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Firm-level Digitalization and Resilience to Shocks:

Role of Fiscal Policy

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Firm-level Digitalization and Resilience to Shocks: Role of Fiscal Policy

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May 2023

ABSTRACT: Would digitalization at firm level strengthen firms' resilience to shocks? And if so, could fiscal policy play any role to promote firm-level digitalization? This paper empirically explores answers to these questions. Based on a local projection method (using the Orbis data covering 1.8 million non-financial firms from 53 countries), we estimate the impacts of aggregate uncertainty shocks on firms' sales, profit margin, and employment. The findings suggest that uncertainty shocks affect digitalized and less-digitalized firms very differently. Digitalized firms weather shocks better, with smaller drops in sales and profits, while less-digitalized ones are worse off, with long-lasting scars. Then we examine the impact of fiscal interventions to promote firms' digitalization, using cross-country panel data (covering 64 countries). The result suggests that aligning the tax regime on digital services with general taxation principles and competitive procurement rules on digital products could effectively support the promotion of firm-level digitalization. Overall, our findings point that firm-level digitalization would help strengthen firms' resilience to a shock, and fiscal interventions can play an important role to promote firm-level digitalization.

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WORKING PAPERS

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TABLE

Glossary

AEs	Advanced Economies
DAI	The World Bank's Digital Adoption Index
DTR	Digital Trade Restrictiveness
EIU	Economic Intelligence Unit
EMs	Emerging Markets
EMDE	Emerging Makets and Development Economies
FTE	Fiscal Transparency Evaluation
GDP	Gross Domestic Product
GFC	Global Financial Crisis
ICT	Information and Communication Technology
IOT	Input-Output Table
LICs	Low-Income Countries
OECD	Organisation for Economic Co-operation and Development
SIR	Susceptible-Infected-Removed
SME	Small and Medium-sized Enterprises
WUI	World Uncertainty Index

Executive Summary

Would digitalization at firm-level strengthen firms' resilience to shocks? And if so, could fiscal policy play any role to promote firm-level digitalization? This paper empirically explores answers to these questions. Based on a local projection method (using the Orbis data covering 1.8 million non-financial firms from 53 countries), we estimate the impact of aggregate uncertainty shocks on firms' sales, profit margins, and employment. The findings suggest that uncertainty shocks affect digitalized and less-digitalized firms very differently. Digitalized firms weather shocks better, with smaller drops in sales and profits, while less-digitalized ones are worse off, with long-lasting scars. Then, we examine the impact of fiscal interventions to promote firms' digitalization, using cross-country panel data (covering 64 countries). The result suggests that aligning the tax regime on digital services with general taxation principles and competitive procurement rules on digital products could effectively support the promotion of firm-level digitalization. Overall, our findings point that firm-level digitalization would help strengthen firms' resilience to a shock, and fiscal interventions can play an important role to promote firm-level digitalization.

I. Introduction

1. **Experiences with shocks (including the COVID-19) reaffirm the importance of securing resilience to shocks**. Following large shock events (e.g., global financial crisis, COVID-19), a number of studies reiterated the criticality of building resilience and the role of the government to build resilience. The April 2022 World Economic Outlook, for instance, focused on the overall resilience of global trade and value chains during the pandemic, noting "*while much of the work of building resilience must be undertaken by firms (as private sector actors), governments can still play a useful role by filling information gaps in supply chains, investing in trade and digital infrastructure, reducing trade costs, and minimizing policy uncertainty*." Further, the October 2022 Fiscal Monitor pointed fostering resilience as a key role of government.[1] Whilst heightened global uncertainty, fast progress in digitalization has fundamentally changed macroeconomy, requiring new government roles in promoting or regulating it (Agrawal and Bütikofer, 2022; Goldfarb and Tucker, 2019; Bar-Isaac et al; 2012). Fiscal policy could promote digitalization, though its impacts have not been fully examined in empirical studies.

2. **To build firm-level resilience, the role of digitalization is well understood, albeit with limited empirical evidence**. The rapid adoption of digital technologies in the private economy has boosted firm productivity through innovation, which contributes to stronger resilience to global shocks. In the context of the pandemic, it further strengthens firm-level resilience, as it would enable business continuation and labor-input diversification. Recently, literature has provided empirical evidence that supports the benefit of digitalization (IMF, 2022a; Copestake et al, 2022; Abidi et al, 2022; Cirera et al, 2021). However, most of them deal with specific countries or regional contexts, which lack external validity. The empirical studies that quantify the cost of digitalization ("digital divide") are also scarce.

3. **This paper focuses on the role of digitalization in building resilience to shocks**. Specifically, using large firm-level panel datasets (1.8 million non-financial firms from 53 countries), the paper estimates the heterogeneous effects of firm-level digitalization in building firms' resilience to uncertainty shock (in terms of firms' sales, profit margins, and employment) using a local projection method. The application of local projection fits our objective given the flexibility in accommodating non-linearity (in our case, a regime switching structure) in the linear regression specification. Further, to unpack the policy driver of firm-level digitalization, we also examine what fiscal policies are more effective in promoting firm-level digitalization. To explore this, we set up a cross-country database (Digital Trade Restrictiveness (DTR) index) that provides a score on the fairness of each country's fiscal institutions (with regard to taxation, custom policy, and procurement) on digital activities for 62 countries.

4. **Key findings of this paper are as the following:**

- Uncertainty shocks create significant heterogeneity between digitalized and less-digitalized firms. Digitalized firms weather shocks better, while less-digitalized ones, especially in the service sector, are worse off, with long-lasting scars.
- Digitalization at firm-level could thus create distinctive inequality in financial performance across firms. Among loss-making firms, the lack of digitalization makes the negative shock even larger and longer

[1] Resilience is defined as "*the ability for households and firms to recover from or successfully adjust to challenges such as macroeconomic crises, pandemics, climate change, or the cost-of-living squeeze associated with spikes in food and energy prices.*"

lasting. In contrast, some digitalized firms could have positive profits even during the crisis by taking advantage of market power especially in emerging markets and developing economies.

- We find mixed results on the digitalization effect on employment. In the short-term, digitalized firms could increase job offering, while in the long-run, the result shows a decline in employment for digitalized firms, possibly reflecting labor substitution with automation.
- Fiscal interventions could support the promotion of firms' digitalization. Fairness and even-handedness of fiscal institutions – specifically, taxation on digital transaction in alignment with the general taxation principles (as set in the Ottawa Taxation Framework Conditions),[2] and competitive procurement rule on digital products – could help effective facilitation of firm-level digitalization.

These findings have important policy implications. First, governments may need to expect long-lasting scars for firms after shocks (if they are not digitalized), which might require support for a longer period: Second, some loss-making firms may not recover after shocks, posing a question on the effectiveness of governments' blanket supports for those affected firms after uncertainty shocks: Finally, governments should play an active role in encouraging firm-level digitalization by establishing fiscal institutions on digital economy on the basis of international taxation principles and open market competition.

5. **This paper is organized as follows**. Section II describes the literature review. Section III explains data and summary statistics. Section IV presents the local projection analysis on the mitigation effect of firm digitalization against aggregate uncertainty shocks, and section V analyzes the role of fiscal policy in promoting firm digitalization. Section VI concludes.

II. Literature Review

6. **There are methodological challenges to measuring digital economy, and several studies use survey-based data to analyze digitalization**. As the Digital Revolution progresses, there is an increasing demand for measuring the economic effects of digitalization. However, the measurement of digitalization in economic statistics requires an update in the International Statistical Standards, which is yet to be established (Moulton et al, 2022). To measure digitalization across firms, literature typically conducts special surveys to directly measure individual firm's status of digital adoption (e.g., e-commerce, work-from-home, use of ICT) (Barrero et al, 2021; Bloom et al, 2015; Kawaguchi et al, 2022). There is, however, no survey conducted across countries, and thus a survey-based study is country-specific, without providing a consistent measure comparable across countries for a global analysis.

7. **A few recent studies—mostly using country or region-specific survey results—provided empirical evidence that supports the benefit of digitalization during economic downturns (Abidi et al, 2022; Cirera et al, 2021)**. These studies highlighted the benefits of digitalization in alleviating scars on firm sales and employment. However, most of them deal with specific countries or regional contexts, which do not provide broader cross-country perspectives. One exception is Copestake et al (2022). They use a global sample of listed non-financial corporations (from S&P Capital IQ) to quantify the role of digitalization in improving the resilience of the economy to typical recessions as well as the COVID-19.

[2] OECD (2003) Implementation of the Ottawa Taxation Framework Conditions: The 2003 Report.

8. **Several studies argued for the role of fiscal policies in spurring innovation and helping overcome barriers to digitalization.** As featured in the 2016 Fiscal Monitor ("Fiscal Policies for Innovation and Growth"), fiscal policy can play a role in stimulating innovation through its effect on Research and Development (R&D), entrepreneurship, and technology transfer (IMF, 2016; Gaggl and Wright, 2017; Bloom et al, 2022; Griffith et al, 2001). A few papers examined whether government policies could alleviate supply- and demand-side barriers for digital adoption. For example, public investment in digital infrastructure will improve digital accessibility and help overcome supply-side constraints (Hjort and Poulsen, 2019; Akerman et al, 2015; De Stefano et al, 2014). Fiscal support for training or liquidity support to firms could incentivize their digital adoption by reducing demand-side barriers (human capital, liquidity constraint) (Bloom, Draca et al, 2010). Besides public investment, training, and liquidity support, government can promote or regulate transactions of digital goods and services through taxation, procurement, or other interventions. To our best knowledge, there have not been any empirical studies that examine how the quality of fiscal institutions matter in a firm's digital adoption.

9. **We contribute to the literature by providing robust global evidence on the size of producer surplus as well as the gap in a firm's financials created by digitalization.** Our analysis uses detailed balance sheet and income statement data from Orbis that covers both listed and non-listed corporations in advanced, emerging market and developing economies. With the comprehensive sample coverage, including small non-listed ones, we can better estimate the heterogeneous effect of digitalization after the shock, by further examining empirical results by sub-groups of firms (loss-making vs. others, by varying age and size of firms). In this sense, the analysis provides representative estimates of the gap in firm's financials after the global shock caused by the digital adoption.

III. Data

A. Orbis Data

7. **We use the financial data for unconsolidated accounts and descriptive data on the company's basic characteristics and their industry classification**. The analysis focuses on non-financial private companies (both listed and non-listed) and excludes state-owned enterprises (for ones whose global ultimate owners are type "S" in the data). After performing data cleaning, the main analysis uses Orbis data that cover about 1.9 million listed and unlisted private non-financial corporations in 53 countries (78 percent Advanced Economies (AE) and 22 percent Emerging Market and Developing Economies (EMDE)) from 2000 to 2017.[3] We retain corporations with at least five annual observations to have sufficient within-company variations and to avoid cyclical shell companies.

- Appendix tables 1 and 2 provide the country and sector compositions in the sample. The sample represents more firms operating in AEs. Fifteen percent is manufacturing firms, and 26 percent of firms engage in wholesale and retail business. Table 1 provides descriptive statistics of variables we use in the analysis. Firm sales and profits are converted to real terms using each country's GDP deflator, which are

[3] First, we drop any observation that has either negative assets, tangible assets, negative employees, or negative sales. Then, we drop any observations that have missing for all of the following variables: total assets, sales, numbers of employees, and total operating revenues. Finally, we drop any observations that are duplicated in the dataset. The sample of our data is from 1998 to 2017. We drop observations that do not have an industry classification. We drop observations that have negative cost of employees and operating revenue. We drop observations that have negative or zero values for total assets and employees.

winsorized at top and bottom 1 percentile. In Panel A, the average firm sales and capital intensity are significantly larger for firms in AEs than ones in EMDEs. However, the average firm size (the number of employees) and profit margins are larger in EMDEs, showing that for AEs, firms in the sample are mostly small and medium-sized enterprises (SMEs).

Table 1. Summary Statistics

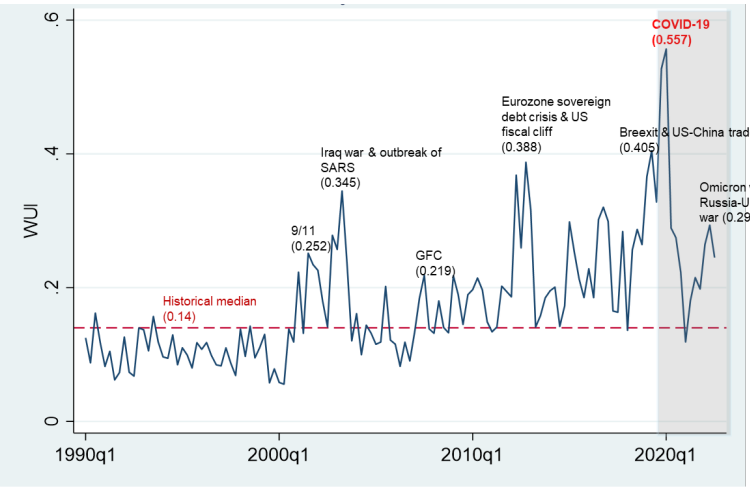
		Advanced economies (AEs)				Emerging & Low-income economies (EMDEs)			
	Sources	N	Mean	Std. dev	Median	N	Mean	Std. dev	Median
A. Firm-level outcome									
Log (sales)	Orbis	14,100,000	13.5	1.7	13.5	2,162,067	12.2	2.3	12.1
Profit margins	Orbis	14,300,000	0.03	0.21	0.03	2,756,365	0.06	0.26	0.05
Log employment	Orbis	14,700,000	15	49	5	2,841,703	41	130	7
B. Shock variable									
WUI shock	Ahir et al (2020)	14,700,000	0.21	0.11	0.19	2,841,703	0.21	0.14	0.18
C. Other variables									
Firm age	Orbis	13,300,000	26.1	12.5	23.6	1,787,633	21.3	9.0	20.3
Current ratio	Orbis	14,400,000	2.7	6.0	1.4	2,653,587	4.8	10.1	1.5
Log (asset)	Orbis	14,600,000	13.4	1.7	13.3	2,819,390	12.4	2.2	12.4
D_Primary	Orbis	14,700,000	0.02	0.1	0.0	2,841,703	0.06	0.2	0.0
D_Manufacturing	Orbis	14,700,000	0.16	0.4	0.0	2,841,703	0.20	0.4	0.0
D_Service	Orbis	14,700,000	0.82	0.4	1.0	2,841,703	0.74	0.4	1.0

B. The Aggregate Uncertainty Measure

8. **As the exogenous shock variable, we use the latest World Uncertainty Index (WUI) from Ahir, Bloom, and Furceri (2022)**. The WUI is a forward-looking quarterly index regularly updated based on frequency counts of the word “uncertainty” in the Economic Intelligence Unit (EIU)’s country reports for 143 countries from 1996.[4] The time series plot below (Figure 1) shows the weighted average of all countries WUI index with some spikes after major economic and political events (e.g., Iraq war and the 9/11, the outbreak of SARS and COVID-19, the GFC and Eurozone sovereign debt crisis). The timeseries of the WUI demonstrates that, after the global moderation, the world has been experiencing historically high (and rising) levels of uncertainty since the Global Financial Crisis (GFC).

[4] The WUI index has been applied to the analysis on COVID-19 (Baker et al, 2021), productivity growth (Adler, Duval, Furceri et al, 2017; Choi et al, 2019), and many country cases.

Figure 1. Time Series of the World Uncertainty Index, 1990Q1 to 2022Q3



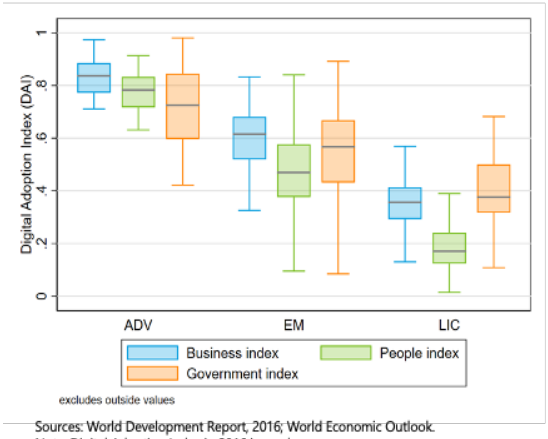
Source: Ahir, Bloom, and Furceri (2022).

C. Digitalization Measure

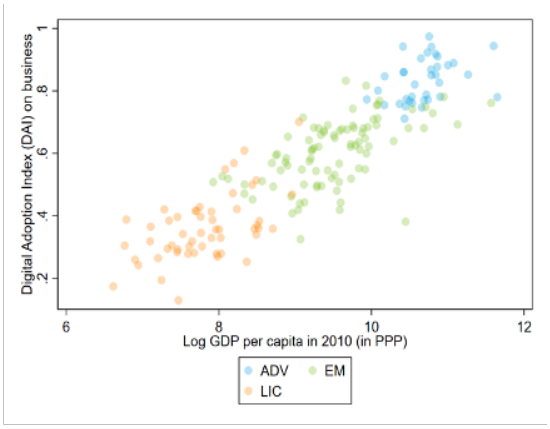
Country-level Digitalization Index

9. **We overview cross-country differences in digitalization speed using the World Bank's Digital Adoption Index (DAI)**. The sub-index disaggregates countries' digital adoption into three dimensions of the economy: people, business, and government. We focus on the DAI (Business), which is the simple average of four normalized indicators: the percentage of businesses with websites, the number of secure servers, the speed of internet, and 3G (third-generation) coverage. Figure 2 (left) compares the distribution of the DAI by income groups, showing a substantial digital gap between advanced (ADV), emerging markets (EM), and low-income countries (LICs). We can confirm that the level of digitalization in business tends to accelerate as a country's per capita income rises (right). While government digitalization progresses in LICs, the digital gap in the private sector is much deeper between advanced and developing economies. Motivated by this fact, this paper casts different focus compared to government digitalization literature (Gupta et al, 2017), examining how fiscal policy could contribute to the promotion of economy-wide digitalization.

Figure 2. Description of the Cross-country Digitalization



Sources: World Development Report, 2016; World Economic Outlook.
Note: Digital Adoption Index in 2016 is used.



Firm-level Digitalization Index

10. **The impacts of digitalization on the economy often consist of measuring household and business uptakes of digital technologies and the intensity of digital activities in our daily lives and work**. This could be achieved by undertaking surveys of specific digital information and communication technology (ICT).[5] On the other hand, these metrics lack a monetary estimate of the value of production associated with digital activity nor quantify productivity gains from using digital technologies results. The impact of digitalization on traditional macroeconomic indicators (such as national accounts) is yet to be well identified. Further, despite the digital transformation occurring in the economy, the measurement of digitalization is still not visible in economic statistics (Moulton et al, 2022; Mitchell, 2021).

11. **For the analyses in this paper, we use the Input-Output Table (IOT) and Orbis data to construct firm-level digitalization index, following the recent literature**. We use OECD's harmonized IOTs that describe inter-sectoral flows of intermediate goods and services across 45 sectors. We define the digital (ICT)-related sector that comprises three sectors with relation to the use of ICT technologies in their production (including manufacturing of computer, electronic and optical equipment; telecommunication; and IT and other information services). For each individual sector j, we compute the share of intermediate inputs coming from the digital industry out of sector j's total intermediate outputs ("digitalization" component of the right-hand side of the equation below). This provides disaggregated variations of intermediate transactions of digital products across sectors over the years. Using the Orbis data, we then multiply by each firm's previous year's total outputs to proxy the monetary value of firm-level digital intensity, scaled by the asset size, to create a granular firm-level digital transaction index.[6] For this indexation, we map Orbis's NACE (Nomenclature of Economic Activities) code to OECD's IOT sector classification at two-digit level. The firm-size adjusted measure of digitalization is defined as follows.

$$D_{ijc,t} = \underbrace{\frac{m_{jc,t}}{x_{jc,t}}}_{\textbf{digitalization}} \cdot \underbrace{\frac{X_{ijc,t-1}}{Asset_{ijc,t-1}}}_{\textbf{firm size adjustment}}$$

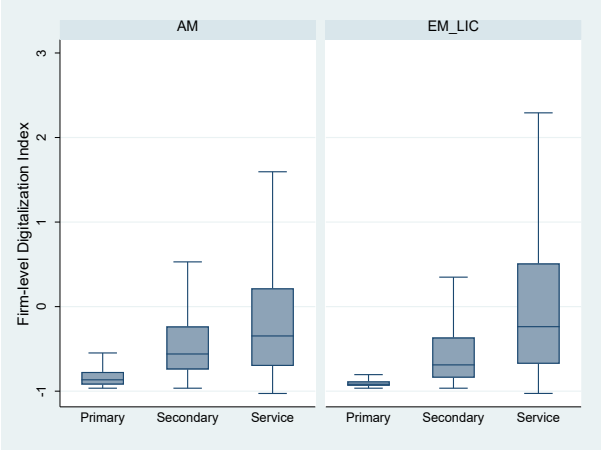
where m_j: digital intermediate inputs (the use of digital products and services) for production in each sector, x_j and X_{ijt-1} are sector j and firm i's output; $Asset_{ijt-1}$ is total assets at year $t-1$ from the Orbis data.

12. **The firm-level digitalization index tends to be higher in service sectors and large-size firms (Figure 3)**. In the left chart, firm digitalization level is higher for the service sectors (information and communication technology, e-commerce in retail & wholesale, software; vs. face-to-face business-like restaurant and hotel) and some manufacturing sectors (production of IT equipment). Even after adjusting for the difference in firms' assets, our digitalization index is positively correlated with the number of employments (the binned scatter plot, right chart). This suggests an indication of scale economy (more digitalization for firms operating with larger labor inputs as benefit size rises for positive externality). Besides natural drivers (industry and firm size), the analysis explores fiscal policy as a potential driver of firm digitalization.

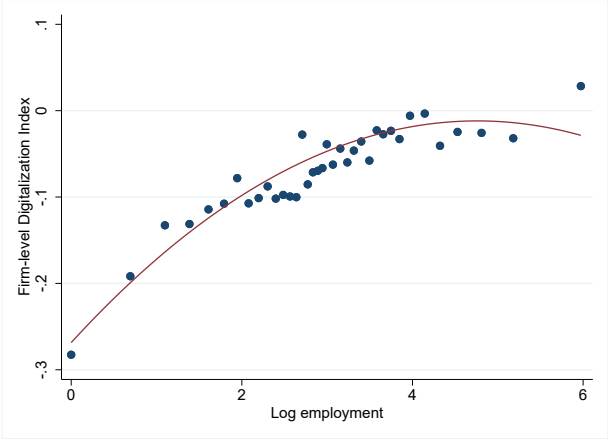
[5] For example, OECD Going Digital Toolkit (https://goingdigital.oecd.org) provides indicators useful for international comparisons.

[6] This assumes that the rate of digitalization is same within sector, but the diffusion of digital transactions in production rises for firms that make larger sales in the same market. This follows historical cross-country observations that the level of digitalization is greater for large businesses than small counterparts before the COVID-19 pandemic (Jaumotte et al, 2023). Other factors that affect firm-level digitalization include an access to broadband internet and firm manager's characteristics (e.g., eduction). However, Orbis does not provide such firm-level information consistently across countries.

Figure 3. Description of the Firm-level Digitalization



Sources: Orbis, OECD Input-Output Table, and author's calculation.



Note: Each dot corresponds to the binned average of firm-level digitalization index in 2015. The sample is divided into 100 equally-sized bins in the computation.

IV. Econometric Analysis

13. **We estimate the impact of aggregate uncertainty shocks on corporate performance regarding sales, profit margin, and employment**. The benchmark model is based on local projection method (Jorda, 2005; Ramey and Zubairy, 2018; Cloyne et al, 2018; Durante, Ferrando, and Vermeulen, 2020) using global uncertainty shocks to identinfy the magnitude and duration of the sacrs at individual firm level. We use the following baseline specification to estimate the impulse response functions after the shock.

$$y_{ijc,t+h} - y_{ijc,t-1} = \beta^h WUI_{c,t} + \gamma^h \mathbf{x}_{ijc,t} + \lambda_c + \phi_j + \delta_t + \varepsilon^h_{ijc,t} \quad (1)$$

where y_{ijct} is the outcome variables: real sales, operating profit margins (operating profits divided by revenues), and employment of firm i in industry j, country c at year t. WUI_{ct} is the change in the World Uncertainty Index (WUI) and $\mathbf{x}_{ijct}$ is a vector of control variables including firm's total asset (in log) and current ratio (current assets divided by current liabilities), and a lag of real GDP growth. Impulse response functions are computed using standard errors clustered by country-industry-year. We estimate eq. (1) for each $h = 0, \ldots 5$. $h = 0$ is the year when the uncertainty shock takes place.

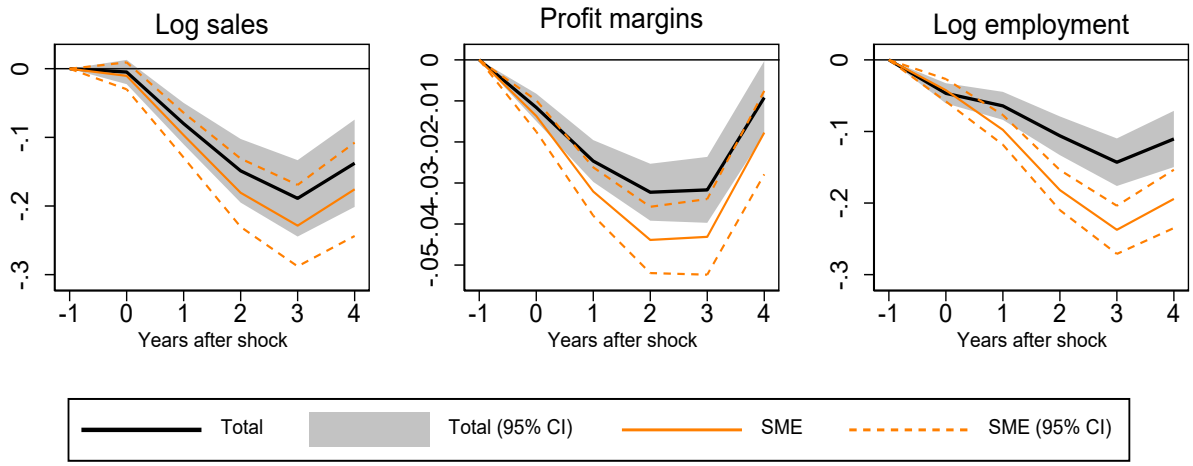
14. **We exploit large four-dimensional variations (firm-industry-country-year) in the firm-level dataset to mitigate concerns about possible reverse causation.** While the causality between uncertainty and macroeconomic outcomes is difficult to be identified, it is plausible that aggregate uncertainty affects firm-level performance than the other way around (Choi et al, 2018; Bloom, 2014). Country-specific policy factors (e.g., policy measures to support the economy) as well as unobserved cross-country heterogeneity in the macroeconomic shocks that affect productivity growth are controlled by country fixed effect λ_c . At the same time, industry fixed effects ϕ_j further accounts for the heterogeneity in shocks across industries along with

year fixed effect δ_t.[7] Once country-industry-year fixed effects are controlled for, it seems implausible that individual firm's productivity growth could influence aggregate-level uncertainty dynamics through other micro-level channels.

A. Baseline Results

15. **Our baseline results point at long-lasting scarring effects after a shock**. Figure 4 shows the impulse responses to the WUI shock β, which captures the scarring effect of aggregate uncertainty shock on firms' outcomes in the real economy. We consider the standardized uncertainty shock of10 percent, which is broadly equivalent to the magnitude of shocks the world experienced after major crises in recent history (e.g., 9/11 and the GFC) above the historical median level (Figure 1). After the 10 percent adverse shock at $t = 0$, the IR functions for the total sample (black line) show significant drops in sales (2 percent), profit margins (0.35 percentage points (pp)), and employment (1.6 percent) on average. The negative effect peaks in year three followed by a gradual recovery thereafter. For the sample of small-sized enterprises (less than 20 employees, orange line), the scarring effect gets even larger at the peak on profits and employments. Annex II confirms the robustness of this baseline result.

Figure 4. Local Projection Regression – Baseline Results



Source: Authors' estimates

Note: $t = 0$ is the year of the shock. Solid lines present the impulse responses (IR) of each outcome using Jorda (2005). The coefficient (y-axis) multiplied by 10 indicates the IR function in reponse to 10 percent increase in the World Uncertainty Index. Dashed lines denote 95 percent confidence intervals.

B. State-dependent Local Projection Estimation

16. **Based on the baseline LP model, we further examine our main research question – how much digital adoption contributes to building firms' resilience to uncertainty shocks**. The advantage of using

[7] For industry fixed effect, we use four-digit industry code (NACE4) to account for disaggregated industry-level heterogeneity within a sector.

local projection is the flexibility to accommodate non-linearity due to the degree of firms' digitalization. Instead of separating the sample into two states (digitalized vs. less-digitalized) using an arbitrary threshold value, we build a regime switching structure in eq. (1), which nests a smooth transition function $G(\cdot)$ as in Auerback and Gorodnichenko (2012), that jointly determines high vs. low digitalization regime in estimating the LP model:

$$y_{ij,t+h} - y_{ij,t-1} = \beta^{H,h} G(\widetilde{D}_{ijc,t}) WUI_{c,t} + \beta^{L,h} \left(1 - G(\widetilde{D}_{ijc,t})\right) WUI_{c,t} + \gamma^h \mathbf{x}_{ijc,t} + \lambda_c + \phi_j + \delta_t + \varepsilon^h_{ijc,t}$$
$$\text{where} \quad G(\widetilde{D}_{ijc,t}) = \frac{\exp(-\kappa \widetilde{D}_{ijc,t})}{1+\exp(-\kappa \widetilde{D}_{ijc,t})},\ \kappa > 0 \qquad (2)$$

where $\widetilde{D}_{ijc,t}$ is our firm-level digitalization index (as discussed in section III.C), which is normalized against global averages of digitalization for each year. We examine the difference in IR functions $\beta^{H,h} - \beta^{L,h}$, which captures the mitigation effect of firm digitalization (prior to the occurrence of shocks) to cope with the uncertainty shock. Same control variables and three error components are included in the regression.

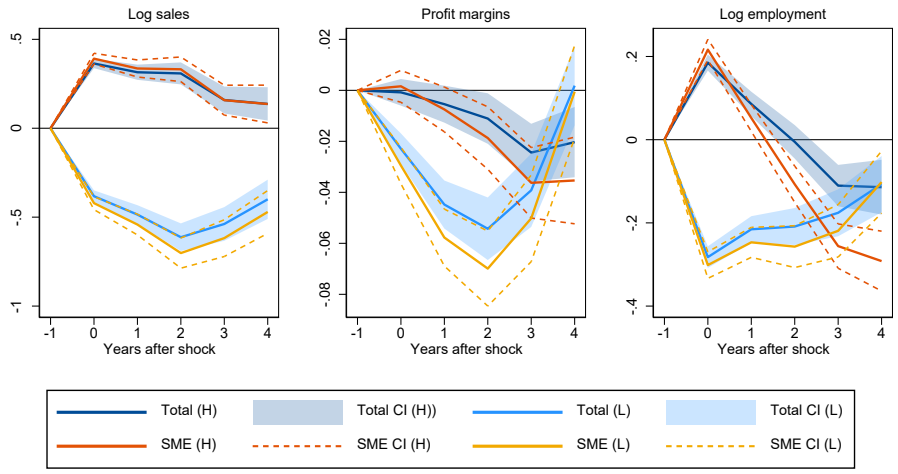
Results

17. **The results indicate significantly better corporate performance after a shock by firms with high digitalization, in terms of sales and profit margins (Figure 5, panel A)**. Less-digitalized firms tend to experience significantly larger drop in sales and profits immediately immediately after the shock. In the medium-term, less-digitalized firms strive to cut operational costs to restore their profitability. Similar results are observed for the sub-sample of SMEs. Panel B plots the impulse responses of the sub-sample of firms in the EMDEs. The difference in corporate performance in the medium-term is found to be particularly large in EMDEs. While financial and employment conditions remain negative for less-digitalized group, we find strong growth in sales, profit margins, and employment for digitalized group after the shock in EMDEs. Although the result looks counterintuitive, this likely reflects skewed market structure with high market concentration on particular firms in EMDEs (de Loecker and Eeckhout, 2021; Cirera et al, 2021). Such firms holding stronger market power could enjoy the benefits after the shock. On the other hand, less-digitalized firms have narrower adjustment margins to deal with global uncertainty shock and experience deeper and longer scars from the shock.

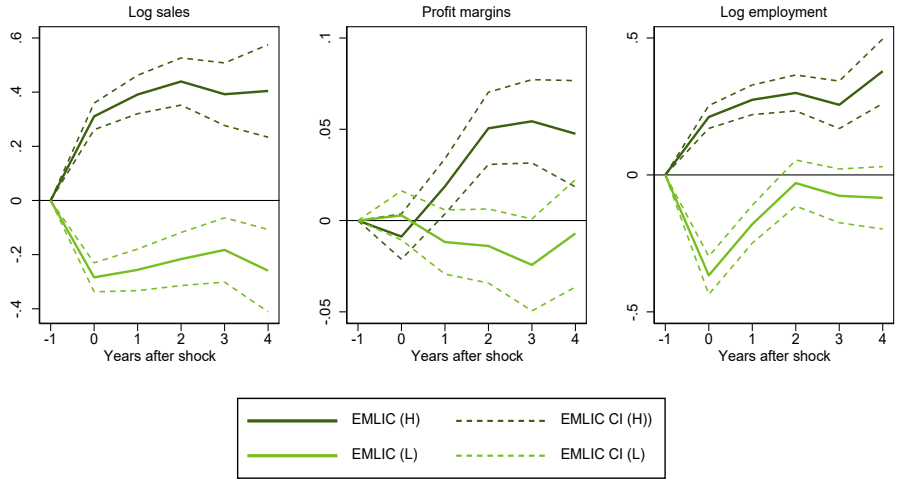
18. **The mitigation effect on employment is mixed (Figure 5, right)**. In the short-run, digitalization may initially mitigate disemployment effect of the shock. This is consistent with recent findings in IMF (2022a) that digitalized firms offer more jobs while less-digitalized firms need to save labor costs. In the long-run, employment trend reverses – digitalization seems to promote the decline in labor share (Grossman and Oberfield, 2022; Kehring and Vincent, 2021; Autor et al, 2020). This possibly reflects that digitalized firms try to be more efficient by substituting labor with technology (labor substitution with automation) (Acemoglu and Restrepo, 2019). The findings in this section suggest digitalization before the crisis could be an important insurance strategy to cope with shocks for the firms.

Figure 5. Local Projection Regression – Regime Switching Model Results

Panel A. Total and SME samples



Panel B. Emergin Market and Developing Economies sample



Source: Authors' estimates

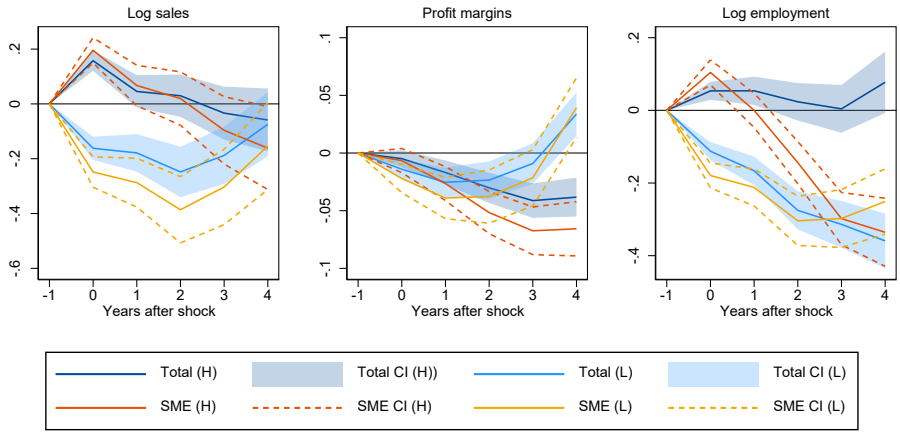
Note: Dashed lines denote 95 percent confidence intervals. In the legend, "H" denotes digitalized group and "L" denotes less-digitalized group as classified by the smooth transition function.

Heterogeneous Effect by Sector

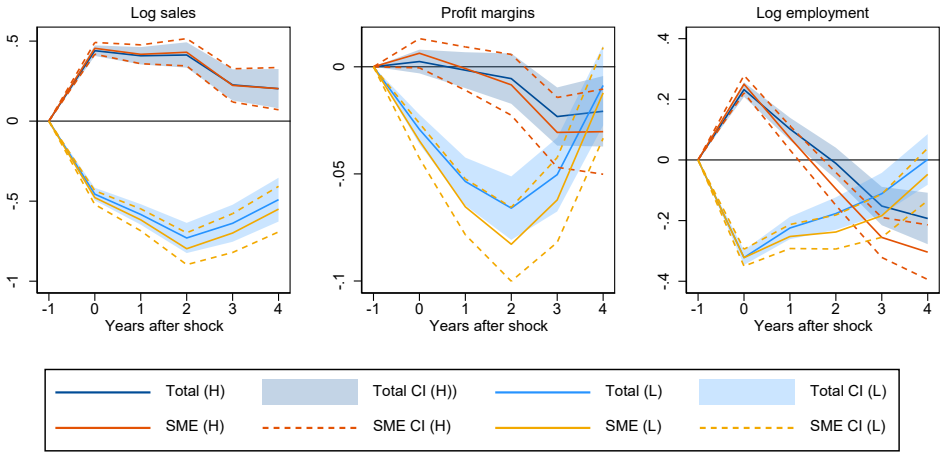
19. **We further analyze the effects by sector (by splitting the sample by manufacturing and service sector)**. As shown in Figure 6, similar patterns are observed for both manufacturing and service sectors, though the mitigation effect of digitalization is more salient in the service sector. The effect on the primary sector could not be precisely estimated given the limited sample size. Digitalization consistently creates winners vs. losers even within each industry group. In the service industry, there are a handful of digitalized firms that tend to benefit larger gains from digitalization process while less-digitalized firms face relatively larger losses. The larger digital gap between winners and losers indicates that the introduction of ICT is essential for firms in the service sector to compete and perform well in the market after the shock.

Figure 6. Local Projection Regression – Heterogeneous Effect by Sector

Panel A. Manufacturing sector



Panel B. Service sector



Source: Authors' estimates

C. Robustness Checks

20. **In light of concerns for possible endogeneity bias, the robustness of the result is tested on two fronts.** The level of digitalization could be correlated with firm or sector-level characteristics, posing a concern of endogeneity bias. For example, firms will be more digitalized if operating in a sector where digital technologies could be easily applied in their production of goods and services or marketing (e.g., online retail business). The capacity of adopting technologies would also depend on the firm's management practices or skill level. Thus, we perform two specification checks to confirm the robustness of our main findings to statistical bias due to endogenous digital adoption:

- **Control country- and industry-specific time trends** at the same time to minimize bias to β due to the selectivity of digital adoption (i.e., estimate may mix that firms performing well in the past are simply adopting digital technology) (middle panel in Figure 7)

- **Control firm-level fixed effect** instead of country-level fixed effect λ_c to account for the bias due to the presence of firm-level unobserved heterogeneity (the bottom panel in Figure 7). This specification addresses the potential bias underlying our firm-level digitalization measure, which omits unobservable firm characteristics (e.g., individual firm's access to broadband internet, manager's education level) that can be correlated with both digital adoption and firm performance.

21. **These robustness checks confirm similar results**. In both alternative specifications, the results present similar trajectory of IR functions to the baseline result (the top panel) though with larger effect size, showing the robustness of our main results.

First, the LP estimates with country- and industry-specific time trends deal with the endogeneity bias due to self-selectivity of firms, i.e., firms operating in a country with higher productivity growth are more likely to digitalize. With both trends controlled, the IR funcation shows similar or slightly larger impact on sales in the short-term (t=0 or 1) than the baseline result. We similarly find significant gaps in real sales and profit margins between digitalized and less-digitalized firms that sustain over time,

Second, instead of estimating the effect of uncertainty shock within country-sector-year level, we estimate eq (2) at firm-level utilizing the variations over years. The trajectory of the IR functions for digitalized and less-digitalized firms are similar to the baseline results (except that profits and employment of the digitalized group remains positive) and shows sizable gaps between two groups.

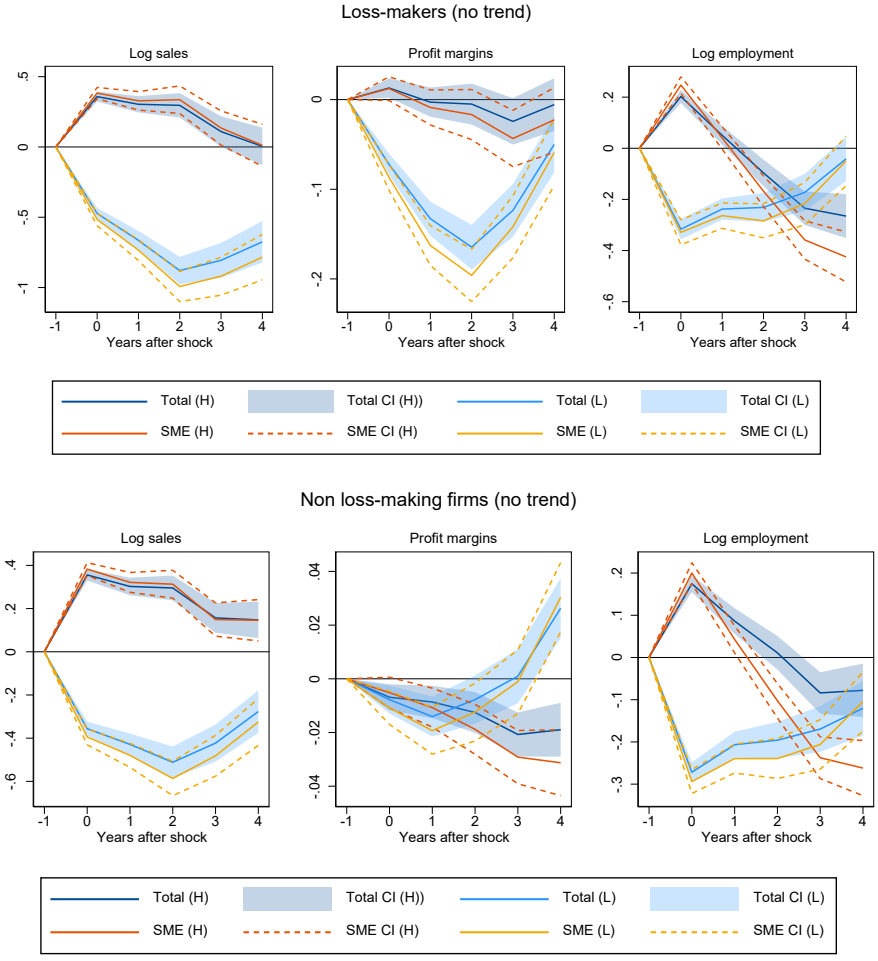
Figure 7. State-dependent Local Projection Regression – Robustness Checks

Source: Authors' estimates
Note: Dashed lines denote 95 percent confidence intervals. In the legend, digitalized and less-digitalized groups are classified by the smooth transition function.

D. Heterogeneous Effect by Initial Financial Performance

22. **Building on these results, we further examine if pre-shock corporate performance (profitability) would affect scarring effects**. Using the firm-level micro data, we track each firm's profitability from three years prior to the shock as their initial condition. We define "loss-makers**"** – firms that are consistently making losses for at least three consecutive years and are older firms (older than ten years of firm age) (in literature, often called "zombies") (upper panel of Figure 8).[8] We hypothesize that digital and disruptive technologies (e.g., artificial intelligence (AI), machine learning) is an important aspect to avoid zombification of small-medium enterprises as it facilitates the expansion of firms' productivity, market access, and cost reduction achieved through production innovation. For the loss-making firms without digitalization (upper panel), the IR function exhibits larger and longer negative scarring effect on sales and profits than other firms (lower panel) and remains negative for a longer period. The heterogeneity in terms of employment is not significant.

Figure 8. Zombification – Difference by Digitalization and Financial Performance



Source: Authors' estimates

[8] Our definition is broader than the usual definition of zombie firms (Caballero, Hoshi and Kashap, 2008). It is defined by firm's insolvency and age, while abstracting from the dependency on financial supports from governments and/or banks due to lack of details on non-concessional financing data available in Orbis.

23. **Based on this result, exploration of firm-level heterogeneity could have important implications on the government's support for the firms being hit by a shock**. From an individual firm's perspective, fiscal support is needed to keep business alive amidst the crisis. The loss-making firms, especially those categorized as zombies, urgently need government's liquidity support to survive. From government's perspective, while reorienting expenditure priorities towards firms hit by the shock is acknowledged as a policy priority (IMF, 2021), given the magnitude of the scarring effects on sales and profits (larger and longer), there may be very little prospect of recovery by *less-digitalized* loss-making firms. The support to these firms—provided in the form of loans or guarantees—could result in the accumulation of fiscal risks. Also, other forms of government support for those firms (e.g., grant) may not help improve their business prospects (in light of significant impacts on their sales). From a fiscal policy perspective, this finding sheds an important insight that digitalization should be one core aspect in designing the targeting rule (besides income-based targeting) of emergency fiscal supports during the crisis.

Box 1. Post-COVID Firm Dynamics: Application of the Results and Case Study

COVID-19 introduced a unique structural break, thus a usual out-of-sample forecasting using pre-COVID data is challenging. To predict post-COVID economic performance, recent macroeconomic literature developed micro-founded SIR (Susceptible-Infected-Removed) models of disease spread that are explicitly built on the trade-off between health risk and economic outcomes (Kaplan et al, 2022).

Acknowledging this caveat, we explore the implication of our findings for post-COVID firm dynamics. We use the above estimates based on pre-COVID 19 firm-level data together with available data on the size of the COVID uncertainty shock.[1] Assuming the WUI index captures some common features of historical global shocks including the COVID-19, we expect larger and longer scars on firms after the pandemic (particularly on less-digitalized firms, in service sectors) than the past crisis. As figure 1 shows, the size of the COVID uncertainty shock is about four times larger than the standardized 10 percent shock as assumed in our baseline analysis. Moreover, given that the pandemic limits face-to-face (physical) interaction, contact-intensive sectors (e.g., transportation, accommodation, food services) would be hit the hardest.

With the caveat mentioned above, the discussions above can be validated by micro-level evidence from recent empirical literature. (Box table 1). Literature draws on surveys that directly ask firm's digital adoption (e.g., World Bank Business Pulse Survey, original firm-level micro surveys) or construct some digitalization index based on sectoral data similar to ours. Overall, the results from the U.S., Asia, emerging and developing countries, support (a) deeper reduction in firm sales and employment after the COVID-19 relative to past crisis episodes and (b) significant role firm digitalization played in mitigating the adverse shocks particularly after the COVID-19.

Box Table 1. Recent Study on Digitalization and Resilience During the COVID-19 (Continued)

Study	Country/ Region	Data	Measure of digitalization	Method	Findings
A. Regional case studies					
Abidi, Herradi, Sakha (2022)	Middle East and Central Asia (13 countries)	EBRD-EIB-World Bank Enterprise survey	General proxy (access to website, email, technology)	DID	Digitalized firms faced smaller sales drop by about 4 p.p than less-digitalized firms
IMF (2022a), Copestake, Estefania-Flores and Furceri (2022)	Asia and Pacific region	NA	Sectoral digitalization (IT good and services input share)	DID	Firms in more digitalized industries recorded 3.4 percent higher sales revenues in a year. Hiring rates are higher in industries using more digital skills. For past recessions, the benefit of digitalization on sales is smaller at 1.4 percent and largest after two years.

Box Table 1. Recent Study on Digitalization and Resilience During the COVID-19 (Concluded)

Study	Country/ Region	Data	Measure of digitalization	Method	Findings
Cirera et al (2021)	38 mainly developing countries	World Bank Business Pulse Survey	General proxy (use of internet, digital platform; digital equipment, remote work)	Descriptive	COVID-19 accelerated digitalization unevenly by the severity of shock, market concentration, type of firms (larger firm, managerial skills etc), and access to government supports. 44 percent of business increased digital adoption.
B. Country case studies					
Kawaguchi, Kitao, Nose (2022)	Japan	Original online survey	Share of remote workers	Bartik IV	Firms initially adopted remote work faced smaller sales drop by 1.5 percent (1.9 percent for low-contact industries) to 10 percent mobility shock. Firms newly adapted to remote work could also shield mobility shock.
Bai et al (2021)	US	Compustat etc	Pre-pandemic Work-from-Home index	DID	Firms with high pre-COVID WfH index had significantly higher sales, net income, and stock returns during the COVID-19.
Pierri and Timmer (2020)	US	Current Population Survey	Establishment's IT adoption (IT budget per employees)	LPM	Local ICT adoption reduced an increase in unemployment rate by 2 p.p.
Cong, Yang, Zhang (2021)	China	Administrative firm data + original surveys	E-commerce, remote work, electronic information system	DID	Digitalized firms experienced smaller sales decline, sustained cash flow, and quick reopening

Note: DID = Difference-in-Difference, LPM = Linear Probability Model, IV = Instrumental variable.

[1] Our analysis in this paper focuses on the pre-COVID sample given limited available Orbis data for the post-COVID 19 period. In parallel, a companion paper (Nose, Honda, et al, forthcoming) will extend the sample to the latest available year after the COVID-19. It provides a focused assessment on the impact of firm digitalization on the post-COVID corporate performance and tax payment recovery after a sharp dip in tax revenue collection during the pandemic.

V. Impact of Fiscal Interventions on Digitalization

24. **How could firm-level digitalization be facilitated?** Of course, in the private sector, each firm would be incentivized to be better equipped with digital technologies as it generally leads to better corporate performance. Acknowledging the benefits of digitalization in facilitating innovation, driving productivity growth, and improving the efficiency of firm organization, each firm is encouraged to adopt and utilize digital technologies (Dabra-Norris et al, 2023; Bloom, Garicano et al, 2014; Bloom, Draca et al, 2010). While such an

incentive plays a critical role to further deepen and enhance firm-level digitalization, this does not necessarily imply that policy actions play no role to promote the digitalization.

25. **This section empirically explores the role of the government in promoting firm-level digitalization**. The government's role in leveraging digital transformation could be multifaceted. The adoption of digital technologies in fiscal operations ("GovTech") has the potential to improve the efficiency of public services (Gupta et al, 2017; Amaglobeli et al, 2023; Nose, 2023; Nose and Mengistu, 2023). Digital adoption by government may itself facilitate an economy-wide digital adoption by encouraging full use of digital solutions by users (citizens and firms). For example, recent literature finds that fintech application to government payments led to the formalization of small business and female's formal labor force participation, which resulted in wider use of digital technologies in the economy. As of today, many governments have initiated digital strategies, with private sector participation, to encourage firms to adopt digital technologies at the national level. This generally requires upskilling the economy, adoption of disruptive technologies in business transactions, and government's supports to Business-to-Business (B2B) start-ups with innovation digital solutions (World Bank, 2016).[9] Aside from the GovTech strategy, the government can also promote the digitalization in the private sector through specific tax and expenditure policy tools. In the literature, to the extent that we are aware, the relationship between GovTech, fiscal policies, and firm-level digitalization has not been empirically explored. This section provides descriptive cross-country evidence to discuss what fiscal policy measures could effectively promote digitalization.

26. **To empirically explore the government's role for firm-level digitalization, we use the fiscal DTR index.** Given the multifaced role of the government, identifying appropriate policy-related variables for analytical use—which are comparable across countries and contains time-series data—is a challenge. A specific policy action by a country (e.g., public supports to business R&D and training, legislative measures to protect data security, privacy protection) may promote firm-level digitalization, but the data for such a policy action is not available across countries for analytical use. We, however, find that the fiscal DTR can be used as fiscal policy measures on digitalization.[10]

- *The fiscal DTR index* measures the quality of fiscal institutions in supporting the adoption of modern technology. The "restrictiveness" index takes a larger value if a country's fiscal regime is against the general principles of tax policy (related to neutrality, simplicity, and fairness) (*a la* OECD (2003)) which hinders digitalization.[11] The sub-component of the fiscal DTR index is disaggregated into three

[9] For an example in the European Union, see https://www.eu-startups.com/2022/08/the-rise-of-govtech-why-startups-should-work-with-governments-sponsored/

[10] The DTR index—compiled by the European Centre for International Policy Economy (ECIPE)— covers 64 countries (in both AEs and EMDEs). It measures the level of regulations which a country imposes on digital transactions (with lower values indicate "digital friendliness" of the country's fiscal institutions) which takes value from 0 (supportive) to 1 (restrictive). The analysis exploits cross-country ratings on the degree of digital-related fiscal intervention using a granular DTR sub-index related to fiscal policies (hereafter "fiscal DTR index").

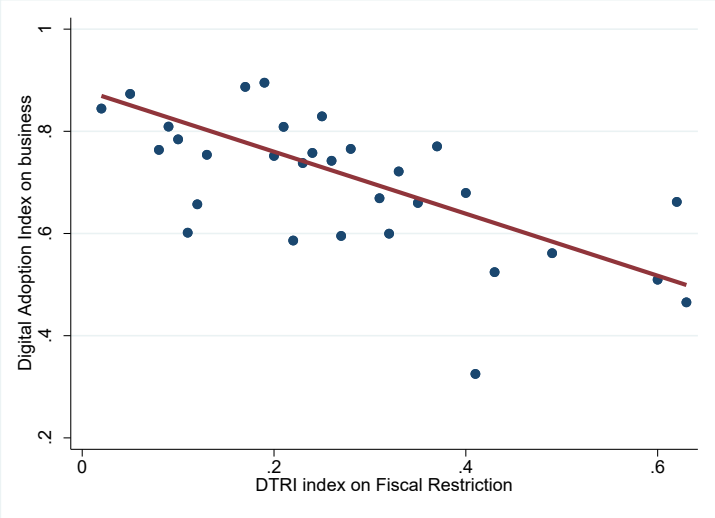
[11] Digital transformation involves the introduction of new technologies – digital platform, establishing credible digital infrastructure, intensive use of data analytics, cross-border Business-to-Business (B2B)/Business-to-Consumer (B2C) online transactions, machine learning and so on. All necessitate the openness to new technology and free market entry by foreign firms. In the DTR data, many countries have some regulations to hinder the digital transformation by regulating market through tax, restrictive tender criteria, and other regulation.

components: (a) tax regime on digital goods and online services, (b) tariffs on ICT trade, and (c) procurement rules on digital products.[12]

27. **As a stylized fact, we find a strong cross-country correlation between a country's digitalization level and a measure of fiscal interventions in the economy's digital activities**. As a measure for digitalization, World Bank's business Digital Adoption Index is used (see section III.C).

- The progress in digitalization and fiscal restriction are negatively correlated, controlling for each country's income level and regional differences. The results suggest more digitalization is associated with less fiscal restriction on digital activities (beyond the international standard).

Figure 9. Digitalization and Fiscal Restriction



Source: World Bank, ECIPE.

28. **Then we further explore the relationship between each sub-component of the fiscal restriction index and digitalization**. Specifically, based on the tobit model below, we examine how much digital-friendly fiscal institutions (i.e., less barrier for digital investments) increase digital adoption in the private economy. The fiscal restriction index is disaggregated into three types of fiscal institutions (taxation, custom policy, and procurement). We group countries by the quartile and sort them from the top (1st quartile is fiscally least restrictive) and 4th quartile is the least friendly (stricter regulations on digital activities). As the DAI censored above and below, the following two-limit Tobit model is used:

$$y^*_{crt} = \beta_q \sum_{q=1}^{2} D_{q,cr} + \gamma \mathbf{x}_{crt} + \lambda_r + \delta_t + \varepsilon_{crt}$$

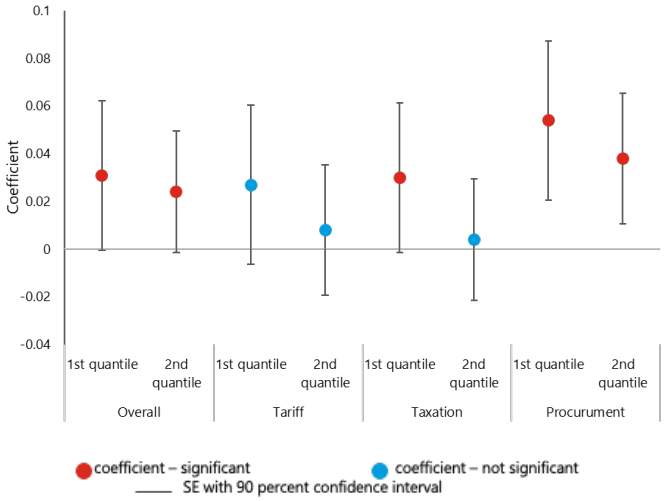
[12] Cases of discriminatory implementation of taxation are reported in ECIPE's database. Several EMs tend to have applied restrictive taxation schemes with unequal treatment (with targeting and ringfensing) by business types (Aslam and Shah, 2020), which fails to meet the basic principles of taxation). For example, tax systems in Brazil are reported to be complex, with many differential tax burden by the type of digital goods and services, VAT tax break, and duplications in tax duty (related to online sales, cross-border payments for software and cloud computing). The ECIPE database also reports many cases on restrictive procurement criteria (e.g., local content requirement, technology mandates in the tender) that limit the participation of foreign digital companies to enter local procurement process.

$$y_{crt} = \begin{cases} y^*_{crt} & \text{if} \quad 0 \le y^*_{crt} \le 1 \\ 0 & \text{if} \quad y^*_{crt} < 0 \\ 1 & \text{if} \quad y^*_{crt} > 1 \end{cases} \tag{3}$$

where y^*_{ct} is the DAI index, D_q is dummy variables corresponding to the 1st and 2nd quartile of each fiscal DTR index, and $\mathbf{x}_{ct}$ is macrovariables that affect a country's digital adoption level (such as income level, skill composition measured by tertiary education completion rate, broadband internet access, and financial development). λ_r and δ_t are region and year fixed effects.

29. **The results suggest that fiscal policy measures can play a role in facilitating firm-level digitalization**. Specifically, the coefficients for the top groups (fiscally least restrictive) —in terms of taxation scheme and procurement—are positive and statistically significant. The groups tend to significantly increase digital adoption by about 3 percentage points and 6 percentage points, respectively, compared with the groups of the bottom half (see Annex III for full results). Given that *the fiscal DTR* "restrictiveness" index mirrors compliance with the basic principle of sound taxation practices, the results indicate that aligning tax regime with international tax standards and having competitive bidding on digital good procurement (in line with Fiscal Transparency Evaluation (FTE) standard, remove barrier for cross-border digital investment, facilitate e-commerce, less corruption) seem effective in supporting firm digitalization. Custom regulations on ICT trade appear less significant.

Figure 10. Estimates for the 1st and 2nd Quartiles of DTRI Ranking (ordered based on the degree of policy supports)



Source: Authors' estimates

Note: Control variables include log GDP per capita, tertiary education completion rate, and region-year fixed effects.

30. **There are some caveats for the analyses.** The DTR index continues to be updated which provides an up-to-date overview of the regulatory environment of the country. However, there are no historical records of the DTR index thus data availability is limited to measure only the current state of the government policy. The sources of information that the ECIPE used to build the DTR index come from publicly available information from various legal and policy documents. However, there could be a scope for expanding the coverage of fiscal policies and regulations considered in the database. The cross-country DTR score is assigned by the ECIPE

on the basis of policy alignment with international standards and best practices.[13] In this regard, the DTR rating process inevitably accompanies some level of subjectivity. With these caveats, the finding in Figure 10 cannot claim any causal relationship between governent's fiscal intervention and firm-level digitalization. In this regard, the policy discussion in this section should be treated as only suggestive evidence.

VI. Conclusions

31. **As the Digital Revolution progresses, enhanced efforts are called for to better understand the implications of digitalization for the economy**. As a part of such efforts, this paper—using global firm data and new firm-level digitalization measures—empirically examines the benefit of digitalization in strengthening firm-level resilience to global crises while quantifying the size of digital divide. We also unpacked what fiscal policies could effectively drive firm-level digitalization.

32. **Our findings point the benefit of digitalization to mitigate the adverse impact of uncertainty shocks, creating significant heterogeneity between digitalized and less-digitalized firms**. Digitalized firms may improve profitability following the shock while less-digitalized ones are worse off, which appears salient in the service sector. Among loss-making firms, the lack of digitalization makes the negative shock even larger and longer-lasting.

33. **We also find that fiscal policy measures can play an important role in facilitating firm-level digitalization**. While each firm would have an incentive to proceed with further digitalization (as the adoption of digital technologies are often expected to raise firm productivity through innovation), it would be important to note that there is scope for the government to play. Specifically, our cross-country analyses suggest that fairness and even-handedness of fiscal institutions related to taxation and procurement rules are critical drivers of firm-level digitalization.

34. **Based on these findings, the following policy implications can be drawn**:

- *First, policymakers should anticipate that scarring effects after uncertainty shocks can be long lasting*. Following such a shock, a key question is not whether one should expect a scarring effect but how long a scarring effect would last. In our analyses, after the 10 percent adverse shock (broadly equivalent to the magnitude of the shock after major crises in recent history above historical median level), on average, firm-level sales, profit margins, and employment are expected to gradually start recovering three years after the shock. COVID-19 had prolonged impacts on firms' profitability, particularly in less-digitalized firms, which would affect the pace of their tax recovery (Bachas, Brockmeyer, Semelet, 2020).
- *Second, it would be important to note that firm-level digitalization would help strengthen resilience to uncertainty shocks.* The findings suggest significant heterogeneity between digitalized and less-digitalized firms. While firm-level digitalization would strengthen the firm's resilience to shocks (at the micro level), with the progress in digitalization in a larger number of firms, the resilience of the overall economy would also be strengthened (at the macro level). It is important to acknowledge such micro and macro level impacts of digitalization. To assess the resilience, the status of firm-level digitalization should be closely monitored and properly measured.

[13] See the methodological note for details (https://ecipe.org/wp-content/uploads/2018/05/DTRI_FINAL.pdf).

- *Third, the government's role to promote firm-level digitalization should be further explored. As suggested in our* empirical analyses, relaxing barriers for firms' digital investment through less restrictive tax regime, tax incentives and subsidies could be a fiscal lever to support the promotion of such digitalization. Further, open and competitive public procurement (e.g., through e-procurement and less stringent regulations on tender criteria for procuring digital goods) may also promote digitalization in private business, consistent with the discussion in the recent literature (Abdou, Basdevant et al, 2022).
- *Fourth, policymakers may take into account the sizable heterogeneity between digitalized and less-digitalized firms, when they consider support for firms in response to an uncertainty shock (as was done in many countries following the COVID-19 pandemic).* Some digitalized firms demonstrate even better performance after a uncertainty shock, while some *less-digitalized* loss-making firms suffer from larger and longer-lasting scarring effects after the shock (with very little prospects for a business recovery). To effectively and efficiently allocate the government's resources, its support for firms should thus be carefully targeted. Fiscal risks should be carefully managed, particularly where ex-post fiscal support (e.g., in the form of loans and/or guarantees) is delivered to less-digitalized firms with weak business prospects.

35. **As a final note, we highlight a few areas for further study**. Specifically, the role of fiscal policy in digitalization should be further explored, upon the availability of more granular data, to obtain more robust empirical evidence. Further, with more availability of post-COVID data, post-COVID firm dynamics can be explored. Our companion paper (Nose, Honda, et al, forthcoming) will further examine tax recovery.

Annex I. Sample

Table A1. The Number of Firms by Country

	Income group	N	Percent
Argentina	EMDEs	25	0.00
Australia	AEs	164	0.01
Austria	AEs	5,312	0.27
Belgium	AEs	27,168	1.38
Brazil	EMDEs	363	0.02
Bulgaria	EMDEs	156,429	7.94
Canada	AEs	50	0.00
Chile	EMDEs	35	0.00
China	EMDEs	38,601	1.96
Croatia	EMDEs	20,802	1.06
Czech Republic	AEs	78,919	4.01
Denmark	AEs	8,704	0.44
Finland	AEs	69,031	3.51
France	AEs	448,408	22.77
Germany	AEs	47,400	2.41
Greece	AEs	5,127	0.26
Hong Kong	AEs	11	0.00
Hungary	EMDEs	27,192	1.38
India	EMDEs	68	0.00
Indonesia	EMDEs	1	0.00
Ireland	AEs	1,553	0.08
Israel	AEs	10	0.00
Italy	AEs	143,109	7.27
Japan	AEs	28,746	1.46
Kazakhstan	EMDEs	318	0.02
Republic of Korea	AEs	30,402	1.54
Latvia	AEs	12,882	0.65
Lithuania	AEs	2,138	0.11
Malaysia	EMDEs	306	0.02
Mexico	EMDEs	9	0.00
Netherlands	AEs	709	0.04
New Zealand	AEs	2	0.00
Norway	AEs	36,458	1.85
Peru	EMDEs	1	0.00
Philippines	EMDEs	35	0.00
Poland	EMDEs	11,630	0.59
Portugal	AEs	52,189	2.65
Romania	EMDEs	73,735	3.74
Russia	EMDEs	86,097	4.37
Singapore	AEs	231	0.01
Slovak Republic	AEs	14,474	0.74
Slovenia	AEs	10,556	0.54
South Africa	EMDEs	2	0.00
Spain	AEs	432,447	21.96
Sweden	AEs	49,893	2.53
Switzerland	AEs	214	0.01
Taiwan	AEs	21	0.00
Thailand	EMDEs	1,284	0.07
Tunisia	EMDEs	1	0.00
Turkey	EMDEs	11	0.00
United Kingdom	AEs	44,874	2.28
United States	AEs	342	0.02
Vietnam	EMDEs	429	0.02
Total		1,968,918	100

Table A2: The Number of Firms by Sector

	Industry	N	Percent
Agriculture, forestry and fishing	Primary	46,378	2.36
Mining and extraction of energy production	Primary	962	0.05
Mining and quarrying of non-energy production	Primary	4,764	0.24
Mining support service activities	Primary	434	0.02
Food products, beverages and tobacco	Manufacturing	39,473	2.00
Textiles & wearing apparel	Manufacturing	31,116	1.58
Wood and products of wood and cork	Manufacturing	16,295	0.83
Paper products and printing	Manufacturing	21,211	1.08
Coke and refined petroleum products	Manufacturing	497	0.03
Chemicals and pharmaceutical products	Manufacturing	11,860	0.60
Rubber and plastic products	Manufacturing	15,331	0.78
Other non-metallic mineral products	Manufacturing	17,069	0.87
Basic metals	Manufacturing	5,395	0.27
Fabricated metal products	Manufacturing	50,529	2.57
Computer, electronic and optical product	Manufacturing	10,256	0.52
Electrical equipment	Manufacturing	10,668	0.54
Machinery and equipment	Manufacturing	23,131	1.17
Motor vehicles	Manufacturing	5,583	0.28
Other transport equipment	Manufacturing	2,543	0.13
Other manufacturing; repair and installation	Manufacturing	42,486	2.16
Electricity, gas, water supply, sewerage	Service	15,932	0.81
Construction	Service	283,029	14.37
Wholesale and retail trade	Service	523,158	26.57
Transportation and storage	Service	85,461	4.34
Accomodation and food services	Service	113,970	5.79
Publishing, audiovisual and broadcasting	Service	23,826	1.21
Telecommunications (ICT-related)	Service	4,765	0.24
IT and other information services (ICT-related)	Service	45,358	2.30
Real estate activities	Service	99,140	5.04
Other business sector services	Service	276,009	14.02
Public administration	Service	429	0.02
Education	Service	22,282	1.13
Human health and social work	Service	48,555	2.47
Arts, entertainment, recreation and others	Service	71,023	3.61
		1,968,918	100

Annex II. Robustness Checks

To alleviate a concern of reverse causation between firm productivity and the uncertainty shock, we check the stability of the baseline estimates under the augmented version of eq. (1) with industry or country-specific time trends (or both). Table A3 compares the baseline estimates with three alternative specifications. The size of scarring effects are similar or even larger with two trend terms controlled for all outcomes, which confirms the robustness of the baseline estimates.

Table A3: Robustness Checks of the Baseline Result

Years after shock		0	1	2	3	4
Log sales	Baseline	-0.005	-0.080***	-0.149***	-0.189***	-0.138***
	w/ industry trend	-0.005	-0.080***	-0.149***	-0.190***	-0.140***
	w/ country trend	-0.005	-0.090***	-0.189***	-0.239***	-0.172***
	w/ both trends	-0.005	-0.090***	-0.188***	-0.238***	-0.171***
Profit Margins	Baseline	-0.012***	-0.025***	-0.032***	-0.032***	-0.009**
	w/ industry trend	-0.012***	-0.025***	-0.032***	-0.032***	-0.009**
	w/ country trend	-0.014***	-0.027***	-0.033***	-0.032***	-0.007
	w/ both trends	-0.014***	-0.027***	-0.033***	-0.032***	-0.007
Log employment	Baseline	-0.047***	-0.064***	-0.106***	-0.143***	-0.110***
	w/ industry trend	-0.046***	-0.064***	-0.105***	-0.142***	-0.110***
	w/ country trend	-0.071***	-0.130***	-0.214***	-0.259***	-0.173***
	w/ both trends	-0.071***	-0.129***	-0.214***	-0.259***	-0.173***

Annex III. Regression Table: Impact of Fiscal Interventions on Digitalization

Table A3 presents the Tobit regression results of eq. (3). The coefficients shown in columns 1, 4, and 7 are summarized in Figure 9 of the main text.

Table A3. The Impact of Fiscal Interventions on Digitalization

Dependent variable: DAI Business index									
DTRI: Quantile by each subindex									
Tariff_q1	0.027	0.006	0.012						
	(0.017)	(0.015)	(0.020)						
Tariff_q2	0.008	0.010	0.008						
	(0.014)	(0.012)	(0.014)						
Tax_q1				0.030*	0.038***	0.026			
				(0.016)	(0.014)	(0.016)			
Tax_q2				0.004	0.012	0.000			
				(0.013)	(0.012)	(0.012)			
Procurement_q1							0.054***	0.031**	0.043**
							(0.017)	(0.016)	(0.018)
Procurement_q2							0.038***	0.040***	0.033**
							(0.014)	(0.013)	(0.014)
Control variables									
Log GDP per capita (in PPP) (lagged)	0.133***	0.097***	0.127***	0.136***	0.078***	0.126***	0.124***	0.097***	0.122***
	(0.012)	(0.018)	(0.012)	(0.011)	(0.019)	(0.011)	(0.011)	(0.019)	(0.011)
Tertiary education completion rate	0.000	-0.001	0.000	0.000	-0.001	0.000	0.001	-0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Broadband subscribers		0.453***			0.526***			0.439***	
		(0.101)			(0.100)			(0.101)	
GCI-Financial Market Development index			0.020*			0.021**			0.013
			(0.010)			(0.009)			(0.010)
N	124	96	123	124	96	123	124	96	123
Region & Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors clustered at country-year level are presented in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.010

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