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Digital Technology Adoption and SMEs' Financial Performance: Evidence from Thailand

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Digital technology adoption and SMEs' Financial Performance: Evidence from Thailand

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Abstract: This paper aims to examine the impacts of digital technology (DT) adoption, with an emphasis on the role of ICT, on SMEs' financial performance using Thailand as a case study during 2018-2021. The importance of DT depth and personnels graduated in a field of ICT was also investigated in this study. Our results show that types of ICT adoption, size of firms and sectors mattered in analyzing impacts of DT on firms' financial performance. SMEs received significant benefits when ICT adoption was considered in terms of purchasing goods and services via the Internet; sales online (e-Commerce) as well as online payments. Due to the nature of industry, the service sector tended to gain more benefits from operating through online activities than the manufacturing sector. In terms of software usage, it generated benefits mostly for the medium and large firms, but less crucial for the small ones. Interestingly, access to the internet, with other purposes than the e-commerce, showed limited impacts in influencing firms' financial performance, even in the large firms. Regarding the technology depth, in general, the results revealed that it generates more positive impacts on income than profits, reflecting high costs of obtaining advanced technology or diversifying DT usage. Limited impacts of ICT personnels graduated and its depth on SMEs' performance generated concerns on shortages of basic and advanced ICT skills and costs of hiring ICT staffs for SMEs.

Keywords: Digital Technologies, SMEs, and Developing Countries

JEL Code: O30; O11; O53

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1. Introduction

Digital Technology (DT) is becoming an ever more important part of the global economy. Like other countries, Thailand puts great policy emphases to harness advantages of the new and emerging economic opportunity brought about by DT. The government has chosen industries, which involved with advanced technology, e.g., smart electronics; new-generation automotive; robotics for industry; and digital industries, as the new engines in moving the country towards industry 4.0 and avoiding a prolong trap in (upper) middle-income level. Not only have policies directly related to digital transformation (e.g., investment strategy, digital infrastructure, rules and regulations) been launched, strategic investment plans and various decrees have also been introduced to effectively induce such transformation (Jongwanich, 2023).

One of the key areas, which has been emphasized in various policy agendas of Thailand, is helping small and medium-sized enterprises (SMEs), which account for about 35 percent of GDP in 2021; 72 percent of total employment and 99 percent of all enterprises, get digitally equipped in the country. For example, in the 20-year National Strategy (2018-2037) - the country's first national long-term strategy development pursuant to constitution – and the 13th national economic and social development plan for 2022 to 2026, policies geared towards developing smart, entrepreneur-based economy, especially SMEs have been clearly emphasized. Several supporting programs have also been initiated to create ecosystems for SMEs. For example, Office of SME Promotion (Osmep), Digital Economy Promotion Agency (Depa), the National Science and Technology Development Agency (NSTDA) together with UOB Thailand, and the FinLab have provided both financial and non-financial supports to SMEs in their digital transformation through the Smart Business Transformation Program (SBTP) since 2019. The government has rolled out numerous measures to create a vibrant startup ecosystem, through funding, incubating and accelerator programs along with tax and non-tax incentives. In addition, the Board of Investment provides special incentives for supporting SMEs to be involved with digital-technology investment and transformation.

Digital technology adoption of Thai SMEs in some areas has been accelerated noticeably after the COVID-19, particularly e-commerce. Electronic Transaction Development Agency (ETDA) – one of the key organizations responsible for digital development in Thailand – revealed SMEs' utilization of e-commerce during 2019-21 increased substantially, with the value

increased from 1.4 million baht to almost 2.0 million baht. Salesforce report (2022)[1] also discovered Thai SMEs have substantially shifted their business operation online and embraced DT faster than many other Southeast Asian countries.

Although Thai SMEs' engagement with digital technology has been accelerated, disparities in DT adoption have been evident in the country. The recent ICT survey in 2021 shows that small firms utilized computer and accessed to the internet far lower than those of medium and large firms, i.e., about 65 and 70 percent of total establishments, respectively for the small firms, comparing to 97 and 70 for the medium and almost hundred percent for the large enterprises. In addition, the percentage of establishments which employed personnels graduated in a field of ICT, was only 13 of total establishments for the small firms while for the medium and large firms, it reached 40 and 70 percent, respectively. This evidence is in line with ITU statistics, revealing only 1 percent of the population was classified as advanced ICT skills while another 20 percent - most of them were in the large firms - had basic ICT skills. With the existing evidence of these accessible disparities, the interesting question is whether DT adoption so far has helped improve performance of Thai SMEs, particularly in an aspect of financial performance, which is one of the key indicators in measuring inequality and a country's growth prospect.

Previous studies paid attention to this issue, however, these studies mostly considered only the impacts of DT on non-financial aspect, such as firms' productivity and labor market outcomes, i.e., employment, worker skills, and wage (e.g., Graetz and Michaels (2018); Bartel, Ichiowski and Shaw (2007); Jongwanich (2022a, b and the works cited therein) while few studies paid attention to the relationship between DT adoption and financial performance (e.g., Foroudi et.al., (2017); Mahakittikun et.al., (2021); Flaminiano etr.al., (2021); Li et.al. (2022a)). Most of those few studies, however, examined primarily the impact of a certain type of technology but ignoring possible synergies between different types of DT, including among different types of ICT, which may simplify the role of DT on firms' financial performance. In addition, depth of DT - defined as both intensity and scale of DT adoption - have been scantly studied in previous studies.

With limited empirical studies concerning these issues, this study aims to investigate the impact of DT, with an emphasis on ICT, on firms' financial performance using Thailand as a case

[1] See the report from https://www.salesforce.com/th/form/pdf/smbtrendsreport/

study during 2018-2021. This study contributes to the existing literature in three ways. First, various types of ICT are employed in this study to investigate their relative importance on firms' financial performance, including computer usage; internet access; software usage; purchase/sale goods or services via the Internet; online payments as well as involvement of ICT personnels graduated. Second, this study constructs depth of ICT usage to realize its role in enhancing impacts of ICT on SMEs' financial performance. Third, not only are small and medium-sized firms examined separately, but their performance is also compared to that of large enterprises to clearly draw inferences regarding impacts of ICT. In addition, while the nature of manufacturing and service sectors tend to be different and ICT adoption of firms in these two sectors is unequal, with a swift acceleration of the latter during the pandemic, these two sectors are examined separately in this study.

The paper's organization is as follows; Section 2 briefly presents a literature survey to lay down an analytical framework and contributions of the paper. Section 3 discusses some digital policies relevant to SMEs in Thailand and shows ICT adoption of Thai SMEs. Methodology, variable measurements, and data are presented in section 4. Section 5 presents results while the last section provides conclusions and policy inferences.

2. Literature Survey

Empirical studies relevent to impacts of DT on firms' performance could be grouped into two main areas, i.e., impacts concerning financial and non-financial performance. The latter refers to both business and economic prospoects and so far, previous empirical studies have paid more attention to the non-financial performance than the financial one. Staring with the former, in general questionaire surveys or face to face interviews were the main methodology employed in the studies so that relatively small samples were used in the analysis. It seems that the impact of certain specific technologies has been analyzed in those studies, while the impacts of different types of ICT adoption have been scantly studied. In addition, some studies (e.g., Li et.al. (2022a)) examine mediated role of some variables such as human capital, organization mechanisms, but the role of technology depth has been scarcely analyzed. For example, Foroudi et.al. (2017) examined impacts of digital technology in terms of software such as the customer relationship management ("CRM) technology; integrated global ERP system, and social media on marketing capability and company's growth using SMEs in United Kingdom as a case study. 21 in-depth face-to-face interviews with managers from different multinational organizations and 6 focus

groups with employees were conducted during October 2015 to September 2016. The results showed that digital technology has an enormous impact on marketing capabilities which leads to core competencies in the UK SME firms. Li et.al. (2022) investigated the combined effects of digitalization, knowledge inertia, and organization mechanisms on firm performance in China in 2021 by adopting a seven-point Likert scale questionnaire. 192 firms provided valid responses, representing a respond rate of around 61 percent and most of the respondent firms were private-owned, which had been in operation for more than 10 years in manufacturing industries. Digitalization was measured through aspects of employing technologies for increasing product value; understanding customers; operation decisions and launching business model while firm performance included sales, profits, ROI and return on sales. The results showed that digitalization induced a positive impact on firm performance, but such positive relationship is negatively moderated by knowledge inertia. However, formal organizational integration mechanisms (cross-functional interfaces) could mitigate the negative moderator effect of knowledge inertia.

Heredia et.al (2022) examined the effect of digital capabilities on firm performance in 2020 and analyzed the mediating role of technological capabilities and the Human Development Index (HDI) in explaining firm performance in terms of demand variations and changes in sales. The study employed data from the World Bank's Enterprise Surveys 2020, which included 999 firms from 27 countries. Digital capabilities were measured by online activities, delivery and remote work while technological capabilities were reflected by supply variation and variation hours of operation. The partial least square structural equation modeling (PLS-SEM) was applied in the study. The results showed that digital capabilities positively influenced firm performance only through technological capabilities. Digital skills in low HDI economies tended to have a more significant indirect effect on firm performance than that in high HDI countries. Flaminiano et.al. (2021) assessed how firms in the Philippines, especially MSMEs, adapted to the new market environment during the COVID-19 and how this affected firm performance and their evolving business strategies. The authors tracked the recovery journey of 677 MSMEs in the Philippines, especially in the National Capital Region (NCR) and the neighboring CALABARZON region during September 2020 - April 2021. The interview was conducted using a hybrid of face-to-face and online discussions. A significant proportion of MSMEs in this study increased their digital technology adoption through e-commerce, digital marketing, and digital payment system. The wider availability of digital technologies and the subsequent rise of e-commerce in the Philippines presented opportunities for expanding market reach and growth in a largely consumption-driven

economy. In Thailand, Mahakittikun et.al. (2021) developed a model based on the technology, organization and environment framework (TOE framework) and determined the impact of mobile payments on firm performance, e.g., cost reduction and sales. A questionnaire survey was used to collect data from merchants in the retail and service firms in Bangkok who had already adopted the mobile payment systems (QR code from mobile banking, mobile wallet, the international wallet, EDC device and mobile POS) in their business from April through June 2019. 387 responses were valid for analyzing in this study with a response rate of 34 percent (65.7 percent were microenterprises and 22.9 percent were SMEs). Results showed that mobile payment could have a positive impact on firm performance. Note that the TOE framework was previously employed in other studies in examining impacts of e-business on sales and financial performance (see Wu et.al., 2003; Zhu et.al., 2004; Alawneh and Hattab, 2009; Soto-Acosta, 2016; and Bhatiasevi and Nagis, 2018).

For non-financial part, various aspects influenced by DT were analyzed, inclduing both business and management such as supply chains (Zhu et.al., 2006; Soto-Acosta, 2016; AlMulhim, 2021; Dubey et al., 2021; Wicaksono and Simangunsong, 2022; Li et.al., 2022b), consumer relations and information accessability (Soto-Acosta, 2016), the firm's human resources (HR) and organizational performance (Alonso-Almeida and Llach, 2013), and economic prospects like productivity/innovation (e.g., Graetz and Michaels (2018); Crespi, Tacsir and Perreira (2019); Hou et.al (2019); Mairesse and Wu (2019); Calvino (2019); Jongwanich (2022a)) and labour market outcomes, i.e., employment/unemployment; workers' skill (Gaggl and Wright, 2017; Bessen, et.al., 2019; Acemoglu and Restrepo, 2017 and 2019). Most of the previous studies showed DTs helped improve various aspects of business and management as well as firm's productivity and innovation. For example, Li et.al. (2022b) investigated how the breadth and depth of DT deployment influence firm's resilience to supply chain disruptions by employing questionnaire survey on Chinese manufacturing firms that adopted at least one type of DT in 2021. 162 Chinese manufacturing firms provided responses, representing a response rate of 38.30% and SMEs firms are the majority of the samples. The findings showed that only DT deployment depth positively affected a firm's resilience to supply chain disruptions while the breadth and depth of DT deployment both improved supply chain coordination. Wicaksono and Simangunsong (2022) examined whether digital technologies as well as supply chains had helped Indonesia's MSMEs during the COVID-19 pandemic using Kimura (2020)'s policy framework. The authors employed information from the 2016 Economic Census on MSMEs, the 2019 Labor force survey data and the 2020 Mandiri Institute MSME survey. The authors revealed that digital technologies had

helped MSMEs to better navigate the adverse impacts of the pandemic, but only 13% of MSMEs adopted the internet for marketing and delivering their products and services. However, impacts of digital technology on labour market outcomes were inconclusive, depending on types of technology, industry and country specific factors.

All in all, empirical studies concerning impacts of DT on financial perfromace are relatively limited. Most of them employed relatively small samples through questionaire surveys or face to face interviews as well as include only a certain specific technology in the analysis. According to Li et.al., 2020 and Ye et al., 2022, firms likely employ a mix multiple digital technologies, instead of deploying a single one. Therefore, focusing on specific technology may ignore the synergies between different technologies and simplified the role of digital technologies.

3. SMEs and ICT adoption in Thailand: First Look

The Thai government has long addressed the importance of ICT and SMEs since the mid-1990s but plans and strategies to connect these two has been promoted only since 2017 when the Thai government announced to move the country toward industry 4.0 and digital industry is chosen as one of the twelve targeted industries.[2] Concerning importance of ICT *per se*, Thai government through the National IT Committee (NITC) launched the first plan at the national level, *Thailand National IT policy (1996-2000)* in the mid-1990s to promote utilization of IT for economic prosperity and social equity. In bringing such policy to implementation, each government agency developed its own master plan in corresponding to the direction set in the National Plan. Since then, a number of national level plans were followed, including for example ICT Policy Framework (2001-10), ICT Master Plan (2002-2006 and extended to cover the period of 2007-08); National Broadband Policy (2010), Information and Communication Technology Policy Framework (2011-2020), Universal Service Obligation (USO) Master Plan for Provision of Basic Telecommunication Services (2012-14). The Ministry of Information and Communication Technology (MICT) was established in 2002 to be the sole unit for implementing all relevant plans and measures and governing all related government agencies. The Ministry was renamed to Ministry of Digital Economy and Society (MDES) in 2016 with a broader scope by incorporating state-owned enterprises and public organizations related to ICT activities. More importantly,

[2] The twelve industries include new-generation automotive, smart electronics, affluent, medical and wellness tourism, agriculture and biotechnology, food for the future, robotics for industry, medical hub, aviation and logistics, biofuels and biochemicals, digital industries, defence, and education development.

Software Industry Promotion Agency (SIPA) was replaced by Digital Economy Promotion Agency (DEPA) which becomes a workhorse to promote and support the development of digital industry and innovation and the digital technology adoption (See details in Jongwanich 2023).

Concerning SMEs policies, in 2001 the Office of Small and Medium Enterprises Promotion (OSMEP) was established under the governance of the Ministry of Industry. The purpose of this agency is to promote, support and strengthen SMEs as well as be a focal point in coordinating the working systems in the government sector and other agencies to ensure harmonization and continuity in supporting SMEs. Budgets of around 1,200 million baht have been allocated to OSMEP for supporting SMEs activities every year. However, as mentioned earlier, supported activities were not directly involved with digitally equipped activities. Expanding channels of product distribution and upgrading the competitiveness of SMEs in sectors with good prospects for trade were prioritized before 2017.

After 2017, national plans have been changed to encourage and assist small and medium-sized enterprises (SMEs) to get digitally equipped. For example, the 20-year National Strategy (2018-2037) - the country's first national long-term strategy development pursuant to constitution, for example, have clearly emphasized policies geared towards developing smart, entrepreneur-based economy, especially SMEs with the ability to create and employ technology and innovation throughout the supply chains. The 13th national economic and social development plan[3] for 2023 to 2027 set two key milestones (No.6 and 7), i.e., Thailand is ASEAN's hub for digital and smart electronics and has strong, high-potential, and competitive SMEs, particularly encouraging and developing SMEs to become digital entrepreneurs. Various indicators are set as a benchmark for measuring their success. For example, the proportion of SMEs' GDP to overall GDP increases to 40 percent, while the proportion of SMEs' exports to overall exports increases to 20 per cent by 2027; the proportion of value of SMEs' e-Commerce to the value of overall e-Commerce increases by no less than 10 per cent from the baseline year (2021); The number of Series C startups rises to 20 in 2027.

Several supporting strategies and action plans have been initiated in various government agencies to create ecosystems for SMEs. For example, OSMEP allocated budgets in 2021-22

[3] The 12th national economic and social development plan (2017-2021) emphasized innovation and technology, but mostly in terms of improving R&D spending, but specific linkage between SMEs and digital technologies had not been mentioned in the plan.

to support ecosystem inclusive services such as creating platforms for promoting SMEs accessibility; SMEs wallet to promote mechanism to reduce costs. OSMEP, Digital Economy Promotion Agency (Depa), the National Science and Technology Development Agency (NSTDA) together with UOB Thailand, and the FinLab have provided both financial and non-financial supports to SMEs in their digital transformation through the Smart Business Transformation Program (SBTP) since 2019. Digital Economy Promotion Agency (DEPA) under Ministry of Digital Economy and Society has DEPA funds, including Digital Manpower Fund, Digital Manpower Executive, Digital Transformation Fund, and Digital RDI (R&D and Innovation) fund for supporting enterprises, including SMEs. In January 2022, SMEs and startups can list their shares to be traded on a new secondary market called LiVE Exchange, with slightly loosen requirement than usual such as no requirement to have a licensed financial advisor to certify the filling documents. In addition, several agencies have rolled out numerous measures to create a vibrant startup ecosystem, through funding, incubating and accelerator programs along with tax (e.g., The 5-year income tax exemption for startup and capital gain tax waiver for ventures) and non-tax incentives.[4] The Board of Investment amended investment incentives to stimulating SMEs investment, including 8 years corporate income tax exemption, import-duty exemption of machinery and raw materials (for exporting) as well as incentives for investments in digital activities such as development of software, digital platform or digital content.[5]

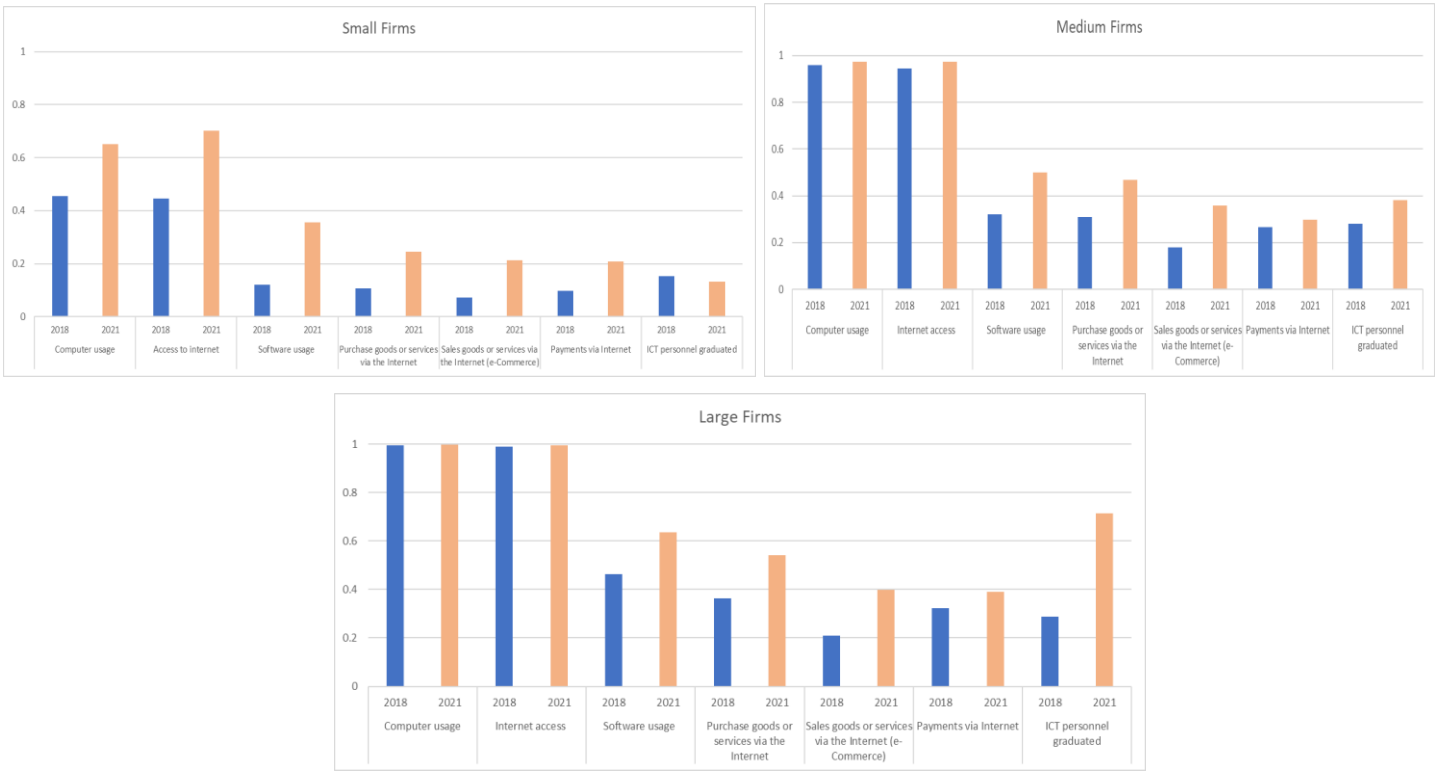
From ICT survey, ICT adoption of SMEs increased in all types during 2018-2021 (Figure 1). For small firms, a proportion of enterprises who utilized computer, software, and internet for a purpose of purchasing/selling goods and service and payments online improved substantially. A noticeable increase was also revealed in terms of accessing the internet for general purposes (see variable measurements in Section 4). However, two concerning points emerge for small enterprises, i.e., (1) although their DT adoption improved substantially during 2018-21, comparing to medium and large firms, the level of their engagement was still far lower, especially in terms of computer usage and internet access where in the medium and large firms, the indicators approached one, i.e., almost all establishment used computer and be able to access

[4] For example, National Science and Technology Development Agency (NSTDA) creates Startup Voucher Program, which provided fund for Thai startups (51 percent of Thai shareholders). National Electronics and Computer Technology Center (NECTEC) and National Innovation Agency (NIA) also have research units and program to support SMEs in engaging with digital technology, including Artificial Intelligence Research Unit (AINRU); Communications and Networks Research Unit (CNWRU) and Bangkok Cyber Tech District.

[5] See more information from https://www.boi.go.th/upload/content/BOI_A_Guide_EN.pdf

the internet and (2) a proportion of enterprises who hired ICT personnels graduated declined in the small firms while this indicator increased noticeably in the medium and large ones.

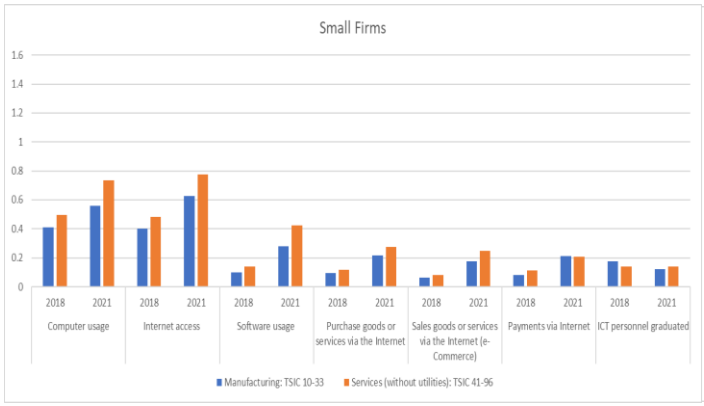
Figure 1: The Share of Enterprise adopting ICT, by Types of Firms, 2018-2021

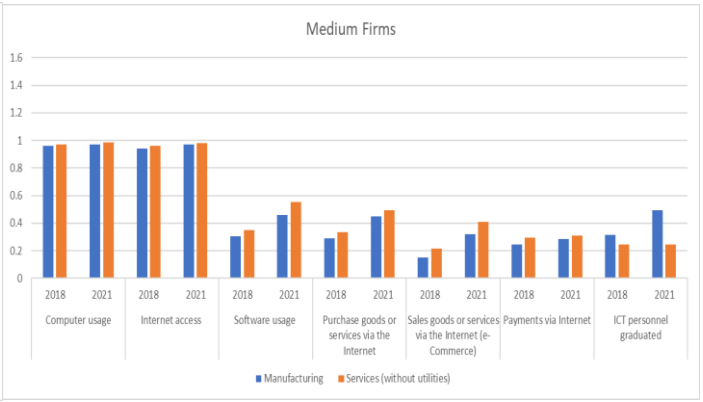


Source: Authors' compilation from various ICT surveys.

ICT utilization of small firms was enhanced in both manufacturing and service sectors, with slightly higher growth appearing in the latter, particularly the internet for a purpose of purchasing/selling goods and service as well as payments, and software usage (Figure 2). For the manufacturing sector, enterprises in electronics and machinery sectors appeared to utilize technologies noticeably while in the service sector, wholesale and retail trade; computer programing; and food delivery were sectors where enterprises engaged well with the technological. This evidence was also observed in the medium and large firms but as computer usage and internet access in these two types of firms had a high base, little change was observed in these two categories. Interestingly, a decline of enterprises who hired ICT staffs in small firms appeared mostly in the manufacturing, but it tends to be steady in the service sector. This evidence contrasts with the medium and large firms where a proportion of enterprises hiring ICT personnels graduated increased in the former. Particularly, in the large firms, the proportion in the manufacturing sector jumped from only 0.3 in 2019 to 0.8 in 2021 and such increasing trend was also appeared in the service sector.

Figure 2: The Share of Enterprise adopting ICT, by Types of Firms and Sectors, 2018-2021





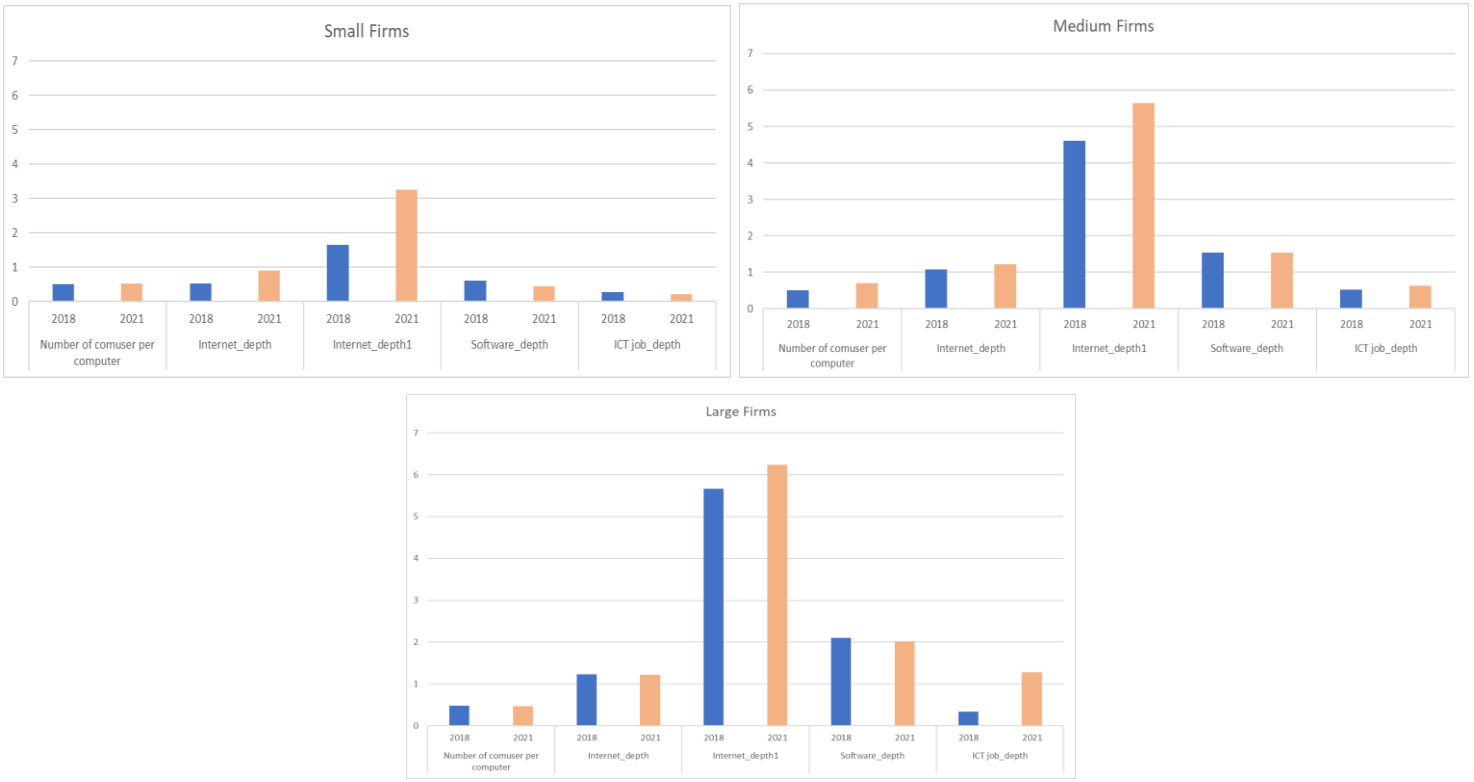
Source: Authors' compilation from various ICT surveys.

Where depth of ICT is concerned, the depth was obviously lower for the small firms than the medium and large ones, particularly in terms of software usage (Figure 3). For the software where scores are calculated from the five types of possible software usage, including self-development, tailor made, open source (OSS); software as a service: Saas and package software (see details of variable measurements in Section 4), the level of depth was the highest in the large firms, followed by the medium and small ones. For the depth of internet access, which includes mobile phone 3G network; Cabel modem; Frame Relay; Broadband; XDSL and leased line, it showed a slight increased for the small firms, though its level was still lower than the medium and large firms in which the progress of internet depth was limited during our studying period. This contrasts with the internet depth (internet_depth1), measured by purposes of using ICT or partners in which transactions and interactions are carried out through DT, where its level and progress were promising in all three types of firms, though the lowest level was still revealed in the small ones. In other words, the internet was employed for various purposes, not only sending

and receiving e-mail but also for e-training; interacting with various government agencies; getting information about goods/services and organizations. Concerning ICT personnels depth, measuring by involvements of ICT personnels in various positions of a company, including chief information officer; information technology development managers; computer system designers and analyst; computer programmer; computer associate professionals and other position relating to IT, it showed a slight declining trend for the small firms but improved noticeably in the medium and large ones.

All in all, this section shows ICT engagement of Thai SMEs has been accelerated over the past five years, but disparities in DT adoption, by both types of firms and sectors, have still been observed in the country. Meanwhile, the ICT depth of small firms has still been lower than that of the medium and large ones.

Figure 3: Technology Depth, by Types of Firms, 2018-2022



Note: See definition of technology depth in Section 4. In this figure, equal weight is applied for all variables. The results resemble when alternative weight for each variable is applied.

Source: Authors' compilation from various ICT surveys.

4. Methodology

To examine the impacts of ICT adoption on SMEs' financial performance, two surveys were employed, including Business Online survey, providing firms' financial information, and ICT survey, from National Statistics Office, Thailand, revealing firms' ICT usage. The study utilized information from those two surveys during 2018-2021. Criterion to define SMEs is from Office of Small and Medium Enterprise Promotion, OSMEP (2020) where for the manufacturing, small enterprises are firms who have an annal income less than (or equal to) 100 million baht and employment less than (or equal to) 50 employees while for services, the former is 50 million baht per year while the latter is 30 employees.[6] For the medium firms, the criteria of annual income and employment are less than (or equal to) 500 million baht and 200 employees for the manufacturing sector and 200 million baht and 100 employees for the service sector. It is crucial to note that there is a limitation regarding firms' financial information. That is information about employment, equity, shareholders, and exports/imports is unobtainable so that financial performance investigated in this study is limited to income and profits and some control variables, especially trade information, cannot be included in the empirical model. Income criterion is also employed to identify SMEs in this study due to data limitations. In addition, since firm ID cannot well match between these two surveys, ICT adoption here are measured and included in the model at the industry level (see Jongwanich, Kohpaiboon, and Obashi, 2022).

The empirical model in examining the impacts of ICT adoption on SMEs' financial performance is based on the previous studies outlined in Section 2 (i.e., Li et.al., 2022; Heredia et.al., 2022) and dynamic panel model (Blundell and Bond, 1998; Blundell, Bond and Windmeijer, 2000) is employed in the study. There are two equations in our analysis. The first equation examines the impact of ICT adoption on firms' financial performance as followed:

$$y_{i,j,t} = \sum_{k=1}^{p} \alpha_k y_{i,j,t-k} + \mathbb{B}_1 \mathbb{X}1_{i,j,t} + \mathbb{B}_2 \mathbb{X}2_{j,t} + \nu_i + \varepsilon_{i,t} \qquad (1)$$

where

$Y_{i,j,t}$ = income (*income*) and net profits (*profits*) of firm i in industry j at time t

$X1_{i,j,t}$ = control variables, including age (*year*); cash to total assets (*cash_asset_1*); current liabilities to total liabilities (*currentliability_totalliability*); long-term investment to total payments

[6] Note that evidence of micro enterprises, i.e., firms who have income less than (or equal to) 1.8 million baht per year and less than (or equal to) 5 employees for both manufacturing and services are excluded due to insufficient financial information.

(*permanentinvest_payment*); income tax to total payments (*incometax_totalpayment*); interest payments to total payments (*interest_totalpayment*); total assets (asset_total) of firm i in industry j at time t

$X2_{j,t}$ = (1) ICT adoption in industry j at time t, composing of computer usage (*com_usage*); internet access (*internet_access*); software usage (software_usage), purchase (*purchase*) / sale (*sale*) of goods and services as well as payments (*payment*) through internet; and ICT staffs participation (*ict_graduate*) and (2) output (*output*) in industry j at time t.

v_i is an unobserved firm-specific effects and $\varepsilon_{i,t}$ is the error term.

Note that the net profits variable is chosen, instead of ROA, since results revealed from both income and profits can to a certain extent imply costs induced by ICT engagement. However, to ensure unbiasedness of the estimation, total assets are included as one of the control variables in the profit model.

For ICT variables, each variable is measured by utilizing information from ICT surveys where a yes/no question is performed, i.e., whether a firm adopts ICT. As mentioned since firm ID cannot well match between ICT and Business Online surveys, ICT adoption here are measured and included in the model at the industry level (Jongwanich, Kohpaiboon, and Obashi, 2022). ICT information at firm level is transformed into that at industry level and a number of establishments[7] are used to adjust each ICT variable.

The second equation includes ICT depth as mediators to realize whether it could help enhance impacts of ICT engagement on SMEs. The interaction terms between ICT adoption and ICT depth at industry level are introduced as followed:

$$y_{i,j,t} = \sum_{k=1}^{p} \alpha_k y_{i,j,t-k} + \mathbb{B}_1 \mathbb{X}1_{i,j,t} + \mathbb{B}_2 \mathbb{X}2_{j,t} + \mathbb{B}_3 \mathbb{X}2_{j,t} \cdot \mathbb{X}3_{j,t} + v_i + \varepsilon_{i,t} \qquad (2)$$

where

$X3_{j,t}$ = ICT depth composing of computer_depth (*com_depth*); internet_depth (*internet_depth and internet_depth1*); software_depth (*soft_depth*); ICT participation_depth (*ict_grad_depth*).

[7] Note that employment is used to define SMEs from ICT survey since no available financial information so that number of establishments are used to adjust DTs, instead of number of workers.

Each variable is constructed from a different set of variables as shown in Table 1. There are three alternatives of computer depth employed in this study, i.e., number of computer users per computer; number of computers per total workers; and number of computer users per total workers. Software depth is constructed from a set of questions regarding software usage, i.e., whether a firm employs package software; whether a firm has self-developed software; tailor made, open source or software as a service. Initially, each item is assigned with the same weight in constructing the depth so that after averaging, the score of software depth equals five. Alternatively, the higher weight is provided to self-developed software; tailor made, software as a service than package software and open-source software, which are usually cheaper and less sophisticated. However, for the sake of comparison, we reweight the alternative measure to equal to five. There are two alternatives for the internet depth: first is the depth measuring through technologies and second is through purposes of using internet. For the first alternative, the depth is constructed from six questions, ranging from whether a firm employs broadband usage; cable modem; XDSL; Leased line; Frame Relay; or mobile phone 3G. As in the case of software, an equal weight is initially assigned to all six items so that after averaging for the whole observations, the total scores of the internet depth equal to six. Alternatively, higher wight is provided to broadband usage, cable modem, ADSL, leased line than that of mobile phone 3G and frame relay or VPN due to their sophistication. Since the importance of using internet for each purpose is unjustified, equal weight is assigned for all purposes and the average score equals to eleven (Table 1). Likewise, equal weight is allocated for each position of ICT personnels participation in an enterprise.

Blundell and Bond (1998) (see also Blundell, Bond and Windmeijer, 2000), panel system *Generalized Method of Moments* (GMM) regression is applied to examine the relationship between ICT adoption and firms' financial performance. Blundell and Bond (1998) proposed a system estimation in which first difference is estimated together with one in level, instead of estimating only equations in first differences and using lagged levels as instruments. The instruments for the regression in difference are its own lagged levels, as proposed by Arellano and Bond (1991), while the instruments for the regression in level are its own lagged first differences of the variable. The appropriateness of the latter is based on the assumption that the first differences are uncorrelated with the error term and unobservable heterogeneity. The GMM regression under Blundell and Bond tries to redress the shortcomings that tend to arise from Arellano and Bond (1991): panel system *Generalized Method of Moments* (GMM) regression. Under Arellano and Bond, the difference estimator has been found to have poor finite sample

properties when the lagged levels of the series are only weakly correlated with subsequent first differences. This has been found to be the case when the explanatory variables have large autoregressive parameters, as in our case. Blundell and Bond (1998) clearly showed that weak instruments could cause large finite-sample biases when using the first-differenced GMM method.[8] Our analysis includes total industries, manufacturing (ISIC 10-33) and two key subsectors - electronics (ISIC 26-27) and automotive (ISIC29), services excluding utilities (ISIC 41-96) and wholesale and retail trade (ISIC 46-47) as a subsector.[9] Note that to analyze the effects of ICT engagement on firms' financial performance in each sector, industrial dummy variables controlled for industrial-specific factors in our panel system GMM are interacted with each ICT variables. Analyzing each group of sectors separately is also employed as an alternative.

Table 1: Information for Technology Depth Construction

Computer_depth (3 alternatives)	**Internet_depth1 (Total scores =11)**
- Number of computer users per computer	- sending-receiving e-mail
- Numbver of computers per total workers	- Getting information about goods/services
- Number of computer users per total workers	- Getting information about government
	- Interacting with various government organization
	- Delivery products
Software depth (Base: total scores = 5)	- Internet banking
- Package software (yes/no)	- For training (e-learning/staff training)
- Self development software (yes/no)	- Video conferencing
- Tailor made (yes/no)	- Instant messaging
- Open source: OSS (yes/no)	- Internal/external recruitment
- Software as a service: Saas (yes/no)	- Others
Internet_depth (Base: total scores = 6)	**ICT job_depth (Total scores = 6)**
- Broadband	- Chief information officer
- Cable modem	- Information technology development managers
- XDSL (ADSL)	- Computer system designers and analyst
- Leased line	- Computer programmer
- Frame Relay or VPN	- Computer associate professionals
- Mobile phone 3G Network	- Other positions relating to IT

Source: Authors' compilation.

[8] However, note that to check the robustness of our results, Arellano and Bond (1991): panel system *Generalized Method of Moments* (GMM) regression is also applied. For independent variables, their lags are included in the analysis as to a certain extent, these could help to redress endogeneity problem as mentioned in Pesaran *et al*., 2001.

[9] Siunce the results of the sub-sectors tend to be resembled those of the whole sector analysis, both in manufacturing and service sectors, we report only impacts of ICT adoption on firms' financial performance for the whole manufacturing and service sector.

5. Results

Tables 2 and 3 show the complete results of the small firms for income and profit performance, respectively; Tables 4 and 5 for the medium firms and Tables 6 and 7 for the large firms. Columns 4-6 report results when depth of technology is included in the analysis for total observations, services and manufacturing sectors respectively. Overall, the results show that types of ICT, firm size, and sectors matter in investigating influence of ICT adoption on firms' financial performance. This implies lumping all observations together and considering a single ICT technology would not well capture the impacts of DT, particularly the synergies between different technologies, and possible different impacts on manufacturing and service sectors.

For the internet for purposes of purchasing goods and services, selling goods and service (e-commerce) and online payments, their positive impacts were obvious for SMEs, especially the medium firms as reflected by the positive coefficients associated with these variables corresponding to these two types of firms (Table 2). The service sector tended to obtain more benefits from utilizing the internet for these purposes than the manufacturing sector. In particular, for the medium firms, coefficients associated with all these purposes in the service sector were positive and significant, either their lag value or concurrent value or both. For the manufacturing sector, the positive impact of this technology was observed only for sales and purchases while for the online payments, the coefficient was positive but statistically insignificance. For small firms, sales and online payment contributed to income increase while benefits from utilizing internet to manage downstream activities (purchase goods and services) are limited. In particular, for the manufacturing, only online payments significantly influenced income increases, while the coefficient associated with *sales* was positive but statistically insignificant. The limited benefits of this technology on the manufacturing sector probably reflect nature of the industry where face-to-face activities between customers and enterprises dominate the business management. It is noteworthy that results, when net profits are considered, resembled those of income in which the positive impacts were obvious in SMEs and the service sector. A revealed positive impact of e-commerce on the net-profits variable, to a certain extent, reflected an ability of SMEs to well manage costs associated with obtaining/utilizing this technology.

Concerning the software, it could generate benefits mostly for the medium and large firms, while it showed statistically insignificant or negative relationship when the small firms are considered. In the medium and large firms, software usage was beneficial to both manufacturing

and service sectors. These results were also revealed when the net profits were considered as the dependent variable. The statistical insignificance of this coefficient associated with the small firms may be due to a relatively low level of software usage and types of the usage, which is dominated by open-source software and software package while other types of sophisticated software, especially self-developed software, were still be limited.

ICT personnels variable positively stimulated net profits only in the large firms, though its impacts on income were revealed in all types of firms, especially in the manufacturing sector. The noticeable impact of this variable in the manufacturing sector, especially in the large firms, tended to be consistent with the fact that ICT personnels in the manufacturing sector grew faster than those in the service sector during our consideration periods (Figure 2). However, the insignificance of this variable associated with the net profits of SMEs raised concern on the issue of ICT personnels shortage so that costs of hiring these persons tended to counter benefits observing in the income analysis. This, to a certain extent, may still reflect insufficient/inefficient policies regarding human capital development in moving the country toward the digital industry (Jongwanich, 2023).

Interestingly, the variable concerning the internet access for general purpose showed limited impacts in influencing firms' financial performance, even in the large firms. Quality of internet access, especially for the small firms where some of them still employed 2G, 2.5G mobile phone network (e.g., GSM, CDMA, GPRS) and analogue modem, and relatively high prices of advanced technologies caused the undesirable outcomes. According to ITU, prices of fixed broadband, mobile broadband and mobile cellular in Thailand over the past decade have been declined noticeably, especially when the price is measured in % of gross national income. However, when the price is measured by considering purchasing power parity (PPP) of population in a country (or considering prices of other products), it seems ICT prices in Thailand, especially in terms of fixed broadband, have not yet declined as expected. Comparing to the selected countries in Asia, prices in Thailand are still more expensive (see Table 8). Probably, this might be due to a method of spectrum allocation, which leads to higher prices than many countries.

Table 8: Prices of fixed broadband, mobile broadband and mobile cellular in selected Asia, 2020

	currency applied	Fixed broadband 5GB	Mobile broadband data only 1.5 GB	Mobile Data and Voice High Usage
China	as % of GNIpc	0.51	0.51	1.08
	PPP	7.18	7.18	15.23
	USD	4.28	4.28	9.08
Indonesia	as % of GNIpc	10.93	1.33	2.43
	PPP	99.64	12.14	22.16
	USD	34.81	4.24	7.74
Malaysia	as % of GNIpc	2.19	0.91	1.19
	PPP	49.8	20.81	27.06
	USD	19.64	8.21	10.67
Philippines	as % of GNIpc	7.85	1.36	2.9
	PPP	64.8	11.22	23.94
	USD	26.14	4.53	9.66
Singapore	as % of GNIpc	0.74	0.37	0.37
	PPP	47.69	23.89	23.89
	USD	35.81	17.94	17.94
Thailand	as % of GNIpc	3.29	1.18	2.66
	PPP	49.43	17.66	39.85
	USD	20.26	7.24	16.33
Viet Nam	as % of GNIpc	3.92	1.04	1.87
	PPP	23.72	6.28	11.3
	USD	8.13	2.15	3.87

Source: Author's compilation from ITU, https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

Regarding the ICT depth, in general, the results revealed that it generates more positive impacts on income than profits, reflecting high costs of obtaining advanced technology or diversify ICT usage, especially in terms of internet depth and software depth (Table 4). Results of the internet depth is in line with what was discussed earlier, i.e., costs of advanced internet technologies caused limited impacts of internet-depth variable on firms' financial performance, even in terms of income. For the software depth, obtaining tailor made software; Saas as well as developing software would still be costly to the medium and even large firms so that its influence was discovered only when income was considered. By contrast, increased participation of small firms in employing OSS and software package in which prices seem to be affordable, comparing to other types of software resulted in a positive impact of the software depth on firms' net profits. Another interesting finding is insignificance of coefficients associated with the depth of ICT personnels in the small firms' net profits, but their significance was shown in the medium and large firms. This result could be caused by a low level of ICT personnels depth in the small firms itself (Figure 3) and probably the still high costs of hiring ICT staffs in various positions. As mentioned earlier, this confirms the supply-side problem in the labour market in which a shortage of advanced and basic ICT skills has been evident. This is consistent with the information from ITU in which only 1 percent of population in Thailand would be classified as advanced ICT skills while around 20 percent tended to have basic skills for ICT in 2020.

Firm specific factors are crucial in determining firms' financial performance, including age, cash to total assets, long-term investment to total payments; income tax to total payments; interest payments to total payments as well as total assets in profit equation (See Tables 2-7).

Coefficients associated with cash to total assets (*cash_assets*$_{i,j,t}$) are positive and significant in the small firms, but mild or insignificant in the medium and large firms. This reflects a crucial element of liquidity assets for the small (and medium) firms in managing their business. Limitations in accessing financial support with a reasonable interest charge, especially through financial institutions, probably cause SMEs to hold a certain proportion of cash for their business management. Thai government have launched several policies to help SMEs access financial supports and in 2022 SMEs and startups can list their shares to be traded on a new secondary market, with slightly loosen requirement as mentioned in Section 3. However, the strong positive sign of this variable tends to reflect inadequacy of policy supports in this regard. In addition, with the negative coefficients associated with the interest payments to total payments (*interest_totalpayment*$_{i,j,t}$) of SMEs, but a mild positive in some cases of the large firms reflect a financial burden of SMEs driven by interest rate expenses. As mentioned earlier, adequate access to financial support of SMEs should go hand in hand with the reasonable borrowing expenses as well as time frames for the debt repayments for SMEs to ensure effectiveness of those measures in improving SMEs' financial status. Another concerning point is the negative coefficients associated with the long-term investment to total payments (*permanentinvest_payment* $_{i,j,t}$) of SMEs. In addition to inadequate financial support policies as well as SMEs' investment promotion strategies, the negative coefficients of this variable may reflect improper schemes to help facilitate allocation of funds to productive activities, especially those relating to rules and regulation for facilitating SMEs investment and for creating cooperation between large enterprises and SMEs.

6. Conclusions and Policy Inferences

This paper aims to examine the impacts of ICT adoption on SMEs' financial performance using Thailand as a case study during 2018-2021. ICT employed in this study are composed of computer usage; internet access; software usage; purchases of goods and services through internet; sale of goods and services through internet (e-commerce) as well as online payments. In addition, the paper also investigates the importance of ICT personnels in SMEs for influencing firms' financial performance. Depth of the ICT adoption was constructed to realize whether it could help enhance impacts of ICT on SMEs' performance. Impacts of ICT engagement on SMEs are compared with those of large firms. While the nature of manufacturing and service sectors is different and DT engagement of firms in these two sectors is unequal, the manufacturing and service sectors are examined separately in this study.

Our results show that types of ICT, size of firms and sectors mattered in analyzing impacts of ICT adoption on firms' financial performance, i.e., income and net profits. SMEs received significant benefits when DT were considered in terms of online activities through internet, especially for the medium firms where purchases of goods and services online; sales of goods and services (e-commerce); and online payments, contributed positively to firms' financial performance. Due to the nature of industry, the service sector tended to obtain more benefits from utilizing e-commerce than the manufacturing sector. In terms of software, it generated benefits mostly for the medium and large firms, but less crucial for the small ones, probably due to a relatively low level of software usage and types of usage, which is dominated by OSS and software package. Interestingly, the internet access for general purposes showed limited impacts in influencing firms' financial performance, even in the large firms. Quality of the internet access, especially for the small firms, and relatively high prices of advanced technologies, measured in terms of purchasing power parity, would still probably cause the undesirable outcomes. ICT personnels participation positively stimulated only net profits in the large firms, though its impacts on income were revealed in all types of firms, especially in the manufacturing sector.

Regarding the technology depth, in general, the results revealed that it generates more positive impacts on income than profits, reflecting high costs of obtaining advanced technology; or diversifying DT usage, especially in terms of internet depth and software depth. Insignificance of ICT personnels depth in the small firms, especially in the net profit analysis, confirmed the supply-side problem in the labour market in which a shortage of advanced and basic ICT skills has led to the high costs of hiring ICT staffs in various positions in a company. Firm specific factors are also crucial in determining firms' financial performance, including age, cash to total assets, long-term investment to total payments; income tax to total payments; interest payments to total payments as well as total assets in the profit analysis.

From the findings, four key policy inferences can be drawn. First, financial support for SMEs to be equipped with DT with reasonable expenses is crucial. Conditions required for the supporting programs should be properly established to encourage SMEs participation. Cooperation among government agencies, financial institutions, and private firms, e.g., the financial program supported by OSMEP together with Depa, NSTDA, FinLab and UOB, should be extensively encouraged and expanded, not only for startups but also for general SMEs. Although since 2017, several agencies, including OSMEP, which is the main public organization for promoting SMEs, have launched various financial-support programs, from our study it seems that the financial-support programs so far have not been enough to help engage SMEs to DT

economically. Second, while costs of obtaining DT are likely to constrain benefits in generating profits for SMEs, infrastructure development should be speed up to ensure efficient logistical systems as well as affordable and reliable digital technologies.

Third, human capital needs to be further developed in the climate of digital transformation. Thai government has several plans to improve human capital development, but policy overlapping and coordination failures across institutions are still the key obstacles in pushing Thailand's digital plan forward. The government should have a proper evaluation criterion in each project/policy and should ensure an effective whole-of-government approach, particularly establishing coordination processes and communication channels across institutions. In addition, public-private partnership in enhancing human capital development should be pro-actively encouraged, especially inspiring large companies to support medium and small enterprises to develop workers' skills. Finally, promoting the medium- to long-term productive investment of SMEs is crucial. The government should act as a good facilitator in stimulating such investment. In particular, burdens arising from establishing unnecessary and cumbersome rules and regulations for SMEs investment and for creating cooperation between large enterprises and SMEs should be prevented to ensure sustainable development of SMEs in the country.

Table 2: Impacts of Digital Technologies on Small Firm's Income

lnincome	Total		Service		Manufacturing		Total		Service		Manufacturing	
	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.
lnincome												
L1.	0.615	0.006***	0.612	0.006***	0.647	0.018***	0.615	0.006***	0.611	0.006***	0.635	0.017***
year	-0.043	0.005***	-0.050	0.005***	0.000	0.004	-0.042	0.004***	-0.049	0.004***	-0.008	0.01
yearsq	0.001	0.0001***	0.001	0.0001***			0.001	0.0001***	0.001	0.0001***	0.000	0.0001
lncash_asset_1												
-.	0.713	0.058***	0.740	0.062***	0.562	0.161***	0.712	0.058***	0.734	0.062***	0.548	0.160***
L1.	-0.251	0.053***	-0.235	0.057***	-0.365	0.148**	-0.249	0.053***	-0.234	0.057***	-0.377	0.146***
lncurrentliability_totalliability												
-.	0.167	0.044***	0.173	0.047***	0.283	0.119***	0.165	0.043***	0.168	0.047***	0.269	0.117**
L1.	-0.054	0.039	-0.031	0.043	-0.094	0.098	-0.055	0.039	-0.034	0.043	-0.111	0.097
lnpermanentinvest_payment												
-.	-0.122	0.030***	-0.110	0.031***	-0.229	0.103**	-0.122	0.030***	-0.109	0.0312***	-0.230	0.102**
L1.	-0.014	0.018	-0.027	0.019	0.104	0.058*	-0.015	0.018	-0.026	0.019	0.098	0.058*
lnincome_totalpayment												
-.	1.241	0.092***	1.251	0.095***	1.282	0.411***	1.241	0.092***	1.251	0.095***	1.322	0.415***
L1.	-0.533	0.071***	-0.510	0.073***	-0.915	0.357**	-0.532	0.071***	-0.512	0.072***	-0.846	0.358**
lninterest_totalpayment												
-.	-0.546	0.065***	-0.527	0.068***	-0.739	0.248***	-0.545	0.065***	-0.524	0.067***	-0.761	0.247***
L1.	0.275	0.063***	0.270	0.065***	0.377	0.231*	0.276	0.063***	0.268	0.065***	0.343	0.229
lncom_usage												
-.	0.906	0.262***	2.170	0.602***	0.076	0.441	-0.028	0.306	-3.398	0.818***	-1.267	0.603**
L1.	0.332	0.140***	0.213	0.157	-0.317	0.42	0.564	0.167***	0.839	0.192***	-1.403	0.726*
lncom_depth												
-.							0.281	0.161*	0.412	0.307	0.378	0.312
L1.							0.529	0.060***	0.382	0.064***	1.002	0.360***
lnsoftware_usage												
-.	-0.222	0.264	-0.457	0.155***								
L1.	-0.071	0.024***	-0.029	0.027	-0.115	0.097	0.075	0.034**	0.251	0.039***	-0.332	0.195
lnsoft_depth												
-.							0.057	0.072	-0.161	0.061***	-0.034	0.209
L1.							0.162	0.029***	0.294	0.035***	-0.120	0.137
lninternet_access												
-.	-0.942	0.249***	-1.996	0.651***	0.102	0.352	-0.219	0.317	1.667	0.739***	1.183	0.649*
L1.	-0.266	0.158*	-0.138	0.178	0.321	0.449	-0.392	0.186**	-0.064	0.226	1.036	0.540*
lninternet_depth												
-.							-0.010	0.162	2.046	0.346***	-0.436	0.385
L1.							-0.323	0.138**	-0.725	0.161***	-0.323	0.398
lnpurchase_online												
-.	0.069	0.079	0.356	0.211*	-0.079	0.114	0.036	0.082	1.093	0.229***	-0.191	0.128
L1.	-0.208	0.037***	-0.095	0.045*	-0.136	0.144	0.134	0.041***	-0.018	0.048	0.306	0.183*
lnsale_online												
-.	0.248	0.047***	-0.008	0.104	0.077	0.094	0.211	0.051***	0.656	0.145***	0.166	0.108*
L1.	0.129	0.030***	0.047	0.018**	-0.074	0.098	0.099	0.033***	0.052	0.04	-0.011	0.109
lnpayment_online												
-.	-0.237	0.067***	-0.340	0.137***	-0.124	0.179	0.171	0.070**	0.638	0.135***	0.157	0.211
L1.	0.146	0.050***	0.165	0.058***	0.243	0.149*	0.186	0.052***	0.170	0.064***	0.304	0.161*
lnoutput												
-.	0.815	0.025***	0.550	0.023***	0.073	0.046*	0.801	0.0260***	0.602	0.023***	-0.008	0.028
L1.	0.001	0.009	0.019	0.011*	0.026	0.021	-0.001	0.009	0.023	0.011**	0.019	0.022
lnict_graduate												
-.	-0.049	0.021**					-0.050	0.022**	-0.384	0.061***	0.075	0.037*
L1.	0.042	0.019**					0.118	0.025***	0.054	0.030**	0.306	0.123**
lnict_grad_depth												
-.			-0.242	0.046***	0.068	0.034**	-0.018	0.016	0.200	0.056***	-0.094	0.025***
L1.			0.025	0.023	0.112	0.1	0.028	0.016*	-0.019	0.019	0.041	0.059
_cons	-4.753	0.661***	-2.293	0.519***	4.355	0.914***	-3.796	0.546***	-1.947	0.528***	6.058	0.999***
No. of Obervation	766,158		664,498		100,382		766,158		664,498		100,382	
No. of Group	424,409		370,884		57,022		424,409		370,884		57,022	
Dummy year	Yes		Yes		Yes		Yes		Yes		Yes	
Dummy industry	Yes		Yes		Yes		Yes		Yes		Yes	
Wald Chi2	51570.51		43954		8530.97		51849.68		44138.38		9048.06	
Prob > Chi2	0.0000		0		0		0		0		0	

Note: Variables' names are in Section 4. The Arellano-Bond test for serial correlation and Sargan test are applied to all reported equations for autocorrelation overidentifying restrictions.
Source: Authors' estimations

Table 3: Impacts of Digital Technologies on Small Firm's Profits

lnincome	Total		Service		Manufacturing		Total		Service		Manufacturing	
	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.
lnincome												
L1.	0.615	0.006***	0.612	0.006***	0.647	0.018***	0.615	0.006***	0.611	0.006***	0.635	0.017***
year	-0.043	0.005***	-0.050	0.005***	0.000	0.004	-0.042	0.004***	-0.049	0.004***	-0.008	0.01
yearsq	0.001	0.0001***	0.001	0.0001***			0.001	0.0001***	0.001	0.0001***		
lncash_asset_1												
-.	0.713	0.058***	0.740	0.062***	0.562	0.161***	0.712	0.058***	0.734	0.062***	0.548	0.160***
L1.	-0.251	0.053***	-0.235	0.057***	-0.365	0.148**	-0.249	0.053***	-0.234	0.057***	-0.377	0.146***
lncurrentliability_totalliability												
-.	0.167	0.044***	0.173	0.047***	0.283	0.119***	0.165	0.043***	0.168	0.047***	0.269	0.117**
L1.	-0.054	0.039	-0.031	0.043	-0.094	0.098	-0.055	0.039	-0.034	0.043	-0.111	0.097
lnpermanentinvest_payment												
-.	-0.122	0.030***	-0.110	0.031***	-0.229	0.103**	-0.122	0.030***	-0.109	0.0312***	-0.230	0.102**
L1.	-0.014	0.018	-0.027	0.019	0.104	0.058*	-0.015	0.018	-0.026	0.019	0.098	0.058*
lnincome_totalpayment												
-.	1.241	0.092***	1.251	0.095***	1.282	0.411***	1.241	0.092***	1.251	0.095***	1.322	0.415***
L1.	-0.533	0.071***	-0.510	0.073***	-0.915	0.357**	-0.532	0.071***	-0.512	0.072***	-0.846	0.358**
lninterest_totalpayment												
-.	-0.546	0.065***	-0.527	0.068***	-0.739	0.248***	-0.545	0.065***	-0.524	0.067***	-0.761	0.247***
L1.	0.275	0.063***	0.270	0.065***	0.377	0.231*	0.276	0.063***	0.268	0.065***	0.343	0.229
lncom_usage												
-.	0.906	0.262***	2.170	0.602***	0.076	0.441	-0.028	0.306	-3.398	0.818***	-1.267	0.603**
L1.	0.332	0.140***	0.213	0.157	-0.317	0.42	0.564	0.167***	0.839	0.192***	-1.403	0.726*
lncom_depth												
-.							0.281	0.161*	0.412	0.307	0.378	0.312
L1.							0.529	0.060***	0.382	0.064***	1.002	0.360***
lnsoftware_usage												
-.	-0.222	0.264	-0.457	0.155***								
L1.	-0.071	0.024***	-0.029	0.027	-0.115	0.097	0.075	0.034**	0.251	0.039***	-0.332	0.195
lnsoft_depth												
-.							0.057	0.072	-0.161	0.061***	-0.034	0.209
L1.							0.162	0.029***	0.294	0.035***	-0.120	0.137
lninternet_access												
-.	-0.942	0.249***	-1.996	0.651***	0.102	0.352	-0.219	0.317	1.667	0.739***	1.183	0.649*
L1.	-0.266	0.158*	-0.138	0.178	0.321	0.449	-0.392	0.186**	-0.064	0.226	1.036	0.540*
lninternet_depth												
-.							-0.010	0.162	2.046	0.346***	-0.436	0.385
L1.							-0.323	0.138**	-0.725	0.161***	-0.323	0.398
lnpurchase_online												
-.	0.069	0.079	0.356	0.211*	-0.079	0.114	0.036	0.082	1.093	0.229***	-0.191	0.128
L1.	-0.208	0.037***	-0.095	0.045*	-0.136	0.144	0.134	0.041***	-0.018	0.048	0.306	0.183*
lnsale_online												
-.	0.248	0.047***	-0.008	0.104	0.077	0.094	0.211	0.051***	0.656	0.145***	0.166	0.108*
L1.	0.129	0.030***	0.047	0.018**	-0.074	0.098	0.099	0.033***	0.052	0.04	-0.011	0.109
lnpayment_online												
-.	-0.237	0.067***	-0.340	0.137***	-0.124	0.179	0.171	0.070**	0.638	0.135***	0.157	0.211
L1.	0.146	0.050***	0.165	0.058***	0.243	0.149*	0.186	0.052***	0.170	0.064***	0.304	0.161*
lnoutput												
-.	0.815	0.025***	0.550	0.023***	0.073	0.046*	0.801	0.0260***	0.602	0.023***	-0.008	0.028
L1.	0.001	0.009	0.019	0.011*	0.026	0.021	-0.001	0.009	0.023	0.011**	0.019	0.022
lnict_graduate												
-.	-0.049	0.021**					-0.050	0.022**	-0.384	0.061***	0.075	0.037*
L1.	0.042	0.019**					0.118	0.025***	0.054	0.030**	0.306	0.123**
lnict_grad_depth												
-.			-0.242	0.046***	0.068	0.034**	-0.018	0.016	0.200	0.056***	-0.094	0.025***
L1.			0.025	0.023	0.112	0.1	0.028	0.016*	-0.019	0.019	0.041	0.059
_cons	-4.753	0.661***	-2.293	0.519***	4.355	0.914***	-3.796	0.546***	-1.947	0.528***	6.058	0.999***
No. of Obervation	766,158		664,498		100,382		766,158		664,498		100,382	
No. of Group	424,409		370,884		57,022		424,409		370,884		57,022	
Dummy year	Yes		Yes		Yes		Yes		Yes		Yes	
Dummy industry	Yes		Yes		Yes		Yes		Yes		Yes	
Wald Chi2	51570.51		43954		8530.97		51849.68		44138.38		9048.06	
Prob > Chi2	0.0000		0		0		0		0		0	

Note: Variables' names are in Section 4. The Arellano-Bond test for serial correlation and Sargan test are applied to all reported equations for autocorrelation overidentifying restrictions.
Source: Authors' estimations

Table 4: Impacts of Digital Technologies on Medium Firm's Income

lnincome	Total		Service		Manufacturing		Total		Service		Manufacturing	
	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.
lnincome												
L1.	-0.099	0.015***	-0.063	0.017***	-0.217	0.027***	-0.098	0.014***	-0.060	0.017***	-0.216	0.027***
year	-0.007	0.001***	-0.007	0.001***	-0.006	0.003*	-0.007	0.001***	-0.007	0.001***	-0.006	0.003*
yearsq	0.000	0.00002***	0.000	0.00002***	0.000	0.0001	0.000	0.0001***	0.000	0.0001***	0.000	0.0001
lncash_asset_1												
-.	0.087	0.046*	0.067	0.053	0.150	0.098	0.085	0.046*	0.072	0.052	0.149	0.097
L1.	-0.164	0.049***	-0.136	0.057**	-0.367	0.098***	-0.166	0.049***	-0.140	0.056**	-0.371	0.098***
lncurrentliability_totalliability												
-.	0.063	0.038*	0.049	0.046	0.069	0.071	0.063	0.038	0.045	0.045	0.071	0.071
L1.	-0.034	0.037	-0.043	0.044	-0.028	0.062	-0.035	0.036	-0.046	0.043	-0.033	0.061
lnpermanentinvest_payment												
-.	-0.070	0.027**	-0.076	0.029***	0.026	0.064	-0.071	0.027***	-0.076	0.029***	0.034	0.064
L1.	0.022	0.024	0.014	0.026	0.061	0.044	0.020	0.023	0.013	0.025	0.063	0.044
lnincome_totalpayment												
-.	0.443	0.108***	0.446	0.115***	1.606	0.523***	0.443	0.111***	0.443	0.117***	1.627	0.527***
L1.	0.462	0.129***	0.443	0.129***	1.406	0.707**	0.457	0.129***	0.434	0.127***	1.440	0.712***
lninterest_totalpayment												
-.	-0.757	0.170***	-0.597	0.159***	-3.556	1.330***	-0.750	0.168***	-0.585	0.156***	-3.592	1.337***
L1.	0.039	0.035	0.049	0.038	-0.068	0.179	0.036	0.035	0.044	0.037	-0.070	0.183
lncom_usage												
-.	-0.643	0.443	-2.810	0.812***	-1.252	0.621**	-0.244	1.352	-0.205	1.147	-2.343	2.332
L1.	0.026	0.272	-0.498	0.465	0.546	0.402	0.654	0.364*	-0.046	0.426	2.876	1.993
lncom_depth												
-.							-0.603	1.634	-3.322	0.678***	0.589	2.793
L1.							-1.302	0.414***	-1.525	0.459***	-4.096	3.061
lnsoftware_usage												
-.	0.092	0.286	-0.045	0.153			0.297	0.564	-0.210	0.282		
L1.	0.089	0.018***	0.127	0.027***	0.012	0.036	0.078	0.023***	0.093	0.033***	0.136	0.060**
lnsoft_depth												
-.							-0.395	1.427	0.788	0.679		
L1.							0.014	0.046	0.099	0.065*	0.340	0.104***
lninternet_access												
-.	0.345	0.349	1.620	0.746**	0.656	0.472	0.463	0.393	2.236	0.734***	1.247	0.548**
L1.	-0.089	0.242	0.081	0.462	-0.830	0.382**	0.181	0.244	0.849	0.403**	-0.257	0.443
lninternet_depth												
-.							-0.096	0.065	-0.158	0.143	-0.103	0.11
L1.							-0.062	0.055	-0.113	0.075	0.014	0.116
lnpurchase_online												
-.	-0.130	0.037***	-0.209	0.075***	-0.158	0.053**	0.134	0.039***	0.187	0.074**	-0.048	0.069
L1.	0.155	0.024***	0.206	0.029***	-0.047	0.062	0.123	0.025***	0.126	0.032***	-0.094	0.069
lnsale_online												
-.	0.113	0.019***	0.092	0.037***	0.132	0.026***	0.094	0.020***	0.046	0.041	0.104	0.033***
L1.	0.010	0.016***	-0.034	0.020*	-0.030	0.0341	0.005	0.015	0.054	0.020***	-0.049	0.035
lnpayment_online												
-.	0.056	0.041	0.186	0.114*	0.020	0.064	0.062	0.042	-0.044	0.145	-0.008	0.067
L1.	-0.078	0.023***	-0.080	0.028***	0.024	0.059	0.054	0.024***	-0.015	0.03	0.097	0.07
lnoutput												
-.	0.319	0.049***	0.131	0.034***	0.025	0.028	0.328	0.052***	0.107	0.031***	0.027	0.028
L1.	0.009	0.009	0.020	0.011*	0.022	0.017	0.011	0.009	0.025	0.012***	0.036	0.018**
lnict_graduate												
-.	-0.014	0.013	0.015	0.031	-0.007	0.036	-0.021	0.013	0.121	0.048***	0.049	0.044
L1.	0.027	0.008	0.035	0.010***	0.035	0.024	0.014	0.009	0.005	0.012	0.052	0.033*
lnict_grad_depth												
-.							-0.031	0.014**	-0.106	0.039***	-0.023	0.025
L1.							0.023	0.012*	0.027	0.016*	-0.044	0.024
_cons	18.207	0.697***	18.740	0.535***	23.004	0.709***	18.049	0.724***	18.714	0.535***	22.859	0.737***
No. of Obervation	32,839		24,667		8,078		32,839		24,667		8,078	
No. of Group	20,542		15,739		4,862		20,542		15,739		4,862	
Dummy year	Yes		Yes		Yes		Yes		Yes		Yes	
Dummy industry	Yes		Yes		Yes		Yes		Yes		Yes	
Wald Chi2	21527.15		14749.61		7191.37		21594.46		15190.44		7347.1	
Prob > Chi2	0		0		0		0		0		0	

Note: Variables' names are in Section 4. The Arellano-Bond test for serial correlation and Sargan test are applied to all reported equations for autocorrelation overidentifying restrictions.
Source: Authors' estimations

Table 5: Impacts of Digital Technologies on Medium Firm's Profits

lnincome	Total		Service		Manufacturing		Total		Service		Manufacturing	
	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.
profits												
L1.	-0.008	0.116	-0.045	0.131	0.253	0.081***	-0.009	0.115	-0.047	0.131	0.254	0.082***
year												
-.	0.001	0.0004**	0.001	0.0004**	0.000	0.0001**	0.001	0.0003**	0.001	0.0004**	0.000	0.0001**
L1.												
lnasset_total												
-.	-0.038	0.019**	-0.037	0.019**	0.082	0.019***	-0.038	0.018*	-0.037	0.019**	0.082	0.019***
L1.	-0.011	0.005**	-0.011	0.005**	-0.097	0.024***	-0.011	0.004**	-0.011	0.005**	-0.097	0.025***
lncash_asset_1												
-.	0.013	0.004***	0.010	0.004**	0.020	0.009**	0.013	0.003***	0.010	0.004**	0.020	0.009**
L1.	0.003	0.004	-0.001	0.005	0.011	0.008	0.003	0.004	-0.001	0.004	0.011	0.009
lncurrentliability_totalliability												
-.	0.014	0.004***	0.014	0.005**	0.015	0.008*	0.014	0.004***	0.013	0.005**	0.015	0.008*
L1.	0.006	0.005	0.010	0.006*	-0.010	0.006	0.006	0.004	0.010	0.006*	-0.010	0.006
lnpermanentinvest_payment												
-.	0.000	0.007	0.000	0.006	0.001	0.005	0.000	0.006	-0.001	0.006	0.001	0.005
L1.	0.010	0.007	0.014	0.007*	0.004	0.003	0.010	0.006	0.014	0.007*	0.004	0.003
lnincome_totalpayment												
-.	0.148	0.043***	0.094	0.044**	0.217	0.035***	0.148	0.0431***	0.094	0.043**	0.217	0.035***
L1.	0.098	0.048**	0.073	0.045*	-0.193	0.020***	0.098	0.047**	0.073	0.045	-0.193	0.020***
lninterest_totalpayment												
-.	0.075	0.058	0.067	0.055	-0.091	0.115	0.075	0.057	0.067	0.055	-0.091	0.115
L1.	-0.059	0.042	-0.056	0.044	-0.016	0.023	-0.059	0.041	-0.056	0.043	-0.016	0.023
lncom_usage												
-.	0.049	0.033	-0.009	0.078	-0.071	0.034**	0.034	0.11	-0.033	0.144	-0.021	0.159
L1.	0.016	0.023	0.017	0.036	-0.030	0.032	-0.017	0.047	-0.014	0.054	0.086	0.172
lncom_depth												
-.							0.034	0.123	0.080	0.115	-0.049	0.196
L1.							0.064	0.063	0.093	0.094	-0.178	0.262
lnsoftware_usage												
-.	-0.019	0.019	-0.004	0.012	-0.004	0.002*	-0.051	0.039	-0.024	0.026		
L1.	0.005	0.003*	0.008	0.004*			0.006	0.003**	0.006	0.005	-0.005	0.003
lnsoft_depth												
-.							0.081	0.114	0.067	0.064		
L1.							0.000	0.005	0.009	0.009	0.001	0.006
lninternet_access												
-.	-0.031	0.029	-0.023	0.068	0.040	0.029	-0.061	0.033*	-0.029	0.085	0.036	0.035
L1.	-0.006	0.014	0.008	0.025	0.014	0.027	-0.047	0.020**	-0.062	0.052	0.025	0.032
lninternet_depth												
-.							0.006	0.005	0.019	0.019	-0.001	0.007
L1.							0.009	0.006	0.004	0.009	-0.006	0.007
lnpurchase_online												
-.	0.008	0.004**	0.032	0.013**	0.000	0.003	0.009	0.005*	0.033	0.013**	-0.001	0.003
L1.	0.010	0.005*	0.016	0.005***	-0.019	0.005***	0.010	0.005*	0.015	0.007**	0.020	0.006**
lnsale_online												
-.	0.001	0.002	-0.004	0.004	0.004	0.002**	0.000	0.002	-0.004	0.006	0.004	0.002**
L1.	-0.001	0.002	-0.002	0.002	0.004	0.001**	-0.002	0.001	-0.003	0.002	0.005	0.002**
lnpayment_online												
-.	-0.002	0.004	-0.029	0.015	0.011	0.004**	-0.004	0.003	0.039	0.022*	0.012	0.004***
L1.	0.000	0.003	-0.002	0.003	0.016	0.005***	0.001	0.002	0.001	0.003	0.016	0.006**
lnoutput												
-.	0.015	0.006	0.008	0.003**	0.001	0.001	0.012	0.005**	0.005	0.003*	0.001	0.001
L1.	-0.001	0.002	-0.002	0.002	0.001	0.001	-0.002	0.001	-0.003	0.002	0.001	0.001
lnict_graduate												
-.	-0.002	0.001	0.006	0.003*	0.001	0.002	-0.003	0.001*	0.009	0.005	0.001	0.003
L1.	-0.002	0.001*	-0.002	0.001	0.001	0.001	-0.004	0.002*	-0.005	0.002*	0.000	0.002
lnict_grad_depth												
-.							0.002	0.002	-0.005	0.005	0.001	0.001
L1.							0.005	0.003*	0.007	0.004*	0.000	0.002
_cons	-0.156	0.058***	-0.069	0.054	-0.018	0.038	-0.111	0.061602	-0.041	0.054	-0.020	0.04
No. of Obervation	32,839		24,667		8,078		32,839		24,836		8,078	
No. of Group	20,542		15,739		4,862		20,542		15,884		4,862	
Dummy year	Yes		Yes		Yes		Yes		Yes		Yes	
Dummy industry	Yes		Yes		Yes		Yes		Yes		Yes	
Wald Chi2	607.92		332.87		10585.79		657.79		385.89		10576.4	
Prob > Chi2	0		0		0		0		0		0	

Note: Variables' names are in Section 4. The Arellano-Bond test for serial correlation and Sargan test are applied to all reported equations for autocorrelation overidentifying restrictions.
Source: Authors' estimations

Table 6: Impacts of Digital Technologies on Large Firms' Income

lnincome	Total		Service		Manufacturing		Total		Service		Manufacturing	
	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.
lnincome												
L1.	0.080	0.062	0.304	0.064***	0.016	0.079	0.096	0.061	0.348	0.065***	0.011	0.077
year	0.005	0.001***	-0.015	0.004***	0.009	0.002***	0.005	0.001***	-0.014	0.004***	0.009	0.002***
yearsq			0.000	0.0001***					0.000	0.0001***		
lncash_asset_1												
-.	-0.074	0.136	0.194	0.173	-0.382	0.230*	-0.082	0.138	0.189	0.167	-0.391	0.229*
L1.	-0.370	0.165**	-0.172	0.177	-0.630	0.309**	-0.345	0.165**	-0.100	0.171	-0.719	0.305**
lncurrentliability_totalliability												
-.	-0.342	0.132**	-0.182	0.167	-0.802	0.258***	-0.320	0.127**	-0.215	0.171	-0.701	0.239***
L1.	-0.268	0.128**	0.028	0.149	-0.721	0.241***	-0.276	0.127**	-0.052	0.153	-0.691	0.232***
lnpermanentinvest_payment												
-.	-0.276	0.118**	-0.107	0.169	-0.398	0.158**	-0.265	0.120**	-0.107	0.173	-0.431	0.164***
L1.	-0.234	0.116**	-0.242	0.191	-0.112	0.151	-0.235	0.119**	-0.265	0.192	-0.160	0.156
lnincome_totalpayment												
-.	0.560	0.575	0.421	0.615	2.977	1.428**	0.507	0.584	0.389	0.631	2.976	1.351**
L1.	0.666	0.568	0.698	0.609	0.998	1.384	0.546	0.574	0.519	0.6216	1.119	1.328
lninterest_totalpayment												
-.	-0.073	0.23	0.135	0.268	-0.607	1.365	-0.104	0.238	0.071	0.278	-0.944	1.485
L1.	0.105	0.069	0.269	0.172	-0.022	0.103	0.098	0.069	0.250	0.153*	-0.029	0.103
lncom_usage												
-.	6.346	2.163***			8.919	3.535**	17.686	15.458			-78.063	34.918**
L1.	2.814	1.395**	-3.177	5.718	4.324	2.177**	2.415	1.513	-5.456	5.932	8.685	3.349**
lncom_depth												
-.							-26.481	25.193			162.731	61.642***
L1.							0.282	0.155*	0.049	0.366	0.532	0.34
lnsoftware_usage												
-.	0.468	0.45	-1.501	0.584**	1.314	0.741*	-0.388	1.022	-3.486	1.207***	7.009	2.241***
L1.	-0.012	0.044	-0.052	0.129	0.032	0.111	0.132	0.089*	0.106	0.167	0.277	0.193
lnsoft_depth												
-.							1.391	1.46	3.814	1.474**	7.870	2.748***
L1.							0.094	0.085	0.074	0.108	0.183	0.154261
lninternet_access												
-.	-6.440	1.868***	-12.877	7.918*	-8.156	3.049***	-2.997	2.016	17.555	18.27	-17.915	5.063***
L1.	-2.700	1.410*	3.246	5.663	-4.110	2.187*	-2.082	1.479	5.461	6.055	-8.374	3.327**
lninternet_depth												
-.							-5.725	11.209	-27.269	74.311	-246.777	76.258***
L1.							0.048	0.081	0.046	0.123	0.028	0.205
lnpurchase_online												
-.	0.087	0.098	-0.363	0.25	0.472	0.132***	0.117	0.108	-0.119	0.299	0.728	0.178***
L1.	0.137	0.067**	0.267	0.149*	0.450	0.161***	0.083	0.082	0.605	0.251**	0.384	0.148***
lnsale_online												
-.	-0.176	0.052***	0.870	0.464*	-0.283	0.080***	-0.153	0.057***	-0.357	0.332	-0.326	0.128**
L1.	-0.039	0.03	0.435	0.237*	-0.118	0.088	-0.066	0.033**	-0.014	0.098	-0.165	0.102
lnpayment_online												
-.	0.097	0.083	0.393	0.297	-0.236	0.129*	0.037	0.087	0.756	0.457*	-0.320	0.15
L1.	-0.046	0.072	0.052	0.142	-0.447	0.195**	-0.197	0.102*	-0.475	0.191**	-0.382	0.201
lnoutput												
-.	-0.065	0.037*	0.017	0.06	0.119	0.061**	-0.072	0.038**	0.059	0.077	0.049	0.067
L1.	-0.091	0.029***	-0.050	0.041	0.077	0.054	-0.081	0.029***	-0.024	0.038	0.065	0.063
lnict_graduate												
-.	-0.006	0.021	0.017	0.044	0.134	0.098	-0.039	0.038	-0.331	0.219	0.164	0.109
L1.	-0.078	0.020***	-0.129	0.032***	0.007	0.073	-0.125	0.028	-0.144	0.041***	0.195	0.103*
lnict_grad_depth												
-.							0.028	0.04	0.347	0.241	0.273	0.147*
L1.							0.000	0.017	-0.131	0.038***	0.160	0.091*
_cons	22.111	1.554***	14.620	1.560***	19.285	2.092***	21.697	1.559***	12.695	1.582***	21.203	2.320***
No. of Obervation	14,390		7,835		6,555		14,390		7,986		6,555	
No. of Group	8,578		4,976		3,662		8,578		5,092		3,662	
Dummy year	Yes		Yes		Yes		Yes		Yes		Yes	
Dummy industry	Yes		Yes		Yes		Yes		Yes		Yes	
Wald Chi2	5049.11		2575.41		2358.69		5052.24		2556.43		2419.29	
Prob > Chi2	0		0		0		0		0		0	

Note: Variables' names are in Section 4. The Arellano-Bond test for serial correlation and Sargan test are applied to all reported equations for autocorrelation overidentifying restrictions.
Source: Authors' estimations

Table 7: Impacts of Digital Technologies on Large Firms' Profits

lnincome	Total		Service		Manufacturing		Total		Service		Manufacturing	
	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.	Coefficient	Robust std. err.
profits												
L1.	0.457	0.103***	0.391	0.29	0.469	0.110***	0.449	0.112***	0.277	0.336	0.470	0.111***
year												
-.	0.000	0.01	0.008	0.005	0.007	0.009	0.015	0.009*	0.009	0.005	0.006	0.009
L1.												
lnasset_total												
-.	-0.019	0.019	-0.016	0.034	-0.021	0.021	-0.021	0.021	-0.007	0.038	-0.022	0.021
L1.	0.045	0.010***	0.037	0.034	0.046	0.010***	0.044	0.011***	0.037	0.036	0.046	0.011***
lncash_asset_1												
-.	0.053	0.36	0.154	0.267	-0.546	0.872	0.146	0.397	0.205	0.27	-0.533	0.852
L1.	-0.088	0.389	0.472	0.394	-1.469	0.937	-0.074	0.475	0.503	0.46	-1.479	0.93
lncurrentliability_totalliability												
-.	0.190	0.253	0.355	0.299	0.642	0.392*	0.385	0.259	0.350	0.332	0.664	0.386*
L1.	0.156	0.263	0.240	0.256	0.812	0.504*	0.210	0.294	0.216	0.305	0.797	0.496*
lnpermanentinvest_payment												
-.	-0.248	0.491	0.255	0.23	0.143	0.151	-0.358	0.476	0.038	0.121	0.130	0.145
L1.	-0.322	0.383	-0.247	0.225	0.076	0.159	-0.415	0.354	-0.346	0.163**	0.074	0.156
lnincome_totalpayment												
-.	4.528	1.733***	4.911	1.765***	14.156	4.615***	7.605	3.333**	4.140	1.666**	14.233	4.605***
L1.	2.829	1.654*	3.427	1.734**	4.499	3.842	5.689	3.747	1.825	1.937	4.392	3.769
lninterest_totalpayment												
-.	-1.131	0.578**	-1.271	0.711*	-4.361	3.948	-1.290	0.729*	-1.302	0.658**	-4.436	3.95
L1.	-0.318	0.180*	-0.303	0.299	-0.366	0.185**	-0.369	0.219*	-0.262	0.256	-0.361	0.184**
lncom_usage												
-.	0.224	3.194			-12.481	3.448***						
L1.	1.736	1.405	-4.232	4.37	-2.958	2.251	-1.745	1.654	-3.997	4.672	-1.452	1.297
lncom_depth												
-.												
L1.							0.116	0.099	0.466	0.269*	0.035	0.109
lnsoftware_usage												
-.												
L1.	0.061	0.068	0.212	0.141	-0.534	0.180***	-0.175	0.094**	-0.029	0.076	-0.180	0.125
lnsoft_depth												
-.												
L1.							-0.255	0.114**	-0.157	0.093*	-0.131	0.159
lninternet_access												
-.	-1.494	2.796	9.930	9.455	9.274	2.917***						
L1.	-1.814	1.399	4.259	4.304	3.088	2.24	1.193	1.591	3.530	4.723	1.274	1.304
lninternet_depth												
-.												
L1.							0.155	0.117	0.072	0.092	0.234	0.27
lnpurchase_online												
-.	-0.049	0.167	-0.042	0.269	-0.129	0.219						
L1.	-0.009	0.115	-0.229	0.158	-0.479	0.176***	-0.128	0.112				
lnsale_online												
-.	0.057	0.084	0.170	0.271	0.074	0.105						
L1.	0.047	0.056	0.260	0.099***	0.154	0.129	0.054	0.049				
lnpayment_online												
-.	-0.048	0.136	-0.476	0.351	0.265	0.183	0.000	0.083				
L1.	-0.144	0.114	-0.380	0.196**	0.881	0.260***	0.204	0.103**				
lnoutput												
-.	0.708	0.175***	0.093	0.109	-0.044	0.195			0.031	0.043	0.006	0.163
L1.	0.040	0.09	0.065	0.040*	-0.014	0.08	0.081	0.089				
lnict_graduate												
-.	0.059	0.035*	0.018	0.029	-0.219	0.099**						
L1.	0.045	0.035	0.068	0.044	-0.018	0.09	0.069	0.040*	0.047	0.046	0.064	0.039*
lnict_grad_depth												
-.												
L1.							0.044	0.026*	0.068	0.034**	0.098	0.050**
_cons	-5.633	2.150***	-3.191	1.749*	0.195	3.232	-1.959	1.384	-0.982	0.874	-0.833	2.373
No. of Obervation	14,390		7,835		6,555		14,780		8,172		6,608	
No. of Group	8,578		4,976		3,662		8,904		5,272		3,693	
Dummy year	Yes		Yes		Yes		Yes		Yes		Yes	
Dummy industry	Yes		Yes		Yes		Yes		Yes		Yes	
Wald Chi2	1225.91		251.61		1271.28		411.64		306.43		1123.77	
Prob > Chi2	0		0		0		0		0		0	

Note: Variables' names are in Section 4. The Arellano-Bond test for serial correlation and Sargan test are applied to all reported equations for autocorrelation overidentifying restrictions.
Source: Authors' estimations

Appendix 1: Data employed in the Analysis

Small firms	Obs	Mean	Std. dev.	Min	Max
income (million baht)	1,939,091	8.7	16.7	-2150.0	100.0
profits (million baht)	2,106,291	-0.7	833.0	-1210000.0	57300.0
asset_total (million baht)	2,106,539	25.7	3270.0	0.0	3190000.0
cash_asset (ratio)	2,101,329	0.2	0.3	-0.9	1.4
currentliability_totalliability (ratio)	2,101,213	0.8	0.3	-0.4	123.8
permanentinvest_payment (ratio)	1,606,416	0.5	28.9	-6088.5	18760.6
incometax_totalpayment (ratio)	1,770,407	0.0	5.3	-2502.1	3649.0
interest_totalpayment (ratio)	1,714,113	13.9	4103.2	0.0	4822963.0
com_usage	2,008,243	0.4	0.1	0.0	0.7
com_depth	2,008,243	2.0	0.2	1.4	3.0
software_usage	2,008,080	0.2	0.1	0.0	0.5
soft_depth	2,008,080	0.5	0.2	0.0	0.9
internet_access	2,008,243	0.4	0.1	0.0	0.7
internet_depth	2,008,243	0.5	0.1	0.0	0.8
ecommerce	2,008,190	0.3	0.1	0.0	0.6
purchase_online	2,008,190	0.1	0.0	0.0	0.2
sale_online	2,007,893	0.1	0.0	0.0	0.2
payment_online	2,008,190	0.1	0.0	0.0	0.2
output	2,103,564	671667.2	702377.9	28.0	1700000.0
ict_graduate	2,041,828	0.1	0.1	0.0	1.0
ict_grad_depth	2,041,828	2.3	0.5	0.0	7.0
Medium firms	Obs	Mean	Std. dev.	Min	Max
income	112,559	216.0	103.0	100.0	500.0
profits	112,556	5.9	189.0	-49500.0	20900.0
asset_total	112,559	272.0	2940.0	0.0	531000.0
cash_asset	112,485	0.1	0.2	-0.2	1.0
currentliability_totalliability	112,521	0.8	0.3	-58.4	1.3
permanentinvest_payment	89,403	2.3	391.9	-0.4	125549.1
incometax_totalpayment	107,662	0.2	14.1	-31.7	3860.3
interest_totalpayment	105,757	48.7	7469.2	0.0	1570273.0
com_usage	107,052	1.0	0.0	0.4	1.0
com_depth	107,052	2.0	0.2	0.7	2.8
software_usage	107,011	0.7	0.1	0.0	1.3
soft_depth	107,011	1.5	0.2	0.5	2.5
internet_access	107,052	1.0	0.0	0.5	1.0
internet_depth	107,052	1.2	0.1	0.6	2.1
ecommerce	106,932	1.1	0.2	0.0	2.3
purchase_online	106,916	0.4	0.1	0.0	0.8
sale_online	106,422	0.3	0.1	0.0	0.8
payment_online	106,794	0.4	0.1	0.0	0.8
output	112,476	894674.3	742563.1	28.0	1700000.0
ict_graduate	106,622	0.2	0.1	0.0	0.9
ict_grad_depth	106,622	3.5	2.0	0.0	8.5
Large firms	Obs	Mean	Std. dev.	Min	Max
income	44,190	5320.0	180000.0	500.0	24900000.0
profits	44,190	314.0	33300.0	-2320000.0	5480000.0
asset_total	44,190	9080.0	427000.0	0.0	70900000.0
cash_asset	44,190	0.1	0.2	0.0	1.0
currentliability_totalliability	44,148	0.8	0.2	0.0	1.1
permanentinvest_payment	44,172	7.0	577.8	-1.9	77558.2
incometax_totalpayment	35,770	0.3	14.5	-0.9	2066.9
interest_totalpayment	42,662	7.9	821.0	0.0	141874.6
com_usage	42,111	1.0	0.0	0.5	1.0
com_depth	31,904	2.1	0.2	0.9	2.7
software_usage	31,904	0.8	0.1	0.0	1.0
soft_depth	31,837	2.0	0.3	0.5	4.0
internet_access	31,837	1.0	0.0	0.0	1.0
internet_depth	31,895	1.4	0.2	0.0	2.3
ecommerce	31,778	1.2	0.2	0.0	2.4
purchase_online	31,744	0.5	0.1	0.0	0.8
sale_online	31,543	0.3	0.1	0.0	0.8
payment_online	31,093	0.4	0.1	0.0	1.0
output	44,156	801712.6	720889.5	28.0	1700000.0
ict_graduate	44,156	0.4	0.3	0.0	1.0
ict_grad_depth	30,055	5.1	2.6	0.0	9.4

Source: Authors' compilation

References

Acemoglu, D. and Restrepo, P. (2017). 'Robots and Jobs: Evidence from US Labour Market', NBER Working Paper No. 23285, National Bureau of Economic Research.

Acemoglu, D. and Restrepo, P. (2019). 'Automation and New Tasks: How Technology Displaces and Reinstates Labor', Journal of Economic perspectives, 33(2): 3-30.

Alawneh, A. and Hattab, E. (2009), "An empirical study of sources affecting e-business value creation in Jordanian banking services sector", International Arab Journal of e-Technology, Vol. 1 No. 2, pp. 1-8.

AlMulhim, A.F. (2021), 'Smart supply chain and firm performance: the role of digital technologies', *Business Process Management Journal*, Vol. 27 No. 5: 1353-1372

Arellano, M., and S. Bond. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58(2), 277-297.

Bartel, A., Ichniowski, C. and Shaw, K. (2007) How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement and Worker Skills. The Quarterly Journal of Economics, 122, 1721-1758.

Bessen, J., A. Goos., A. Salomons., and W. Berge. (2019), 'Automatic Reaction – What Happened to Workers at Firms that Automate?', CPB Discussion Paper February, CPB Netherlands Bureau of Economic Policy Analysis.

Bhatiasevi, V. and Naglis, M. (2018), Elucidating the Determinants of Business Intelligence Adoption and Organizational Performance, Information Development, 266666918811394.

Blundell, R., & S. Bond. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1), 115-143.

Blundell, R., Bond, S. and Windmeijer, F. (2001), "Estimation in dynamic panel data models: Improving on the performance of the standard GMM estimator", Baltagi, B.H., Fomby, T.B. and Carter Hill, R. (Ed.) *Nonstationary Panels, Panel Cointegration, and Dynamic Panels* (*Advances in Econometrics, Vol. 15*), Emerald Group Publishing Limited, Bingley, pp. 53-91.

Calvino, F. (2019), 'Technological innovation and the distribution of employment growth: a firm-level analysis,' Industrial and Corporate Change, 28(1), 177–202.

Crespi, G., E. Tacsir and M. Pereira (2019), 'Effects of innovation on employment in Latin America,' Industrial and Corporate Change, 28(1), 139–159.

Dubey, R., Bryde, D. J., Blome, C., Roubaud, D., & Giannakis, M. (2021). Facilitating artificial intelligence powered supply chain analytics through alliance management during the pandemic crises in the B2B context. *Industrial Marketing Management, 96*, 135–146.

Flaminiano, J. P., F. J. Paolo., C. C. Ed and A. S. Therese (2021), 'Journey to Recovery and the Next Normal for Philippine MSMEs'. Available at SSRN: https://ssrn.com/abstract=3963541 or http://dx.doi.org/10.2139/ssrn.3963541

Foroudi, P., Gupta, S., Nazarian, A. and Duda, M. (2017), "Digital technology and marketing management capability: achieving growth in SMEs", *Qualitative Market Research*, Vol. 20 No. 2, pp. 230-246.

Gaggl, P. and G.C. Wright (2017), 'A Short-run View of What Computers Do: Evidence from a UK Tax Incentives', Applied Economics, 9(3) : 262-94

Graetz, G. and G. Michaels (2018), 'Robots at Work', The Review of Economics and Statistics, 100(5): 753-68.

Heredia, J., M. Castillo-Vergara., C. Geldes., F. M. C. Gamarra., A. Flores., and W. Heredia (2022), 'How do digital capabilities affect firm performance? The mediating role of technological capabilities in the "new normal"', Journal of Innovation & Knowledge vol. 7 (2): 100171.

Hou, J., C. Huang, G. Licht, J. Mairesse, P. Mohnen, B. Mulkay, B. Peters, Y. Wu, Y. Zhao and F. Zhen (2019), 'Does innovation stimulate employment? Evidence from China, France, Germany, and The Netherlands,' Industrial and Corporate Change, 28(1), 109– 121.

Jongwanich, J. (2022). *The Economic Consequences of Globalization on Thailand*, Routledge, Taylor & Francis Group.

Jongwanich, J. (2023), 'Readiness of Thailand towards the Digital Economy', *Journal of Southeast Asian Economies* Vol. 40, No. 1 (2023), pp. 64–95.

Jongwanich, J., A. Kohpaiboon and A. Obashi. (2022), 'Technological Advancement, Import Penetration and Labour Markets: Evidence from Thai Manufacturing', *World Development*, 151 March, 105746.

Li, L., Z. Wang., F. YE., L. Chen and Y. Zhan (2022a), 'Digital technology deployment and firm resilience: Evidence from the COVID-19 pandemic', Industrial Marketing Management vol. 105 (August): 190-99.

Li, L., Z. Wang., F. YE., L. Chen and Y. Zhan (2022b), 'Digital technology deployment and firm resilience: Evidence from the COVID-19 pandemic', Industrial Marketing Management vol. 105 (August): 190-99.

Mahakittikun, T., S. Suntrayuth and V. Bhatiasevi (2021), 'The impact of technological organizational-environmental (TOE) factors on firm performance: merchant's perspective of mobile payment from Thailand's retail and service firms', Journal of Asia Business Studies, VOL. 15 NO. 2: 359-383.

Mairesse, J. and Y. Wu (2019), 'Impacts of innovation, export and other factors on firm employment growth in Chinese manufacturing industries,' Industrial and Corporate Change, 28(1), 123–138.

Maria del Mar Alonso-Almeida & Josep Llach (2013) Adoption and use of technology in small business environments, The Service Industries Journal, 33:15-16, 1456-1472

Pesaran, M.H., Y. Shin. And R.J. Smith, 2001, 'Bounds Testing Approaches to the Analysis of Level Relationships', *Journal of Applied Econometrics*, Vol. 16, pp.289-326.

Soto-Acosta, P., Popa, S. and Palacios-Marque´ s, D. (2016), "E-business, organizational innovation and firm performance in manufacturing SMEs: an empirical study in Spain", Technological and Economic Development of Economy, Vol. 22 No. 6, pp. 885-904.

Wicaksono, T.Y and A. Simangunsong (2022), 'Digital Technology Adoption and Indonesia's MSMEs during the COVID-19 Pandemic', *ERIA Discussion Paper Series* No. 426, Economic Research Institute for Asia and East Asia.

Wu, F., Mahajan, V. and Balasubramanian, S. (2003), "An analysis of e-business adoption and its impacton business performance", Journal of the Academy of Marketing Science, Vol. 31 No. 4, pp. 425-447.

Zhu, K., Kraemer, K.L. and Dedrick, J. (2004), "Information technology payoff in e-business environments: an international perspective on value creation of e-business in the financial services industry", Journal of Management Information Systems, Vol. 21 No. 1, pp. 17-54.

Zhu, K., Kraemer, K.L. and Xu, S. (2006), "The process of innovation assimilation by firms in different countries: a technology diffusion perspective on e-business",Management Science Letters, Vol. 52No. 10, pp. 1557-1576.