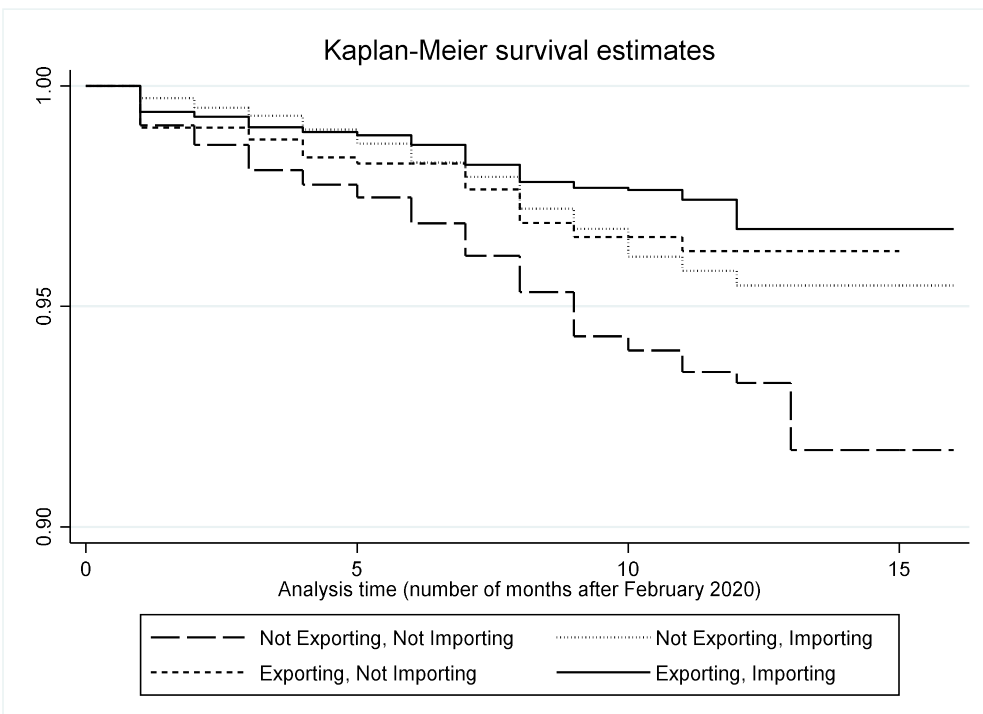
Compared to non-exporters, exporters had higher survival probability during the first 16 months of the pandemic. This difference is significant based on the log-rank test which rejects the null hypothesis that the respective survival curves of exporters and non-exporters are equal ($\chi^2 = 25.13$, p-value = 0.000). Similarly, the log-rank test ($\chi^2 = 32.92$, p-value = 0.000) also suggests that firms with pre-pandemic importing activities had better survival prognosis during the lockdowns compared to non-importers.[10] In terms of combined importing and exporting status, Figure 1 indicates that the survival curves based on trading activities significantly differ according to the log-rank test ($\chi^2 = 46.90$, p-value = 0.000). Two patterns are worth noting. First, purely domestic-oriented firms (i.e., not exporting and not importing) have a steeper survival curve compared to other types of firms. In contrast, the group of simultaneous exporters and importers have the flattest survival curve. This means that during the early phase of the pandemic, firms with no trade linkages have the highest exit probability. Any form of trading activities (i.e., exporting, importing, or both) is associated with better survival prognosis. This suggests that without any strategic responses or government support, purely domestic firms were more vulnerable to the economic hibernation induced by the pandemic. Second, the hazard rate of simultaneous exporting and importing firms started to slow down much earlier compared to partially-internationalized and purely-domestic firms. By the end of 2020, failure among exporting and importing

[10] Simple Cox PH regressions of firm exit on exporting (importing) status show that the exporters (importers) are 43.8 percent (43.4%) less likely to exit compared to non-exporters (non-importers). Both results satisfy the PH assumption at $\alpha = 0.05$.

firms has become fewer, while the survival curve of non-traders would continue to descend until the first quarter of 2021. This indicates that globally oriented firms were more robust and adapted faster to the wild card shocks.

These patterns provide preliminary support for H7 which argues that exporters have better survival probability than non-exporters during the pandemic-induced economic hibernation. The results also refute the common misconception that trade-oriented firms were more likely to exit during the lockdowns since they were more exposed to supply chain disruptions, global demand shocks, and stringent cross-border regulations. This is consistent with the argument of Arriola et al. (2020) that exposure to global shocks does not automatically translate to actual losses, especially when firms know how to manage the risks. Since domestic and globally-oriented firms were both exposed to wild card COVID-19 shocks, the self-selection literature provides the most plausible explanation for the better performance of exporters, especially those connected to GVCs: they have superior traits, richer international experience, more extensive foreign networks, and broader access to domestic and foreign resources that helped them navigate turbulent market conditions better. Their international linkages also provided more diversity in terms of input sources and destination markets, especially since local supply chains were also not immune to disruptions (Miroudot, 2020). This is supported by the log-rank test result ($\chi^2 = 4.82$, p-value = 0.028) suggesting that exporters linked to multinationals had better survival prognosis than those without a similar connection. Multinational affiliations most likely provided access to resources such as market knowledge, equipment, subsidies, and loans that partly eased the constraints caused by COVID-19 disruptions.

Figure 1. Survival Curves by Exporting and Importing Status



Source: Author's estimates

Table 2 summarizes the incidence rates of establishments that implemented certain emergency innovations and operational adjustments to cope with COVID-19 shocks. At the onset, these strategic responses to pandemic shocks confirm Gölgeci and Ponomarov's (2013) previous result that firms do respond to disruptions, although the nature of the responses expectedly vary depending on how establishments internalize the shocks, especially vis-à-vis their own resources and capabilities. This also supports H1 which hypothesizes that firms responded to the wild card COVID-19 crisis with a variety of strategies. With Goodman and Kruskal's gamma equal to 0.369, starting or increasing remote work arrangement registered the strongest positive correlation with exporting.

Table 2. Incidence Rates of Emergency Innovations and Business Adjustments During the Pandemic

Innovation and Business Adjustments	Type	Exporting Status			Censored Firms or Assumed Survivors		
		Non-Exporters	Exporters [a]	Gamma [b]	Non-Exporters	Exporters [a]	Gamma [b]
Reduced total work hours per week	Process & Organizational	44.26	39.29***	-0.102***	43.74	39.02***	-0.097***
Temporarily closed	Process & Organizational	44.00	34.87***	-0.190***	44.47	34.99***	-0.196***
Furloughed some workers	Process & Organizational	41.15	36.82***	-0.091***	41.13	36.67***	-0.094***
Converted the production line or services offered	Process & Product	31.06	32.09	0.024	30.71	31.88	0.027
Decreased the number of temporary workers	Process & Organizational	28.30	24.83	-0.089***	28.03	24.71	-0.085***
Started or increased business activity online	Process & Marketing	27.95	28.68	0.018	28.15	28.75	0.015
Started or increased remote work setup	Process & Organizational	23.91	40.56***	0.369***	23.96	40.73***	0.371***
Laid off some workers	Process & Organizational	24.09	20.74***	-0.096***	21.07	18.91**	-0.067**
Introduced new/ improved products or services	Product	18.56	18.73	0.005	18.59	18.74	0.005
Discontinued some goods or services	Product	17.17	14.04***	-0.118***	17.14	14.02***	-0.118***

Source: Author's estimates
*** $p < 0.01$,** $p < 0.05$,* $p < 0.1$
Shaded (unshaded) rows are classified as "negative" ("positive") emergency innovations and business adjustments.
[a] The significance indicators pertain to the test of equality of proportions between non-exporters (baseline) and exporters.
[b] Goodman and Kruskal's gamma is a measure of rank correlation between ordinal categorical variables.

There are two interesting patterns worth discussing. First, firms were more likely to implement non-technological retrenchment measures during the disruptions given the direct and immediate impact of these adjustments on the cost structure. In contrast, revenue-raising innovations were less common in the face of muted consumption in a contracting global economy. This is consistent with H2 which argues that during economic hibernation, firms will respond to the consequent decline in demand by employing cost-adjusting rather than revenue-raising measures. For instance, 44.26 percent of non-exporters and 39.29 percent of exporters reduced their total work hours sometime during the lockdowns. Furloughing of workers is another prevalent labor adjustment adopted during the pandemic. A large proportion of firms (44 percent of non-exporters and 34.87 percent of exporters) also implemented temporary closure as a response to mandatory lockdowns, weak sales, and input shortages. Laying off workers was less prevalent possibly due to employment regulations and labor hoarding to minimize rehiring costs once the business has recovered. More importantly, Didier et al. (2021) argue that firms are generally averse to adjustments that can destroy important business relationships with partners, suppliers, and employees, especially when shocks are transitory. These results are aligned with the supposed sequencing of responses to shocks according to Nadiri and Rosen (1969) and Ardiyono and Patunru (2023). Lien and Timmermans (2024) also found that Norwegian firms implemented pandemic-induced innovation projects whose benefits can be realized quickly. This implies less preference for radical innovations that required significant technological investments amidst a highly uncertain environment. Table 3 confirms that technology-intensive strategies such as converting the production line or services offered, starting or increasing business activities online, and adopting remote work arrangements were only secondary measures since they usually required more time and resources to implement. Moreover, introducing new or improved products or services was not common given that this was less effective in the face of shrinking demand amidst economic hibernation. They also have time, technological, skills, and financial requirements that may be hard to meet during the crisis. Discontinuing some goods or services offered was the least used strategy.

Second, "negative" emergency innovations and business adjustments (e.g., reduced total hours of operations per week, temporarily closed, furloughed some workers, decreased number of temporary workers, laid off some workers, discontinued the production of some goods or the offering of any services) had higher incidence rates among non-exporters. In contrast, "positive" technology-intensive responses were more prevalent among exporters (e.g., converted the production line or services offered, started or increased business activity online, started or increased remote work arrangement, introduced new or improved products or services). Using a different global micro dataset, Borino et al. (2024) documented a similar pattern about international firms being more (less) likely than domestic firms to implement "resilient" strategies such as teleworking ("retreating" measures such as filing for bankruptcy and laying off workers). Goodman and Kruskal's gamma statistics were calculated to quantify this relationship. As shown in Table 2, exporting is positively (negatively) related with positive (negative) emergency innovations and business adjustments. In particular, exporting (non-exporting) has a significant negative (positive) correlation with all "negative" emergency adjustments. The strongest negative correlation is observed between exporting and temporary closure, suggesting that exporters were less likely than non-exporters to temporarily close during the lockdowns. In contrast, exporting (non-exporting) is positively (negatively) correlated with "positive" technology-intensive responses, although this relationship is significant only for starting or increasing remote work arrangement. The preceding results are robust when we focus on the group of assumed survivors or censored firms only.

4.2. Survival Analysis

Since the baseline semi-parametric Cox regressions did not satisfy the proportional hazards assumption, we only used the Cox results to get an idea of the shape of the cumulative hazard function. This was then matched with the cumulative hazard curves produced using standard parametric survival models (i.e., Weibull, lognormal, and exponential). All models controlled for shared frailty for each country-sector pair to account for unobserved random effects or within-group correlations (Ugur & Vivarelli, 2021). This is intuitive given that firms within the same industry and country most likely experienced similar shocks that hit their respective sectors during the pandemic-induced economic hibernation. Although the preliminary results are not shown due to space constraints, the final choice for the parametric survival model (i.e., Weibull) was based on the lowest Akaike information criterion (AIC), highest likelihood criterion, and best model fit.

Table 3 summarizes the estimated coefficients of the Weibull AFT models. Models 1 to 3 pertain to regression estimates using the entire baseline cohort while the rest shows the results for the subsample of exporters. Models 1 and 4 are control for baseline pre-pandemic characteristics, Models 2 and 5 add the dummy variable for government support vis-à-vis two aggregate shocks which proxy for the severity (i.e., Stringency index) and duration (i.e., vaccine delay) of the COVID-19 disruptions.[11] Models 3 and 6 add idiosyncratic negative demand and supply shocks experienced by establishments. This sequencing is based on the assumption that although all establishments experience the same aggregate pandemic shocks, there can be significant heterogeneity in the actual firm-level impacts of these shocks. Across all models, the estimated Weibull parameter $\hat{p}$ is greater than one, indicating that the risk of failure

[11] As a consistency check, Models 1' and 4' were estimated using the narrow definition of failure as described in Footnote 8. The results are broadly aligned with Models 1 and 4, which validates our taxonomy in Table 1.

increases with time. For instance, $\hat{p} = 3.042$ in Model 3, which implies that establishments are four times more likely to fail after the sixth month than after the third month (i.e., $(6/3)^{3.041-1}$). For the same timeframe, $\hat{p} = 2.518$ in Model 6 indicates that exporters are only three times more likely to fail. This is consistent with the previous stylized facts suggesting that exporters had better survival prognosis during the pandemic. For Models 1 to 5, $\hat{\theta}$ or the variance of the shared frailty effect is significantly different from zero, suggesting that establishments in the same sector within a country experienced similar aggregate conditions during the lockdowns.

Table 3. Estimated Coefficients of the Weibull AFT Model

Variable	All Firms				Exporters			
	1'	1	2	3	4'	4	5	6
Employment size (ln)	0.225***	0.191***	0.182***	0.099***	0.254**	0.179*	0.159	0.110
	(0.045)	(0.043)	(0.047)	(0.029)	(0.106)	(0.095)	(0.107)	(0.068)
Age (ln)	0.221***	0.262***	0.222***	0.058	0.322*	0.356**	0.268	0.070
	(0.069)	(0.067)	(0.073)	(0.045)	(0.188)	(0.173)	(0.193)	(0.117)
Labor productivity (ln)	0.026	0.049**	0.046*	0.005	0.207**	0.196***	0.170**	0.093**
	(0.025)	(0.024)	(0.026)	(0.015)	(0.082)	(0.073)	(0.075)	(0.045)
Pre-pandemic process innovation (dummy)	-0.040	0.040	-0.002	-0.068	0.024	0.090	-0.095	-0.290
	(0.143)	(0.142)	(0.154)	(0.085)	(0.348)	(0.318)	(0.354)	(0.216)
Pre-pandemic product innovation (dummy)	0.356***	0.302**	0.266**	0.048	0.997***	0.698**	0.660**	0.203
	(0.128)	(0.122)	(0.135)	(0.076)	(0.343)	(0.288)	(0.329)	(0.195)
Foreign equity ≥ 10% (dummy)	-0.166	-0.190	-0.081	-0.039	-0.152	-0.120	-0.048	-0.161
	(0.157)	(0.154)	(0.170)	(0.108)	(0.306)	(0.279)	(0.306)	(0.187)
Baseline: No exports and no imports								
Importer only (dummy)	0.309***	0.296***	0.231*	0.088				
	(0.115)	(0.111)	(0.122)	(0.070)				
Exporter only (dummy)	0.049	0.116	-0.081	-0.169				
	(0.186)	(0.187)	(0.191)	(0.107)				
Importer & exporter (dummy)	0.324**	0.349**	0.308**	0.149	0.320	0.254	0.520**	0.405***
	(0.144)	(0.140)	(0.156)	(0.103)	(0.264)	(0.248)	(0.264)	(0.154)
Stringency index (ln)			-2.448***	-1.200***			-3.533***	-1.655***
			(0.550)	(0.348)			(1.005)	(0.561)
Vaccine delay (ln)			-3.380***	-2.268***			-3.228*	-0.755
			(0.924)	(0.581)			(1.760)	(0.951)
Government support (dummy)			0.784***	0.068			1.228***	0.347*
			(0.127)	(0.064)			(0.346)	(0.179)
Baseline: No negative idiosyncratic shock								
Negative supply shock only (dummy)				-0.174				9.619
				(0.178)				(132938)
Negative demand shock only (dummy)				-0.246*				9.446
				(0.137)				(56863.47)
Negative supply & demand shocks (dummy)				-0.358***				-0.609***
				(0.101)				(0.224)
Intercept	2.823***	2.674***	32.721***	21.668***	1.004	1.347	35.206***	13.756**
	(0.372)	(0.354)	(5.802)	(3.863)	(1.014)	(0.925)	(11.227)	(6.073)
Country-sector shared frailty	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$\hat{\theta}$ (variance of shared frailty effect)	2.042***	1.438***	1.345***	2.266***	1.950***	2.042***	0.884***	0.167
$\hat{p}$ (Weibull parameter)	1.356	1.283	1.270	3.042	1.068	1.070	1.046	2.518
Number of observations	7,227	8,753	8,205	7,863	2713	3,258	3,069	2,964
Log-likelihood	-1261.68	-1519.59	-1285.42	-546.936	-342.781	-406.260	-325.521	-127.638
LR χ^2	83.87***	87.55***	166.21***	91.71***	37.67***	32.10***	71.41***	61.58***
AIC	2547.366	3063.181	2600.841	1129.872	705.561	832.520	677.041	287.276

Source: Author's estimates

*** $p < 0.01$,** $p < 0.05$,* $p < 0.1$

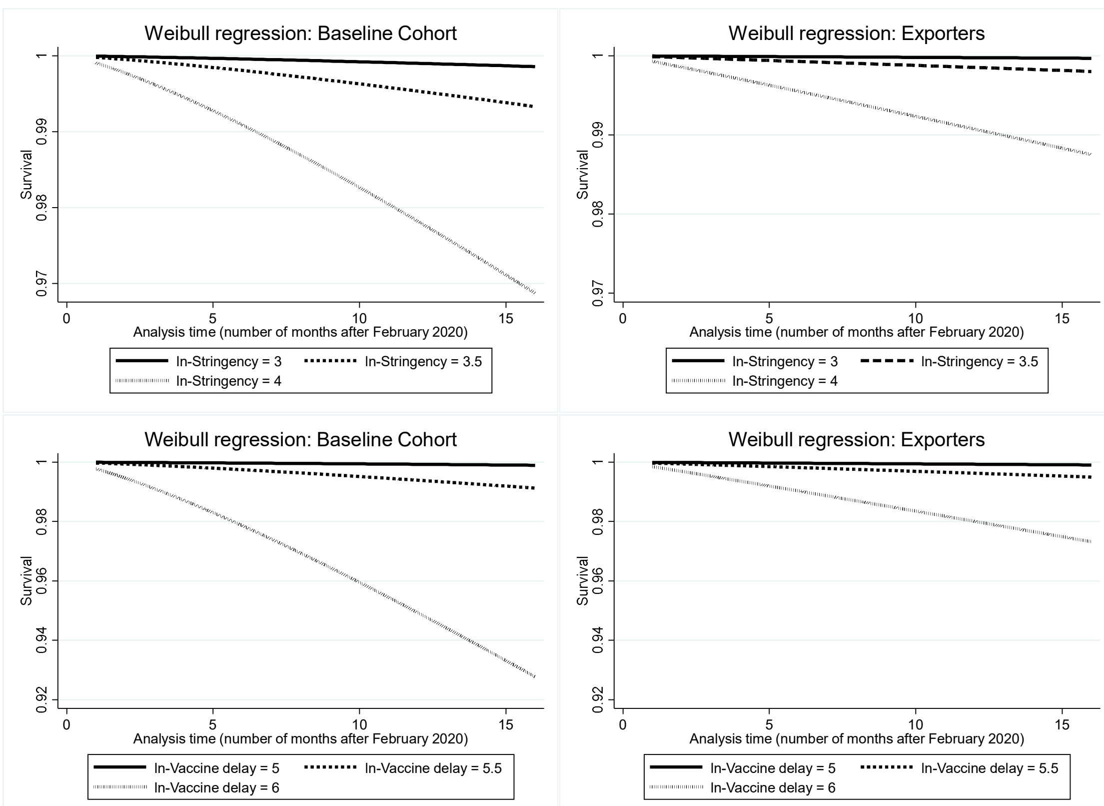
The effect of a unit change in variable X_k on the expected failure time is calculated as $(\exp(\hat{\beta}_k) - 1) \times 100$.

Numbers in parentheses are standard errors.

The baseline results in Models 1 and 4 confirm previous findings that superior pre-pandemic characteristics delay the closure time of firms, especially exporters (Wagner, 2021; Croucher et al., 2025). In particular, pre-2020 employment size, age, labor productivity, and product innovation significantly helped decelerate the failure time in the baseline models. This supports H6 which hypothesizes that strong pre-pandemic capabilities significantly boosted firm survival amidst the economic hibernation. However, majority foreign ownership and pre-pandemic experience in process innovation are consistently insignificant across models.

In the baseline regressions without controls for shocks, having a successful pre-COVID-19 product innovation has the strongest positive effect on survival –it significantly extended the expected survival time of the firms in the baseline cohort by 35 percent. For exporters, expected survival time was doubled as a result of having prior product innovations. The positive effects of experience (proxied by age) and labor productivity on the expected survival in Model 4 are higher compared to the estimates in Model 1. Consistent with H6 and H7, this implies that exporters have better survival probability than non-exporters partly due to their superior pre-crisis characteristics. Moreover, Model 1 suggests that simultaneous exporting and importing (a common proxy for GVC participation) significantly improves survival prognosis.

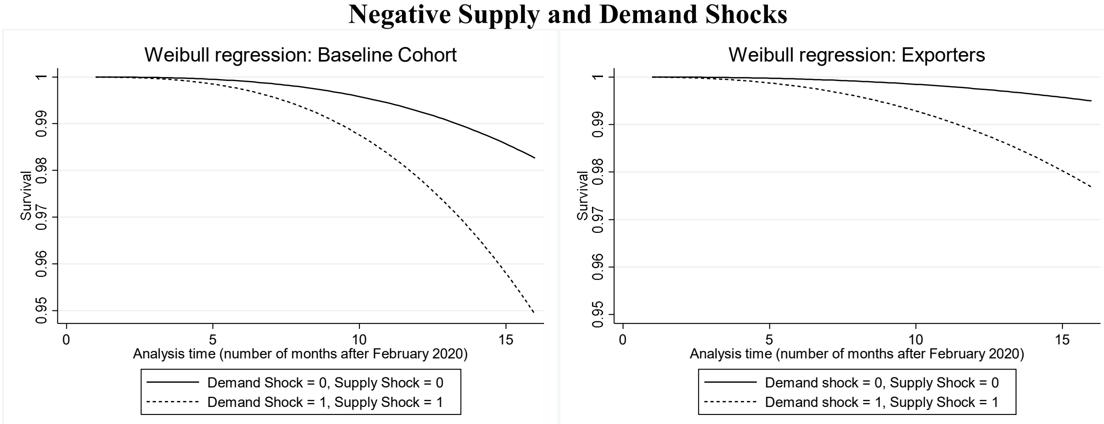
Figure 2. Estimated Survival Curves of Exporters for Different Severity and Duration of COVID-19 Shocks



Source: Author's estimates.

While the aggregate shocks virtually affected all sectors, the disruptions ultimately hit firms differently partly based on their capabilities to respond and adjust. Models 3 and 6 additionally control for the idiosyncratic negative demand and supply shocks experienced by firms during the lockdowns. The results provide evidence for H4 which hypothesizes that firms hit by simultaneous demand and supply shocks were more likely to exit. For the baseline sample, simultaneous demand and supply shocks accelerated failure time by 30 percent. For exporters, the reduction in expected survival time was more drastic at 45.6 percent (see Figure 3). The insignificant effect of purely negative input supply shocks supports the argument in H2 that hibernation-induced demand shocks were more binding than disruption-driven supply shocks given that the erosion in global demand resulted from deliberate government policies that restricted economic activities to contain the coronavirus. Hence, firm-level actions to address shrinking revenues were less effective than cost-reducing adjustments. It is also interesting to note that controlling for firm-level shocks crowded out the significant positive effect of most pre-pandemic capabilities on firm survival. For the baseline sample, only employment size remained significant, while labor productivity and importing are the robust drivers of exporters' survival amidst pandemic shocks. This implies that the most productive exporters with strong GVC linkages were best equipped to weather COVID-19 disruptions. Nevertheless, the lengthening effect of labor productivity on exporters' expected survival time was significantly slashed from 21.7 percent in Model 3 to just 9.7 percent in the face of pandemic shocks in Model 6. The positive way to look at it is that without superior pre-pandemic productivity, exporters would not have been able to counterbalance the adverse impact of COVID-19 on their operations. Finally, government support became insignificant in Model 3 and significant only at 10 percent in Model 6 after controlling for the idiosyncratic shocks. This is consistent with H5 which argues that government interventions that cannot completely address simultaneous demand and supply shocks will not effectively boost firm survival. In fact, stringency remains highly significant in Models 3 and 6, suggesting that relaxing strict containment measures would have been more effective than government subsidies to prevent business failure.

Figure 3. Estimated Survival Curves for Firms that Experienced Negative Supply and Demand Shocks



Source: Author's estimates.

Table 4 summarizes the estimates of the Weibull AFT regressions augmented with the dummies for various emergency innovations implemented by firms as of the first and second COV-ES rounds. The results suggest that most of the emergency responses have no effect on extending the expected survival time of firms. For exporters, all business adjustments are insignificant after controlling for pandemic shocks and pre-crisis characteristics. This is consistent with H3 which hypothesizes that in the face of fast-mutating aggregate and idiosyncratic pandemic shocks, small-scale or delayed emergency responses may not significantly improve firm survival. For the baseline sample, the effects of some emergency innovations are statistically significant but with mixed directions. For the first round, establishments that immediately reduced their total operating hours during the early lockdowns significantly improved expected survival time by 34 percent. This is consistent with the primacy of working hour adjustments in the expected sequencing of firm-level responses to shocks (Nadiri and Rosen, 1969; Ardiyono and Patunru, 2023). With enough time to adjust as of the second round, relying more on temporary workers and doing business transactions online both significantly extended firms' expected survival time by 21 percent. Consistent with H3, notice that the significant exit-delaying strategies are cost-reducing adjustments. In fact, converting production line or services offered, which is a potential revenue-raising innovation, even accelerated the failure time of firms in the baseline sample by 19 percent. This is aligned with the findings of Sidorkin and Srholec (2014) and Lim and Morris (2023) which suggest that risky product innovations during volatile periods may compromise a firm's financial health and profitability. This also supports H3 which argues that in the face of evolving pandemic shocks, ill-timed innovative responses may no longer be effective by the moment they are implemented. With a limited window for learning which strategies could work, the generally insignificant results in Table 4 suggests that the majority of emergency innovations and business adjustments adopted during the pandemic were likely signs of distress and trial-and-error last-ditch efforts by struggling establishments, including exporters, to avoid exit.[12]

Table 4. Estimated Weibull AFT Models with Emergency Innovations and Business Adjustments

Emergency Innovations and Business Adjustments	All Firms		Exporters	
	As of Round 1	As of Round 2	As of Round 1	As of Round 2
Furloughed some workers	-0.064	0.119*	-0.324	-0.319
	(0.069)	(0.071)	(0.230)	(0.217)
Reduced total operating hours per week	0.294***	0.004	0.322	-0.054
	(0.074)	(0.075)	(0.225)	(0.228)
Increased number of temporary workers	-0.054	0.186***	-0.004	0.291
	(0.074)	(0.071)	(0.241)	(0.228)
Temporarily closed	-0.085	0.117	-0.011	0.038
	(0.073)	(0.073)	(0.255)	(0.245)
Converted production line or services offered	0.034	-0.207***	-0.039	-0.215
	(0.074)	(0.064)	(0.209)	(0.198)
Started or increased business activity online	-0.004	0.190**	-0.148	0.319
	(0.082)	(0.080)	(0.262)	(0.248)
Started or increased remote work setup	0.051	0.087	0.312	0.260
	(0.079)	(0.077)	(0.264)	(0.255)
Country-sector shared frailty	Yes	Yes	Yes	Yes
$\hat{\theta}$ (variance of shared frailty effect)	1.885***	2.656***	0.000	0.000
$\hat{p}$ (Weibull parameter)	3.231	3.332	2.336	2.393
Number of observations	5,807	6,462	2,298	2,537
Log-likelihood	-345.240	-341.271	-83.606	-85.164
LR χ^2	94.76***	119.83***	59.72***	61.28***
AIC	740.480	732.542	213.213	214.327

Source: Author's estimates

*** $p < 0.01$,** $p < 0.05$,* $p < 0.1$

Numbers in parentheses are standard errors. All models controlled for the variables in Models 3 and 6 in Table 3. However, column 5 removed the interaction between negative demand and supply shocks due to convergence issues. Shaded rows are considered "negative" innovations or business adjustments.

4.3. Consistency Check: Robustness and Resilience of Surviving Firms

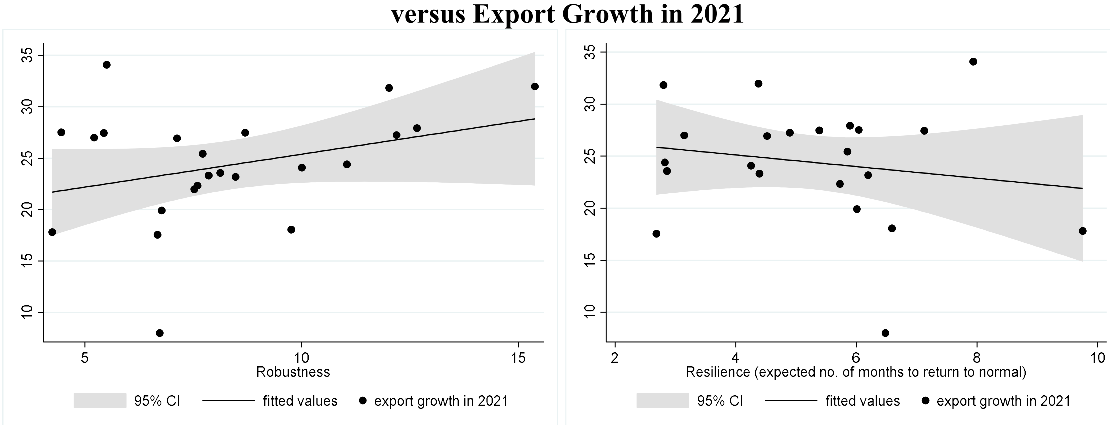
While survival is a strong indicator of business robustness in the face of wild card shocks, the COV-ES also collected additional information that partly captured firms' expected robustness and resilience given prolonged disruptions that heightened business uncertainty. In particular, the surveys asked the following questions:

- Keeping the cost structure as it is now, how many weeks would this establishment be able to remain open if its sales stopped as of today?
- In how many months is it expected that this establishment's sales will get back to normal?

[12] Although the sample and period covered are not identical, these results are in sharp contrast to Islam and Fatema (2023) which found positive and highly significant effects of various business strategies (e.g., online activity, remote work, new product, and government support) on survival. One possible reason is that the current study controlled for a broader set of firm-level capabilities, aggregate and idiosyncratic pandemic shocks, and shared frailty that eclipsed the supposed positive effect of emergency innovations and business strategies on survival.

The first question is an indicator of extreme robustness or endurance of firms to keep going amidst adverse conditions, while the second is negatively related with resilience or the ability of firms to bounce back as defined by Mirodout (2020). The validity of these indicators is supported by Figure 4 which shows the average weighted robustness and resilience per country. The graphs suggest that robustness has a positive correlation with the strength of export rebound in 2021; while longer expected recovery time, as measured by the resilience variable, is negatively related with the recovery of exports in the countries included in the sample.

Figure 4. Country-Level Weighted Average Robustness and Resilience versus Export Growth in 2021



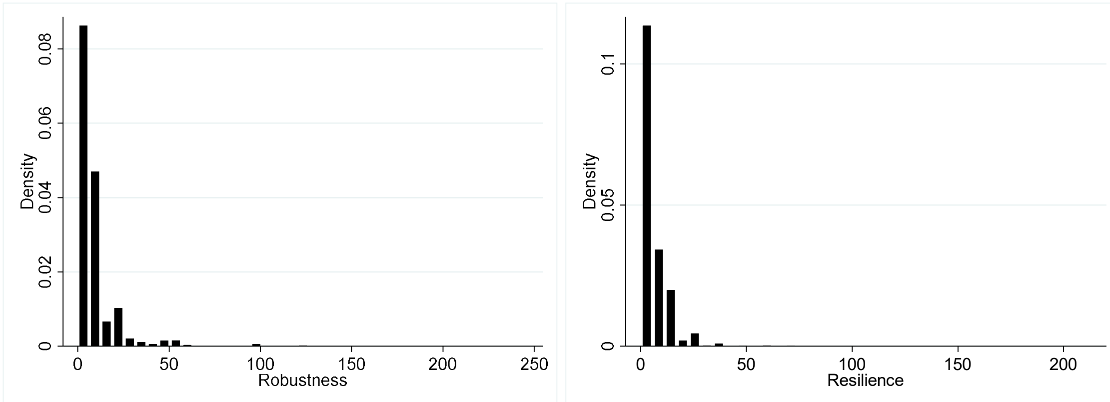
Source: Author's calculations using WBES and WTO exports data.

As a consistency check of our survival analysis, the final set of regressions analyzed the characteristics that significantly contribute to a firm's expected robustness and resilience, conditional on survival. The analysis was restricted to right-censored firms (i.e., assumed survivors) based on the argument that robustness and resilience are coincidental with survival. This restriction will also validate the accuracy of our identification of assumed survivors in Table 1: we hypothesize that the covariates that significantly extend expected survival time should also contribute to survivors' robustness and resilience. Since the two questions generated count data whose histograms in Figure 5 resemble a negative binomial (NB) distribution, we used the following model to estimates the coefficient vector $\boldsymbol{\delta}$ which captures the effects of the covariates in vector $\boldsymbol{x}_j$ on the probability of firm j's outcome variable y_j (i.e., robustness and resilience):

$$p(y_j) = \frac{\Gamma\left(\frac{1}{\alpha} + y_j\right)}{\Gamma(y_j + 1)\Gamma\left(\frac{1}{\alpha}\right)} \left(\frac{1}{1 + \alpha \exp(\boldsymbol{x}_j \boldsymbol{\delta})}\right)^{\frac{1}{\alpha}} \left(\frac{\alpha \exp(\boldsymbol{x}_j \boldsymbol{\delta} + \varepsilon_j)}{1 + \alpha \exp(\boldsymbol{x}_j \boldsymbol{\delta})}\right)^{y_j}. \quad (6)$$

Equation 6 is a negative binomial density function characterized by the overdispersion parameter α. Preliminary analysis showed that the overdispersion parameter is significantly different from zero, which makes Poisson regression inappropriate for modelling our robustness and resilience indicators. To our knowledge, no previous study used the cross-country COV-ES data to analyze these dimensions of firms' robustness and resilience amidst the pandemic, especially using negative binomial regressions. Gopalan and Reddy (2025) also studied robustness and resilience, although their definitions (i.e., based on survival) and methodology (i.e., probit) are different.

Figure 5. Histograms of the Robustness and Resilience Indicators of Assumed Survivors



Source: Author's calculations.

The NB regression results summarized in Table 5 confirm that the key factors contributing to firms' survival during the pandemic were also significant determinants of robustness and resilience in the face of disruptive COVID-19 shocks. In terms of robustness, size and labor productivity have a significant effect on exporters' ability to withstand extreme shocks: a unit increase in ln-employment extends the expected robustness of exporters by 0.68 week, other things constant. Similarly, a unit increase in ln-labor productivity translates to an additional 0.81 week in robustness. Pre-pandemic process innovation is insignificant in the baseline sample and only weakly significant for exporters. Compared to the baseline sample, pre-pandemic product innovations of exporters have slightly lower average marginal effect which is significant only at 10 percent. Consistent with H2 and H3, this suggests that withstanding prolonged disruptions rely more on firm-level efficiency (i.e., the labor productivity effect) rather than innovativeness. Interestingly, all aggregate and idiosyncratic shock variables are insignificant for exporters' robustness, suggesting that the largest, most efficient, and most robust exporters were well-equipped to endure more severe and protracted pandemic disruptions. Similar to earlier results, vaccine delay is highly significant for robustness in the baseline sample partly because it includes establishments whose operations are conditional on less stringent mobility and social distancing regulations (e.g., retail, hotels, restaurants, and transport services).

In terms of emergency responses, only one product-innovative strategy has a significant positive effect on the robustness of exporters: introducing new or improved products or services significantly extended exporters' expected robustness by 1.7 weeks. This suggests that the most radical technological innovations amidst highly volatile wild card crises are only viable for the strongest exporters. All other strategies are insignificant, with the exception of converting production line or services offered which effectively slashed surviving exporters' expected robustness by 1.5 weeks. This supports our earlier arguments that most of the business strategies implemented by establishments during the lockdowns were last-ditch attempts of struggling firms to avoid exit.

For resilience, only size has a significant effect on exporters' expected speed of recovery: a unit change in ln-employment shortens the recovery period by 0.69 month. Unlike in the baseline sample, labor productivity has no significant effect on the resilience of exporters. This also contradicts the highly significant contribution of labor productivity to exporters' robustness. While endurance was intuitively driven by efficiency amidst economic hibernation, firm-level resilience was limited by the rebound of global economic activities; that is, efficiency-enhancing adjustments cannot completely support recovery amidst weak demand and pessimistic economic prospects. Similar to the robustness model, ln-stringency and ln-vaccine delay are insignificant for exporters' resilience. However, having experienced idiosyncratic supply and demand shocks delayed the expected recovery period of exporters by three to four months. This means that how aggregate shocks were felt at the firm-level matter more for the individual recovery of exporters. In terms of emergency responses, cost-cutting measures such as furloughing some workers, temporarily closure, doing online business transactions, and discontinuing some products or services have significant but negative effects on the speed of rebound. Most notably, surviving exporters that discontinued some products or services were expected to prolong recovery period by 2.6 months. These results confirm our earlier findings that many emergency innovations and business adjustments implemented by establishments during the lockdowns were likely signs of distress rather than significant boosters of survival, robustness, and resilience. With a limited window for learning, the insignificance of most emergency innovations also implies that exporters were experimenting to test what strategies would work. This is consistent with the observation of Lien and Timmermans (2024) that firms negatively affected by the pandemic had stronger motivations to innovate. However, our analysis suggests that whether these motivations translate to positive outcomes during crisis times is another matter.

Interestingly, having received government support within the first six months of the pandemic has a positive and significant effect in the resilience model. This suggests that among surviving exporters, firms that received government assistance were also expecting a slower rebound to pre-pandemic level of sales. On a positive note, this suggests a good targeting system given that the aid beneficiaries were actual firms in distress. In contrast, government support is insignificant in the robustness model, indicating that the strongest exporters held their own amidst the lockdowns. This is consistent with the result of Kozeniauskas et al. (2022) that high-productivity firms were less likely to take up government support during the pandemic. The foregoing results suggest that while the interventions implemented by the government partly improved exporters' survival prognosis, speedy recovery from the shocks required a different set of policies (e.g., fast-tracking vaccination and easing the supply and demand shocks).

Table 5. Negative Binomial Regressions for the Robustness and Resilience, average marginal effects

Variable	Robustness (weeks)		Resilience (months)	
	All firms	Exporters	All firms	Exporters
Employment size (ln)	0.453***	0.679***	-0.566***	-0.691***
	(0.140)	(0.197)	(0.108)	(0.159)
Age (ln)	0.034	-0.372	0.010	0.389
	(0.237)	(0.388)	(0.180)	(0.292)
Labor productivity (ln)	0.296*	0.810***	-0.269**	-0.070
	(0.155)	(0.243)	(0.104)	(0.175)
Pre-pandemic process innovation (dummy)	0.411	0.954*	0.068	-0.202
	(0.404)	(0.568)	(0.321)	(0.456)
Pre-pandemic product innovation (dummy)	1.095***	0.904*	-0.168	0.106
	(0.386)	(0.500)	(0.266)	(0.401)
Foreign equity ≥ 10% (dummy)	0.568	0.048	-0.407	-0.701
	(0.492)	(0.617)	(0.405)	(0.488)
Baseline: No exports and no imports				
Importer only (dummy)	0.865**		0.371	
	(0.414)		(0.311)	
Exporter only (dummy)	1.232**		0.481	
	(0.546)		(0.419)	
Importer & exporter (dummy)	1.356***	-0.009	0.504	-0.030
	(0.431)	(0.539)	(0.343)	(0.427)
Stringency index (ln)	-26.186	-7.989	16.304	1.612
	(18.600)	(32.866)	(10.591)	(3.588)
Vaccine delay (ln)	-158.419**	-48.981	73.110*	-13.729
	(70.67)	(122.557)	(40.155)	(9.740)
Government support (dummy)	0.080	0.343	0.492*	0.927**
	(0.323)	(0.519)	(0.253)	(0.389)
Baseline: No negative idiosyncratic shock				
Negative supply shock only (dummy)	-0.326	0.678	1.768***	3.355***
	(0.780)	(1.507)	(0.626)	(0.952)
Negative demand shock only (dummy)	-0.529	0.036	3.320***	4.040***

	(0.488)	(0.699)	(0.388)	(0.609)
Negative supply & demand shocks (dummy)	-0.703*	0.099	3.520***	3.609***
	(0.373)	(0.554)	(0.314)	(0.490)
Furloughed some workers	-0.795**	-0.663	0.906***	0.983**
	(0.342)	(0.527)	(0.248)	(0.384)
Reduced total operations hours per week	-0.137	-0.816	0.177	0.580
	(0.349)	(0.553)	(0.255)	(0.413)
Increased the number of temporary workers	0.004	-	1.055***	0.470
	(0.385)	-	(0.263)	(0.434)
Temporarily closed	-0.658*	-0.017	1.214***	1.350***
	(0.350)	(0.553)	(0.251)	(0.400)
Converted production line or services offered	-1.872***	-1.509***	0.552**	0.628
	(0.318)	(0.503)	(0.257)	(0.411)
Started or increased business activity online	0.338	-	0.154	1.051**
	(0.342)	-	(0.260)	(0.448)
Started or increased remote work setup	0.798**	-	0.174	-0.323
	(0.313)	-	(0.266)	(0.390)
Introduced new or improved products or services	1.429***	1.717***	-0.221	0.469
	(0.446)	(0.632)	(0.318)	(0.514)
Discontinued some products or services	-1.134**	-0.608	2.221***	2.566***
	(0.464)	(0.707)	(0.307)	(0.452)
Country fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
No. of observations	4,987	2,059	4,658	1,939
$\hat{\alpha}$ (overdispersion parameter)	0.593***	0.547***	2.432***	2.715***
Log-pseudolikelihood	-15709.068	-6655.286	-11031.923	-4350.681
LR χ^2	-	-	751.31***	753.88***
AIC	31546.14	13428.57	22191.85	8823.362
Pseudo-R^2	0.038	0.034	0.028	0.036

Source: Author's estimates
*** $p < 0.01$,** $p < 0.05$,* $p < 0.1$
Numbers in parentheses are robust standard errors. Some emergency innovations were excluded in columns 3 and 5 due to convergence issues.

5. Concluding Remarks

This study assembled a large cross-country firm-level dataset using the WBES and COV-ES to analyze the potency of exporters' pre-crisis capabilities, emergency innovations, and business adjustments as survival tools amidst the economic hibernation induced by wild card COVID-19 shocks. The stylized facts suggest that exporters, especially those with GVC linkages, had better survival prognosis than non-exporters despite the former's larger exposure to global shocks (H7). This is confirmed by the parametric Weibull AFT regressions, which identified labor productivity and GVC linkages as the most robust pre-crisis characteristics that contributed to exporters' survival amidst pandemic-induced disruptions (H6). However, the effect of pre-pandemic innovations was mixed across models, which indicates that the positive impact of innovativeness on firm's overall health during benign periods may not necessarily contribute to survival, robustness, and resilience amidst the massive disruptions generated by COVID-19. Of the aggregate and idiosyncratic shocks analyzed, stringency and simultaneous negative supply and demand shocks significantly accelerated the failure time of exporters (H4); while the duration of disruptions (as proxied by vaccine delay) seemed more relevant in the speed of recovery. In terms of emergency responses to the disruptions, the stylized facts showed that non-technological retrenchment measures were more prevalent than revenue-raising innovations. Moreover, exporting is positively related with positive technology-intensive emergency innovations, while negatively related with drastic negative business adjustments (H1, H2). Nevertheless, the Weibull and negative binomial regressions suggest that most of these emergency responses were either insignificant or negatively related to exporters' survival, robustness, and resilience. With a limited window for learning effective strategies, this implies that the documented emergency innovations and business adjustments were likely signs of distress and mainly used as trial-and-error last-ditch efforts to avoid exit (H3).

Consistent with the self-selection hypothesis, the empirical results suggest that exporters with superior productivity before the COVID-19 pandemic were less likely to be weed out by the crisis. Moreover, exporters with superior capabilities proved more robust and resilient amidst the economic hibernation caused by the lockdowns. Against this background, the insignificance of government support in the survival and robustness models and the negative relationship with resilience raise important questions on what forms of government intervention are appropriate during times of crisis (H5). Could expanding the size and types of public support have saved more firms from the cleansing effect of COVID-19 shocks? But given the dwindling resources due to recession, should government aid have been given to relatively unproductive firms that are still bound to fail due to the forces of creative distraction? Or should financial support be given directly to the employees of those struggling firms? The significance of relaxing stringent containment measures and fast-tracking vaccination vis-à-vis the insignificance of government aid also raises the question of whether government efforts should instead be directed towards improving the business and regulatory environment during disruptions. These are important issues that warrant a closer look in future research and policy discussions.

A key message suggested by our analysis is that the best time to have prepared for a massive disruption such as COVID-19 was many years before the shock hit. As the results suggest, firms with better pre-crisis attributes were also the most robust and resilient during the pandemic. However, their superior capabilities were built through many years of learning and accumulating experience. This highlights the advantage of early investment in R&D, technological capabilities, and strategic planning skills. Not only do they drive growth, they also future-proof the firm against wild card shocks. Governments may consider interventions that improve access to these resources, especially by smaller firms. Reducing the cost of doing business, particularly during disruptive wild card episodes, cannot be overemphasized.

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Appendix 1. Distribution of the Baseline Cohort of Firms

Country	Region	Status[a]	Non-Exporters	Exporters	Total
Bulgaria	Europe	UM	347	186	533
Croatia	Europe	H	166	179	345
Cyprus	Europe	H	212	52	264
Czech Republic	Europe	H	153	250	403
Estonia	Europe	H	131	143	274
Georgia	Central Asia	UM	360	148	508
Greece	Europe	H	297	234	531
Hungary	Europe	H	330	291	621
Italy	Europe	H	263	153	416
Jordan	MENA	UM	348	155	503
Latvia	Europe	H	135	108	243
Lithuania	Europe	H	114	100	214
North Macedonia	Europe	UM	177	114	291
Malta	Europe	H	131	64	195
Moldova	Europe	UM	207	78	285
Mongolia	East Asia	LM	276	22	298
Morocco	MENA	LM	508	250	758
Poland	Europe	H	695	252	947
Portugal	Europe	H	465	301	766
Romania	Europe	H	369	158	527
Slovak Republic	Europe	H	211	119	330
Slovenia	Europe	H	83	165	248
Zambia	Sub-Saharan Africa	L	436	121	557
Total			6,414	3,643	10,057

Source of data: WBES

[a] L – low income, LM – lower middle income, UM – upper middle income, H – high income

Appendix 2. Description of Main Variables Used

Variable	Unit	Description	Source
Dependent variables			
Failure status	Dummy	1 if permanently closed at the date of censoring	COV-ES
Failure time	Months	Number of months from February 2020 until permanent closure or date of censoring	COV-ES
Robustness	Weeks	Number of weeks the establishment expects to remain open without sales and without adjustment in cost structure	COV-ES
Resilience	Months	Number of months the establishment expects its sales to go back to normal level	COV-ES
Characteristics in the baseline (pre-pandemic) survey			
Employment	Persons	Number of employees	WBES
Age	Years	Number of years since the establishment started operations	WBES
Labor productivity	ln	Natural logarithm of sales per worker	WBES
Process innovation	Dummy	1 if establishment introduced new or significantly improved process within last three years	WBES
Product innovation	Dummy	1 if establishment introduced new product or services within last three years	WBES
Exporter	Dummy	1 if establishment has direct or indirect exports	WBES
Importer	Dummy	1 if establishment imported inputs	WBES
Foreign	Dummy	1 if foreign equity ownership ≥ 10%	WBES
COVID-19 shocks			
Stringency	Index	Average of daily stringency level from Q2 to Q3 of 2020	OWID
Vaccine Delay	Days	Number of days from February 1, 2020 to the first day of recorded COVID-19 vaccination in the country	OWID
Demand Shock	Dummy	1 if demand for establishment's products and services decreased	COV-ES
Supply Shock	Dummy	1 if establishment's supply of inputs and raw materials decreased	COV-ES
Govt. Support	Dummy	1 if establishment received any national or local government support in response to the crisis	COV-ES

COV-ES – World Bank COVID-19 Follow-up Surveys, WBES – World Bank Enterprise Surveys, OWID – Our World in Data