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Digital divide among firms in ASEAN before, during, and after the COVID-19 pandemic

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Digital tool adoption of firms in ASEAN and their business performances before and after the COVID-19 pandemic

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Abstract

The study conducted a comprehensive examination of the digital divide in the ASEAN region through a large-scale questionnaire survey targeting regional MSMEs. Two types of surveys, web and phone, were employed to capture a diverse range of responses, considering company size, industry, and geographical location. Findings reveal that before COVID, basic digital devices and e-payment systems were widely adopted, even by entry-level firms, while other digital tools saw limited adoption, widening the digital divide. Post-COVID, digitally developed firms accelerated their adoption of digital tools, especially web conferencing and e-commerce, while entry-level firms showed little progress. The study identifies a five-stage progression in digital tool adoption, highlighting the need for tailored support at each stage. Firm attributes significantly influenced adoption: economic development levels positively affected smaller firms, firm size consistently impacted adoption, and rural firms were not disadvantaged. FDI and ownership structure also played crucial roles, with FDI firms adopting a broader range of tools but lagging in advanced tools. Participation in global value chains positively influenced adoption, especially at higher stages. Public and private support benefited digitally developed firms but was less effective for entry-level firms, indicating a need for targeted support mechanisms. The study underscores the connection between digital tool adoption and improved business performance post-COVID, with digitally developed firms experiencing positive growth and entry-level firms showing increased robustness. The findings suggest that policymakers should provide targeted assistance, enhance support access, and address stage-specific challenges to ensure all firms benefit from digital transformation initiatives.

1 Introduction

The disparities between micro, small, and medium-sized enterprises (MSMEs) and large enterprises in the adoption of information and communication technologies (ICTs) have been widely recognized as the policy issue of digital divide since the 1990s when the Internet had become available for citizens and businesses (Kuwayama, Tsuji, & Ueki 2005). The continuous radical innovations in wired and wireless Internet and Internet-enabled tools (hereafter digital tools) have been help mitigating different social and economic constraints and achieving sustainable economic growth (Fernández-Portillo, Almodóvar-González, & Hernández-Mogollón, 2020; Appiah-Otoo & Song, 2021). However, this characteristic of rapid innovation speed allows only digital-capable users to benefit the state-of-the-art digital tools and remains digital divide unsolved (Paunov & Rollo, 2016; Gnanon, 2019).

The outbreak of COVID-19 pandemic had stopped almost all movement of people and

business activities or had been significant constraints in various socio-economic activities for a certain period. The COVID-19 pandemic revealed the importance of digital tools as alternatives and complementarities to physical communication and collaborations among people and businesses and the continuity of these activities (Seetharaman, 2000). During and after the COVID-19 pandemic, as many papers pointed out, the pandemic accelerated the pace of the digital adoption globally (Gao et al. 2023; Modi 2022; Redjeki and Affandi 2022). At the same time in the extraordinary situation where many firms bankrupted, the pandemic also raised a concern of widening digital divide and survivability among firms more than the normal situation before the pandemic (Khalil, Abdelli, & Mogaji, 2022). However, we do not have much information on what kinds of tools firms have adopted, how the COVID-19 pandemic affected the introduction of different digital tools, how serious is the digital divide, and what factors promoted the adoption of digital tools. It became imperative to accurately assess the extent of the digital divide in the region and take necessary measures to bridge this gap.

Digital divide will be measured with the difference in the digital technology adoption among the firms and the different performances among the firms adopted digital technologies. Several research show that some factors influence the use of digital technologies by MSMEs. Acopiado et al. (2023) finds that younger, and partnership, and larger size companies within the categories of MSMEs have tendency to promote digital payment adoption during the COVID-19 pandemics. Priyano et al. (2023) determines three factors of business digitalization in Indonesian SMEs: 1) a level of digital maturity/literacy; 2) experiences in liquidity issues; and 3) supports by social capital. With respect to the gaps in firm performance, Oikawa et al. (2024) shows that, in the pandemic's early phases, digitalized MSMEs in Indonesia disproportionately encountered negative effects on their business outcomes, which disappeared during later stages. This previous research suggested the limited understanding of the digital tool adoption, and its effect of before, and during the COVID-19 pandemics.

The Association of Southeast Asian Nations (ASEAN) has recognized the significance of addressing digital disparities among MSMEs to achieve inclusive and sustainable growth. The COVID-19 pandemic has led to a rapid proliferation of digital services throughout society. However, a significant digital divide is emerging among companies in the ASEAN region too, particularly MSMEs, due to various factors such as limited digital skills among employees and financial constraints in implementing digital tools. Nevertheless, existing studies on the digital divide in MSMEs need to expand their research scope. For instance, a study conducted by JETRO (2020) focused on barriers to digital technology adoption based on a questionnaire survey, but its coverage was limited to Japanese foreign-affiliated firms in ASEAN. Therefore, a survey with a broader reach, encompassing ASEAN local MSMEs and consumers, is scarce but highly valuable. It is imperative to accurately assess the extent of the digital divide in the region and take necessary measures to bridge this gap.

Given these circumstances, the 24th ASEAN Economic Minister Plus Three Consultation on September 13, 2021, noted Japan's proposal to conduct research on closing the digital divide among MSMEs in the region. Subsequently, the Senior Economic Officials' Meeting (SEOM) Plus Three endorsed the concept note intersessionally on April 27, 2022. In this connection, the ASEAN Secretariat requested the support of the Economic Research Institute for ASEAN and East Asia (ERIA) to undertake the ASEAN Plus Three Research Project for Closing the Digital Divide in MSMEs.

To comprehensively examine the actual state of the digital divide in the region, we conducted a large-scale questionnaire survey targeting regional MSMEs. The survey solicited responses from

a diverse range of MSMEs, taking into account their company size, industry, and geographical location. Two types of surveys were conducted: a web survey and a phone survey. The web survey was conducted in all ASEAN Member States (AMS) to get a broad picture of the digital divide in ASEAN, and responses were also collected from large companies to understand the differences from MSMEs. The phone survey was conducted in three target countries (Indonesia, Malaysia, and Vietnam) to collect responses from companies, including those that may not have access to the online environment, which the web survey may not cover.

This paper reports 10 findings based on two surveys. Firstly, we examine the current and pre-COVID digital technology adoption levels of firms in ASEAN. We also conduct a cluster analysis on the combinations of digital tools that firms adopt to detect firms' digital tool adoption patterns or stages that firms climb towards digital transformation. Next, we conduct regression analyses to examine the effects of development level, firm size, location (urban vs rural), other firms' basic attributes (e.g., firm age), and public and private supports on digital tool adoption. Additionally, we regress business performance after COVID compared to before COVID on the digital tool adoption levels of firms. Finally, we examine the difficulties that firms report facing in digital tool adoption.

The remaining structure of this article is as follows: Section 2 explains the questionnaire survey conducted by ERIA and presents the summary statistics of variables used in this study. Section 3 outlines 10 empirical findings based on aggregate figures of digital tool adoption and several regression analyses. Finally, Section 4 provides the conclusion.

2 Method

2.1 Questionnaire Survey

ERIA conducted a questionnaire survey on the digital divide of MSMEs in the ASEAN Member States: Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam. The survey's primary purpose is to understand the actual conditions of relevant digital divide factors and how to overcome the obstacles MSMEs encounter to close the digital gaps among MSMEs in ASEAN.

The questionnaire encompasses four main sections. The first section provides a comprehensive overview of surveyed companies, gathering information on their location, industry, size, management, ownership, customer and supplier types, and characteristics of ultimate decision-makers, along with business performance metrics. The second section assesses digitalization status, categorizing 24 digital tools into six groups and evaluating adoption stages, objectives, success, and barriers. The third section explores difficulties and concerns during digital tool implementation, covering internal and external factors in various phases. The fourth section focuses on evaluating public and private sector support, including its types, outcomes, and areas for improvement, while also seeking input on priorities for encouraging digital adoption among companies in ASEAN. The complete questionnaire is available in Oikawa et al. (forthcoming). The total time required for respondents to complete the questionnaire is approximately one hour.

2.1.1 Targeted firms

The survey was designed to identify digital tool adoption levels of firms from the following four perspectives: country, scale, industry, and location. The survey encompasses every size of firms: micro (with less than 10 employees), small (10-19 employees), medium (20-199), and large (200 and more) firms. The classification of firm sizes follows that of ADB Asia SME Monitor 2022

database (2022). The survey covers every category of industries classified into five industries for the sampling purpose described below: (1) Agriculture, Forestry, Fishing, (2) Services, (3) Light Manufacturing 1 (Consumer goods or consumables), (4) Light Manufacturing (Others), and (5) Heavy Manufacturing. The survey also collected industry information at the US SIC 1987 two-digit level.¹ The geographic scope of the survey encompasses both urban and rural areas within these countries. Urban and rural classification is derived from the World Urbanisation Prospects Report (United Nations, 2019).

2.1.2 Sampling and data collection

The survey was conducted using a combination of web and phone surveys to collect responses from a wide range of companies in AMS. The web survey was conducted to collect responses from a broader range of companies to obtain a broad grasp of the trends in the digital divide in ASEAN. The phone survey was conducted to collect responses from micro and small-sized companies to obtain the reality of the digital divide in a form more akin to an on-the-ground survey only for three countries: Malaysia, Indonesia, and Viet Nam. The collection method of this survey was stratified sampling, aiming at collecting a specific number of samples from each target segment. The web survey aimed to collect 6,000 samples from 300 segments (20 samples per segment) and 3,000 samples from the phone survey (100 samples per segment). The segments that fell short of the target number of responses were compensated by collecting more than the target number of responses in other segments. In the web survey, segments that did not reach the target number of responses were supplemented by sample sizes from other segments. Therefore, it should be noted that the number of samples per segment was more unevenly distributed in the web survey than in the phone survey.

The longlist of firms for the web survey is based on the SIS International Research (SIS) panel. The panel has been developed over 35 years by SIS primarily from the information available online, such as the search engines and the map services provided by the private sector (i.e., Google Maps), including firm websites and/or corporate official social networking accounts (e.g., Facebook, LinkedIn), and direct inquiries by emails asking them for their information to the firms that can be contacted. The company information on the panel has been updated continuously through data collection activities and other relevant research operations by SIS. Therefore, the panel used for the web survey does not match the public official statistics according to the nature of the panel. When conducting direct inquiries by email to those companies, CEO or business owners are the primary respondents, but senior management levels are also included, especially for the larger companies.

The phone survey is based on the global firm database provided by D&B Hoovers (DBH).

¹ Agriculture encompasses all relevant sub-industries of Agriculture, Forestry, and Fishing, categorized under the US SIC 1987 codes 01-09. Manufacturing (Light1) refers to relatively labor-intensive manufacturing industries that produce consumables. This category includes Food and Kindred Products (20), Tobacco Products (21), Textile Mill Products (22), and Apparel and Other Finished Products Made From Fabrics and Similar Material (23). Manufacturing (Light2) comprises other labor-intensive manufacturing industries, such as Lumber and Wood Products, Except Furniture (24), Furniture and Fixtures (25), Paper and Allied Products (26), Printing, Publishing, and Allied Industries (27), Rubber and Miscellaneous Plastics Products (30), Leather and Leather Products (31), and Fabricated Metal Products, Except Machinery and Transportation Equipment (34). Manufacturing (Heavy) encompasses relatively capital-intensive manufacturing industries, which include Chemicals and Allied Products (28), Petroleum Refining and Related Industries (29), Stone, Clay, Glass, and Concrete Products (32), Primary Metal Industries (33), Industrial and Commercial Machinery and Computer Equipment (35), Electronic and Other Electrical Equipment and Components, Except Computers (36), Transportation Equipment (37), and Measuring, Analyzing and Controlling Instruments; Photographic, Medical and Optical Goods; Watches and Clocks (38). This category also includes Mining (10-14). Services encompass a wide range of other industries, including Construction (15-17), Transportation and Public Utilities (40-49), Wholesale Trade (50-51), Retail Trade (52-59), Finance, Insurance, Real Estate (60-67), Services (70-89), and Public Administration (91-99).

The firm list of the DBH database is collected and updated continuously based on the national registries for foundational information, such as company names and addresses, but then adds the additional attributes, such as company size, industries, by using many other sources and processes. A special note should be given that the company information of the database relies on the national registries, meaning the accuracy of the data should be dependent on the national registration system and process.

As a result, the web survey distributed the questionnaire link to 14,586 companies among AMS and successfully collected 6,187 responses (response rate: 42.4%). In the phone survey, 18,601 companies were contacted and gathered 3,111 responses (response rate: 16.7%). The survey was carried out from March 31, 2023, to July 7, 2023. Of the respondents who completed the survey, several respondents had duplicate company names, business IDs or Tax IDs. Therefore, for respondents with duplicates of any of these, one respondent with an earlier response date was considered a valid response, and the rest were considered invalid responses. As a result, the number of valid responses is 6,048 out of 6,187 respondents who completed the web survey. The number of valid responses for the phone survey is 3,099 out of 3,111 respondents who completed the survey.

2.2 Measurements and Descriptive Statistics

Tables 1, 2, 3, and 4 show the distribution of countries, sizes, industries, and areas, respectively. As mentioned in the above subsection, our sampling approach is stratified sampling, but due to difficulties in collecting the same number of samples from relatively small population, the distribution of the web survey samples is not even across countries, sizes, industries, or areas. In contrast, the distribution of the phone survey samples is almost even across the segments, except for firm sizes.

This study covers 24 digital tools, falling under six categories. The first one is the intra-firm management tools (IM). Recognizing the fundamental tools integral to intra-firm communication and organization, this category encompasses: E-mail and/or chat applications (IM1), which facilitate internal (or external) communication among employees or relevant stakeholders, improving collaboration and information sharing; Mobile devices (IM2), particularly smartphones, serve as essential user interfaces for business applications to perform a wide range of tasks; Computers (IM3), essential for daily business operations, from data processing to running software applications; Office suite (IM4), which provides tools for document creation, data analysis, and presentations (e.g. Microsoft Office and Google Workspace); and Web meeting systems (IM5), which allow virtual meetings and remote collaboration, reducing the need for physical presence and travel.

The second one is the procurement tools (PR). Focused on tools facilitating the acquisition of goods and services, this category includes: Electronic Data Interchange (EDI) (PR1), which automates the exchange of business documents between trading partners, improving efficiency and accuracy; and E-payment systems (PR2), which facilitate secure and quick payments for goods and services, streamlining the procurement process.

The third one is the logistics tools (LG). Encompassing tools pivotal to the seamless flow of materials and information, logistics tools include: Document or cargo delivery applications (LG1), which manage and track the delivery of documents and goods, ensuring timely and accurate logistics operations; and Storage or inventory management systems (LG2), which optimize inventory levels, track stock, and manage warehousing activities, reducing costs and improving efficiency.

The fourth one is the sales and marketing tools (SM). Vital for outreach and commerce, this

category includes: EDI (SM1), which streamlines the exchange of sales documents and orders with customers, improving transaction speed and accuracy; Social networking sites (SNS) (SM2), which are platforms for marketing and engaging with customers, building brand awareness and customer relationships; E-commerce (SM3), which is online platforms for selling products and services, expanding market reach and sales opportunities; E-payment (SM4), which enables secure and efficient payment from customers for both online and offline transactions, enhancing customer convenience; and Sales management and automation tools (SM5), which automate and manage sales processes, track performance, and improve customer relationship management.

The fifth one is the overall company operation tools (OC). Enabling comprehensive business management, tools in this category include: Enterprise Resource Planning (ERP) (OC1), which integrates core business processes, providing a centralized system for managing operations, financials, and resources; Cloud storage or centralized servers (OC2), which securely store and access data from anywhere, facilitating data sharing and collaboration; and Cybersecurity or protection software (OC3), which protects business data and systems from cyber threats, ensuring data integrity and compliance.

The last one is the advanced digital tools (AT). At the forefront of technological innovation, this category includes: 3D printing (AT1), which allows rapid prototyping and manufacturing of custom products, reducing time-to-market and production costs; Artificial intelligence (AI) (AT2), which enhances decision-making, automates tasks, and provide predictive insights, improving efficiency and innovation; Augmented reality (AR) (AT3), which enhances customer experience and training by overlaying digital information on the physical world; Drones (AT4), which are used for surveillance, delivery, and data collection, improving operational efficiency and safety; Internet-of-Things (IoT) devices (AT5), which connect and automate devices and systems, providing real-time data and improving operational control; Radio frequency identification (RFID) (AT6), which tracks and manages assets and inventory in real-time, reducing errors and theft; and Robotics (AT7), which automate repetitive tasks, improving precision, efficiency, and safety in manufacturing and other processes.

For the regression analysis examining the effect of firms' circumstances and attributes on digital tool adoption, we measure the adoption level of each category of digital tools by simply counting the number of tools adopted in each category as of 2023 (post-COVID-19 period). In the intra-company management tools category, 'IM' signifies the number of tools adopted; 'PR' stands for the number of procurement tools adopted; 'LG' represents the number of logistics tools adopted; 'SM' denotes the number of sales and marketing tools adopted; 'OC' indicates the number of overall company operation tools adopted; 'AT' signifies the number of advanced digital tools adopted; and 'TTL' represents the total number of digital tools adopted.

Additionally, we focus on the following attributes of firms. To conduct regression analyses, we construct the following variables: 'lnI' represents the level of economic development, measured by the log of the income level of the country classified by the World Bank (n.d.); 'lnE' represents the log of employees of firms; 'FDI' is a dummy variable for respondents from foreign-affiliate firms; 'AGEf' is the age of respondent firms; 'OWNER' is a dummy variable for respondents from owner-managed firms; 'AGEu' is the age of ultimate decision-makers in respondent firms; 'FEMu' stands for a dummy variable for respondents with female ultimate decision-makers; 'EDUu' is the highest education level of ultimate decision-makers in respondent firms; 'MNFc' is a dummy variable for respondents with direct multinational firm customers; and 'MNFs' is a dummy variable for respondents with direct multinational firm suppliers. For external support for firms' digital adoption, 'Public support' is a dummy variable for respondents who have experienced

public sector support; ‘IA support’ is a dummy variable for support from industry associations; ‘MNF support’ represents a multinational firm support dummy; and ‘LF support’ is a local firm support dummy. The summary statistics for these variables are shown in Table 5.

For the regression analyses of the business performance after COVID-19 compared to before COVID-19, ‘GROWTHs’ is a dummy variable indicating respondents with positive growth in sales in 2022 compared to 2019. Similarly, ‘ROBUSTs’ stands for a dummy variable representing respondents with positive growth or the same level in sales in 2022 compared to 2019. ‘GROWTHp’ signifies a dummy variable for respondents with positive growth in the profit margin ratio in 2022 compared to 2019. ‘ROBUSTp’ is a dummy variable for respondents with positive growth or the same level in the profit margin ratio in 2022 compared to 2019. The summary statistics for those variables and the regressors of digital tool adoption levels are shown in Table 6. Note that we exclude new firms that entered the market after COVID-19 due to the purpose of the regression.

It should be noted that there are differences in firms' attributes, digital tool adoption levels, and business performance after COVID compared to before COVID. Table A.1 compares these two datasets by removing the samples of the web survey that are not micro and small firms and are not based in Indonesia, Malaysia, and Vietnam to align with the phone survey. As seen in the table, these two datasets are significantly different. In particular, the level of digital tool adoption of firms in the web survey is significantly higher than that in the phone survey. Thus, taking Finding 3 below into consideration as well, we regard the web dataset as the sample with larger firms and relatively more digitally advanced micro and small firms, which we referred to as ‘digitally developed firms’. Meanwhile, we consider the phone survey as the samples of less digitally advanced micro and small firms, which we referred to as ‘digitally entry-level firms’.

3 Empirical Findings

3.1 Digital technology adoption levels of firms in ASEAN

Finding 1 (Digital Tool Adoption Before COVID): Before COVID, basic digital devices (e.g., computers and mobile phones) and e-payment for procurement purposes were well adopted by firms in ASEAN, even by digitally entry-level firms. Meanwhile, other digital tools, including sales and marketing tools, had limited adoption among digitally entry-level firms. Advanced tools were limited in adoption in general. Furthermore, they widened the adoption gaps (except RFID) between digitally developed firms and entry-level firms.

Table 7 shows that before COVID, almost 90 percent of firms from the web survey and 80 percent from the phone survey had already adopted mobile devices (IM2) and computers (IM3), categorized under basic intra-company management tools. E-payment for procurement (PR2) is also a relatively well-adopted digital tool for firms in ASEAN, including the phone before COVID; almost 80% of firms from the web survey and more than 50% of firms from the phone survey had adopted that tool. Other digital tools, except for overall company tools and advanced tools, had been adopted by almost more than half of firms from the web survey, but firms from the phone survey had limited adoption rates. Advanced digital tools such as AI are very limited in adoption by firms from both the web and phone surveys. While the adoption rates are limited in general, there are still differences between larger firms and smaller firms, as suggested by the table.

Finding 2 (Digital Tool Adoption After COVID): After COVID, ASEAN firms that were digitally developed before COVID have steadily increased their adoption rates for various digital tools. Particularly, there was a significant surge in the adoption of web conferencing systems and e-commerce for sales and marketing purposes. However, micro and small firms that were at the digitally entry-level before COVID did not show progress in adopting digital tools. The digital tool adoption level of newly entered firms after COVID is almost the same as the before-COVID level of the incumbent firms.

Table 7 shows that for the web survey firms, the firms somewhat more advanced in digitalization, as mentioned in the previous section, roughly 10-20 percent of respondent firms advanced their digital tool adoption for procurement, logistics, sales and marketing, and overall company operation purposes after COVID. In particular, 38 percent of firms from the web survey adopted web meeting systems. Digital tools for sales and marketing were also well adopted during this period. Meanwhile, as mentioned in the previous section, firms from the phone survey, particularly micro and small firms that adopted fewer digital tools before COVID, did not show any progress in digitalization.

Table 7 also reports the digital tool adoption level of newly entered firms after COVID. It shows that newly entered firms from both web and phone surveys have almost the same figure of each digital tool adoption as the incumbent firms at the time before COVID. This means that newly entered firms, or young firms, do not necessarily start their operations with a higher adoption of digital tools. We will examine this point again later.

Finding 3 (Digital Tool Adoption Order): A specific digital tool adoption order, divided into five stages, was observed: At the elementary stage, firms do not or very limitedly adopt digital tools. At the second stage, firms well adopt basic intra-company management tools, such as mobile phones and computers. They also started adopting digital payment for procurement. At the third stage, they proceed with adopting digital tools for procurement and sales and marketing purposes, while still being limited in adopting business process automation tools, such as EDI for customers and suppliers, and sales management and automation tools. At the fourth stage, they start adopting business process automation and overall company operation tools such as ERP and cloud storage. Cybersecurity is also addressed by the majority of firms at this stage. At the last stage, they adopt a wide range of advanced digital tools.

Figure 1 reports the five stages of digital tool adoption identified by cluster analysis. Specifically, we used k-means clustering on samples combining both the web and phone datasets regarding each firm's adoption of 24 digital tools as of 2023. We determined the number of clusters, k, by finding the kink point of the curve plotting the within-cluster sum of squares against k (Makles, 2012).² As shown in Figure 1, firms at the first stage do not or very limitedly adopt digital tools. These firms do not use digital tools in their business.

Firms classified into the second stage group adopt only basic digital tools, such as basic intra-company management tools and digital payment for procurement. Among the second stage group firms, approximately 100% have adopted mobile devices (IM2) and computers (IM3), and close to 80% have adopted e-payment for procurement (PR2), while the adoption of the other digital

² The number of clusters, k, was six, selected based on the kink point. However, two clusters shared the attribute of being limited in the total number of digital tools, while differing in which digital tools they adopted. Thus, we combined them into one group and named it the stage 2 group. The authors will share the original results upon request.

tools is limited. These firms use digital tools for basic communication, calculation, and payment to suppliers, but they are far from realizing the potential benefits of digitalization.

The third stage group firms are fully equipped with basic intra-firm management tools and expand their usages of digital tools to procurement and sales and marketing. Almost 100% of these firms adopt e-mail and/or chat applications (IM1), mobile devices (IM2), computers (IM3), office suite (IM4). They also highly adopt e-payment for procurement (PR2), SNS (SM2), and e-payment for customers (SM4). However, they do not widely adopt other procurement and sales and marketing tools, such as EDI for procurement and sales, and logistics management. This indicates that they have not advanced to business process automation and still rely on paper-based transactions with suppliers and customers and manual warehouse and stock management.

At the fourth stage, firms adopt digital tools more comprehensively, including business process automation tools not adopted by the third stage firms, and overall company operation tools. They adopt almost 100% of all digital tools classified under intra-company management (IM), procurement (PR), logistics (LG), and sales and management tools (SM). Furthermore, 84% of them adopt ERP systems (OC1), 72% use cloud storage or centralized servers (OC2), and 70% use cybersecurity or protection software (OC3). It is worth noting that cybersecurity issues start being addressed at this stage, but still, 30% of the fourth stage firms, which already use digital tools and are digitally connected to suppliers and customers, do not prepare for cyber threats. Mayadunne and Park (2016) point out that SMEs are likely to behave as risk takers, making riskier choices to minimize loss under uncertainty, based on prospect theory proposed by Kahneman and Tversky (1979).

Fifth stage firms remarkably adopt a wide range of digital tools, including advanced tools. They fully adopt overall company operations tools, including cybersecurity. Moreover, they highly adopt a wide range of advanced tools: 89% for 3D printing (AT1), 92% for AI (AT2), 82% for AR (AT3), 80% for Drones (AT4), 95% for IoT devices (AT5), and 89% for RFID (AT6). For robotics (AT7), the share of firms adopting them is 66%, likely reflecting that robotics tend to be used in specific sectors, such as manufacturing.

Table 8 shows the profiles of firms at each stage by reporting the share of outward attributes of firms in terms of survey type (web or phone), size (micro, small, medium, or large), industry (10 industries), and location (urban or rural). Almost all stage 1 and 2 firms come from the phone survey samples, and both groups are very similar in terms of other attributes. This suggests that the factors of dividing stages 1 and 2 may be more fundamental than outward ones. Meanwhile, stage 3, 4, and 5 firms mostly come from the web survey samples. Comparing these three stage firms, small-scale firms are significantly more prevalent in the third stage than in the fourth and fifth firms, while there is no significant size difference between the fourth and fifth stage firms. Regarding industry differences, stage 3 firms are more prevalent in the agriculture industry and less in the heavy manufacturing industry compared to stage 4. Stage 4 firms are more prevalent in manufacturing industries and less in service industries, particularly other services, compared to stage 5 firms. Lastly, the location of firms distinguishes stage 3 from stage 4 and 5 firms, with stage 4 and 5 firms being more urban areas than rural.

These five patterns of digital tool adoption follow an order from the first to the fifth. The adoption rates of digital tools for the first category are the highest, followed by the second, and subsequently, the third, fourth and fifth categories. We will use the five-stage categorization to analyze subjective difficulties in digital tool adoption later.

3.2 Digital technology adoption and firm attributes

Finding 4 (Digital Tool Adoption Levels by Economic Development, Firm Size, and Location): *Economic development levels do not positively influence the adoption of digital tools by advanced firms, while they do positively affect unadvanced, smaller firms. Firm size significantly and positively influences the digital tool adoption levels across any types of firms. Firms based in rural areas are not necessarily at a disadvantage in terms of digitalization compared to those in urban areas.*

Table 9 displays the results of the regression of seven measures of digital tool adoption levels measured in 2023 (after COVID), on firm attributes from the web survey. The level of economic development (lnI), which is measured by the income level of the country classified by World Bank (n.d.), does not have a positive effect on the digital tool adoption of firms from the web survey. Meanwhile, as shown in Table 11, for the firms from the phone survey, the levels of economic development positively influence the adoption of digital tool, particularly in sales and marketing (SM), overall company operation (OC), and advanced tools (AT).³

The scale of firms (lnE) from the web survey has a significantly positive impact on the digital tool adoption levels for almost all types (Table 9). Furthermore, even for unadvanced micro and small firms from the phone survey, the result is the same (Table 10); the coefficients of lnE are significantly positive for all digital adoption level measurements. Firm size is considered a proxy for the needs to reduce operational costs and available resources for digitalization. These results suggest that needs and resources are essential factors for the digitalization of firms.

The location of firms, whether in rural or urban areas, does not primarily influence overall digitalization levels. Table 9 shows that firms based in rural areas experience a negative impact on the adoption of intra-company management and procurement tool according to the data from the web survey, whereas their adoption of logistics tools is positively affected. However, there are no significant impacts on the adoption of other digital tools, nor on the total number of adopted digital tools. Similarly, for unadvanced micro and small firms from the phone survey, as indicated in Table 10, the RURAL coefficient is significantly positive for intra-company management tools (IM), while it is significantly negative for sales and marketing (SM), overall company operations (OC), and advanced tools (AT). These contrasting effects balance out, resulting in no significant impact on the total number of digital tools adopted due to the rural location. Therefore, being based in a rural area does not necessarily mean that firms are at a disadvantageous environment in digitalization.

Finding 5 (Digital Tool Adoption Levels by Basic Firm Attributes): *FDI firms generally exhibit a higher level of digital tool adoption across a wide range of categories, except for advanced digital tools compared to domestic firms. Younger firms are more likely to adopt digital tools for the digitally developed firm samples, whereas less likely for the digitally entry-level firm samples.*

The coefficients of FDI, as shown in Table 9, are significantly positive for digital tool adoption levels in almost all the models, except for the model related to advanced tools, where the coefficient of FDI is notably negative. Consequently, the impact of FDI on the total number of

³ Not reported in this paper, for the phone survey, the results of regression of each digital tool on the same independent variables in Table 10 shows that lnI significantly positively influences the adoption of EDI for customers (SM1), Sales management and automation tool (SM5), Cloud storage or centralized server (OC2), Cybersecurity or protection software (OC3), 3D printing (AT1), and Drone (AT4).

digital tools is not significantly detected. In the context of FDI and development, FDI firms, equipped with multinational firms' technology, are often considered to provide higher technologies that are not available in host countries (OECD, 2002). Our results show that while FDI firms generally exhibit a high level of digital tool adoption, they do not tend to adopt advanced tools. Note that the samples from the phone survey do not include any FDI firms; thus, we do not include FDI in the regressors for the phone survey, and the result reported in Table 10 does not include the coefficients of FDI.

Younger firms tend to adopt digital tools more, according to the samples from the web survey. The coefficients of AGEf are negative for almost all models except for procurement. However, the results from the phone survey are opposite: older firms tend to adopt digital tools more. While the coefficient in the procurement (PR) model is negative, the coefficients are positive in the models for sales and marketing (SM), overall company operation (OC), advanced tools (AT), and the total number of digital tools.

Finding 6 (Digital Tool Adoption Levels by CEO/Owner Attributes): *Owner-managed firms show a significantly lower level of digital tool adoption. The age of ultimate decision makers generally does not impact digital tool adoption. However, within the owner-managed firms, younger ultimate decision makers adopt digital tools less frequently for the digitally developed firm samples, whereas more for digitally early-level firm samples. Firms with higher education levels of ultimate decision-makers generally exhibit higher digital tool adoption levels. Furthermore, being an owner-managed firm positively modifies the effect of the education level.*

To understand SMEs' ICT investment decisions, it is crucial to focus on the CEO or owner-managers. SMEs typically have flat organizational hierarchies where the owner-manager makes most long-term planning decisions, including those related to ICT, and usually has full control over the company's financial and human resources (Elbeltagi et al., 2013).

Furthermore, owner-managed firms, managed or practically controlled by the owner as the president, chairperson, or adviser, are often observed in SMEs. They are argued as having both advantages and disadvantages in terms of business performances and investment decisions. On the positive side, for example, owner-managed firms often adopt a long-term perspective in their strategic and investment decisions, compared to non-owner-managed firms (James 1999). On the negative side, owner-managers may be inefficient on decision making due to the chances of exploiting profits for private rents (Fama and Jensen, 1983). It is worth examining whether there are differences between owner-managed and non-owner-managed firms and whether attributes of ultimate decision makers (CEO or owner-managers) can impact the digital tools adoption levels. Additionally, it is essential to explore whether being an owner-managed firm can modify the impact of these attributes on digitalization.

Owner-managed firms tend to have more adopted digital tools than non-owner-managed firms, as shown in Table 9. The coefficients of OWNER are significantly positive for many of models: intra-company management (IM), procurement (PR), sales and marketing (SM), and advanced tools (AT). Consequently, the coefficient of OWNER for the total number of digital tools is also positive. Note that the regression results for the phone survey reported in Table 10 do not include OWNER in the regressors because almost all the samples from the phone survey are owner-managed firms, with only a few samples are not being owner-managed firms.

Another notable feature is the influence of the education level of ultimate decision-makers on digital tool adoption. Table 10 shows that the coefficients of EDUu are significantly positive for

all the models for firms before COVID. Both during and after COVID, education levels tend to have a positive effect on the adoption of digital tools.

Finding 7 (Digital Tool Adoption Levels by Differences in GVC): *The influence of having multinational firm customers or suppliers (GVC participation) on digital tool adoption is positive in general. Remarkably, digital tools that are adopted at higher stages (overall company operation and advanced tools) are impacted by GVC participation.*

Digital tool adoption represents one form of technology transfer from outside of firms, and one of the ways for this transfer is from trade partners. Multinational firms, being advanced in technology in general, are more equipped with digital tools for cross-border trade and communication. Therefore, we expected a positive influence of having multinational firm customers or suppliers on digital tool adoption. Tables 9 and 10 show that having multinational firm customers or suppliers tends to lead to more digital tool adoption in general for both the digitally developed firm samples and the digitally entry-level firm samples.

Finding 8 (Digital Tool Adoption Levels and public and private supports): *Public and private supports have positive impact on a wide range of digital tool adoption for the digitally developed firm samples, whereas they are not necessarily useful for the digitally entry-level firm samples.*

Tables 9 and 10 report contrasting results of the effects of public and private support on digital tool adoption between the digitally developed firm samples and the digitally entry-level firm samples. Table 9 reports that public support and the three types of private support significantly positively affect digital tool adoption levels in total. In particular, support from industry associations significantly impacts digital tool adoption in all the models. These results show that current public and private support for firms' digital tool adoption works well for the digitally developed firm samples.

Meanwhile, we cannot find public or private support positively affecting digital tool adoption for the digitally entry-level firm samples, except for support from multinational firms. Furthermore, Table 5 shows that a limited number of digitally entry-level firms (about 5%) have experienced public support, industry association support, and multinational firm support. While 25% of these firms experienced local firm support, the impact on digital tool adoption is significantly negative. These results indicate that external support for digitalization does not reach digitally entry-level firms well, and even when it does, the support does not necessarily lead to the expected results.

3.3 Digital technology adoption and business performance

Finding 9 (Digital Tool Adoption and Business Performance after COVID): *For digitally developed firm samples, equipping with digital tools for procurement and sales and management purposes tends to increase the probability of positive growth in sales after COVID compared to before COVID. Furthermore, general digital tool adoption tends to increase the probability of non-negative growth, or robustness, in sales after COVID compared to before COVID. Meanwhile, for digitally elementary-level firm samples, it is observed that the adoption levels of sales and marketing, overall company operation, and advanced tools positively impact the robustness of business performance, but not its growth.*

Finding 9 is based on the results of regression of business performances on digital tool adoption levels of firms. These regressors include firm attributes that we discussed above as control variables. Table 11 shows that firms with a high score in procurement and sales and marketing digital tools tend to experience positive growth after COVID compared to before COVID. Regardless of the timing of adoption, an increase in the level of adoption of procurement and sales and marketing tools positively influences the probability of positive growth in sales. Meanwhile, any level of digital tool adoption positively affects the probability of non-negative sales growth regardless of the adoption timing.

Table 12 present the results for the phone survey firms. Table 12 does not include the digital tool adoption score in the regressors because almost no incumbent firm samples adopted additional digital tools after COVID. The results are different from the web survey in that the positive effect on business performance growth vanishes, but they still indicate the importance of the digital tool adoption level for sales and marketing, overall company operation, and advanced tools before COVID in achieving robust sales performance.

3.4 Difficulties in digital technology adoption

Finding 10 (Reported difficulties in digital tool adoption): *Firms at the first stage, which adopt digital tools to a limited extent, face significant internal human resource challenges in collecting and managing the necessary information for adopting digital tools. Firms at the second stage, equipped with limited basic tools, cannot find the next digital tools to adopt both due to insufficient business knowledge to identify necessary tools and limited digital tools matching their business needs. Firms at the third stage, equipped with various digital tools but limited in business automation tools, and those at the fourth stage, equipped with a variety of business automation tools, face challenges in securing IT human resources and financial resources. Firms at the most advanced stage, fully equipped with advanced tools, face not only a shortage of human resources equipped with high IT skills but also challenges in engaging all employees in their digital transformation.*

Tables 13-15 show difficulties in digital tool adoption categorized by internal and external factors, chosen by each firm group of digital tool adoption stage as classified in section 3.1, across the following three phases: the information gathering phase, the adoption phase, and the post-adoption phase. The information gathering phase involves identifying company issues and obtaining knowledge or information about digital tools. The adoption phase involves planning the implementation, including selecting solutions or tools, budget allocation, and users training. The post adoption phase involves deploying and using the tools in actual business operation.

Firms at the elementary stage, which limitedly adopt digital tools, face significant and more internal challenges across all three phases. During the information gathering phase, they struggle with limited IT knowledge (86%), indicating a lack of internal IT human resources to understand and implement digital tools effectively. Additionally, unknown resources (85%) are considered to be a major difficulty, as these firms do not know where to find information or whom to consult. Post-adoption, employees' limited skills (82%) are considered to be a critical barrier, as staff struggle to use digital tools effectively. These results suggest that firms at this stage face significant internal human resource challenges in collecting and managing the necessary information for adopting digital tools.

Firms at the second stage, equipped with only basic tools such as mobile devices, computers,

and e-payment for procurement, emphasize somewhat distinct difficulties from firms at the first stage. During the information gathering phase, limited information in local language (84%) is a key external challenge, indicating that firms struggle to find relevant local data to inform their digital tool adoption. Diagnostic inability (81%) is another significant internal factor, reflecting difficulties in identifying company issues that require digital tools. During the adoption phase, insufficient solutions (80%) pose a major external challenge, as firms find it difficult to identify adequate solutions provided by IT vendors that meet their needs. Firms at the second stage consider they cannot find the next digital tools to adopt both due to an internal factor of insufficient business knowledge to identify necessary tools and an external factor of limited digital tools matching their business needs.

Firms at the third stage, equipped with various digital tools but limited in business automation tools, emphasize more concrete resource challenges. In the information gathering phase, limited IT knowledge (76%) remains a crucial internal factor, hindering their ability to effectively adopt more advanced tools. During the adoption phase, financial constraints (78%) become a significant internal issue, limiting their ability to allocate sufficient budgets for digital tool implementation. Post-adoption, employees' limited skills (79%) emerge as a major internal difficulty, affecting the effective use of digital tools and integration with existing systems. These findings indicate that firms at the third stage have significant difficulties in IT human resources and financial resources for advancing digitalization.

Firms at the fourth stage, equipped with a variety of business automation tools such as EDI, SFA, and ERP, encounter difficulties similar to those of firms at the third stage. In the information gathering phase, unknown resources (80%) are considered to be one of the major internal challenges. During the adoption phase, financial constraints (82%) are a major internal issue, limiting their ability to invest in and implement these advanced tools. Post-adoption, employees' limited skills (80%) continue to be a critical barrier, affecting the effective use and ongoing integration of business automation tools. Firms at the third and fourth stages share similar challenges in securing IT human resources and financial resources.

Firms at the fifth stage, the most advanced stage, fully equipped with digital tools including advanced ones such as AI and IoT, face challenges primarily related to internal factors. During the adoption phase, IT staff shortage (84%) is a major issue, indicating a lack of skilled personnel to implement and manage these advanced tools. Post-adoption, employees' limited skills (86%) present the most significant barrier, as staff struggle to effectively use these advanced digital tools. Additionally, employees' reluctance (79%) to adopt and adapt to new technologies further complicates the post-adoption phase, hindering the full utilization of the advanced tools. These results show that firms at the most advanced stage face not only a shortage of human resources equipped with high IT skills but also challenges in engaging overall employees in their digital transformation.

4 Conclusion

The study conducted a comprehensive examination of the digital divide in the ASEAN region through a large-scale questionnaire survey targeting regional MSMEs. Two types of surveys, web and phone, were employed to capture a diverse range of responses, considering company size, industry, and geographical location.

This study offers insights into the dynamics of digital tool adoption, the factors advancing the adoption, the relationship between digitalization and business performance during COVID, and firms' subjective difficulties in digitalization among ASEAN firms before and after the COVID-

19 pandemic. The finding regarding pre-COVID digital tool adoption reveal that before the pandemic, basic digital devices and e-payment systems were widely adopted even by digitally entry-level firms in ASEAN. However, other digital tools, especially those for sales and marketing, saw limited adoption among these firms. Advanced tools were generally underutilized, exacerbating the digital divide between digitally developed and entry-level firms.

Regarding the post-COVID digital tool adoption, the pandemic accelerated digitalization among digitally developed firms, particularly in web conferencing and e-commerce tools. However, micro and small firms that were at the entry-level before COVID did not show significant progress in adopting digital tools. Newly entered firms after COVID had digital adoption levels similar to incumbent firms before the pandemic, indicating a stagnant trend among new entrants.

The study also detected distinct stages of digital tool adoption. A clear progression in digital tool adoption was observed, divided into five stages. From limited adoption at the elementary stage to comprehensive adoption of advanced tools at the final stage, firms exhibited a structured approach to digitalization. This progression underscores the importance of tailored support at each stage to facilitate seamless transitions.

The study delves into the influence of firm attributes on digital tool adoption. Economic development levels positively influenced digital tool adoption among smaller, less advanced firms but not among advanced firms. Firm size consistently influenced digital tool adoption positively across all types of firms. Interestingly, rural firms were not necessarily at a disadvantage compared to their urban counterparts in terms of digitalization.

Firm-specific attributes such as being FDI firms and owner-managed firms are notable in digital tool adoption. FDI firms generally adopted a wider range of digital tools, although they lagged in advanced tools compared to domestic firms. Younger firms were more likely to adopt digital tools among digitally developed firms but less likely among entry-level firms.

Regarding the role of CEO/Owner attributes, owner-managed firms showed significantly lower levels of digital tool adoption. The age of ultimate decision-makers did not broadly impact digital adoption. However, younger decision-makers in owner-managed firms adopted digital tools less frequently among digitally developed firms and more frequently among entry-level firms. Higher education levels of decision-makers were associated with greater digital tool adoption, and being owner-managed positively modified this effect.

The study further explored the role of GVC participation. Participation in GVCs positively influenced digital tool adoption, particularly at higher stages involving overall company operations and advanced tools. This underscores the importance of global engagements in driving digital transformation.

The study also revealed that public and private support had a positive impact on digital tool adoption for digitally developed firms but were less effective for entry-level firms. This suggests a need for more targeted support mechanisms to assist entry-level firms in their digitalization.

The findings also underscore the connection between digital tool adoption and business performance after COVID. Digital tool adoption significantly enhanced business performance for digitally developed firms, leading to positive growth in sales post-COVID. For digitally entry-level firms, digital adoption improved business robustness but did not necessarily drive growth. This indicates that while digital tools enhance resilience, their impact on growth varies by digital maturity.

Lastly, regarding firms' subjective difficulties in digital tool adoption, firms at different stages of digital adoption faced varying challenges. Initial stages struggled with internal human resource

capabilities and identifying appropriate tools, while advanced stages faced shortages of IT-skilled human resources and engagement issues in digital transformation. These challenges highlight the need for stage-specific interventions to support digital adoption.

As policy implications, the findings underscore the need for tailored support to bridge the digital divide between digitally developed and entry-level firms. Policymakers should focus on providing targeted assistance to entry-level firms, enhancing access to public and private support, and fostering industry collaborations. Strategies should address the specific challenges faced at each stage of digital adoption, ensuring that all firms can benefit from digital transformation initiatives.

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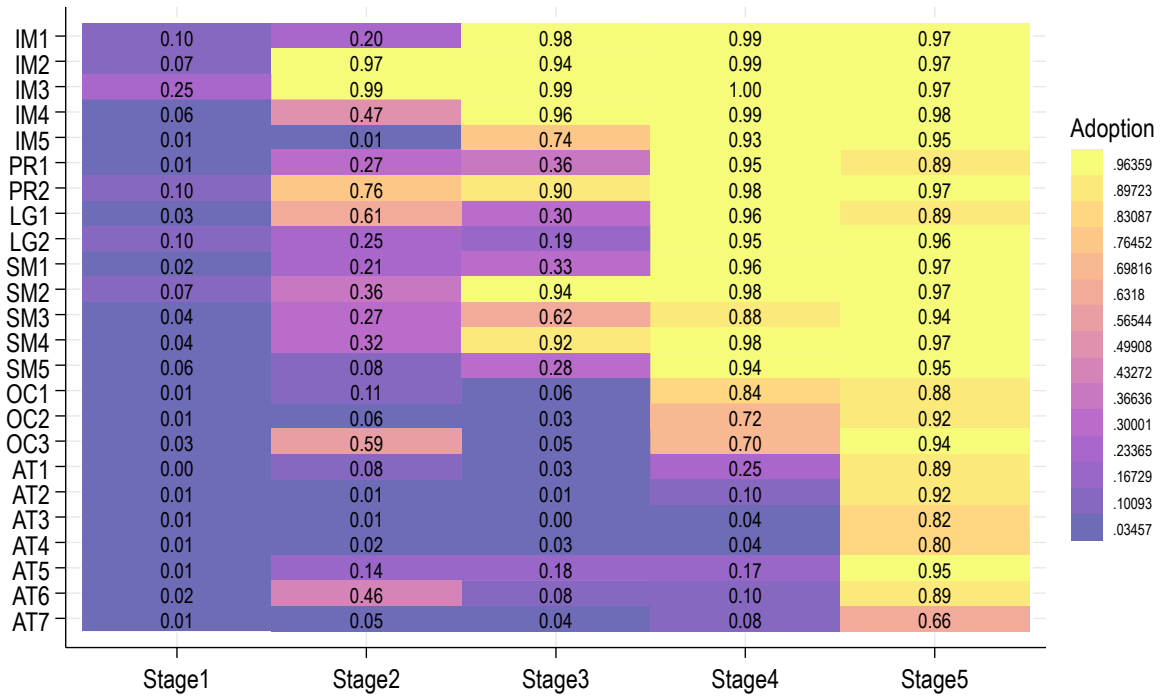
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Figure 1: Digital tool adoption order identified by cluster analysis (all)



IM1 = e-mail and/or chat application, IM2 = mobile device, IM3 = Computer, IM4 = Office suite, IM5 = Web meeting system, PR1 = EDI, PR2 = e-payment, LG1 = Document or cargo delivery application, LG2 = Storage or inventory management system, SM1 = EDI, SM2 = SNS, SM3 = e-commerce, SM4 = e-payment, SM5 = Sales management and automation tool (e.g. salesforce), OC1 = ERP, OC2 = Cloud storage or centralized server, OC3 = Cybersecurity or protection software, AT1 = 3D printing, AT2 = Artificial intelligence (AI), AT3 = Augmented reality (AR), AT4 = Drone (e.g. farming management), AT5 = Internet-of-Thing (IoT) device, AT6 = Radio frequency identification (RFID), AT7 = Robotics (e.g. factory robots, farming robots)

Note: The number in each cell represents the fraction of firms that have adopted the corresponding digital tool within the respective stage group as of 2023. For example, the figure in the top-left cell indicates that 18% of the firms classified into the stage 1 group have adopted e-mail and/or chat application tools as of 2023.

Source: Authors.

Table 1: Country distribution of respondent firms

	Web		Phone	
	Frequency	Percentage	Frequency	Percentage
Brunei	238	3.9		
Cambodia	567	9.4		
Indonesia	893	14.8	1018	32.8
Lao PDR	160	2.6		
Malaysia	930	15.4	1039	33.5
Myanmar	360	6.0		
Philippines	695	11.5		
Singapore	645	10.7		
Thailand	701	11.6		
Viet Nam	859	14.2	1042	33.6
Total	6048	100.0	3099	100.0

Source: Authors

Table 2: Firm size distribution of respondent firms

	Web		Phone	
	Frequency	Percentage	Frequency	Percentage
Micro	278	4.6	677	21.8
Small	1409	23.3	2422	78.2
Medium	2878	47.6		
Large	1483	24.5		
Total	6048	100.0	3099	100.0

Micro = Firms with 1-4 workers. Small = Firms with 5-19 workers. Medium = Firms with 20-199 workers. Large = Firms with more than or equal to 200 workers.

Source: Authors

Table 3: Industry distribution of respondent firms

	Web		Phone	
	Frequency	Percentage	Frequency	Percentage
Agriculture	747	12.4	613	19.8
Manufacturing(Light1)	1031	17.0	632	20.4
Manufacturing(Light2)	1048	17.3	618	19.9
Manufacturing(Heavy)	1096	18.1	607	19.6
Construction	391	6.5		
Transportation	259	4.3	53	1.7
Wholesale	220	3.6	192	6.2
Retail	300	5.0	63	2.0
Finance	328	5.4	58	1.9
Other Services	628	10.4	263	8.5
Total	6048	100.0	3099	100.0

Note: Agriculture encompasses all relevant sub-industries of Agriculture, Forestry, and Fishing, categorized under the US SIC 1987 codes 01-09. Manufacturing (Light1) refers to relatively labor-intensive manufacturing industries that produce consumables. This category includes USSIC 20-23. Manufacturing (Light2) comprises other labor-intensive manufacturing industries, including USSIC 24-27, 30, 31, and 34. Manufacturing (Heavy) encompasses relatively capital-intensive manufacturing industries, which include USSIC 28, 29, 32, 33, and 35-38. This category also includes Mining (10-14). Finance encompasses all relevant sub-industries of Finance, Insurance, Real Estate (60-67). Other services encompass Services (70-89), and Public Administration (91-99).

Source: Authors

Table 4: Location distribution of respondent firms

	Web		Phone	
	Frequency	Percentage	Frequency	Percentage
Urban	4315	71.3	1341	43.3
Rural	1733	28.7	1758	56.7
Total	6048	100.0	3099	100.0

Note: The urban and rural classification is derived from the World Urbanisation Prospects Report (United Nations, 2019).

Source: Authors

Table 5: Summary statistics for regression variables 1: Digital tool adoption scores and attributes of firms

	Web				Phone			
	Mean	SD	Min	Max	Mean	SD	Min	Max
TTL	14.90	5.75	0	24	6.24	3.21	0	19
IM	4.62	0.92	0	5	2.25	1.07	0	5
PR	1.59	0.63	0	2	0.90	0.50	0	2
LG	1.32	0.87	0	2	0.75	0.54	0	2
SM	3.96	1.38	0	5	1.08	1.16	0	5
OC	1.54	1.38	0	3	0.65	0.66	0	3
AT	1.87	2.51	0	7	0.61	0.67	0	4
lnI	7.97	0.90	7	10	7.94	0.65	7	8
lnE	4.05	1.51	1	7	2.24	0.74	1	4
RURAL	0.29	0.45	0	1	0.57	0.50	0	1
FDI	0.10	0.31	0	1	0.00	0.00	0	0
OWNER	0.89	0.31	0	1	1.00	0.04	0	1
AGEf	21.10	17.35	1	124	16.44	13.49	2	124
AGEu	48.34	11.64	22	80	48.57	11.93	22	80
FEMu	0.11	0.31	0	1	0.10	0.30	0	1
EDUu	5.83	1.02	1	7	5.29	1.47	1	7
MNFc	0.24	0.43	0	1	0.28	0.45	0	1
MNFs	0.18	0.38	0	1	0.26	0.44	0	1
Public support	0.10	0.30	0	1	0.06	0.24	0	1
IA support	0.30	0.46	0	1	0.04	0.20	0	1
MNF support	0.22	0.41	0	1	0.04	0.21	0	1
LF support	0.20	0.40	0	1	0.25	0.43	0	1

Notes: TTL = Total digital tool adoption score, IM = Intra-company management tool adoption score, PR = Procurement tool adoption score, LG = Logistics tool adoption score, SM = Sales management tool adoption score, OC = Overall company operation tool adoption score, AT = Advanced tool adoption score. lnI = log of income level of a firm's country (see section 3.2). lnE = Log of employees. FDI = Foreign-affiliate firm dummy. AGEf = Age of firms. OWNER = Owner-managed firm dummy. AGEu = Age of ultimate decision makers. FEMu = Female ultimate decision maker dummy. EDUu = Highest education level of ultimate decision makers. MNFc = Dummy variable for firms with multinational firm customers. MNFs = Dummy variable for firms with multinational firm suppliers. Public support = Public sector support dummy. IA support = Industry association support dummy. MNF support = Multinational firm support dummy. LF support = Local firm support dummy.

Source: Authors.

Table 6: Summary statistics for regression variables 2: Business performance and digital tool adoption scores of firms in COVID-19

	Web				Phone			
	Mean	SD	Min	Max	Mean	SD	Min	Max
GROWTHs	0.38	0.49	0	1	0.03	0.18	0	1
ROBUSTs	0.89	0.31	0	1	0.33	0.47	0	1
GROWTHp	0.39	0.49	0	1	0.03	0.18	0	1
ROBUSTp	0.89	0.31	0	1	0.32	0.47	0	1
TTLb	11.80	5.85	0	24	6.29	3.64	0	19
TTLa	3.24	4.69	0	24	0.02	0.32	0	9
IMb	3.95	1.38	0	5	2.14	1.19	0	5
IMa	0.72	1.15	0	5	0.01	0.13	0	4
PRb	1.31	0.78	0	2	0.87	0.56	0	2
PRa	0.30	0.63	0	2	0.01	0.07	0	1
LGb	1.05	0.91	0	2	0.69	0.58	0	2
LGa	0.28	0.62	0	2	0.00	0.08	0	2
SMb	3.21	1.69	0	5	1.22	1.21	0	5
SMa	0.79	1.34	0	5	0.00	0.08	0	2
OCb	1.11	1.29	0	3	0.72	0.67	0	3
OCa	0.43	0.91	0	3	0.00	0.03	0	1
ATb	1.17	1.90	0	7	0.66	0.69	0	4
ATa	0.73	1.51	0	7	0.00	0.02	0	1

Notes: GROWTHs = Positive sales growth dummy in 2022 compared to 2019. ROBUSTs = Non-negative sales growth dummy in 2022 compared to 2019. GROWTHp = Positive profit margin ratio growth dummy in 2022 compared to 2019. ROBUSTp = Non-negative profit margin ratio growth in 2022 compared to 2019. TTL = Total digital tool adoption score, IM = Intra-company management tool adoption score, PR = Procurement tool adoption score, LG = Logistics tool adoption score, SM = Sales management tool adoption score, OC = Overall company operation tool adoption score, AT = Advanced tool adoption score. Subscript 'b' represents 'before COVID', while subscript 'a' represents 'after COVID'.
Source: Authors.

Table 7: Percentages of digital tool adoption by respondent firms before and after COVID-19

	Web incumbents		Web new	Phone incumbents		Phone new
	Before	After	After	Before	After	After
Intra-company management tools (IM)						
IM1	0.87	0.08	0.76	0.23	0.00	0.03
IM2	0.87	0.09	0.77	0.75	0.00	0.94
IM3	0.89	0.08	0.82	0.82	0.00	0.96
IM4	0.85	0.10	0.78	0.34	0.00	0.52
IM5	0.48	0.36	0.62	0.00	0.00	0.00
Procurement tools (PR)						
PR1	0.54	0.15	0.57	0.24	0.00	0.20
PR2	0.77	0.15	0.73	0.63	0.01	0.75
Logistics tools (LG)						
LG1	0.53	0.15	0.54	0.43	0.00	0.75
LG2	0.52	0.14	0.54	0.26	0.00	0.13
Sales and marketing tools (SM)						
SM1	0.56	0.14	0.61	0.16	0.00	0.23
SM2	0.82	0.12	0.75	0.36	0.00	0.15
SM3	0.55	0.22	0.60	0.28	0.00	0.11
SM4	0.78	0.14	0.75	0.32	0.00	0.17
SM5	0.50	0.17	0.50	0.10	0.00	0.02
Overall company operation tools (OC)						
OC1	0.40	0.15	0.47	0.09	0.00	0.07
OC2	0.35	0.15	0.44	0.07	0.00	0.02
OC3	0.36	0.14	0.45	0.56	0.00	0.38
Advanced digital tools (AT)						
AT1	0.21	0.10	0.30	0.08	0.00	0.03
AT2	0.15	0.12	0.21	0.01	0.00	0.00
AT3	0.09	0.13	0.14	0.00	0.00	0.00
AT4	0.13	0.10	0.15	0.00	0.00	0.00
AT5	0.25	0.11	0.29	0.14	0.00	0.03
AT6	0.19	0.10	0.21	0.40	0.00	0.37
AT7	0.13	0.08	0.15	0.04	0.00	0.01

Notes: Incumbent firms already began operating before the COVID-19 pandemic (in 2019). Meanwhile, new firms started their operations after the COVID pandemic started (in 2020) or later. IM1 = e-mail and/or chat application, IM2 = Mobile device, IM3 = Computer, IM4 = Office suite, IM5 = Web meeting system, PR1 = EDI, PR2 = e-payment, LG1 = Document or cargo delivery application, LG2 = Storage or inventory management system, SM1 = EDI, SM2 = SNS, SM3 = e-commerce, SM4 = e-payment, SM5 = Sales management and automation tool (e.g. salesforce), OC1 = ERP, OC2 = Cloud storage or centralized server, OC3 = Cybersecurity or protection software, AT1 = 3D printing, AT2 = Artificial intelligence (AI), AT3 = Augmented reality (AR), AT4 = Drone (e.g. farming management), AT5 = Internet-of-Thing (IoT) device, AT6 = Radio frequency identification (RFID), AT7 = Robotics (e.g. factory robots, farming robots).

Table 8: Profiles of firms by digital tool adoption stages

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Survey type					
Web survey	0.27	0.06	0.99	0.99	1.00
Phone survey	0.73	0.94	0.01	0.01	0.00
Firm size					
Micro firms	0.18	0.23	0.07	0.02	0.01
Small firms	0.72	0.74	0.37	0.16	0.13
Medium firms	0.09	0.02	0.46	0.48	0.52
Large firms	0.01	0.01	0.10	0.33	0.34
Industry					
Agriculture	0.20	0.20	0.18	0.09	0.08
Manufacturing (Light1)	0.26	0.19	0.15	0.17	0.18
Manufacturing (Light2)	0.16	0.20	0.22	0.19	0.10
Manufacturing (Heavy)	0.11	0.21	0.14	0.27	0.13
Construction	0.01	0.00	0.04	0.05	0.11
Wholesale	0.06	0.06	0.04	0.02	0.05
Retail	0.05	0.02	0.07	0.04	0.03
Finance	0.02	0.02	0.04	0.04	0.09
Other Services	0.10	0.08	0.08	0.08	0.18
Location					
Urban area	0.51	0.44	0.68	0.72	0.75
Rural area	0.49	0.56	0.32	0.28	0.25

Notes: The number in each cell represents the share of firms with the corresponding profile among firms at the respective stage. Micro firms have 1-4 workers. Small firms have 5-19 workers. Medium firms have 20-199 workers. Large firms have more than or equal to 200 workers. Agriculture encompasses all relevant sub-industries of Agriculture, Forestry, and Fishing, categorized under the US SIC 1987 codes 01-09. Manufacturing (Light1) refers to relatively labor-intensive manufacturing industries that produce consumables. This category includes USSIC 20-23. Manufacturing (Light2) comprises other labor-intensive manufacturing industries, including USSIC 24-27, 30, 31, and 34. Manufacturing (Heavy) encompasses relatively capital-intensive manufacturing industries, which include USSIC 28, 29, 32, 33, and 35-38. This category also includes Mining (10-14). Finance encompasses all relevant sub-industries of Finance, Insurance, Real Estate (60-67). Other services encompass Services (70-89), and Public Administration (91-99). The urban and rural classification is derived from the World Urbanisation Prospects Report (United Nations, 2019).

Table 9: Effects of firm attributes on digital tool adoption (Web survey)

	TTL	IM	PR	LG	SM	OC	AT
lnI	-0.096 (0.092)	-0.014 (0.025)	-0.019 (0.014)	-0.097*** (0.021)	-0.050 (0.031)	0.031 (0.023)	0.052 (0.037)
lnE	0.795*** (0.048)	0.084*** (0.010)	0.073*** (0.006)	0.112*** (0.007)	0.166*** (0.013)	0.147*** (0.011)	0.213*** (0.022)
RURAL	0.003 (0.124)	-0.069** (0.027)	-0.038** (0.016)	0.041* (0.022)	-0.039 (0.036)	0.050* (0.030)	0.059 (0.055)
FDI	0.221 (0.216)	0.071* (0.037)	0.078*** (0.026)	0.088*** (0.033)	0.178*** (0.056)	0.171*** (0.052)	-0.365*** (0.113)
OWNER	-3.638** (1.761)	0.659* (0.392)	0.210 (0.220)	-0.512** (0.246)	-0.740 (0.488)	-0.534 (0.344)	-2.722*** (0.667)
AGEf	-0.017*** (0.004)	0.002*** (0.001)	-0.000 (0.000)	-0.002*** (0.001)	-0.002** (0.001)	-0.004*** (0.001)	-0.010*** (0.002)
AGEu	0.009 (0.021)	-0.004 (0.005)	-0.005* (0.003)	0.001 (0.003)	0.000 (0.006)	0.021*** (0.004)	-0.005 (0.010)
OWNER X AGEu	0.039* (0.021)	0.008* (0.005)	0.009*** (0.003)	0.014*** (0.003)	0.014** (0.006)	-0.002 (0.005)	-0.004 (0.010)
FEMu	0.311 (0.638)	-0.196 (0.126)	-0.248*** (0.084)	-0.058 (0.092)	-0.397** (0.177)	0.515*** (0.146)	0.693*** (0.268)
OWNER X FEMu	-1.032 (0.673)	0.064 (0.136)	0.163* (0.089)	0.046 (0.097)	0.230 (0.188)	-0.558*** (0.152)	-0.977*** (0.280)
EDUu	0.547** (0.244)	0.290*** (0.053)	0.194*** (0.030)	0.126*** (0.033)	0.208*** (0.067)	0.026 (0.049)	-0.296*** (0.092)
OWNER X EDUu	0.470* (0.249)	-0.151*** (0.054)	-0.095*** (0.030)	-0.017 (0.034)	0.039 (0.069)	0.123** (0.051)	0.571*** (0.095)
MNFc	0.753*** (0.201)	-0.099*** (0.037)	0.010 (0.024)	0.014 (0.029)	0.015 (0.052)	0.241*** (0.047)	0.573*** (0.093)
MNFs	1.034*** (0.206)	0.119*** (0.034)	-0.007 (0.025)	0.089*** (0.031)	0.109** (0.055)	0.280*** (0.050)	0.444*** (0.103)
Public support	1.275*** (0.238)	-0.001 (0.044)	0.041 (0.027)	0.105*** (0.032)	-0.030 (0.059)	0.386*** (0.048)	0.774*** (0.114)
IA support	1.145*** (0.142)	0.100*** (0.027)	0.200*** (0.017)	0.102*** (0.023)	0.246*** (0.038)	0.223*** (0.034)	0.275*** (0.071)
MNF support	0.596*** (0.156)	0.011 (0.029)	0.050*** (0.019)	0.049** (0.025)	0.054 (0.042)	0.135*** (0.036)	0.298*** (0.080)
LF support	0.737*** (0.160)	0.010 (0.031)	0.089*** (0.020)	0.203*** (0.025)	0.154*** (0.043)	0.349*** (0.037)	-0.068 (0.074)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6048	6048	6048	6048	6048	6048	6048
R-squared	0.479	0.193	0.285	0.400	0.322	0.502	0.412

Note: Standard errors in parentheses. TTL = Total digital tool adoption score, IM = Intra-company management tool adoption score, PR = Procurement tool adoption score, LG = Logistics tool adoption score, SM = Sales management tool adoption score, OC = Overall company operation tool adoption score, AT = Advanced tool adoption score.

Source: Authors

* p<0.10, ** p<0.05, *** p<0.01

Table 10: Effects of firm attributes on digital tool adoption (Phone survey)

	TTL	IM	PR	LG	SM	OC	AT
lnI	0.331*** (0.099)	-0.003 (0.033)	-0.003 (0.018)	0.008 (0.022)	0.112*** (0.042)	0.142*** (0.023)	0.076*** (0.027)
lnE	0.481*** (0.072)	0.069*** (0.025)	0.046*** (0.013)	0.060*** (0.015)	0.137*** (0.028)	0.072*** (0.016)	0.097*** (0.017)
RURAL	-0.061 (0.094)	0.102*** (0.033)	0.026 (0.016)	0.017 (0.019)	-0.073** (0.035)	-0.076*** (0.020)	-0.057*** (0.022)
AGEf	0.016*** (0.005)	-0.001 (0.002)	0.001 (0.001)	-0.004*** (0.001)	0.012*** (0.002)	0.004*** (0.001)	0.003*** (0.001)
AGEu	-0.025*** (0.005)	-0.008*** (0.002)	-0.002*** (0.001)	-0.004*** (0.001)	-0.002 (0.002)	-0.004*** (0.001)	-0.005*** (0.001)
FEMu	0.824*** (0.136)	-0.000 (0.046)	0.029 (0.024)	0.021 (0.031)	0.321*** (0.059)	0.219*** (0.033)	0.234*** (0.040)
EDUu	0.221*** (0.032)	0.185*** (0.012)	0.062*** (0.005)	0.012** (0.006)	0.073*** (0.012)	-0.052*** (0.007)	-0.058*** (0.008)
MNFc	1.711*** (0.125)	0.272*** (0.040)	0.175*** (0.022)	0.038 (0.026)	0.654*** (0.051)	0.267*** (0.027)	0.305*** (0.031)
MNFs	1.570*** (0.118)	0.446*** (0.041)	0.130*** (0.020)	0.143*** (0.025)	0.293*** (0.045)	0.281*** (0.026)	0.278*** (0.028)
Public support	-0.242 (0.231)	-0.611*** (0.077)	-0.125*** (0.048)	-0.069 (0.052)	0.486*** (0.083)	0.051 (0.044)	0.027 (0.053)
IA support	0.076 (0.270)	-0.299*** (0.106)	-0.167*** (0.035)	-0.035 (0.050)	0.300*** (0.060)	0.174*** (0.037)	0.104*** (0.037)
MNF support	0.798*** (0.227)	-0.544*** (0.074)	-0.086* (0.049)	-0.303*** (0.061)	0.678*** (0.087)	0.631*** (0.066)	0.422*** (0.058)
LF support	-0.587*** (0.126)	-0.704*** (0.044)	-0.165*** (0.023)	-0.318*** (0.026)	0.351*** (0.046)	0.176*** (0.027)	0.073** (0.029)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3099	3099	3099	3099	3099	3099	3099
R-squared	0.399	0.308	0.258	0.147	0.361	0.335	0.277

Standard errors in parentheses

Note: TTL = Total digital tool adoption score, IM = Intra-company management tool adoption score, PR = Procurement tool adoption score, LG = Logistics tool adoption score, SM = Sales management tool adoption score, OC = Overall company operation tool adoption score, AT = Advanced tool adoption score.

Source: Authors

* p<0.10, ** p<0.05, *** p<0.01

Table 11: Effects of digital tool adoption on performance post-COVID-19 compared to pre-COVID-19 (Web survey)

	TTL	IM	PR	LG	SM	OC	AT
Dependent variable: GROWTHs							
DSCOREb	-0.000 (0.002)	0.022*** (0.008)	0.057*** (0.012)	0.010 (0.009)	0.021*** (0.006)	-0.019*** (0.007)	-0.012*** (0.004)
DSCOREa	-0.001 (0.002)	0.009 (0.010)	0.077*** (0.014)	0.016 (0.013)	0.026*** (0.007)	-0.023*** (0.009)	-0.012** (0.005)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5742	5742	5742	5742	5742	5742	5742
R-squared	0.142	0.144	0.147	0.143	0.145	0.144	0.145
Dependent variable: ROBUSTs							
DSCOREb	0.010*** (0.001)	0.031*** (0.007)	0.047*** (0.009)	0.019*** (0.006)	0.037*** (0.004)	0.009** (0.005)	0.020*** (0.003)
DSCOREa	0.010*** (0.001)	0.022*** (0.008)	0.055*** (0.010)	0.025*** (0.009)	0.040*** (0.005)	0.018*** (0.005)	0.015*** (0.004)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5742	5742	5742	5742	5742	5742	5742
R-squared	0.113	0.102	0.102	0.098	0.113	0.097	0.108
Dependent variable: GROWTHp							
DSCOREb	0.002 (0.002)	0.023*** (0.008)	0.072*** (0.012)	0.013 (0.009)	0.028*** (0.006)	-0.015** (0.007)	-0.003 (0.004)
DSCOREa	-0.001 (0.002)	0.007 (0.010)	0.083*** (0.014)	0.012 (0.013)	0.029*** (0.007)	-0.020** (0.009)	-0.021*** (0.005)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5742	5742	5742	5742	5742	5742	5742
R-squared	0.151	0.153	0.157	0.151	0.154	0.152	0.153
Dependent variable: ROBUSTp							
DSCOREb	0.010*** (0.001)	0.029*** (0.007)	0.043*** (0.009)	0.012* (0.006)	0.035*** (0.004)	0.007 (0.005)	0.020*** (0.003)
DSCOREa	0.011*** (0.001)	0.021*** (0.008)	0.052*** (0.010)	0.020** (0.008)	0.039*** (0.005)	0.024*** (0.005)	0.020*** (0.003)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	5742	5742	5742	5742	5742	5742	5742
R-squared	0.110	0.097	0.098	0.093	0.108	0.095	0.107

Notes: Standard errors in parentheses. TTL = Total digital tool adoption score, IM = Intra-company management tool adoption score, PR = Procurement tool adoption score, LG = Logistics tool adoption score, SM = Sales management tool adoption score, OC = Overall company operation tool adoption score, AT = Advanced tool adoption score.

* p<0.10, ** p<0.05, *** p<0.01

Table 12: Effects of digital tool adoption on performance post-COVID-19 compared to pre-COVID-19 (Phone survey)

	TTL	IM	PR	LG	SM	OC	AT
Dependent variable: GROWTHs							
DSCOREb	-0.004** (0.002)	-0.015*** (0.005)	-0.036*** (0.012)	-0.001 (0.009)	-0.002 (0.005)	0.011 (0.011)	-0.017** (0.008)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2229	2229	2229	2229	2229	2229	2229
R-squared	0.093	0.097	0.099	0.090	0.091	0.091	0.093
Dependent variable: ROBUSTs							
DSCOREb	0.003 (0.003)	-0.075*** (0.008)	-0.000 (0.020)	-0.098*** (0.019)	0.093*** (0.011)	0.117*** (0.019)	0.058*** (0.017)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2229	2229	2229	2229	2229	2229	2229
R-squared	0.328	0.351	0.328	0.340	0.357	0.343	0.332
Dependent variable: GROWTHp							
DSCOREb	-0.001 (0.002)	-0.015*** (0.004)	-0.025** (0.012)	0.010 (0.008)	0.008 (0.005)	0.025** (0.011)	-0.007 (0.008)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2229	2229	2229	2229	2229	2229	2229
R-squared	0.099	0.105	0.104	0.100	0.101	0.104	0.100
Dependent variable: ROBUSTp							
DSCOREb	0.004 (0.003)	-0.069*** (0.008)	-0.003 (0.020)	-0.083*** (0.019)	0.089*** (0.011)	0.109*** (0.019)	0.054*** (0.018)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2229	2229	2229	2229	2229	2229	2229
R-squared	0.319	0.339	0.319	0.328	0.346	0.333	0.323

Standard errors in parentheses

Notes: TTL = Total digital tool adoption score, IM = Intra-company management tool adoption score, PR = Procurement tool adoption score, LG = Logistics tool adoption score, SM = Sales management tool adoption score, OC = Overall company operation tool adoption score, AT = Advanced tool adoption score.

* p<0.10, ** p<0.05, *** p<0.01

Table 13: Reported difficulties in digital tool adoption during the information gathering phase by adoption stage

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Internal factors:					
Diagnostic inability	0.79	0.81	0.60	0.77	0.77
Unknown resources	0.85	0.73	0.68	0.80	0.65
Language barriers	0.81	0.67	0.71	0.72	0.67
Limited IT knowledge	0.86	0.63	0.76	0.73	0.64
External factors:					
Limited local information	0.72	0.84	0.66	0.65	0.69
No nearby support	0.52	0.72	0.61	0.64	0.60

Note: Diagnostic inability = Inability to diagnose the company's issue that may require digital tools. Unknown resources = Not knowing where to find the information or whom to consult with. Language barriers = Language barriers to search and understand the available information. Limited IT knowledge = Limited IT knowledge due to a lack of internal IT human resources to understand the information. Limited local information = Limited information in local language. No nearby support = No supporting organizations nearby.

Source: Authors.

Table 14: Reported difficulties in digital tool adoption during the adoption phase by adoption stage

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Internal factors:					
Tool identification issue	0.75	0.65	0.58	0.74	0.55
Financial constraints	0.51	0.41	0.78	0.82	0.67
IT staff shortage	0.80	0.49	0.75	0.75	0.84
External factors:					
Insufficient solutions	0.79	0.80	0.64	0.73	0.48
No local support	0.66	0.66	0.62	0.69	0.70
Limited funding sources	0.35	0.16	0.50	0.50	0.39

Note: Tool identification issue = Inability to identify the tools that match with company's issues or needs. Financial constraints = Limited financial resources to invest in digital tools. IT staff shortage = Lack of IT human resources who can plan and implement digital tools. Insufficient solutions = Limited or no solution that can meet the business needs. No local support = No support from the solution providers available in the country or area. Limited funding sources = Limited source of fund.

Source: Authors.

Table 15: Reported difficulties in digital tool adoption during the post adoption phase by adoption stage

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Internal factors:					
Employees' reluctance	0.45	0.60	0.64	0.78	0.79
Employees' limited skills	0.82	0.73	0.79	0.80	0.86
Integration difficulty	0.70	0.66	0.60	0.67	0.59
Budget constraints	0.54	0.30	0.61	0.68	0.50
External factors:					
No local support	0.79	0.60	0.68	0.65	0.52
Internet instability	0.63	0.43	0.36	0.51	0.64

Note: Employees' reluctance = Employees are not eager to onboard the adoption as they find digital tools confusing and they increase the work process. Employees' limited skills = Employees' inability to use digital tools due to limited skills. Integration difficulty = Inability to integrate new digital tools with the ones already implemented. Budget constraints = Lack of budget to upgrade digital tools so the solutions are outdated or some features cannot be used. No local support = No customer support available in the country or area. Internet instability = Internet instability that affects consistent use.

Source: Authors.

Table A.1: T-test for mean difference between web and phone survey among micro and small firms in Indonesia, Malaysia, and Viet Nam

	Web	Phone	Diff	p-value
TTLb	9.942	6.287	3.655	0.000
IMb	3.712	2.137	1.575	0.000
PRb	1.033	0.868	0.165	0.000
LGb	0.668	0.684	-0.016	0.636
SMb	2.739	1.217	1.522	0.000
OCb	0.681	0.716	-0.035	0.417
ATb	1.109	0.665	0.444	0.000
GROWTHs	0.280	0.035	0.245	0.000
ROBUSTs	0.839	0.329	0.510	0.000
GROWTHp	0.286	0.033	0.253	0.000
ROBUSTp	0.842	0.322	0.520	0.000
FDI	0.013	0.000	0.013	0.003
AGEf	15.522	21.672	-6.150	0.000
OWNER	0.917	1.000	-0.083	0.000
AGEu	43.854	50.942	-7.088	0.000
FEMAu	0.161	0.078	0.083	0.000
EDUu	5.316	5.326	-0.010	0.831
MNFc	0.093	0.324	-0.231	0.000
MNFs	0.071	0.279	-0.208	0.000

Notes: TTL = Total digital tool adoption score, IM = Intra-company management tool adoption score, PR = Procurement tool adoption score, LG = Logistics tool adoption score, SM = Sales management tool adoption score, OC = Overall company operation tool adoption score, AT = Advanced tool adoption score. Subscript 'b' represents 'before COVID'. GROWTHs = Positive sales growth dummy in 2022 compared to 2019. ROBUSTs = Non-negative sales growth dummy in 2022 compared to 2019. GROWTHp = Positive profit margin ratio growth dummy in 2022 compared to 2019. ROBUSTp = Non-negative profit margin ratio growth in 2022 compared to 2019. FDI = Foreign-affiliate firm dummy. AGEf = Age of firms. OWNER = Owner-managed firm dummy. AGEu = Age of ultimate decision makers. FEMu = Female ultimate decision maker dummy. EDUu = Highest education level of ultimate decision makers. MNFc = Dummy variable for firms with multinational firm customers. MNFs = Dummy variable for firms with multinational firm suppliers.