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DIGITAL TRANSFORMATION FOR INCLUSIVE AND SUSTAINABLE DEVELOPMENT IN ASIA

Edited by Subhasis Bera, Yixin Yao, Amitendu Palit, and Dil B. Rahut

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Abbreviations

A4AI	Alliance for Affordable Internet
ADB	Asian Development Bank
AFOLU	agriculture, forestry, and other land use
AI	artificial intelligence
ASEAN	Association of Southeast Asian Nations
BIHS	Bangladesh Integrated Household Survey
COVID-19	novel coronavirus disease
CSR	corporate social responsibility
DTR	digital technology trade
EPOV	energy poverty
FE	fixed effects
GB	gigabyte
GDIP	Global Digital Inclusion Partnership
GDP	gross domestic product
GDP	gross domestic product
GNI	gross national income
GSDP	gross state domestic product
GSMA	GSM Association
GVC	global value chain
HHE	household enterprise
ICT	information and communications technology
ICT	information and communication technology
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPS	Im, Pesaran, and Shin
ITU	International Telecommunication Union
IV	instrumental variable
LDC	least developed country
LLDC	landlocked developing country
MSMEs	micro, small, and medium-sized enterprises
NSDP	net state domestic product
PIP	Poverty and Inequality Platform
POI	point of information
PRC	People's Republic of China
REER	real effective exchange rate
SDG	Sustainable Development Goal
SIDS	small island developing states
SMEs	small and medium-sized enterprises

STEM	science, technology, engineering, and mathematics
UDISE+	Unified District Information System for Education Plus (India)
UN	United Nations
UNE	unemployment
WDI	World Data Institute
WGDP	world global gross domestic product

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Introduction: Navigating the Digital Divide—Connectivity, Inclusion, and Progress in Asia and the Pacific

Subhasis Bera, Dil Rahut, Amitendu Palit, and Yixin Yao

The increasing interdependence among nations necessitates the establishment of advanced communication mechanisms. These mechanisms, built on digital technologies, are marked by rapid innovation and widespread adoption. Digital connectivity is an indispensable catalyst for global progress, collaboration, and development, transcending geographical boundaries. It fosters inclusive growth, facilitates the exchange of knowledge and ideas, and is a cornerstone of the modern interconnected world. Nevertheless, discrepancies in its adoption rates have given rise to what is commonly known as the digital divide. This divide obstructs the realization of the benefits of digitalization, even for those who possess access alongside those who do not.

Recognizing the significance of digital connectivity, various countries and international development organizations emphasize its importance. Consequently, the rapid proliferation of digital technologies across nations exhibits a K-shaped growth pattern. Some high-income countries experience favorable growth rates, while low-income counterparts face negative trajectories. Even within individual countries, disparities in growth among income groups persist. In both cases, a significant portion of the population remains unable to reap the benefits compared to their counterparts, perpetuating the digital divide. Affordability emerges as a crucial issue, prompting governments to provide subsidies for digital connectivity. However, recent studies reveal that federal subsidies for universal broadband access in the United States have not yielded the desired outcomes (Kane 2023). Consequently, subsidies alone cannot bridge the digital divide entirely, necessitating targeted efforts to identify and address nonfinancial barriers. In this context, disruptive technologies can be pivotal in targeted digital inclusion initiatives.

In pursuing economic growth, Asian countries have witnessed the rapid adoption of digital technologies. However, this adoption has not resulted in convergence due to the region's heterogeneous economic, social, and political landscape and regulatory frameworks. This lack of convergence poses challenges to building effective digital regional integration. Therefore, comprehending the current convergence status and analyzing the determinants of digital connectivity across countries is imperative. This study delves into the convergence status of various communication technologies to formulate a comprehensive policy framework.

While many studies delve into the Schumpeterian convergence of technology, the rapid evolution of digital technologies has led to the coexistence of various technologies and platforms. This coexistence necessitates a comparison based on a composite index. However, constructing a meaningful strategy or policy framework requires revisiting the original dataset due to aggregation bias, oversimplification, and a lack of transparency (Greco et al. 2019; Freudenberg 2003). Digital connectivity can be achieved through various coexisting communication technologies, such as mobile networks, the internet, or broadband connections. Hence, separate analyses for each technology type may provide a deeper understanding of digital connectivity across countries. Additionally, the application of specific technologies depends on the field of operation, such as education, trade, health, and the environment. Therefore, digital connectivity pathways must consider using digital technologies in various operational fields with the existing framework.

Impediments to Cross-border Digital Connectivity

Chapter 1 of this book deals with the status of the digital divide and impediments to cross-border digital connectivity. Asian countries in terms of digital connectivity and economic growth, continue to be the fastest-growing in the world. The adoption of disrupted technologies remains colossal while the region hosts leaders in 5G and fiber optic rollouts. Consequently, the data flow due to digital connectivity is more voluminous in East Asia than the global average, contributing to economic growth. In East Asia, small businesses comprise 60% to 99% of all businesses, are responsible for 50% to 98% of all employment, and contribute 35% to 70% of gross domestic product (GDP). Most of these businesses spend a significant amount on information and communication technology (ICT). Again, daily time spent using the internet is also very high in Asian countries, especially in the Philippines, Malaysia, Thailand, and Indonesia. India is exhibiting the fastest-growing number of internet subscriptions.

Despite the rapid innovation and surge in the diffusion of internet penetration, the digital divide still exists across and within countries. Therefore, regardless of government initiatives, there is a call for further strategies to provide the affordable, accessible, resilient, and reliant digital connectivity needed for the foundation and operation of an inclusive digital society. Securing an inclusive digital future for all, including the most vulnerable, is an urgent policy priority. Although studies attempt to distinguish the factors responsible for this digital divide in developed and developing countries, researchers consider ubiquitous affordability as a common reason for the digital divide in developed and developing countries (Reddick et al. 2020; Fister et al. 2022; World Bank 2021; Weiss et al. 2015). Notwithstanding, various studies suggest subsidies to tackle low affordability (Oughton et al. 2022; Oughton 2023), while the Information Technology & Innovative Foundation argues that federal broadband subsidy programs are a mess of redundancies in the United States and have failed to close the geographic digital divide.

The major affordability components are the user's income and the data price. Since the data price is conditional on the volume and quality (i.e., uninterrupted and speed) of the services, the International Telecommunication Union (ITU) collects data as a price basket. A World Bank study deems data prices less than 2% of PCI affordable.

Brewer and Jeong (2023) in Chapter 1 consider the income decile to analyze the affordable connectivity of five Asian countries. The study shows that although multiple data plans and plans for targeted groups (such as students, remote workers, etc.) prevail in these countries, price variation remains conditional on service provider, volume of data, urbanization, and government interventions. Therefore, in the Asia and Pacific region where income inequality prevails, enhancing digital connectivity across borders requires a consensus and universal access plan.

The economic growth of countries in Asia and the Pacific is mainly backed by the micro, small, and medium-sized enterprises (MSMEs), especially since the novel coronavirus disease (COVID-19) pandemic. MSMEs' reliance on digital technology helped them survive in difficult times of lockdown and prosper during the post-COVID era. Adopting digital technology allows MSMEs to access more information, resources, inputs and finance, which in turn helps reduce the distribution time and costs and enhance access to the larger market. Moreover, digital technology transformation also stimulated more innovation in business models and, thus, more efficient production for MSMEs. Therefore, improved digital connectivity can help MSMEs to prosper, drive economic growth, and reduce income inequality (Mustaffa and Beaumont 2002). On the other hand, lack of affordability, awareness, and access to available digital technology may hinder digital transformation and potential economic growth. This lack of access may exacerbate the growth of MSMEs in a disadvantageous position in the global market and may lead to extinction.

Consequently, the digital divide in the MSME sector may be detrimental to the smooth market mechanism and stall economic growth. Therefore, successful digital connectivity also requires understanding the digital divide in MSMEs. In this book, the study by Rachbini, Irhamna, and Rosyadah (Chapter 2) shows that the digital divide exists in Indonesian MSMEs. This divide is prominent between rural and urban MSMEs and legal and unauthorized ones. Using World Bank survey data on the Indonesian digital economy, the study analyzes the determinants of digital technology use by Indonesian MSMEs. It shows that financial literacy and financial skills in operating businesses significantly affect MSMEs' digitalization process. Therefore, enhancing financial literacy with the help of digital finance can foster the digitalization process.

Reaping the benefits from digital connectivity is conditional on the participation of all stakeholders. Participation in the process is again conditional on the incentives that stakeholders receive. Recent initiatives to use citizen-generated data to respond quickly to queries or service requests encourage citizens to participate in the digital connectivity enhancement process. Similarly, through effective market regulation and collaboration, technology companies are encouraged to participate to enhance digital connectivity. The role of technology companies is essential as they create a supply by developing various hardware and software and enhancing the skill sets of the workers. On the other hand, employees are also required to use the technology to improve their standard of living.

Private companies can create and expand the market by empowering citizens and providing facilities to enhance digital connectivity. However, the rapid pace of innovation in digital technology and shifts in consumption patterns drive technological companies to innovate continuously. Nonetheless, technological innovation seldom occurs in isolation, as highlighted by the United Nations Conference on Trade and Development (UNCTAD) in 2021. Consequently, there is a pressing need to integrate technology companies into efforts to bolster digital inclusivity.

A survey conducted by the World Benchmarking Alliance[1] in 2023 reveals that while the global average digital inclusion score has

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[1] The companies have been assessed on four measurement areas: enhancing universal access to digital technologies; Improving all levels of digital skills; fostering trustworthy use by mitigating risks and harms; and innovating openly, inclusively, and ethically (WBI n.d.).

increased by 6.8%, a substantial 174 out of 200 companies fall short of critical scores, necessitating substantial progress in their digital transformation efforts. This survey underscores that less than 14% of the world's leading technology companies actively contribute to digital inclusion. Noteworthy initiatives in this realm include Meta's subsea cable network, Google's Affordable Connectivity Program, Cisco's Networking Academy, Amazon's AWS Educate program, IBM's SkillsBuild program, and Microsoft's DigiSkills program. However, among the top technology firms, merely 14% are engaged in digital inclusion efforts. Additionally, it is worth noting that several technology companies have discontinued their digital inclusion initiatives as part of their corporate social responsibility practices. Furthermore, these companies' initiatives often operate in isolation and may not align with national digital inclusion plans. Therefore, fostering collaboration between the government and technology companies is imperative to fully harness the benefits of digitalization. This collaborative endeavor's success hinges on a comprehensive development framework, robust regulatory measures, and transparent practices.

In Chapter 3, Tobing advocates for a collaborative approach between government entities and private technology firms. Tobing suggests providing incentives to encourage technology companies to participate in such collaboration, whether these incentives take a direct or indirect form. Clear industry strategies, sound data governance, and transparent practices indirectly motivate technology companies to engage in initiatives that promote digital inclusion.

Therefore, stakeholders need to construct a comprehensive digital development framework, delineating specific roles and responsibilities for each stakeholder. As a regulatory authority, the government must monitor the functioning of the strategy and/or policy framework.

Digital Transformation for Sustainability

Rapid innovation and diffusion of digital technologies transform the social and environmental structure and functioning. Therefore, sustainable development requires considering digital transformation due to its impact on society and the environment. Digital transformation expects to reduce the reliance on fossil fuels, reduce pollution, and conserve resources. On the other hand, digital technology's resource-hungry nature is expected to increase energy consumption and electronic waste. According to experts (Shift Project 2019), the share of global carbon dioxide (CO_2) emissions caused by digital technology increased from 2.5% to 3.7% between 2013 and 2018. Another study by the Borderstep Institute shows that the greenhouse gas emissions caused by the production, operation, and disposal of digital end devices and infrastructure are between 1.8% and 3.2% of global emissions (as of 2020). Considering both the positive and negative impacts of digital technology, a policy framework requires achieving a convergence of the circular economy and Industry 4.0 to enhance resource use efficiency and sustainability (Sarc et al. 2019). Environmental sustainability, as one of the crucial principles of sustainability, concerns the pursuit of meeting needs without compromising the quality of the environment.

The study by Jupesta et al (2023) (Chapter 4) depicts the twinning relationship between digitalization and climate change mitigation across sectors, focusing on the existing technology, market, and policy on the interaction between digitalization and climate change mitigation. In agriculture, using artificial intelligence (AI) for precision farming can reduce the required resources as well as utilize weather predictions. Therefore, the use of AI can reduce waste and hence, CO_2 emissions. Moreover, by combining high-resolution satellite images and cloud computing to handle big data, a country can help prevent the conversion of forests. Along the same lines, using smart home systems can help increase residential energy efficiency, and 3D printing technology can help in sustainable construction and reduce greenhouse gas emissions. Energy efficiency is also conditional on the accuracy of demand and supply of energy, and digital technology-based energy management strategies can enhance the accuracy of demand and supply of energy. In this regard, strategic use of solar energy can increase the supply without causing environmental stress if solar panels are installed without obstructing agricultural land. The use of solar panels can also be extended to residential areas and industrial areas. However, energy requirements outpaced the energy-efficiency improvement, albeit Industry 4.0 technologies use resources more efficiently (Freitag, Berners-Lee, and Widdicks 2021). Therefore, there is a need to enhance awareness regarding energy-efficient machines, tools, and other technologies. Since the energy requirement is high in the transport industry, a study on European countries argues for increased use of digital technology in the transport sector. According to the study, digital technology on passenger vehicles can reduce energy consumption and greenhouse gas emissions by 34% and 43%, respectively. The study also argues that there is a trade-off between digitalization and climate change mitigation. Therefore, there is a call for formulating a strategy to reap the benefits of digital connectivity.

Researchers argue that the energy efficiency using digital technology is conditional on the awareness and skill of the user. Furthermore, digitalization and green transition center around the anthropogenic emissions caused by human activities. Inevitably, strategy formulation remains inadequate without considering education and skills in understanding the pattern of human activities. Hence, providing better education and public awareness on digital technology and climate change mitigation will be a high priority to achieve United Nations 2030 sustainable development agenda. Lack of awareness, education, and skill impacts social inequity.

Education can increase awareness and prepare students for the future of work and society as digital technology transforms various sectors, creating demands for technical skills, soft skills, digital citizenship skills (i.e., ethics, safety, and responsibilities), and competencies (IEEE n.d.). However, only provision for digital connectivity to improve awareness, education, and skills is unlikely sufficient to achieve digital inclusion (Dijk and Hacker 2003). There is a need to impart training and equip individuals with digital skills. In this regard, schools have an important role to play. The study by Nair and Mishra (Chapter 5) reveals that in India, enrollment in a school is conditional on the existing digital infrastructure, especially after the COVID-19 pandemic. The study also shows that functioning computers stimulate enrollment along with the teacher-student ratio. Therefore, there is a need for digital infrastructure development in schools. This digital infrastructure, on the one hand, familiarizes students with the technology, and on the other hand, demands prerequisite digital skills of the teacher to open a wide array of learning opportunities.[2]

Education can help these groups leverage ICT to overcome discrimination, exclusion, or isolation, improve their quality of life, and contribute to social change. Education can also help raise awareness of the issues and challenges faced by these groups and foster a culture of respect, diversity, and solidarity among all members of society.

Using panel data, the study shows the role of schools in closing the technological divide by providing technology access and digital resources to students who lack similar opportunities at home or within their communities. Moreover, digital literacy training provided by schools can also enhance the required digital skills to navigate the digital realm. The role of schools in providing digital literacy is more substantial in marginalized areas. The study also pointed out the possible variation across regions.

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2 The study focuses on identifyng the factors that influence the choice of school for enrollment.

Digital Finance for Resilience and Prosperity

Among the multi-dimensional aspects of digital connectivity, two-way communications for rapid and effective response and secure and safe financial transactions are of immense importance to reap the benefits. One of the fundamental components of the digital divide relates to access to basic financial services. Millions of people, especially in underserved and remote areas, lack access to traditional brick-and-mortar banks. Digital finance, which encompasses mobile banking, digital wallets, and online payment platforms, has the potential to reach these unbanked and underbanked populations. The drive to use digital technology for financial transactions stimulates innovations and grants digital finance, also known as fintech, to offer products and services through multiple channels. Digital financial transactions through various channels provide greater opportunities and benefits for the digitally excluded or underserved and consequently help connect people and reduce inequality (Carraro and Anand 2019). Therefore, the impact of digital connectivity is also conditional on the wide and efficient use of digital finance. Digital finance can foster financial transactions, savings, and insurance claims. Therefore, analyzing the various ways to use digital financial transactions to expedite digital connectivity is also essential (ITU 2021). Part III of this book deals with the two specific uses of digital finance—one deals with mobile money to mitigate weather shocks, while the other pertains to the use of digital finance in an express delivery system connecting the digital world with the physical world.

The study by Liang and Zou (Chapter 7) shows that in the People's Republic of China, at the city level, a 10 percentage point increase in digital finance is significantly associated with a 3.16 percentage point increase in the number of express delivery points and a 3.81 percentage point increase in the number of new express delivery points. The study, using the instrumental variable method, shows that digital finance improves the service efficiency of the express delivery system and provides more significant benefits of digital connectivity. Therefore, there is a need for improving digital finance to reap the benefits of digital connectivity. However, the promotion effect of digital finance on express delivery is more salient in areas with high education levels, larger internet user sizes, and better road infrastructure. Therefore, countries should improve basic infrastructure and education to enhance digital connectivity.

Developing countries mainly suffer from the lack of digital public infrastructure to reap the benefits, especially when there is an external shock. Weather shocks, including droughts, floods, and extreme weather events, pose significant challenges to communities worldwide, particularly in regions dependent on agriculture and vulnerable to climate change. In recent years, the adoption of mobile money services has emerged as a powerful tool in enhancing resilience and mitigating the adverse effects of weather shocks. Kenya's M-Pesa, Pakistan's crop insurance, and Uganda's refugee community are examples of using mobile money in dealing with weather shocks.

The study by Matsuura, Islam, and Tauseef (chapter 6) focuses on using mobile money in dealing with weather shocks and poverty reduction in Bangladesh. The study uses a nationally representative household survey and historical granular monthly precipitation data. By employing fixed effect and instrumental variable approaches, the study found that mobile money compensates for the negative effect of rainfall shocks in Bangladesh. The study also reveals that mobile money enables geographically disadvantaged and poor households to smooth out their food consumption during droughts and receive increased overseas remittances, which enhances household welfare compared to the nonusers of mobile money. Therefore, digital finance using mobile money helps absorb weather shocks and scopes to overcome disaster and poverty.

Global Trade and Connectivity

Digital technology plays a crucial role in fostering inclusive growth as a means to reduce income inequality. Countries and international organizations consider cross-border trade a significant economic growth channel to reduce income inequality (Krugman and Obstfeld 2018; Segerstrom 2013). Cross-border trade can increase foreign income, create employment, and propel growth. Adopting new technologies makes the traditional trade process faster and more cost-effective, creating more opportunities. However, competition and heterogeneous regulations across countries can limit the benefits of cross-border trade. Furthermore, continuous and rapid technological development, especially digital technology, disrupts the traditional trade process and forces countries to be more efficient in digital trade to sustain themselves in the competitive world.

Despite the theoretical framework of international trade, recent statistics in the past 3 decades show a trend of rising inequality within and across countries. One plausible explanation for this increasing inequality is the rise in globalization regarding trade flows, tariffs, capital flows, or offshoring in developed and developing countries (Harrison, McLaren, and McMillan 2011). Increased trade between developed and developing countries also drives efficient use of resources.

One of the primary resources for product or service trade is energy. Therefore, energy efficiency in production and consumption can benefit economies. On the one hand, using digital technology in production and trade activities requires energy efficiency, whereas on the other hand, openness, the element of globalization, boosts investment in renewable energy research and development, and reduces energy poverty (Zhang et al. 2022). Again, digital trade has a wide range of profound positive socioeconomic impacts. On the one side, it upsurges competitiveness (Soylu et al. 2023). In the Asian region, it is worth noting that Asian economies confront various issues and challenges that may affect digital trade. One of the issues in Asian economies is energy poverty, which could be interlinked with digital trade.

The study by Syed and Rahut (Chapter 8) deals with the impact of digital trade on energy poverty and unemployment. Using a panel data model, the study shows that digital trade is immune to global adverse shocks such as the COVID-19 outbreak. Therefore, it is imperative to promote and/or facilitate digital trade. Furthermore, the study shows that energy poverty decreases digital trade, whereas unemployment triggers and promotes digital trade. The study suggests improving the energy infrastructure and use of renewable energy in promoting digital trade to reduce inequality and foster economic growth.

Digitalization uses technologies to transform business processes, products, and services. Digitalization can promote global value chain (GVC) participation by enabling firms to access information, markets, and resources more efficiently and effectively. Digital technologies can reduce transaction costs, communication costs, coordination, and transportation across borders, lowering trade barriers. By providing online services and information, digital platforms can also help firms overcome non-tariff barriers such as customs procedures, standards, and regulations. For example, the Asia-Pacific Trade Facilitation Forum is a regional initiative that aims to enhance trade facilitation through digital solutions (Reddy and Sasidharan 2023). Digital technologies can improve the efficiency and quality of production processes and enable firms to create new products and services that meet the demands of global markets, hence increasing GVC participation. Digital platforms can also foster collaboration and coordination among different actors in the GVC, such as lead firms, intermediaries, and end users. For example, the Asian Development Bank has launched the project "Enhancing SME Participation in Global Value Chains", which aims to support small and medium-sized enterprises (SMEs) in Asia and the Pacific to leverage digital technologies to integrate into GVCs (Urata 2022). Therefore, it is clear that to understand the benefits of digital connectivity, it is also important to understand GVCs.

The study by Korwatanasakul (Chapter 9) elucidates the link between digitalization and GVC participation at the firm level, focusing on SMEs in Asia and the Pacific. The logit and probit model study shows that digitalization in firms, especially SMEs, exhibits higher GVC participation. Therefore, it highlights the role of digital technologies in facilitating international market access and enhancing supply chains. However, the impact of digitalization on GVC participation differs between SMEs and large firms. In the case of large firms, the effects of digitalization on GVC participation diminish due to their widespread adoption of basic digital technology. Therefore, to improve trade activities, digital connectivity is essential for allowing smaller firms to participate in GVCs and foster economic growth.

Conclusion

This book highlights the multifaceted relations between digital connectivity, economic growth, and sustainability in the modern interconnected world. The rapid innovation and adoption of digital technologies have transformed various aspects of society and the economy, offering both opportunities and challenges. Undoubtedly, the lack of universal access to digital technologies and discrepancies in access to digital connectivity remains a significant barrier to reaping the benefits of digitalization. Despite government initiatives and subsidies, affordability remains a common hurdle, particularly in regions with income inequality. To bridge this divide, targeted digital inclusion efforts that address nonfinancial barriers are imperative.

In expanding digital connectivity, there is a need to promote digital finance, including mobile money, as a crucial initiative in mitigating the impact of weather shocks and fostering financial inclusion. Mobile money services have proven effective in helping communities withstand the challenges posed by weather-related disasters, contributing to resilience and poverty reduction.

Awareness and empowerment are essential to reap the benefits of disruptive change caused by the adoption of digital technologies. To enhance awareness and empowerment, education and skills development are key components. Schools are pivotal in increasing awareness and developing skills by providing digital infrastructure and skills training, especially in underserved areas. Schools help enhance financial literacy and digital skills to prepare individuals for the digital future.

Increasing awareness, in turn, helps to achieve sustainability without stressing the environment. However, the relationship between digitalization and sustainability is complex. While digital technology helps reduce resource consumption and promote sustainability, it also contributes to energy consumption and electronic waste. A comprehensive policy framework that aligns circular economy principles with Industry 4.0 is necessary to enhance resource use efficiency and environmental sustainability.

Increased digital connectivity opens windows of opportunities for trade and globalization. Digital trade and globalization present both opportunities and challenges. Digital technologies can make cross-border trade more efficient and inclusive, reducing income inequality. However, competition and heterogeneous regulations across countries can limit the benefits of globalization. To foster trade, countries require efficient use of resources. Energy efficiency and renewable energy adoption are crucial for sustainable economic growth, and digital trade can play a significant role in this context. Therefore, countries must develop energy infrastructure and promote renewable energy to supply energy sources.

A complex and multifaceted interplay exists between digital connectivity, economic growth, sustainability, and inclusiveness. To harness the full potential of digitalization and ensure equitable benefits, basic infrastructure for digital technologies, energy resources, and education is required. Therefore, a holistic approach that considers education, skills development, policy frameworks, and international collaboration is essential.

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PART I

Bridging the Digital Divide

1

Inequality and Access to Mobile Data

Jonathan Brewer and Yoonee Jeong

1.1 Introduction

The novel coronavirus disease (COVID-19) pandemic has resulted in new paradigms of life that are highly dependent on communications. Schools, governments, healthcare providers, and businesses have started to prioritize digital interactions over in-person interactions. People without connectivity are unable to take part in these new methods of interaction. In Asia and the Pacific, the GSM Association (GSMA) estimates that 96% of the region's population lives within reach of mobile data networks, but only 47% were connected by the end of 2022 (GSMA 2022).

Access to Meaningful Connectivity, including affordable mobile data, is critical to social inclusion and economic opportunities. Poverty is a factor that limits access. Many in the Asian Development Bank's (ADB) developing member countries find it difficult to afford access to levels of mobile data that enable Meaningful Connectivity. With most web traffic in Asia originating from mobile devices (Williams 2021), affordability of mobile data is likely a significant contributor to this connectivity gap.

The de facto standard for determining affordable connectivity is a measurement of the cost of an allocation of mobile data relative to a percentage of gross national income (GNI) per capita (Broadband Commission for Sustainable Development 2018). The best known targets are "1 for 2" (A4AI 2018) and "5 for 2" (A4AI 2021). These were developed by the Broadband Commission for Sustainable Development led by the International Telecommunication Union (ITU) and the Alliance for Affordable Internet (A4AI). They define affordable broadband as a 1 or 5 gigabyte (GB) allocation of data available for 2% of GNI per capita.

Assuming a country has affordable connectivity because it meets a simple affordability target is problematic for a few reasons. These measurements can tell us whether mobile data is generally affordable in a country, but not if it is not affordable for people at all income levels. They do not account for pricing that varies by location across a country. The A4AI's 5 GB threshold set to be met by 2026 is just one-third of current global average mobile data consumption (Ericsson 2023), and has not been adjusted to take into account modern communications demands. These targets also consider a measurement of general internet access, when providers increasingly offer differential pricing for applications and services with high traffic requirements.

This chapter builds on the research done for ADB's working paper "Last Mile Connectivity: Addressing the Affordability Frontier" (Brewer, Jeong, and Husar 2022). It aims to provide a comprehensive view of affordability across income deciles by evaluating the cost of broadband against an income-adjusted GNI per capita figure based on the World Bank's Poverty and Inequality Platform (PIP) data. Using income deciles allows us to estimate the percentage of a population that can afford the data required for Meaningful Connectivity more accurately than existing methods.

It addresses the issue of higher data requirements by calculating the affordability of three utilization thresholds: 5 GB per month, 15 GB per month, and 40 GB per month. These thresholds take into account 2026 targets, existing global average use, and levels of use that will be normal 5 years from now. This chapter also identifies and explores situations where affordable products have limited geographic coverage. Finally, it examines a number of ways some carriers make mobile data more affordable for specific applications and segments of their populations.

1.2 Background

For much of the world's population, the internet is an inextricable part of daily life. Its reach extends into virtually every aspect of human activity, facilitating everything from communication to entertainment, and from work to study. Global consumer demand for broadband grew during the COVID-19 pandemic even as it became less affordable (ITU 2022). This means people chose to maintain internet access over other goods and services.

This pervasive technology is most often accessed via smartphones in developing economies. A significant number of people are unconscious consumers of internet access; they know only the applications on their smartphones, but not that the apps are dependent on the internet (Silver et al. 2019). The pervasiveness of the internet has far-reaching effects, as suggested by an extensive body of academic literature.

One notable area of impact is education. A 2020 literature review on internet access and education underscored a significant correlation:

students with home-based internet access exhibited improved educational achievements and skills (Daoud et al. 2020). This finding highlights the critical role of the internet in fostering knowledge acquisition and educational attainment.

Beyond its educational effects, the internet and mobile technologies have the potential to alleviate societal disparities. They can significantly contribute to reducing income inequality, a phenomenon observed in both low and middle-income economies and high-income ones (Canh et al. 2022). Social media use, primarily on mobile devices, has proven to have a positive effect on the performance of small to medium enterprises in developing economies (Qalati et al. 2021). These platforms provide a potent tool for business growth, enabling enterprises to reach broader audiences, better interact with their customers, and expand their markets.

The internet's impact extends into the realm of health and well-being, especially for older adults (Tavares 2020). Research suggests a positive association between internet use and the overall health and wellness of this demographic. By providing access to health information, social connections, and mental stimulation, the internet has become a valuable resource for promoting the well-being of older adults.

The cultural implications of the internet are also significant. Smartphone users are more likely to interact with individuals from diverse backgrounds, enhancing the global interconnectedness and mutual understanding (Silver and Huang 2019). They also tend to stay more connected with friends and are more likely to access new information about health and government services, thereby promoting social cohesion and public engagement.

Meaningful Connectivity to the internet enables all these positive benefits. We introduce this framework for evaluating internet connectivity in the next section of the chapter. Later we explore levels of mobile data use, its growth, and how COVID-19 increased data use. Finally, we introduce the concept of income inequality and how it affects affordability.

1.2.1 Meaningful Connectivity

As the world has moved on from the telephone as its primary means of communication, existing frameworks for measuring access to connectivity have failed to keep pace. Universal service promoted the concept of all homes having a telephone and the ability to make a call. Universal access recognized that in developing countries this was not always achievable, and promoted the idea that everyone in a population should be able to access telecommunications services—whether in-home or via public locations.

Meaningful Connectivity is a concept developed in parallel by the A4AI and the Broadband Commission for Sustainable Development (Broadband Commission) led by the ITU and UNESCO. Each released similar frameworks in 2019. A4AI's framework, now promoted by the Global Digital Inclusion Partnership (GDIP), has clear and aggressive goals (Table 1.1).

Table 1.1: GDIP's Meaningful Connectivity Framework

A Fast Connection	4G-like speed
An Appropriate Device	Smartphone ownership
Enough Data	An unlimited broadband connection
Regular Access	Daily use

GDIP = Global Digital Inclusion Partnership.

Source: Global Digital Inclusion Partnership (2023). https://globaldigitalinclusion.org/our-work/meaningful-connectivity/ (accessed 6 March 2023).

Minimum speeds, personal device ownership, and daily access are all reasonable goals to meet on a global basis. Meaningful Connectivity's call for an unlimited connection is more difficult to achieve given the limited data capacity of mobile networks.

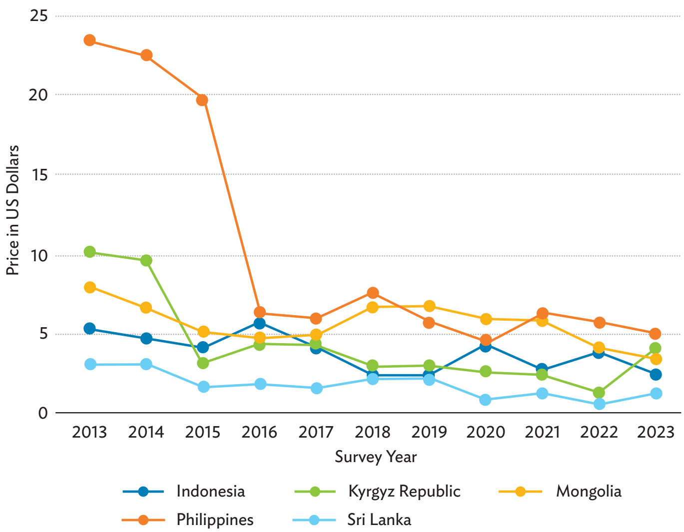
Another of A4AI's advocacy programs, also developed in parallel by the Broadband Commission for Sustainable Development led by the ITU, is the idea that affordable data should be available for less than 2% of GNI per capita. How much data is considered enough has evolved over time. A "1 for 2" goal targeting 1 GB per month of data was set a decade ago to be met by 2016. A "5 for 2" goal targeting 5 GB of traffic per month is a current goal to be met by 2026 (A4AI) or 2030 (Broadband Commission 2018).

1.2.2 Trends in Mobile Broadband Pricing

The ITU has conducted an annual information and communications technology (ICT) price basket survey since 2012 (ITU 2012). One of the data points collected is the cost of low amounts of mobile cellular data. While the quantity of data used in the survey has never precisely aligned with "1 for 2" targets, some studies have derived "1 for 2" scores from the collected pricing (UNESCAP 2021).

Over time the ITU has changed the level of data associated with their low-usage basket (previously called Data-only mobile-broadband basket) from 0.5 GB between 2012 and 2017, to 1.5 GB between 2018–2020, and to 2 GB in 2021 (ITU 2023). Figure 1.1 shows pricing over the past 10 years in several markets.

Figure 1.1: Data-only Mobile Broadband Basket from ITU and This Study



ITU = International Telecommunication Union.

Sources: ITU ICT Price Baskets, historical data series, April 2023 release, author.

The ITU's choice in basket size over time has been widely supported by academic literature. The World Data Institute (WDI), via a 2021 Brookings blog post titled "Measuring internet poverty" (Crespo Cuaresma et al. 2021) posited that 1.5 GB of data per month was enough to participate in the internet revolution. They said this level of data was enough to satisfy the basic needs of internet access to check email, do shopping, and browse web pages for up to 40 minutes a day. The WDI considered people with access to less than 1.5 GB of data per month to be in internet poverty.

Figure 1.1 shows us that over the past 7 years pricing has remained relatively static, while data allocations measured have tripled. Both the WDI's analysis and the ITU's choice of basket size are problematic;

while data allocations have risen, they have not risen in line with actual consumption.

1.2.3 COVID-19 and Mobile Data Consumption

The COVID-19 pandemic instigated a surge in mobile data use due to the onset of worldwide movement restrictions. These lockdowns drastically changed the dynamics of education and work, with many individuals compelled to adapt to virtual modes of engagement. Students new to e-learning found that participating in online classes could require up to 1 GB of data per day (World Bank 2021b). The shift to remote work saw teleworkers using between 0.15 and 0.6 GB of mobile data per hour while performing their duties from home (Bai 2020). Video conferencing applications like Google Meet, WebEx, and Zoom became a substitute for many formerly in-person interactions. These platforms can consume between 0.38 and 1.1 GB of traffic per hour, a demand that escalated as the number of participants in each meeting rose (Chang et al. 2021). The pandemic underscored the essential role of mobile data in enabling connectivity in a socially-distanced world.

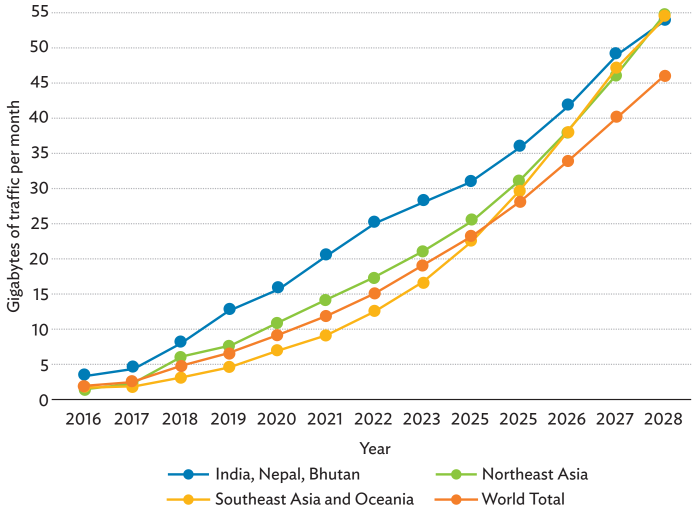
1.2.4 Data Targets for Today and the Future

In a 2021 paper, the World Bank Group's digital development team estimated that foundational internet access in developing economies required around 0.66 GB per month (World Bank 2021a). This covered activities like using websites for public services, health information, shopping, learning, and news. They found that average recreational use for social media and online entertainment added another 5.2 GB per month to that baseline, for a total requirement of around 6 GB per month. This figure, a full four times greater than the WDI's measurement of internet poverty, still falls far below the threshold of average mobile data use today.

Ericsson found in 2022 that average mobile data was 15 GB per device, and nearly 25 GB per device in India as shown in Figure 1.2 (Ericsson 2023). Their data shows a steady increase in data consumption per user over time, and they predict the rate of growth will remain steady for the next 5 years.

Over the long term, traffic on the internet increases at a rate of around 30% per annum. This trend has been observed and predicted for more than a decade, with Cisco's Visual Networking Index recognizing the phenomenon early on (Cisco 2012). Mobile data traffic consumption follows a similar trend. Ericsson's Mobility Visualizer predicts global average mobile growing from just under 2 GB per device in 2016 to around 46 GB per device by 2028.

Figure 1.2: Mobile Data Traffic per Device from Ericsson Mobility Visualizer



Sources: Ericsson (2023).

A 2022 ADB paper posits that average mobile broadband should be affordable for all, meaning an ever-increasing bucket of data should be available for 2% of GNI per capita (Brewer, Jeong, and Husar 2022). This position is the basis for our inclusion of 15 GB and 40 GB targets in this chapter's analysis.

Lastly, there are exploratory initiatives by the United Nations Office of Secretary General's Envoy to Technology to set a new global target around universal and meaningful connectivity by adding affordability indicators for the bottom 40% of income earners among others. This chapter will contribute toward justifying the need for more granular assessment of mobile data price.

1.2.5 Inequality and Mobile Affordability

Income inequality is a worldwide phenomenon especially prevalent in developing economies (Moffatt 2019). Income distributions are often positively skewed, with mean incomes greater than the median. This leaves most members of a population with normal or low incomes, not high incomes (Sulistyaningrum and Tjahjadi 2022).

Measuring the cost of an amount of data against 2% of GNI per capita can tell us whether or not mobile data is generally affordable in a country, but not if it is affordable for people at all income levels. In particular it cannot tell us what percentage of a population would find broadband affordable if they were in a broadband service area. Measuring the cost of data using realistic income distributions can help solve this problem.

Adjusting GNI per capita for examining broadband affordability is an established technique. The most recent example is a paper by the World Bank which compared the cost of broadband as a percentage of average GNI per capita to that of the bottom 40% for a set of six countries (World Bank 2021a). They found a significant disparity in affordability in all markets between average members of a population and members belonging to the lowest four deciles of income earners.

1.2.6 The World Bank's Poverty and Inequality Platform

The World Bank is the source of the income distributions used in this chapter, via their Poverty and Inequality Platform (PIP). At a basic level, the PIP income distributions are derived from household surveys on budgets or spending, generally conducted in conjunction with national statistics offices in each country considered. Though exact methods vary from country to country, statistics are often based on the monetary value of household consumption.

The PIP statistics are only generated when recent survey data are available and many developing economies lack recent surveys. This problem is particularly acute among ADB developing member countries in the Pacific islands, Uzbekistan, Azerbaijan, Nepal, and India.

1.3 Target Countries

This analysis depends on the availability of transparent mobile data pricing from multiple providers and on the availability of recent poverty and inequality data. For development relevance, lower middle income developing member countries were considered.

Indonesia, the Kyrgyz Republic, Mongolia, the Philippines, and Sri Lanka met these criteria and were chosen as examples for analysis. They represent a range of country size, population density, level of urbanization, and level of internet use, as described in Table 1.2.

Table 1.2: Summary Statistics of Countries in the Study

Country	Population (2021)	Pop Density (per square kilometer)	Urbanization	GNI per Capita, Atlas (2021)	Gini Coefficient	Internet Users % (2021)
Indonesia	273,753,191	145	57%	$4,180	37.9	62%
Kyrgyz Republic	6,691,800	34	37%	$1,180	29.0	78%
Mongolia	3,347,782	2	69%	$3,730	32.7	84%
Philippines	113,880,328	376	48%	$3,550	40.7	53%
Sri Lanka	22,156,000	354	19%	$4,030	37.7	67%

Source: World Bank (2023).

1.4 Methodology

Using the latest Telegeography GlobalComms database, 18 carriers were identified in the five target countries. Details of 111 different plans were found on carrier websites. Data for each plan were recorded in a table including the plan's name, whether it is pre or post-paid, the term of the plan, its cost in local currency, and the amount of data traffic supplied. Plan pricing was also saved in the internet archive at survey time.

Plans were selected for offering general internet access at low prices; hundreds of special purpose plans bundling entertainment or social media for an extra fee were excluded. In cases where the lowest cost plans also had data bonuses available to particular applications, or valid only in particular geographic areas, data bonuses were not recorded. Plans with validities of 1 day to 1 month were recorded, while plans with longer terms were not. The lowest cost plan from each carrier that included at least 40 GB of traffic per month was recorded, while plans with even greater monthly traffic allocations at higher costs were not.

Costs for all plans were normalized to US dollars using average market conversion rates for the week beginning 8 May 2023.[1] Varying plan lengths were normalized to exactly 1 month (365/12) by multiplying their duration and cost. Where using a set of smaller time-limited top-ups could result in the only available product for 5, 15, or 40 GB per month, the time validity of plans was adjusted down to emulate faster data consumption by a consumer.

1 Rp1 = $0.000068, Som1 = $0.011425701, MNT1 = $0.00028606559, ₱1 = $0.018, SLR1 = $0.0031.

Population data and GNI for each country were retrieved from the World Bank's API using the wbstats R module (Piburn 2020). Atlas method, a calculation of the size of the economy based on GNI converted to US dollars, smoothed for currency fluctuations using a 3-year moving average, was chosen for the GNI measurement (World Bank 2014).

Income decile data were retrieved from the World Bank's PIP using the pipr R module (Fujs et al. 2022). The most recent year of income deciles for each country was used.[2]

A decile-adjusted monthly GNI per capita was calculated for each country by dividing the GNI by the population, then dividing by 12, then by multiplying the result by each of the income deciles. Mobile affordability was found by calculating the percentage of the decile-adjusted monthly GNI per capita required to purchase mobile data plans at 5 GB, 15 GB, and 40 GB per month.

In the charts generated for each country in the results section, the colored bars represent the median plan cost, and error bars show the minimum and maximum costs found for relevant plans.

1.5 Results

1.5.1 Indonesia

Indonesia's population of 274 million is spread across around 6,000 islands spanning roughly 5,000 kilometers from east to west. Around 57% of its population lived in urban areas in 2021, a figure increasing faster over the past 40 years than any of the other countries in this survey (World Bank 2023). Population density across wide areas of Indonesia, especially in Borneo and West Papua, is fewer than 10 people per square kilometer.

Indonesia's four major mobile operators report 4G network coverage of between 80% and 98% of the population (Telegeography). Operators report they have 294 million 4G subscribers, which is greater than 100% penetration. The ITU (2021) estimates that 67% of the population has internet access (Economist Impact 2022). Where 4G coverage is available, 5 GB per month of mobile data is almost universally affordable.

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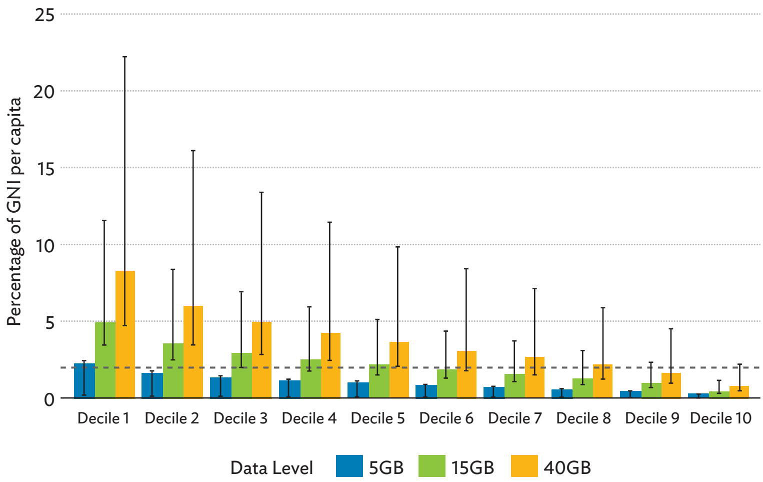
2 Indonesia = 2022, Kyrgyz Republic = 2020, Mongolia = 2018, Philippines = 2021, and Sri Lanka = 2019.

Figure 1.3: Mobile Affordability in Indonesia



GB = gigabyte, GNI = gross national income.

Sources: World Bank (2023), World Bank Poverty and Inequality Platform (version 2023 0328_2017_01_02_PROD), pip.worldbank.org (accessed 23 July 2023), https://im3.id/ (accessed 27 April 2023), https://www.smartfren.com/ (accessed 16 May 2023), https://www.telkomsel.com/ (accessed 12 March 2023), https://www.xl.co.id/ (accessed 16 May 2023).

The median cost for 5 GB of data in a month as shown in Figure 1.3 is less than 2% of GNI per capita across almost all segments of the population. The lowest cost 5 GB per month package is offered by im3, the provider claiming the largest 4G coverage. At the 15 GB per month level, median broadband prices are affordable for 50% of the population. Only the wealthiest 20% of Indonesians would find 40 GB per month priced at the median affordable, but 60% of the population might be able to find an affordable service based on the lowest available prices.

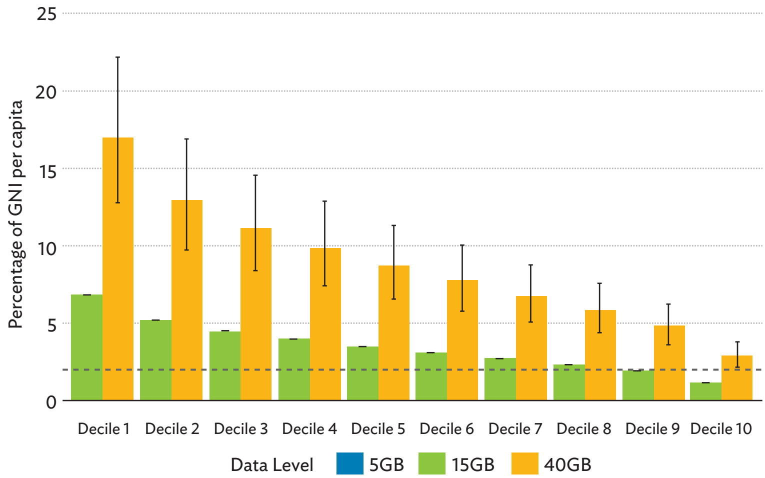
Indonesia's carriers are unique amongst those in this study in offering extra urban use broadband quotas. These "area", "local", or "zone" offerings are data allocations that can be consumed in certain cities around the country as a bonus to many prepaid data packages. im3, Smartfren, Telkomsel and XL all offer localized bonus quotas with their size sometimes varying from location to location. The size and price of bonus offerings means that for some of Indonesia's urban poor, 15 GB or even 40 GB per month plans can be universally affordable.

1.5.2 Kyrgyz Republic

Around 6.6 million people live in the Kyrgyz Republic, with large concentrations around Bishkek and Osh. Overall urbanization in 2021 was 37%, an increase of only 4% over the past 60 years (Telegeography). A largely mountainous country, many regions have fewer than 10 people per square kilometer.

The 4G coverage of Kyrgyz Republic's three mobile operators is between 97%–99% of the population (Economist Impact 2022). They report 5,170,000 4G mobile subscriptions. The ITU (2021) estimates that 78% of people in the Kyrgyz Republic use the internet.

Figure 1.4: Mobile Affordability in Kyrgyz Republic



GB = gigabyte, GNI = gross national income.

Sources: World Bank (2023), World Bank Poverty and Inequality Platform (version 2023 0328_2017_01_02_PROD), pip.worldbank.org (accessed 23 July 2023), https://beeline.kg/ (accessed), https://mega24.kg/ (accessed 12 May 2023), https://o.kg/ (accessed 7 March 2023).

Mobile data in the Kyrgyz Republic has until recently been affordable at low allocations—for example 1 or 2 GB per month quotas, as shown in Figure 1.1. In 2023 carriers changed their plans, eliminating low end plans and increasing data allocations for all other offerings. Figure 1.4 shows that based on available pricing today, no 5 GB plans are available at all. 15 GB of data is affordable for those in the top two deciles, and close to affordable for those in the 7th and 8th deciles.

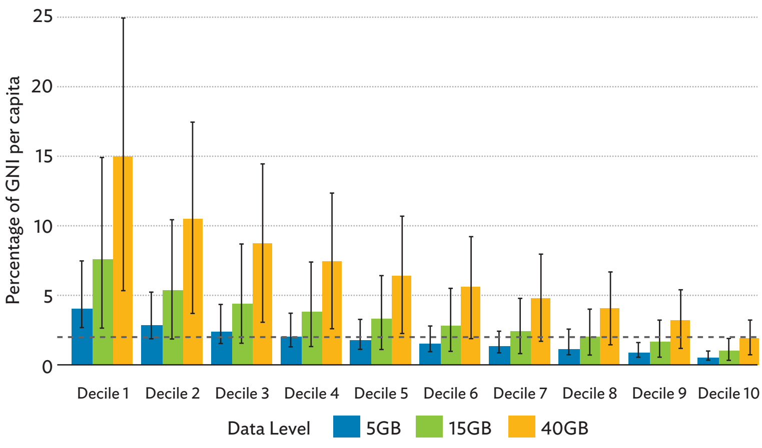
Only one operator now sells a low-use plan; it includes 100 MB of data per day. At SOM225 per 28 days, Beeline's Zhany Birge 3.1 GB per month plan exceeds 2% of GNI per capita, meaning there are no affordable entry-level mobile data plans available in the Kyrgyz Republic.

1.5.3 Mongolia

More than half of Mongolia's rapidly urbanizing population of around 3.2 million is centered around the capital, Ulaanbaatar. In all, 69% of its population is urban, the highest rate of urbanization in this study (Telegeography). Outside a handful of towns separated by long distances, most of Mongolia's land has fewer than one person per 10 square kilometers. An extensive terrestrial fiber backbone connects all of Mongolia's urban areas (ITU 2023).

Mongolia's mobile operators claim between 40% and 85% population cover of the country (Economist Impact 2022). They report 2,985,000 4G subscribers. The ITU (2021) estimates that 84% of Mongolians use the internet.

Figure 1.5: Mobile Affordability in Mongolia



GB = gigabyte, GNI = gross national income.

Sources: World Bank (2023), World Bank Poverty and Inequality Platform (version 2023 0328_2017_01_02_PROD), pip.worldbank.org (accessed 23 July 2023), https:///gmobile.mn/ (accessed 1 December 2022), https://www.mobicom.mn/ (accessed 1 May 2023), https://www .skytel.mn/ (accessed 6 February 2023), https://www.unitel.mn/ (accessed 5 December 2022).

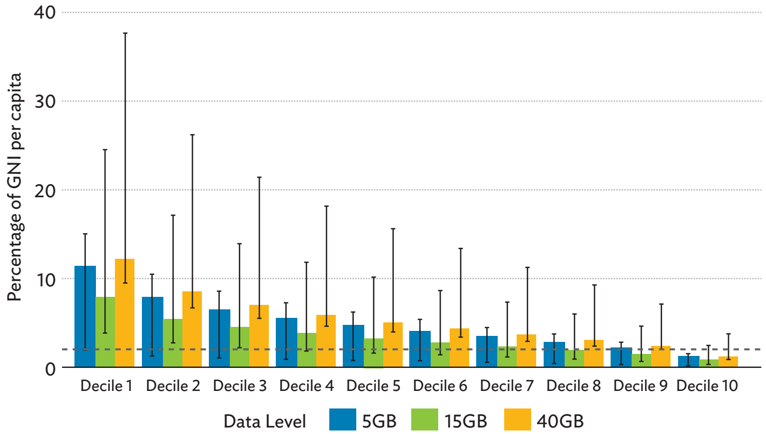
Where the lowest cost plans are available, Figure 1.5 shows that data in Mongolia are affordable for roughly 90% of the population. Considering average mobile data prices, 5 GB of data per month is only affordable to those in Decile 4 or above.

For most of Mongolia's population living in remote areas, mobile data is highly unaffordable. GMobile is Mongolia's only provider with extensive remote area coverage with their CDMA 450 network. In every case in Figure 1.5 the highest cost plans on offer, shown by the tops of the error bars, are from GMobile. Data for remote users can also be very slow; CDMA 450 does not offer 4G-like speeds.

1.5.4 The Philippines

Much like Indonesia, the Philippines is an archipelago with more than 7,000 islands. Its population of 114 million live on around 2,000 of them. While urbanization in the Philippines is lower than in Indonesia, its overall population density is around two and a half times greater (Telegeography). Its main cities are well connected with fiber optic networks (Economist Impact 2022) and have extensive mobile coverage, but rural and remote areas often have few or no communications options.

Figure 1.6: Mobile Affordability in the Philippines



GB = gigabyte, GNI = gross national income.

Sources: World Bank (2023), World Bank Poverty and Inequality Platform (version 2023 0328_2017_01_02_PROD), pip.worldbank.org (accessed 23 July 2023), https://dito.ph/ (accessed 3 May 2023), https://www.globe.com.ph/ (accessed 6 March 2023), https://smart.com.ph/ (accessed 8 April 2023).

The Philippines, three mobile operators claim between 78%–96% population coverage of the country with their long-term evolution networks (Economist Impact 2022). They report 114,097,000 4G and 5G mobile subscribers, for greater than 100% penetration. The ITU (2021) estimates that 53% of people in the Philippines use the internet.

As shown in Figure 1.1, until 2016 the Philippines had the most expensive mobile data offerings of the countries in this study. Dual threats of regulation by former president Rodrigo Duterte (CNN Philippines 2016) and potential competition from new operators (Ramli 2015) may have helped reduce rates by more than two-thirds between 2015 and 2016.

Data rates today from dominant operators Globe and PLDT are still exceptionally high compared to other operators in this survey, and Figure 1.6 shows the median price for data is still unaffordable for all but the wealthiest three deciles.

New entrant Dito Telecommunity has the smallest coverage area of Philippine operators at 78% of population, but has the lowest data prices by far. In every case in Figure 1.6 the lowest end of the error bars is a Dito mobile data plan. Where it is available, their 8 GB Level Up plan at ₱99 per month is universally affordable. While competitor Globe offers a similar 8GB plan available for ₱99, the Globe plan's validity is only 7 days while Dito's plan is valid for 30 days.

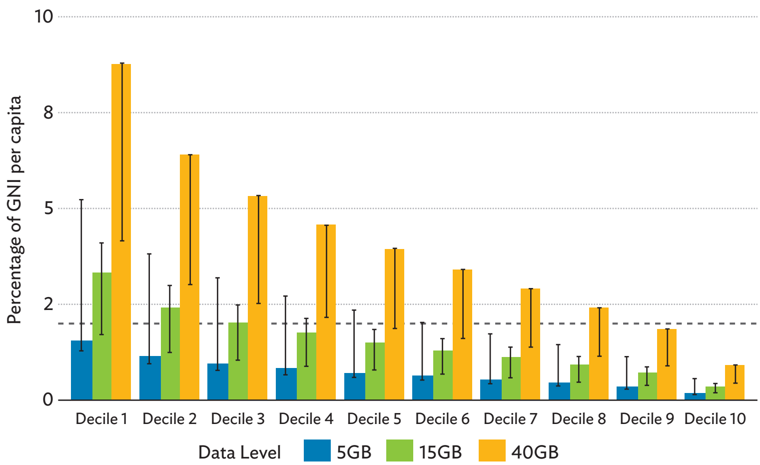
Short validity of data plans in the Philippines is a large part of the reason Meaningful Connectivity remains elusive for most of the population. Both Globe and Smart offer 5 GB prepaid data plans for ₱50 as their least expensive offerings. This price would be universally affordable if the data purchased was available for 1 month and not 3 or 5 days. Figure 1.6 shows that 15 GB per month plans are more affordable than 5 GB plans. While more affordable they may be less consumed. 15 GB per month plans often require a 1-month advance purchase that does not fit well with a culture accustomed to purchasing small quantities of most goods as needed (Soriano 2019).

1.5.6 Sri Lanka

Sri Lanka's population in 2021 was around 22 million people. With an overall urbanization rate of 19%, Sri Lanka has the most rural population of the countries in this study (Telegeography), and its major cities have the smallest populations. Urbanization has not changed significantly in 60 years (Telegeography); Sri Lanka is likely to remain a rural country in the future. Despite its highly dispersed population, density is high at 354 people per square kilometer, on par with the Philippines.

Sri Lanka's four largest mobile network operators claim between 70%–95% population coverage with their 4G networks (Economist Impact 2022). 2G and 3G however remain dominant technologies. With only 12,660,000 claimed 4G subscriptions, Sri Lanka has the lowest level of 4G subscriptions in this study. The ITU (2021) estimates that as of 2021 67% of Sri Lankans use the internet.

Figure 1.7: Mobile Affordability in Sri Lanka



GB = gigabyte, GNI = gross national income.

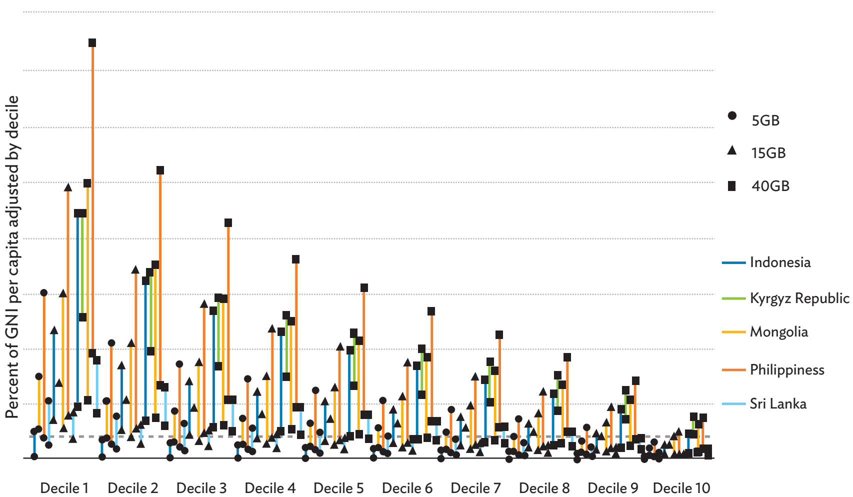
Sources: World Bank (2023); World Bank Poverty and Inequality Platform (version 2023 0328_2017_01_02_PROD), pip.worldbank.org (accessed 23 July 2023), https://www.airtel.lk/ (accessed 24 January 2023), https://www.dialog.lk/ (accessed 12 April 2023), https://hutch.lk/ (accessed 19 May 2023), https://www.mobitel.lk/ (accessed 9 May 2023).

As shown in Figure 1.7, mobile data access in Sri Lanka is universally affordable. Where available, some 15 GB per month plans also fall below 2% of GNI per capita threshold for all income deciles. As with Dito in the Philippines, Sri Lanka's lowest price data is not available everywhere. Its best price plans are offered by Airtel, who cover only 70% of the population with their 4G network.

1.6 Discussion

Looking at the aggregate of country data generated by the study in Figure 1.8, it is clear that outside Indonesia most data plans in most countries are unaffordable for people in the lower three- or four-income deciles. Observations made on individual carrier coverage, pricing, and special offers leave a number of areas to be discussed beyond the raw statistics.

Figure 1.8: Mobile Affordability by Decile, Data Level, and Country



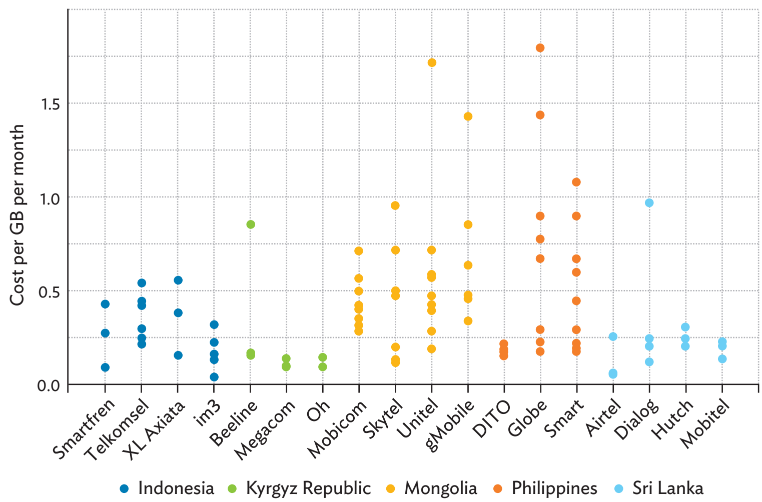
GB = gigabyte, GNI = gross national income.

Sources: World Bank (2023), World Bank Poverty and Inequality Platform (version 20230328_2017_01_02_PROD), pip.worldbank.org (accessed 23 July 2023), https://im3.id/ (accessed 27 April 2023), https://www.smartfren.com/ (accessed 16 May 2023), https://www.telkomsel.com/ (accessed 13 March 2023), https://www.xl.co.id/ (accessed 16 May 2023), https://beeline.kg/ (accessed 7 March 2023), https://mega24.kg/ (accessed 12 May 2023), https://o.kg/ (accessed7 March 2023), https:///gmobile.mn/ (accessed 1 December 2022), https://www.mobicom.mn/ (accessed 1 May 2023), https://www.skytel.mn/ (accessed 6 February 2023), https://www.unitel.mn/ (accessed 5 December 2022), https://dito.ph/ (accessed 3 May 2023), https://www.globe.com.ph/ (accessed 6 March 2023), https://smart.com.ph/ (accessed 8 April 2023), https://www.airtel.lk/ (accessed 24 January 2023), https://www.dialog.lk/ (accessed 12 April 2023), https://hutch.lk/ (accessed 19 May 2023), https://www.mobitel.lk/ (accessed 9 May 2023).

1.6.1 Mobile Data is a Commodity

Given the wide range of population, urbanization, geography, and GNI per capita across the five countries of the study, one might expect to find a significant variation in the cost of data from one market to another. Analysis of data plans shown in Figure 1.9 does not prove this. Every country in the study had some plans with data available for less than $0.25 per gigabyte per month. Considering this pricing, it is not surprising that the Kyrgyz Republic has affordability issues since GNI per capita there is one-third of the other countries in this survey (World Bank 2023).

Figure 1.9: Monthly Cost per Gigabyte for All Providers and Plans

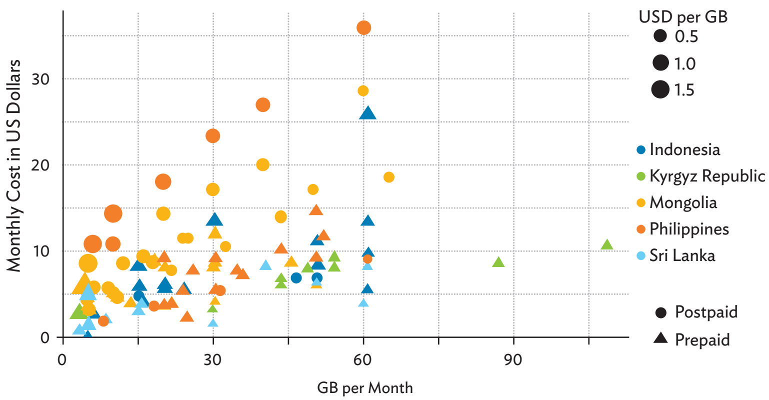


GB = gigabyte.

Sources: https://im3.id/ (accessed 27 April 2023), https://www.smartfren.com/ (accessed 16 May 2023), https://www.telkomsel.com/ (accessed 13 March 2023), https://www.xl.co.id/ (accessed 16 May 2023), https://beeline.kg/ (accessed 7 March 2023), https://mega24.kg/ (accessed 12 May 2023), https://o.kg/ (accessed 7 March 2023), https:///gmobile.mn/ (accessed 1 December 2022), https://www.mobicom.mn/ (accessed 1 May 2023), https://www.skytel.mn/ (accessed 6 February 2023), https://www.unitel.mn/ (accessed 5 December 2022), https://dito.ph/ (accessed 3 May 2023), https://www.globe.com.ph/ (accessed 6 March 2023), https://smart.com.ph/ (accessed 8 April 2023), https://www.airtel.lk/ (accessed 24 January 2023), https://www.dialog.lk/ (accessed 12 April 2023), https://hutch.lk/ (accessed 19 May 2023), https://www.mobitel.lk/ (accessed 9 May 2023).

Outside Mongolia, high per gigabyte prices depend more on operator than they do on country. Within countries, Figure 1.10 shows that whether or not a plan was prepaid or postpaid has a greater impact on its cost than any other factor. Most postpaid plans are more expensive than prepaid.

Figure 1.10: Mobile Pricing by Country and Plan Type



GB = gigabyte.

Sources: https://im3.id/ (accessed 27 April 2023), https://www.smartfren.com/ (accessed 16 May 2023), https://www.telkomsel.com/ (accessed 13 March 2023), https://www.xl.co.id/ (accessed 16 May 2023), https://beeline.kg/ (accessed 7 March 2023), https://mega24.kg/ (accessed 12 May 2023) https://o.kg/ (accessed 7 March 2023), https:///gmobile.mn/ (accessed 1 December 2022), https://www.mobicom.mn/ (accessed 1 May 2023), https://www.skytel.mn/ (accessed 6 February 2023), https://www.unitel.mn/ (accessed 5 December 2022), https://dito.ph/ (accessed 3 May 2023), https://www.globe.com.ph/ (accessed 6 March 2023), https://smart.com.ph/ (accessed 8 April 2023), https://www.airtel.lk/ (accessed 24 January 2023), https://www.dialog.lk/ (accessed 12 April 2023), https://hutch.lk/ (accessed 19 May 2023), https://www.mobitel.lk/ (accessed 9 May 2023).

1.6.2 Geographic Availability and Affordability

Indonesia, Mongolia, the Philippines, and Sri Lanka all have situations where rural users lack access or choice when it comes to the lowest cost plans. Not all carriers have extensive coverage, and some carriers with better coverage charge a premium for their services. In Mongolia Skytel has the lowest cost broadband, but its long-term evolution coverage is limited to main cities. Indonesia's Smartfren has lower cost data than Telkomsell or XL, but has minimal 4G network coverage outside

Java. In the Philippines the lowest available prices are from DITO Telecommunity, which has far less coverage than incumbents Globe and Smart. In Sri Lanka, the best pricing is from Airtel, who cover only 60%–70% of the population with their 4G network.

Where mobile broadband service is available to rural users, lower incomes mean it is less affordable. In analyzing the issue, the GSMA finds that "rural and remote areas across developing world markets are typically inhabited by the poorest segment of the population living significantly below the country's average GDP per capita" (GSMA Intelligence 2016). Quantifying the impact of rural poverty on internet affordability is possible in some markets; in the Asia and Pacific region, the PIP provides separate rural and urban income distributions for the People's Republic of China, India, and Indonesia (World Bank Group 2020). A more sophisticated model might analyze the affordability of products with the best geographic coverage through the lens of rural income distributions.

1.6.3 Terms and Validity

The complexity of mobile plans is significant across all five markets. Carriers in Indonesia, Mongolia, and the Philippines all offer some plans with less than 7 days of validity. In the Kyrgyz Republic and Mongolia, plans are commonly valid for 28 days. In other markets the longest duration for prepaid plans tends to be 30 days. Fewer than one-quarter of plans surveyed have a duration tied to a calendar month, and the majority of these plans are postpaid.

Inexpensive prepaid data plans with short terms can seem attractive to those with a need and enough money to top up. Over time they are almost always more expensive than plans with longer validity. Unused data on these plans expires with their term limits, which can be as short as one day. Users who have not yet loaded a new prepaid plan into their account can find their account balances exhausted by punitive default data charges.

1.6.4 Prepaid vs Postpaid Plans

When it comes to data access, prepaid plans generally offer better value from a cost per gigabyte perspective than postpaid plans, as shown in Figure 1.9. This better value does not always translate into better affordability.

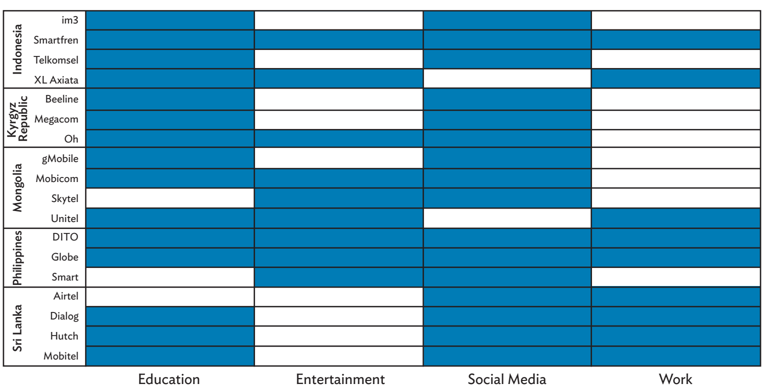
A user in Mongolia on Mobicom might pay around $0.72 per GB on a postpaid plan for 5GB of data a month. On a prepay plan they could achieve a rate of $0.29 per GB—but only on plans that last less than 1 month. Extending these short duration plans to get a better per GB rate would more than double a user's monthly spend over a postpaid plan. Perhaps for this reason the rate of postpaid subscriptions in Mongolia has increased over the past 5 years from around 12% to 19% (Government of Mongolia Statistics 2022).

Similar situations can be found in the Philippines with all three carriers. One example is Dito's "Level Up P99" 8 GB postpaid data plan. While it is far more expensive per gigabyte than Dito's P50 "Data 50" plan, it lasts 1 month, while "Data 50" lasts only 7 days. Dito's "Level Up P99" plan is the least expensive postpaid plan of all surveyed from an overall cost perspective at $1.78 per month and is at the lower end of the scale from a data cost perspective at $0.23 per gigabyte.

1.6.5 Affordable Mobile Internet vs Affordable Mobile Data

Across all markets, mobile data plans bundle access to entertainment or social media, often with separate data quotas dedicated to streaming social media. Figure 1.11 shows the availability of special bundles by carrier shaded in green. All but two carriers surveyed have special social media plans, and all but three have special education-focused plans.

Figure 1.11: Providers Offering Content-Specific Bundles



Sources: https://im3.id/ (accessed 27 April 2023), https://www.smartfren.com/ (accessed 16 May 2023), https://www.telkomsel.com/ (accessed 13 March 2023), https://www.xl.co.id/ (accessed 16 May 2023), https://beeline.kg/ (accessed 7 March 2023), https://mega24.kg/ (accessed 12 May 2023), https://o.kg/ (accessed 7 March 2023), https:///gmobile.mn/ (accessed 1 December 2022), https://www.mobicom.mn/ (accessed 1 May 2023), https://www.skytel.mn/ (accessed 6 February 2023), https://www.unitel.mn/ (accessed 5 December 2022), https://dito.ph/ (accessed 3 May 2023), https://www.globe.com.ph/ (accessed 6 March 2023), https://smart.com.ph/ (accessed 8 April 2023), https://www.airtel.lk/ (accessed 24 January 2023), https://www.dialog.lk/ (accessed 12 April 2023), https://hutch.lk/ (accessed 19 May 2023), https://www.mobitel.lk/ (accessed 9 May 2023).

In the Philippines, Smart's Giga plans offer 1 GB per day of access to TV streaming sites like Netflix plus additional data for the rest of the internet. Double Giga provides 2GB of data to TV streaming sites per day plus more data and calls and texts. Smart Powerall plans can include unlimited texts, unlimited texts and access to Tiktok, or those plus unlimited calls. Dito's App Boosters offer 1 GB of general internet access a week with an additional 7 GB of application-specific data for entertainment, social media, or work.

Sri Lanka's Airtel offers inexpensive work from home plans with very low-cost access to Microsoft applications, Zoom, and Google Classroom. They have social media packs with unlimited access to WhatsApp, Facebook, YouTube, and Facebook Messenger.

In Indonesia, XL Axiata offers special YouTube quotas on many of their plans, and access to a range of productivity applications on their Xtra Combo Plus VIP packages. Many of Telkomsel's plans include special data buckets for access to apps like Tiktok, Prime Video. 1 GB of Tiktok access for 1 day on Telkomsel is cheaper than 500 megabytes of general internet access.

Beeline, Mega, and Oh in the Kyrgyz Republic all bundle access to popular social media applications with their default mobile data plans, either with additional data quotas or with unlimited access.

In Mongolia both Skytel and Unitel have a wide range of application specific bundles, while Mobicom and GMobile have a more limited selection.

Considering the World Bank's findings attributing 87% of data use to social media and streaming, special purpose data plans could help promote Meaningful Connectivity (World Bank 2021a). They undeniably provide people with the higher data quotas they want, often at prices far below that of general internet access. What is problematic about these plans is they violate the basic principles of network neutrality. Mobile operators have essentially curated the internet for their subscribers who either cannot afford general internet access or might not see it as a priority given the closed, app-based environments on offer.

1.7 Targeted Affordability Interventions

During the COVID-19 pandemic many governments and mobile operators worked together to help ease the financial burden on workers and students stuck at home during lockdowns. Some more notable interventions included Indonesia's XL giving away 350,000 mobile packages to students for distance learning (XL Axiata 2020) and Mongolia's partnership with its operators to make all traffic to its government education portal free to access (Government of Mongolia 2020).

With most world governments considering their countries to be post-COVID, few programs established to help students and remote workers during the pandemic remain in place. Some operators, however, still offer plans that help students or all citizens with access to education.

To counter the lack of affordable access in Mongolia, GMobile and Skytel offer Meta's Free Basics service across their networks (gMobile 2021; SKYtel 2023). Through this program, operators allow unlimited free access to Facebook, Twitter, Wikipedia, and more than 20 other websites providing communications, general, business, education, and health resources. These sites are provided as text only; photos and videos are not displayed.

The Kyrgyz Republic's Megacom offers free access to Wikipedia and Codecademy with their education tariff, a free option for subscribers that can be activated by a USSD code (MEGA 2023). The option is provided to any users with a positive balance as long as they are not roaming.

Low-cost data plans or free access to eLearning platforms for students and teachers are also present in Indonesia (Paket Belajar), the Kyrgyz Republic (Mugalim or Bilim plans), Mongolia (Unitel eMeeting), and Sri Lanka (e-Thaksalawa).

1.8 Conclusion

Access to Meaningful Connectivity, including enough data, is an essential foundation for social inclusion and economic prosperity. As schools, governments, health providers, and companies continue to rely more heavily on digital interactions, it is vital to ensure that everyone can participate in these interactions.

Based on a 5 GB per month data target established and accepted by GDIP and the Broadband Commission, this study finds mobile data to be universally affordable, where available, in Indonesia and Sri Lanka. It finds mobile data affordable for 80% of Mongolians, where available.

Carriers in the Kyrgyz Republic have priced out all but the wealthiest in society. In the Philippines one operator offers universally affordable data services in limited areas, and two operators offering data that is more broadly available but unaffordable for all but the nation's wealthiest people. Inequality is a major factor in these markets.

The demands of e-learning and work from home, and Ericsson's measurements of average mobile data use make it clear that 5 GB of data per month is not enough. Higher targets like 15 GB should be evaluated today, and 40 GB per month should be the goal 5 years from now.

While targets need to increase, a pragmatic evaluation of the problem might consider the demands of social and streaming media, and how those demands are being fulfilled in some markets at a lower cost than general internet access. Adjusting targets to match this reality could be expedient but would come at the cost of network neutrality.

The restricted geographic availability of the lowest cost data plans should be a concern for policy makers and campaigners for equality. In four of the five countries reviewed, where inequality and geography intersect there is a crisis of affordability. As shown Figure 1.8, the most broadly available plans in these markets are more than twice the affordability threshold.

While income inequality can be a factor preventing internet access, Mercedes García-Escribano of the International Monetary Fund also finds that “the lack of universal and affordable access to the internet may widen income inequality within and between countries” (Garcia-Escribano 2020). Working toward equality in access to telecommunications could be an important step toward reducing inequality overall.

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2

Digital Divide among Micro, Small, and Medium-Sized Enterprises: What Can We Learn from Household Enterprises?

Eisha Maghfiruha Rachbini, Ariyo Dharma Pahla Irhamna, and Syifa Rifa Rosyadah

2.1 Introduction

Rapid growth of the digital economy has positively contributed to Indonesia's economic resilience during the coronavirus disease (COVID-19) pandemic. As the backbone of the country's economy, micro, small, and medium-sized enterprises (MSMEs) were among those impacted by the economic shock. Based on a survey by Statistics Indonesia (2020), the pandemic negatively impacted the revenue of about 67.7% of micro and small businesses in 2020. About half of those impacted faced several problems, such as product marketing and sales, as well as difficulties paying for expenses.

The use of digital technology helped MSMEs survive in difficult times when physical economic activities were paused due to lockdown. Digital platforms allow them to increase access to information, resource their inputs and financing, shorten distribution chains, and reach larger markets. A digital technology transformation also potentially triggers more innovation in the MSME business model and, thus, more efficient production.

Academic debate on how MSMEs have coped with digital transformation during recent years is ongoing. Some scholars argue that digitalization has the potential to upgrade MSMEs' quality, allowing them to compete with larger firms and expand their markets globally (Mustaffa and Beaumont 2002). One argument in favor of digitalization is that it can increase the efficiency and productivity of MSMEs. By automating processes and utilizing cloud-based solutions, MSMEs can reduce costs and increase speed and accuracy in their operations (Autio and Fu 2022). Digitalization can also provide MSMEs with greater access to customers and suppliers, allowing them to expand their reach and increase sales (Mustaffa and Beaumont 2002).

However, MSMEs also might encounter challenges and constraints when adopting digital technology. The digital divide among marginalized groups in the economy, including MSMEs, may hinder digital transformation and potential economic growth. These concerns highlight that MSMEs may struggle to adopt and fully utilize digital technology, potentially leading to their disadvantage and even extinction, especially MSMEs in remote areas (Rupeika-Apoga, Bule, and Petrovska 2022).

In addition, the cost and complexity of implementing and maintaining digital technologies present significant challenges for MSMEs. Many lack the resources and expertise to invest in digital technology and may struggle to keep up with the rapid pace of technological change (Rupeika-Apoga, Bule, and Petrovska 2022). This can result in MSMEs being left behind as larger firms adopt new technologies and gain a competitive advantage (Autio and Fu 2022). The academic debate surrounding MSMEs and digitalization is an emerging topic that is complex and multifaceted. While digitalization has the potential to provide significant benefits for MSMEs, the challenges associated with its adoption and utilization cannot be ignored.

This chapter intends to observe MSMEs and digital technology development, particularly to the digital divide among MSMEs in Indonesia. In addition, the chapter also examines determining factors explaining MSMEs' digital technology usage for business. The study looks at several variables of interest as determinants of MSMEs' digital technology utilization, such as financial factors, location, firm size, and formal legalization. By examining these variables empirically, this chapter aims to understand the challenges MSMEs face in using digital technology and thus determine the most effective strategies for supporting MSMEs in their digital transformation.

The role of government in supporting MSMEs in digital transformation has also been a subject of debate. Some scholars argue that governments should provide incentives and support so that MSMEs are able to adopt and effectively utilize digital technology (Mustaffa and Beaumont 2002). Others argue that the government should focus on creating an environment that supports the development of digital solutions and the growth of MSMEs, rather than directly funding them (Rupeika-Apoga, Bule, and Petrovska 2022).

In the case of Indonesia, more studies on MSMEs' usage of digital technology specifically for their business activity are required. Due to limited data, many previous studies exploring MSMEs' digital technology development uses their activities on accessing internet, communication, and technology, without specifically focusing on whether these activities related to their business or production. Therefore, this chapter helps fill that gap by providing an empirical quantitative study based on internet use of household enterprises for productive activities and its determining factors.

2.2 Literature Review

There are several literature reviews about MSMEs' digital adoption. Some categorize their adoption of digital technology into three phases of digital integration: digital infrastructure, digital platform, and frontier technology. First, MSMEs adopt basic technology infrastructure, such as smartphones and the internet, to integrate into the digital economy (Middleton 2021). In this stage, MSMEs are able to introduce the application of information and communication technology (ICT) into their business. The second stage is digital platform adoption. At this level, MSMEs utilize digital platforms to improve business processes (Cenamor, Parida, and Wincent 2019). In a more advanced stage, MSMEs adopt frontier technologies such as artificial intelligence, big data, and blockchain in their production and business processes (UNCTAD 2022).

Digital transformation is defined as the use of technology to increase a company's performance (Westerman et al. 2011). Barland (2013) revealed that digital adoption could form new revenue streams through a two-sided market business model. Furthermore, the use of digital technology could improve user experience (Abel-Hamid et al. 2022; Sahu, Deng, and Mollah 2018), operational efficiency, and innovation for new business models (Fitzgerald et al. 2013).

Digital transformation is essential for entrepreneurs and managers in conducting their business (Chonsawat and Sopadang 2020). However, the use of digital technologies such as social media and cloud computing might not necessarily indicate that firms or business enterprises underwent a digital transformation (Everett 2021). Further, Everett (2021) highlighted that digital transformation requires continuously pursuing innovation, capacity in responding change promptly, and ability to capitalize on challenges and prospects.

However, not all MSMEs can benefit from digital technology. Some MSMEs face challenges accessing and using digital technology. This is known as the digital gap. In their recent work, Lythreatis, Singh, and

El-Kassar (2022) describe the digital divide as the gap in ICT access, usage, and outcome, which is influenced by three distinct segments (education, age, and belief) as well as by nine major categories (sociodemographic, socioeconomic, personal elements, social support, type of technology, digital training, rights, infrastructure, and large-scale events). They also suggest that knowledge and skills are a significant factor in the digital divide.

To successfully take advantage of digital adoption, MSMEs need to secure three main types of infrastructure: (i) ICT, (ii) financial, and (iii) legal and regulatory. In addition, sufficient digital skills are also important (Muller 2020). However, many MSMEs have limited access to the infrastructure and digital skills.

Van Dijk (2006) distinguishes four kinds of barriers to digital technology. First, motivational access gap due to the lack of basic digital experience, fear of technology, and perceived threats from new technologies. Second, material access gap, which refers to barriers that set physical boundaries for access to a computer or mobile phone and network connection. This also includes the cost of internet subscriptions and mobile phone accounts. Third, skill access gap, which relates to users' ability to maximize the benefits of ICT. And last, usage access gap, which means how ICT use is influenced by users' demographic characteristics and the development of ICT infrastructure. For example, people with high broadband connectivity may use ICT for a longer time. In the case of MSMEs, they often encounter these four digital technology barriers.

Consistent with Van Dijk (2006), a study by Dyerson, Harindranath, and Barnes (2009) found that MSMEs are concerned about the cost of ICT investment and the benefits to business. When it comes to ICT investment, it is important to consider that the benefits should outweigh the costs of investment and maintenance. Therefore, commercial aspects and potential benefits are the drivers of adoption. Not all MSMEs will necessarily catch up with large companies once the penetration and diffusion of ICT exceed a certain level. This is simply because ICT may not bring significant benefits and MSMEs stick to traditional business processes (Barba-Sánchez, Martínez-Ruiz, and Jiménez-Zarco 2007). In addition, the ICT gap with large companies may be influenced by MSMEs' limited knowledge of digital technology. The lack of experience in this field and the small size of the business make it hard to hire a dedicated ICT expert (Solaymani, Sohaili, and Yazdinejad 2012; Arendt 2008).

Regarding financial infrastructure, it is harder for MSMEs to obtain credit from legitimate financial institutions than for large companies (ILO 2019). Financial institutions are more reluctant to give credit to MSMEs because of their lower creditworthiness. Moreover, MSMEs also lack information about financial products. Adequate financial literacy among MSMEs means not only their increased awareness of various financial instruments but also the business skills and techniques necessary to run business prudently and effectively. Therefore, MSMEs need support to improve their financial literacy to make their businesses more profitable (AFI 2020).

As MSMEs do not have sufficient access to information to improve digital literacy and financial infrastructure, regulatory support becomes important for them. A study by Nghi, Trinh, and Thuan (2020) revealed that regulatory support has a positive impact on MSMEs' digital adoption. The government can implement policies that are pro-MSMEs such as digital technology training or providing credit assistance to encourage digital adoption.

2.3 Digital Adoption: Opportunities and Challenges for MSMEs in Indonesia

Indonesia's digital adoption has been one of the fastest growing among Southeast Asian countries in recent years. It was triggered during the pandemic when business and economic activities were constrained due to lockdown. Several aspects are considered as opportunities and challenges for MSMEs' digital acceleration in Indonesia.

2.3.1 Demographic Aspect

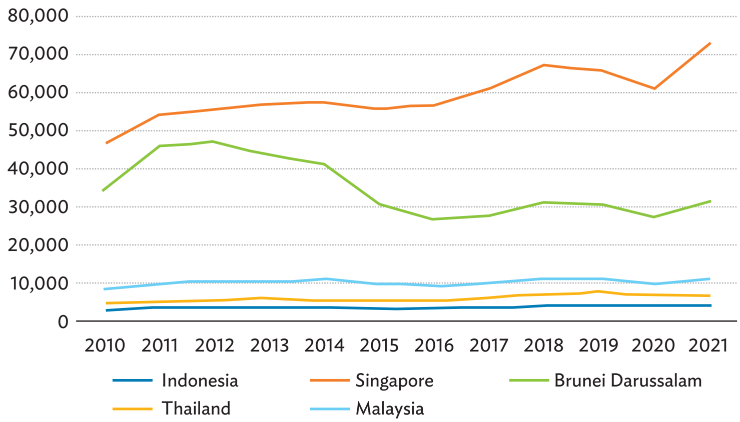
Indonesia's population was 275.77 million in 2022, dominated by people in their productive age with close to 70% of the total population. In addition, Indonesia also has a large population under the age of 15, around 24% of the total population (Statistics Indonesia 2022a). The high number of young people is a strength for the Indonesian economy, especially in terms of digital transformation because they tend to be more adaptive to digital participation.

2.3.2 Economic Growth

Indonesia is as an archipelagic country with around 17,499 islands spanning over an area of 7.81 million square kilometers. Indonesia's vast territory separated by sea poses challenges to equitable development. For the past decade, Indonesia's economic growth was 4.27% on average and its economic value reached Rp19,588.4 trillion in 2022, making Indonesia's gross domestic product (GDP) the largest in Southeast Asia. The government predicted Indonesia will be the world's fourth-largest economy in 2045.

In line with this increase, GDP per capita in Indonesia also improved, increasing more than 50% from 2010 to $4,327 in 2021. However, the GDP per capita is still lagging relative to other Southeast Asian countries (Figure 2.1): $72,794 in Singapore, $31,449 in Brunei Darussalam, $11,109 in Malaysia, and $7,066 in Thailand.

Figure 2.1: GDP per Capita of Selected ASEAN Member States ($)

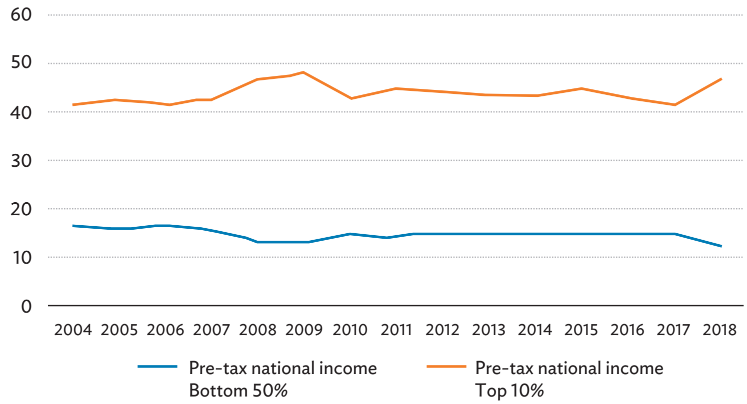


ASEAN = Association of Southeast Asian Nations, GDP = gross domestic product.

Source: World Bank (2022).

Indonesia's situation with a high economic growth but low GDP per capita indicates that the country's income distribution among households is unlikely to improve over the years. Figure 2.2 displays Indonesia's income distribution from the top 1% and bottom 50% of earners. The graph shows that the distribution of income from 2004 to 2018 has not improved; in fact, the gap has slightly increased. In 2004, the top 1% contributed 41.2% of total income and the bottom 50% contributed 16.5%. In 2018, the contribution of the top 1% had increased to 46.8% of total income but the bottom 50% only contributed 12.4%.

Figure 2.2: Indonesia's Income Distribution
(%)



Note: Percentage income distribution from top 10% and bottom 50%.

Source: World Inequality Lab (2018).

2.3.3 Information and Communication Technology Development

In the context of ICT development, internet and technology-related products have been rising dramatically over the years. In 2023, about 78.19% of the Indonesian population, or 215.26 million people, have internet connection (Association of Indonesian Internet Service Providers 2023). In addition, mobile phone ownership has increased by 37.25% since 2012 (Statistics Indonesia 2022b). The World Bank (2021) reported that 80% of the average time spent online was for leisure, communication, and social media.

According to Statistics Indonesia (2021a), the ICT Development Index in Indonesia was 5.76 on a 10-point scale in 2021. However, the value of the index was not equal between provinces. When categorized into high (7.51–10.00), medium (5.01–7.50), low (2.51–5.00), and very low (0.250), most provinces in Indonesia fall into the moderate category (Table 2.1). Only one province (Jakarta) is in the high category, and two provinces (East Nusa Tenggara and Papua) are still in the low category.

Table 2.1: ICT Development Index, by Category and Province

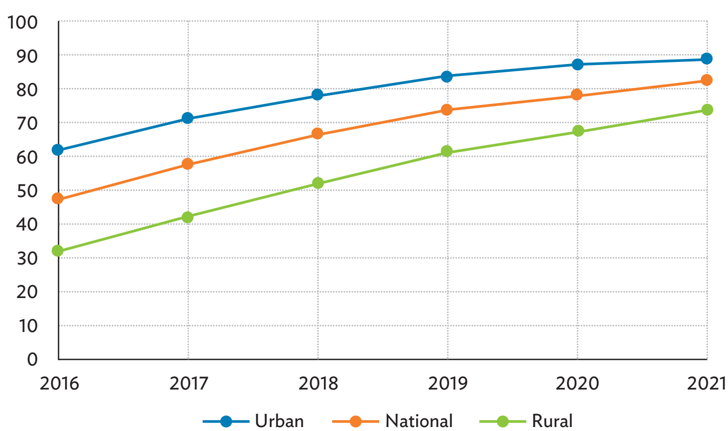
High	Moderate	Low
Jakarta	Yogyakarta, Riau Islands, Bali, East Kalimantan, Banten, North Kalimantan, West Java, North Sulawesi, West Sumatra, Riau, South Kalimantan, East Java, Bengkulu, Central Java, South Sulawesi, North Sumatra, Southeast Sulawesi, Jambi, Bangka Belitung, Central Kalimantan, Maluku, South Sumatra, Gorontalo, Lampung, Aceh, Central Sulawesi, West Papua, West Kalimantan, and West Nusa Tenggara	East Nusa Tenggara, Papua

ICT = information and communication technology.

Source: Statistics Indonesia (2021a).

The development of ICT itself tends to widen the gap, as can be seen between Jakarta, which has the highest ICT Development Index, and Papua, which has the lowest. In 2020, the difference between these two provinces was 4.11 and widened to 4.31 in 2021. Nonetheless, some provinces, such as West Sulawesi and North Maluku, have raised their index from the low to the moderate category. The ICT gap has happened not only at the province level but also at the rural–urban level. In 2021, 88.53% of people in urban areas accessed the internet compared with only 73.57% in rural areas (Figure 2.3).

Figure 2.3: Internet Access, by Areas
(%)



Source: Statistics Indonesia (2021b).

The gap in ICT development encourages the government to improve ICT infrastructure in every region, especially in the rural areas. Moreover, this effort has been included in the National Medium-Term Development Plan for 2020–2024 as strategic priority projects. Government programs that have been carried out to improve ICT infrastructure include the Palapa Ring Project, the Multifunctional Satellite Indonesia Raya, and the Program for the Provision of Multifunctional Satellites and Base Transceiver Stations.

2.3.4 MSME Digital Adoption

A survey by the Association of Indonesian Internet Service Providers (APJII) in 2022 shows that as much as 87.43% of MSMEs have used the internet in business processes. That is, only 12.57% of MSMEs do not use the internet. Breaking down further the internet usage by size of the business to the total number of companies, the figures are 63.59% microenterprises, 65% small businesses, and 72.04% medium-sized businesses. According to the survey by Katadata Insight Center (2020), the main objective of MSMEs using the internet is for promoting products through social media, which was mentioned by 60.2% of respondents. MSMEs also used the internet to seek information on business development (mentioned by 44.7% of respondents) and find and order raw materials (35.9%). However, Java's MSMEs digital adoption is still higher than on any other island in Indonesia. Based on East Ventures Digital Competitiveness Index 2022, Java scored 49 out of 100 points in terms of digital adoption, followed by Bali and Nusa Tenggara with a score was 22 and Sumatra in third place with a score of 21. Meanwhile, Kalimantan scored 19, Sulawesi 14, and Maluku–Papua 10. This indicates that digital adoption among MSMEs is not equal between areas.

2.3.5 Knowledge and Skills

As mentioned, although many MSMEs have adopted the internet, they also face challenges to fully maximizing digital adoption. A major challenge is digital literacy and digital competence. According to Indonesia's Ministry of Communication and Information Technology, the Digital Literacy Index of Indonesians is 3.54 or at a moderate level. Still, Indonesia lags the other major Association of Southeast Asian Nations (ASEAN) countries, particularly Malaysia, Philippines, Singapore, and Thailand. This can be seen by the knowledge and technology outputs ranking on the Global Innovation Index of these ASEAN-5 countries (Table 2.2). Over the past 5 years. Since 2018, Indonesia has always had the lowest ranking among the ASEAN-5 countries, with

Singapore constantly in first position. The limited digital skills among MSMEs in Indonesia discourages internet adoption. Even if the MSMEs use the internet, many of them face difficulty optimizing internet usage.

Table 2.2: Knowledge and Technology Outputs Ranking in ASEAN-5

Country	2018	2019	2020	2021	2022
Singapore	11	11	14	13	13
Malaysia	34	35	38	31	39
Indonesia	86	82	71	74	78
Thailand	40	38	44	40	43
Philippines	49	31	26	24	41

Source: Global Innovation Index (2022).

2.4 MSME Digital Adoption in Selected Countries of the Association of Southeast Asian Nations

MSMEs in ASEAN, like in Indonesia, play an important role in the economies as they comprise a significant share (95%–99%) of total enterprises in the region (Muller 2020). For instance, the MSME share of total enterprises in 2019 was 99.9% in Indonesia, 99.5% in Thailand, and 99.5% in the Philippines (ADB 2020). Meanwhile, in Malaysia and Viet Nam, MSMEs also have the largest share in total enterprise units, at about 97.2%.

In terms of employment, MSMEs in ASEAN economies have also contributed notably by providing jobs. MSMEs in Indonesia, for example, employ about 97% of workers nationally. Meanwhile, MSMEs account for about 69.5% of total national employment in Thailand, 48.4% in Malaysia, and 38.0% in Viet Nam. These data indicate that MSMEs in ASEAN have become vital drivers of the regional economy as well as the backbone to economic development in the region.

In this digital era 5.0, MSMEs' digital adoption has been acknowledged to positively impact their business. To optimize potential benefits, digital transformation is inevitable for MSMEs. What MSMEs in ASEAN have in common, particularly with those in emerging economies, is the challenges in digital technology adoption. Therefore, this section details a benchmarking study of MSMEs' development of digital adoption and its challenges, as well as policy support for MSMEs' digital transformation in selected ASEAN countries, specifically Malaysia, the Philippines, Thailand, and Viet Nam.

2.4.1 Malaysia

During the COVID-19 lockdown, businesses in Malaysia were forced to adopt digital technology. Thus, the value of e-commerce improved in 2020, soaring to RM896 billion from RM677 billion in 2019. Despite the increasing technology adoption among businesses, the country's MSMEs face difficulty making optimal use of it. Around 77% of MSMEs in Malaysia still use basic digital technology. A survey by SME Corporation and Huawei Technologies (2018) shows that MSMEs rarely used advanced technology such as the Internet of Things (IoT), cloud computing, and data analytics. Of 2,033 MSMEs, only 35% utilized IoT within their organizations primarily for security, surveillance, and fleet management.

Mohamad (2021) highlighted that the lack of digital skills among the MSME workforce was the main reason for the digital lag of MSMEs. Another obstacle was the financing and digitalization cost such as for internet, hardware, and software subscriptions. Approximately 34% of business owners in the SME Corp. and Huawei (2018) survey felt that cloud computing is expensive. Moreover, around 60% of participants were unaware of available financing options.

Given the significance of technology and the digital divide among MSMEs, the Government of Malaysia has introduced the National Policy on Industry 4.0 (Industry4WRD). Its main objective is to create a robust ecosystem that supports companies in the industry 4.0 era. A key aspect of this policy involves raising awareness about the benefits of technology for MSMEs. To bridge the gap in digital competency among workers, the government has also established training centers focusing on technology.

In 2023, the national budget allocated substantial funds to promote MSMEs. Specifically, the government is granting RM100 million to support the digital transformation of MSMEs. Additionally, MSMEs will enjoy a reduced tax rate of 15% in 2023. These initiatives are aimed at fostering the growth and competitiveness of MSMEs in Malaysia.

2.4.2 Philippines

Google, Temasek, and Bain & Co. (2022) reported that the digital economy in the Philippines amounted to $20 billion in 2022, or an increase of 22% from the previous year. The report also highlighted that the country's digital economy will continue its upward trend. Overall, e-commerce contributed $14 billion to the digital economy, making it the largest digital sector in the Philippines, followed by the online media sector, which contributed $3.1 billion. However, the World Bank (2020) reported that the country's digital adoption falls behind its middle-income regional peers.

The primary obstacles hindering the adoption of digital technology in the business sector include limited digital infrastructure, expensive internet services, and insufficient market competition (World Bank 2020). According to Ookla (2023), the average mobile broadband speed in the Philippines stands at 26.98 megabits per second, which lags behind countries such as Singapore, Malaysia, Thailand, and Viet Nam. Additionally, Filipinos face higher internet costs than their regional counterparts. To address these challenges, the Government of the Philippines, through the Department of Information and Communications Technology, has initiated the National Broadband Plan. This strategic plan aims to expedite the deployment of fiber-optic cables and wireless technologies across the country. In support of this initiative, the 2023 National Budget has allocated ₱1.5 billion for the National Broadband Plan project. The hope is that this investment will improve digital infrastructure, reduce internet costs, and enhance the overall competitiveness of the country's business landscape by encouraging greater adoption of digital technology.

2.4.3 Thailand

The Government of Thailand has been actively involved in the country's digital technology readiness as indicated in the National Strategy (2018–2037). In 2020, the European Center for Digital Competitiveness ranked Thailand as the second most digitally competitive country based on the progress made in developing its ecosystem and the shifting mindset toward digitization in the ASEAN region. Table 2.3 provides information about the Index of Digital Entrepreneurship Systems. Thailand has a relatively high index score compared to the world and ASEAN average. The index evaluates the country's infrastructure, finance, and network, as well as support related to digitization of entrepreneurship.

Thailand possesses a reasonably well-developed digital infrastructure, although its availability and accessibility are not evenly spread throughout the country. According to data from 2021, about 85.27% of the country's population has access to the internet. Thailand is also one of the pioneers in Asia and the Pacific to roll out 5G in the commercial market. The high score on the Index of Digital Entrepreneurship Systems indicates that entrepreneurship has sufficient access to a relatively wide variety of financing options. If Thailand can fully optimize digital technology, the digital economy is expected by 2030 to contribute around $79.5 billion to the economy (AlphaBeta 2021; UNCTAD 2021).

Table 2.3: Thailand's Asian Index of Digital Entrepreneurship

	Digital Entrepreneurship Stand-up	Digital Entrepreneurship Start-up	Digital Entrepreneurship Scale-up
ASEAN	35.45	34.20	36.44
Global	31.96	31.91	31.96
Thailand	43.14	41.69	44.34

ASEAN = Association of Southeast Asian Nations.

Source: Prasarnphanich (2022).

Tourism serves as a significant driver of the Thai economy, contributing 18.21% to GDP before the pandemic. Most businesses in the country are MSMEs. Taken together, Thailand has many MSMEs in the tourism sector. Digitalization in this sector can enhance market access, but digital technology infrastructure and financing are still a problem for MSMEs in the sector, especially those in rural areas. Many rural tourism MSMEs find it difficult to afford internet connectivity and access credit, especially short-term loans. Despite the large investment in digital infrastructure, the availability of and access to the internet in rural areas remain inferior to urban areas. The stakeholders also mentioned that local vendors may have to pay for internet access, creating barriers to internet adoption. The country has seasonal times for tourism: International tourism peaks from October to February and domestic tourism in April, while the other months are categorized as low season. Credit in the offseason is required to keep businesses going (GSMA 2022).

2.4.4 Viet Nam

The Government of Viet Nam actively promotes entrepreneurship and supports the growth of its entrepreneurial ecosystem. The government has eased business regulations through several policy reforms that facilitate the establishment of businesses. These reforms have significantly improved the country's ranking in the World Bank Doing Business survey 2020 to 70th position, which is 29 places higher than its ranking in 2014 (OECD 2021). To enhance digital transformation, the government attracts technology companies by offering a 10% tax incentive for a period of 15 years. Additionally, Viet Nam has implemented various policies that aim to bolster the development of MSMEs. The 2011–2015 SME Development Plan is a comprehensive policy to support MSMEs through initiatives such as improving the legal framework, enhancing access to credit, fostering technological innovation, and strengthening human resources (Hoa and Khoi 2017).

The problems MSMEs face in adopting digital technology are access to financing and digital literacy. Commercial banks continue to encourage traditional commercial credit processes that are not aligned with the characteristics of MSMEs. To overcome these challenges, the government provides special credit for MSMEs through the SMEs Development Fund and the Credit Guarantee Fund. Unfortunately, the full potential of these funds has not been realized due to the complexity of the application process and a lack of awareness among MSMEs (OECD 2021). To enhance digital awareness among MSMEs, the Ministry of Planning and Investment's Business Development Department, in collaboration with the United States Agency for International Development, has launched a platform that serves as a comprehensive resource offering information on business digital transformation, support activities, consultations, and training programs.

2.5 Methodology and Data

This study applied a probit model to examine the determining factors explaining MSMEs' digital adoption in Indonesia. By definition, in accordance with the Government Regulation of the Republic of Indonesia No. 7/2021, MSMEs are categorized by size of capital and annual sales. In addition, Statistics Indonesia also categorizes firms based on total number of employees: microenterprise (1–4), small enterprise (5–19), medium-sized enterprise (20–99), and large enterprise (100 and above).

This study utilized the World Bank Digital Economy Household Survey (DEHS) 2020, which provides information on household enterprises, as well as individual digital adoption and economic activity. By using this dataset, this chapter focuses on observing household enterprises (HHEs), which the survey defines as households conducting business activities.

This study intends to provide empirical evidence on HHEs representing MSMEs in Indonesia. The DEHS 2020 consisted of 3,063 households, of which about 1,542 are HHEs. In the DEHS 2020, such enterprises employ between 1 and 28 workers. Therefore, according to the classification from Statistics Indonesia, HHEs in the survey by definition represent micro, small, and medium-sized enterprises. The HHEs in our study comprise 1,515 microenterprises (98.2%), 23 small enterprises (1.5%), and 4 medium-sized enterprises (0.3%).

Also, this study provides information on whether HHEs use the internet for their business operations and economic activity. We only focus on HHEs' domestic economic activity, since the DEHS 2020 does not provide information about their engagement in international trade. The study for this chapter covered varied information about HHEs' characteristics, including location, year of establishment, legal status, financial access, financial skills, and digital literacy. The observation sample of the DEHS 2020 was collected from about 27 provinces in Indonesia, including urban and rural areas.

The equations for the probit model are as follows:

$$y_i^* = \alpha + x_i\beta + z_i\gamma + u_i \quad (1)$$

$$y_i = 1[y_i^* > 0] \quad (2)$$

$$Prob(y_i = 1 | x_i) = G(\alpha + x_i\beta + z_i\gamma + u_i) \quad (3)$$

Equation (1) expresses the dependent variable y_i^*, which represents a dummy variable of 1 if household enterprise i uses internet for its business and economic activity. The parameter x_i is a set of main independent variables, including financial access, financial skill, location, and firm legalization. In addition, the parameter z_i is a set of control variables, such as firm age, total employment, and firm size. The parameter u_i represents the error term in the model. This model follows a standard normal cumulative distribution function and is estimated using maximum likelihood estimation, given in equation (3).

Table 2.4: List of Variables

Variables	Variable Code	Description	Unit	Hypothesis	Source
Dependent Variables					
Internet	Internet	Whether HHE uses Internet for business and economic activity.	Binary (1 = Yes; 0 = No)		World Bank
Independent Variables					
Firm age	Age	The age of the HHE since its founding	Years	–	World Bank
Firm formal legalization	Legal	HHE has a formal business permit, legalized by the Government	Binary (1 = Yes; 0 = No)	+	World Bank
Location	Location	Whether HHE is in urban areas	Binary (1 = Urban; 0 = Rural)	+	World Bank
Total employees	Tot_emp	Total of employees	Person	+	World Bank
Firm size	Size	Firm has at least one employee	Binary (1 = Yes; 0 = No)	+	World Bank
Financial access	Bank	HHE has a bank account	Binary (1 = Yes; 0 = No)	+	World Bank
Financial skill	Finance	Owner of HHE has separated their financial management between personal and business accounts	Binary (1 = Yes; 0 = No)	+	World Bank

HHE = household enterprise.

Source: Authors' compilation.

Table 2.4 lists variables included in the model. The main independent variable includes firm's location, formal legalization, financial access, and financial skill. Location is a dummy variable of 1 if the HHE is located in an urban area. This variable is expected to be positively related to HHE internet use. It represents occurrence of a digital divide for HHE adoption of internet use, specifically those in urban areas with more access to internet connection compared to those in rural areas. Formal legalization is also among the main independent variables and expected to be positively related to HHE internet use. This dummy variable of 1 represents whether the HHE satisfies the legal requirements to be considered a formal business. Firm's financial access is a dummy variable of 1 if the HHE owns a bank account. This variable is expected to be positively related to a firm's digital technology adoption, i.e., internet use for business. Furthermore, the financial skill variable denotes financial capacity of the HHE in managing its finances. This dummy variable shows whether the HHE separates its financial accounts for personal and business matters. Other independent variables, such as firm age, total employment, and firm size, are also included as control variables. Firm age is expected to be negatively related to HHE internet use. The younger firms are expected to be more adaptable with digital technology. Other variables, such as total employment and firm size, are expected to be positively related to HHE digital adoption, i.e., internet use for business. Table 2.5 summarizes the descriptive statistics of all HHEs and those using the internet for business and economic activity.

Table 2.5: Descriptive Statistics

		All HHEs			Using Internet		
Variable	Unit	Obs	Mean	Std. Dev	Obs	Means	Std. Dev
Internet	Binary	1,542	0.480	0.500	290	1	0
Age	Years	1,542	10.795	10.980	290	7.572	7.807
Legal	Binary	1,542	0.173	0.378	290	0.331	0.471
Loc	Binary	1,542	0.662	0.473	290	0.817	0.387
Tot_emp	Ages	1,542	0.569	1.641	290	2.898	3.739
Size	Binary	1,542	0.338	0.473	290	0.393	0.489
Financial access	Binary	1,542	0.499	0.500	290	0.686	0.465
Finance skill	Binary	1,542	0.329	0.470	290	0.455	0.499

HHE = household enterprise.

Source: Authors' compilation.

The DEHS 2020 also provides comprehensive information related to HHEs and their digital economy activities, particularly the classification of business sectors. Table 2.6 summarizes HHEs based on economic sectors. The biggest share of HHEs operated in wholesale and retail trade, or repair of motor vehicles and motorcycles (592 MSMEs), followed by manufacturing (238 MSMEs) and accommodation and food service activities (200 MSMEs). In terms of digital adoption, the sector with the most HHEs that have adopted the internet was wholesale and retail trade, or repair of motor vehicles and motorcycles.

Table 2.6: Digital Adoption of Household Enterprises, by Sector

Economic Sector	No. of HHEs	No. of HHEs Using Internet
Agriculture, forestry, and fishing	256	15
Mining and quarrying	3	–
Manufacturing	238	61
Electricity, gas, steam, and air-conditioning supply	1	–
Water supply; sewerage; waste management and remediation activities	2	–
Construction	11	6
Wholesale and retail trade; repair of motor vehicles and motorcycles	592	112
Transportation and storage	95	24
Accommodation and food service activities	200	32
Information and Communication	14	6
Real estate activities	3	1
Professional, scientific and technical Activities	12	2
Administrative and support service activities	18	3
Public administration and defense; compulsory social security	1	–
Education	1	1
Arts, entertainment, and recreation	7	1
Other service activities	60	18
Activities of household as employers; undifferentiated goods and services producing activities of households for own use	12	5
Others	16	3

HHE = household enterprise.

Source: Authors' compilation.

Table 2.7 shows the result of different mean equations grouped by internet usage. Based on the table, the group that uses the internet is younger than the group not using the internet. In terms of financial aspects, MSMEs that use the internet have higher financial access and skills. This means they most likely have bank accounts and have separated their financial accounts for personal and business purposes. There was a mean difference in the location variable between these two groups. The average for the group that uses the internet is higher, which means many internet users are located in cities. Last, on average, the internet group has a larger business size in comparison to the non-internet group.

Table 2.7: Estimation Results of Different Mean Equations

(1) Variable	(2) Not Using Internet	(3) Using Internet	(4) Difference (2)–(3)	(5) Prob (diff<0)	(6) Prob (diff=/0)	(7) Prob (diff>0)
Age	11.54153	7.572414	3.96912	1.0000	0.0000	0.0000
Legal	0.1365815	0.3310345	−0.194453	0.0000	0.0000	1.0000
Location	0.6267943	0.8172414	−0.1904471	0.0000	0.0000	1.0000
Tot_emp	0.4505582	1.07931	−0.6287521	0.0000	0.0000	1.0000
Size	0.3258786	0.3931034	−0.0672249	0.0146	0.0293	0.9854
Financial access	0.4553429	0.6862069	−0.230864	0.0000	0.0000	1.0000
Finance skill	0.2995208	0.4551724	−0.1556516	0.0000	0.0000	1.0000

Source: Authors' estimation.

2.6 Empirical Results and Analysis

Table 2.8: Probit Estimation

Variable of Interest	(1)	(2)
Age	−0.0300894***	−0.0295959***
Legal	0.2566427**	0.2910457**
Loc	0.6915724***	0.698107***
Tot_emp	0.0467289*	–
Bank	0.2778989 **	0.2766375***
Finance	0.1977188*	0.2098315*
Size	–	0.1421825
R2	0.1004	0.0967
Prob > chi2	0.000	0.000

Note: ***, **, and * represent significance level at ***p < 0.01, **p < 0.05, *p < 0.1, respectively.

Source: Authors' estimation.

In Table 2.8, columns 1 and 2 provide models 1 and 2 probit estimation results, respectively. Model 1 uses the number of total employees as a control variable. Meanwhile, model 2 uses the firm size dummy variable (1 if the HHE has employees; 0 otherwise) as a control variable. As observed, MSMEs' tendency to use the internet depends on the firm's location, formal legalization, age and size, access to formal finance institution, and financial skill.

The probit results suggest that the probability of internet adoption is associated with the firm's location (rural or urban area). If a firm is in an urban area, the probability of internet adoption increases by 69% in models 1 and 2. This finding is consistent with Lai and Widmar (2021) who emphasize that internet adoption in remote areas has been problematic for years.

The results indicate that a digital divide remains among MSMEs in the region. MSMEs in urban areas are more likely to use digital technology for their business. This is not surprising, as mentioned earlier, since ICT development in urban areas is more advanced than in rural areas. Our results confirm the hypothesis of a positive relationship between urban areas and internet adoption.

Columns 1 and 2 show a positive relationship between formal legalization and internet adoption. Specifically, firm formal legalization increases the probability of internet adoption by 25.66% in model 1 and 29.10% in model 2. In line with these results, Muller (2020) also highlights the importance of the legal and regulatory infrastructure required to optimize MSMEs' digitalization. Accordingly, this study confirms the positive impact of formal legalization on internet adoption.

The bank variable shows a positive and significant influence on the firm's internet adoption. The probability of internet adoption increases when a firm has a bank account. Both models show a 27% increase in probability. The finance explanatory variable also has a significant positive impact on internet adoption. In model 1, when a firm has adequate financial skills, the probability of internet adoption increases by 19.77%. Meanwhile, model 2 estimates an increased probability of 20.98%. Our findings suggest that financial access and skills are important for a firm's internet adoption and confirm our hypothesis of a positive relationship.

The results of models 1 and 2 indicate that younger firms have a higher probability of adopting internet use. In model 1, younger firm age increases the likelihood of internet adoption by 3.0%. The results of model 2 show that the probability of internet adoption increases by 2.9% the younger the company is. This result is also in line with Lythreatis, Singh, and El-Kassar (2022) that younger firms have more access to internet than older firms.

The control variable in model 1, *tot_emp*, shows a positive and significant influence on firm internet adoption. An increase in the number of employees increases the probability of internet adoption by 4.6%. However, the control variables in model 2 show a positive effect, though not significant. The model 2 results indicate that the presence of more employees increases the likelihood of internet adoption by 14.21%.

2.7 Conclusion

The fast-growing internet development in Indonesia is seen to be an opportunity for MSMEs to improve their business. However, MSMEs themselves face challenges in digital adoption because of several factors, including limited financial and ICT access. This chapter looked at MSMEs and digital technology development, particularly the digital divide among MSMEs in Indonesia. In addition, this chapter also examined the determining factors explaining MSMEs' digital technology use for their business. A non-linear probability model is applied to analyze microdata for Indonesia from the World Bank DEHS 2020.

Our study also tested the mean differences to confirm that there are significant differences in the MSME characteristics between two groups, such as those using the internet and those not. Our findings show that the probit model indicates a significant result in estimating the probability of digital technology adoption, i.e., internet usage for MSMEs in urban and rural areas. This highlights that a digital divide remains among MSMEs in the region. Rural areas where more internet connectivity and services are needed face challenges such as talent shortage, skills, training, and jobs. Another important finding of our study is that MSMEs' formal legalization has a positive and significant effect on their participation in digitalization. Therefore, the government should actively promote MSMEs to register legally and to simplify procedures and administration for MSMEs to register as formal enterprises.

This chapter also finds that MSMEs' financial literacy is important to explain their use of digital technology. Two significant variables determine whether MSMEs use digital technology: access to formal financial institutions and financial skills in operating their business. MSMEs with adequate financial literacy are more likely to use digital technology for their operations. Based on our findings, MSMEs must be able to easily access formal financial institutions. Moreover, the government should encourage banks and other formal financial institutions to expand financial access to MSMEs and to provide digital training for their business.

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3

Incentivizing Corporate Actors for Digital Inclusion: Options for Tech Companies' Accountability to Narrow the Digital Divide

Dio Herdiawan Tobing

3.1 Introduction

Digitalization has become a new buzzword, dubbed as an engine to accelerate growth. Just like any engine in the world, however, not all are able to utilize the momentum as circumstances may differ. According to the International Telecommunication Union (ITU) (2023), although 63% of the world's population is connected to the internet because of the opportunities presented by the pandemic, more than a third, or equivalent to 2.7 billion people, still do not have access to the internet. Of these, most live in least developed countries (LDCs), landlocked developing countries (LLDCs), and small island developing states (SIDS). The gaps in access also present between countries and within countries, with 87% of people living in developed countries having access to the internet compared to less than half of the population living in developing countries. In addition, only 40% of people in rural areas are connected online, the same as half of those who live in the cities that have internet access. This has centered the public discourse on how to address the intricacy of allocating the perks of digitalization, known as digital inclusion, to those at the margin. In some cases, digital inclusion means providing the right access and opportunities to the right people (United Nations 2022a); in other cases, inclusion also extends to how much support actors owning more resources provide to different groups in society to obtain the gains out of available opportunities online NDIA n.d.). For this study, digital inclusion refers to the degree of equal opportunity for everyone, without any exceptions, to access, utilize, and innovate in the various aspects of technology, encompassing digital access, skills, and usage.[1]

Reflecting such discrepancies in defining digital inclusion, the approaches to tackle issues also vary. Governments employ different policies, and private sector actors have launched a wide range of initiatives depending on the most pressing issues relevant to their digital users. For instance, programs in Africa such as Kenya Ajira's digital project focuses on promoting digital literacy to help young people improve job opportunities, thus reducing unemployment. Similarly, a public–private partnership such as Smart Africa Digital Academy was the direct result of an initial commitment from African governments to utilize Africans' digital-based knowledge economy through affordable access to broadband and technology devices by inviting private sectors such as MTN, a prominent market operator company, to contribute to Africans' digital skills academy (Smart Africa 2022). On the other hand, an approach employed by the Government of the United Kingdom (2017) slightly differs through its Plan for Britain, which accentuated the plan to "build a stronger, fairer country that works for everyone, not just the privileged few" and emphasize that the priorities will be directed to research and development to uplift its digital sphere based on enhanced artificial intelligence (AI), as well as expanding its financing for digital spaces. Meanwhile, the Africa Digital Financial Inclusion Facility, which is supported by the African Development Bank and backed by the Bill & Melinda Gates Foundation, the Agence Française de Développement, the Ministry of Finance of the Government of Luxembourg, and the Ministry of the Economy and Finance of the Government of France, prioritizes 60% of initiatives to ensure appropriate digital infrastructure is in place such as on interoperability, market infrastructure, digital identity, and digital registries in key sectors. Another 20% of initiatives have been launched to instill digital products and innovation through support directed through financial technologies (fintech), government payments, credits, micro insurance, and value chains, while the remaining 20% are split between improving policy and regulation and distributing needed capacity building (ADFI 2023).

While prioritization differs among stakeholders, whole-of-society partnership is at the heart of these digital inclusion-driven initiatives and/or policies, and contextualizing the initiatives and/or policies itself matters to address the core issue of why digital exclusion still presents in particular groups and/or regions. To assess the stark problem affecting digital inclusion, various institutes, think tanks, governments, and

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1 Given the intention of the study is to explore the universality of digitalization, it does not explore the measurement of the quality of digital inclusion.

partnerships, such as Economist Intelligence Unit (EIU), World Bank, ITU, Institute for Business in the Global Context (IBGC) of the Fletcher School, Roland Berger, and World Benchmarking Alliance (WBA), issue their own classifications and measurements. These recurring measurements are expected to provide the right measurement for the existing issues on digital exclusion and thus offer well-fitting solutions to the problem. Most of these measurements rank how different countries perform in ensuring their populations reap the benefits of digitalization (World Bank 2021; EIU 2022; ITU 2023; Roland Berger 2021), with measurements like WBA (2023a) providing a niche approach to assess major companies in participating to enhance digital inclusion for their users, while IBGC (2023) examines the issue of digital inclusion applying the socioeconomic parity lens to different countries.

This chapter seeks to explore how the relationship between governments and private actors should look in the efforts to bridging digital gaps in Asia and the Pacific through regulatory and policy program approaches. In doing so, this chapter first discusses the overall performance of digital technology companies on digital inclusion globally, while drawing international and regional policy commitments to address the existing digital disparity. The chapter will then illustrate that such commitments are better addressed through a closer partnership with the private sector. It takes a closer look at existing government initiatives in Asia and the Pacific that enable digital inclusion. Finally, the chapter draws out possible entry points as regulatory proposals for governments and the private sector to collaborate in narrowing the digital divide in countries in the region.

3.2 Coursing Digital Inclusion: Where Is the Globe At?

The world remains on its gradual course to close the digital divide and reduce exclusion of populations. A wide range of multilateral commitments, public–private partnerships, and whole-of-community approaches seek to alleviate the notion that digitalization only benefits a few groups. Among other instances, ITU plans its agenda called Connect 2030 to bridge the divide and build a better world using technological and rapid advancement. This agenda includes five goals to achieve by 2023, one of which is advancing inclusiveness to bridge the digital divide and provide broadband access for all. These are mapped through 10 targets that encompass internet access based on households, countries, affordability between countries, gender, and age (Table 3.1). Yet, the course to achieve these targets might be steeper than expected, looking at the state of global digital access in 2022.

Table 3.1: Inclusiveness Goal under ITU Connect 2030—Targets by 2023

Goal 2. Inclusiveness: Bridge the digital divide and provide broadband access for all
By 2023, in the developing world, 60% of households should have access to the Internet
By 2023, in the least developed countries, 30% of households should have access to the Internet
By 2023, in the developing world, 60% of individuals will be using the Internet
By 2023, in the least developed countries, 30% of individuals will be using the Internet
By 2023, the affordability gap between developed and developing countries should be reduced by 25% (baseline year 2017)
By 2023, broadband services should cost no more than 3% of average monthly income in developing countries
By 2023, 96% of the world population covered by broadband services
By 2023, gender equality in Internet usage and mobile phone ownership should be achieved
By 2023, enabling environments ensuring accessible telecommunications/ICTs for persons with disabilities should be established in all countries
By 2023, improve by 40% of the proportion of youth/adults with telecommunication/ICT skills

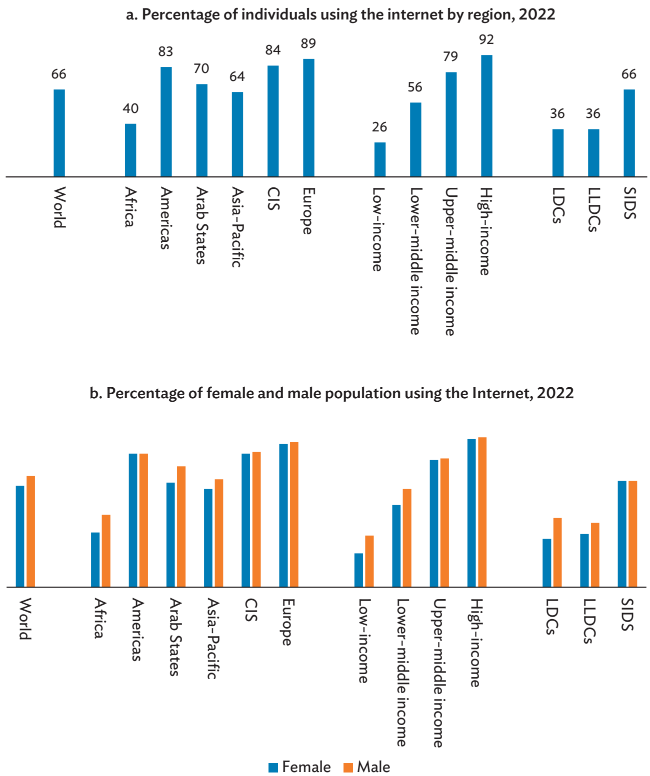
ICT = information and communication technology, ITU = International Telecommunication Union.

Source: ITU (2023).

Compared to a decade ago, the total number of internet users has doubled from 2.4 billion to 5.3 billion users (ITU 2022c). While this is commendable as a starting point in proliferating equal access to the internet, ITU's (2022d) recent publication, Measuring Digital Development, revealed existing gaps between gender, country income, and continents in 2022. Compared to women's access, 259 million more men had internet access; this is equivalent to a 0.6% difference between men and women connected online (ITU 2022e). On a positive note, gender parity has generally been achieved in high-income and upper middle-income countries where the difference is 1.0%. However, disparity persists in lower middle-income and low-income countries, respectively indicating a 10.0% and 11.0% difference between men and women with internet access (ITU 2022e). The 2023 target to have 30% of the population in LDCs using the internet was achieved, with 36% of the population in these countries connected, but discrepancies in LDCs and LLDCs remain, with minimal progress made on gender parity in the past three years (Figure 3.1). The disparity is also clear across larger regions and continents: While more than 80% of individuals living in the Americas, the Commonwealth of Independent States (CIS), and

Europe have internet access, only 40% of people in Africa are connected (ITU 2022b). The 2023 target of broadband subscriptions has also been achieved, with 108 mobile phone subscriptions per 100 inhabitants (ITU 2022b). However, it is important to note that the high penetration does not clearly explain where the subscriptions concentrate and which households pay for the subscriptions. Regional disparities across continents also remain, with 86 per 100 inhabitants in Africa having access to mobile phone subscriptions, compared with 109 in the Americas, 111 in Asia and the Pacific, 121 in Europe, and 147 in the CIS. Most importantly, while 75% of young people worldwide use the internet, only 39% in low-income economies actively using it (ITU 2022d).

Figure 3.1: Percentage of Individuals Using the Internet, by Region and Gender, 2022

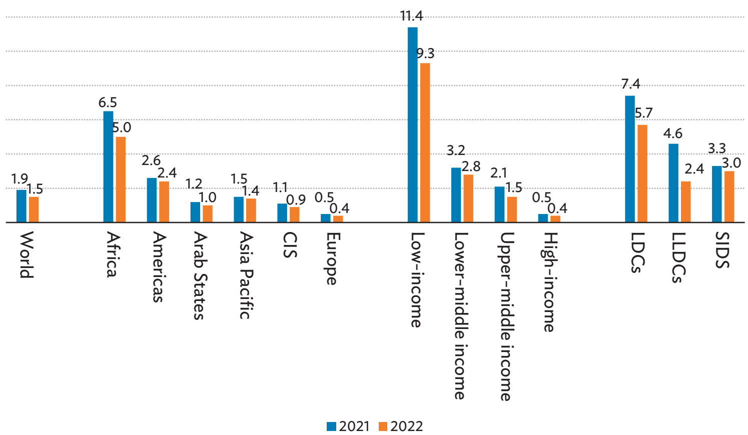


CIS = Commonwealth of Independent States, LDC = least developed country, LLDC = landlocked developing country, SIDS = small island developing states.

Source: ITU (2022d).

The persistent gaps in individuals' access to the internet in LDCs and lower-income countries across different socioeconomic indicators point to what extent the services are affordable relative to their income, which affects the population's understanding and skills in utilizing technologies and the internet. Although the price for purchasing mobile broadband services has dropped worldwide after the COVID-19 pandemic, the median prices individuals pay for internet access in lower middle-income and low-income economies are respectively 10 and 30 times higher compared with high-income economies, upon adjusting for the difference of their gross national income per capita. On a positive note, Africa saw a 1.5% reduction of share prices in mobile broadband in 2022 compared to the previous year. Low-income countries noted a similar trend, with a 2.1% decline in share prices, from 11.4% share in 2021 to 9.3% share in 2022 (ITU 2022e; Figure 3.2). Further, the complexity in connecting the lack of ownership and affordability with meaningful connectivity can be traced to limited data availability to measure the levels of digital skills among the population. To date, across the five clusters to measure digital skills—communication and collaboration, problem solving, safety, content creation, and information and data literacy—only 78 countries submitted data, with variance of

Figure 3.2: Data-Only Mobile Broadband Service Basket Prices, 2021–2022
(% of gross national income per capita)



CIS = Commonwealth of Independent States, LDC = least developed country, LLDC = landlocked developing country, SIDS = small island developing states.

Source: ITU (2022d).

availability data in each of category. Out of these five categories, a median of 50% and average between 31% and 65% of individuals performed best in communication and collaboration skills. Meanwhile, from these limited data, the lowest median of population pointed to lack of skills in information and data literacy (ITU 2022).

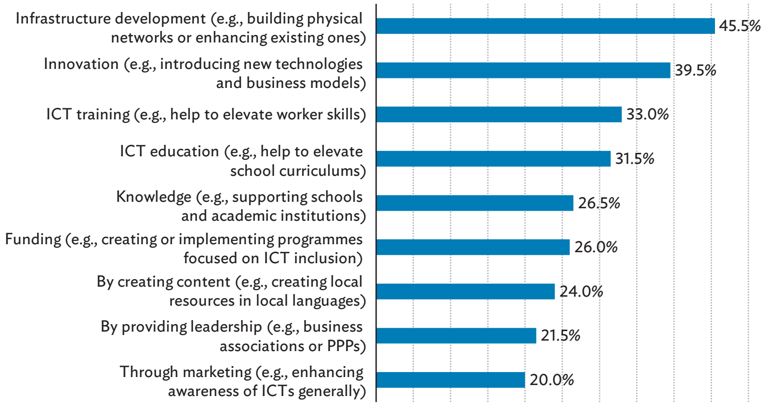
To move the needle and advance digital inclusion amid the persistent gaps outlined earlier, international communities have vowed for greater collaboration and partnership. For instance, *Our Common Agenda* released by the United Nations Secretary-General's Envoy on Technology in 2021 encompasses a wide range of stakeholders from governments, multilateral systems, the private sector, civil society, grassroots organizations, and academia to individuals, including young people, who will be required to ensure that a Global Digital Compact to be agreed at the Summit of the Future in September 2024 foresees an open, free, and secure digital future for all. At least seven actions are proposed to improve digital cooperation: (i) connect all the people to the internet, including all schools; (ii) avoid internet fragmentation; (iii) protect data; (iv) apply human rights online; (v) introduce accountability criteria for discrimination and misleading content; (vi) promote regulation of AI; and (vii) foster digital commons as a public good (United Nations 2021). The G20 Digital Economy Ministers' Meeting in September 2022 highlighted the public sector's role in ensuring the right incentives exist to boost private investment and innovation, thus supporting community-led programs for digital skills and training as needed (Indonesia Ministry of Communications and Informatics 2022). The next section will shed light on the extent to which the private sector should be provided space to partake in the role of advancing digital access for the global population.

3.3 Why Should the Private Sector Be Given a Seat to Help Advance Digital Inclusion?

The private sector is arguably an important actor in advancing digital inclusion as it incorporates the necessary resources to spur innovation, though some may argue that their profit-seeking tendency strays from the idea of contributing to providing access for those at the margin. Yet, evidence suggests that in some developing countries, the private sectors serve as a platform to accelerate digital finance adoption, particularly at the onset of the COVID-19 pandemic. For instance, e-commerce platforms have mushroomed across developing countries, with Latin America topping the growth at 37% (GPFI and World Bank 2021).

This is a rational choice for private sectors: the more people are connected online, the more people would use private services offered by companies. In addition, should the inclusion policies that extend to advancing literacy skills succeed, more digital users would be aware of the available services and could generate meaningful feedback for the companies and thus generate better insights on needed improvements. Ultimately, digital inclusion would precipitate meaningful access that would enable private sectors to offer advanced services and products, as well as expanded markets abroad (EIU 2022). A survey launched by EIU (2022) in Indonesia (Figure 3.3) revealed that the private sector is believed to have the greatest role in developing infrastructure (45.5%), catalyze innovation (39.5%), and provide ICT training (33.0%) and education (31.5%).

Figure 3.3: The Private Sector's Role in Bridging the Digital Divide Based on Indonesian Respondents



ICT = information and communication technology, PPP = public–private partnership.

Source: EIU (2022).

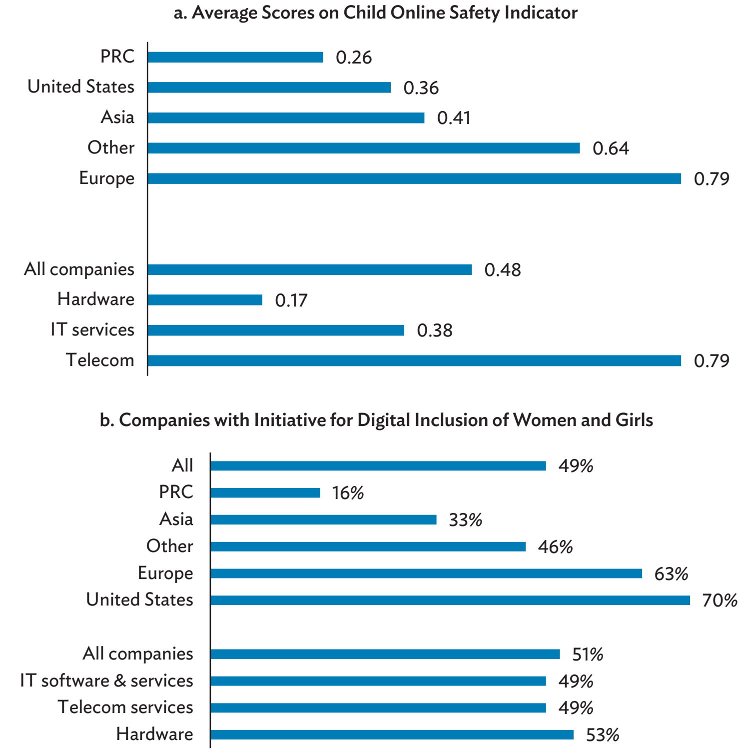
With the prominence of the private sector's role in bridging the divide, the assessment offered by the World Benchmarking Alliance (WBA), which aims to generate a movement to incentivize private sectors taking part in the sustainability agenda, can serve as a basis to generate insight on how these actors' commitment translate into practice.

Among different indexes, WBA (2023a) just launched its third Digital Inclusion Benchmark, which scores 200 of the world's most influential technology companies in advancing an inclusive digital society. WBA (2023) has defined digital inclusion from the perspective of equitable access, quality skills, meaningful utilization that could mitigate risk and harm, and inclusive and ethical innovation. Of 200 assessed companies, 64 are in the United States, 46 in Asia (excluding the People's Republic of China), 41 in Europe, 25 in the People's Republic of China, and the remaining 24 in other areas. By company type, most assessed companies were telecom services (40%), followed by IT software and services (31%) and hardware companies (29%) (WBA 2023b).

Similar to the ITU findings at the global and regional level, most technology companies were still behind in fulfilling their part to ensure their users benefited from the digital services they offer (WBA 2023a). Of 200 assessed companies, only 27 scored 50 or above the benchmark. Although 38 of 200 assessed companies provided devices at the onset of the COVID-19 pandemic to ensure equitable access, 24 of these 38 discontinued their assistance despite vulnerable groups continuing to need access to devices. On average, by type of industry, telecommunication companies performed the best compared to hardware companies and IT software and services firms. In addition, based on geographical location of the assessed companies, those in Europe had the highest average progress in digital inclusion, followed by companies in Asia, the United States, other continents, and the People's Republic of China (WBA 2023b). In addition, the top 10% of the 200 assessed companies are geographically varied: eight with headquarters in the United States (Apple, Microsoft, Cisco, Dell, Verizon, HP, IBM, and Qualcomm), followed by seven firms in Europe (Telefonica, Orange, Deutsche Telekom, Telia, Telenor, Vodafone, and Ericsson) and five companies in Asia and the Pacific (Samsung, Telstra, Singtel, SK Telecom, and AIS) (WBA 2023a).

The 200 major companies assessed by WBA also fared differently in aspects linked to digital use that are closely associated with their core businesses. The commitment to cybersecurity of technology companies globally and focused on Asia and the Pacific was rather low commitment, as only around 32% of companies disclosed a high-level commitment to cybersecurity in its business codes, governance statements, or other related policy documents. As regards protecting the rights of children online and providing access for women in technology, among other issues (Figure 3.4), only three (Singtel, Telefonica, and Vodafone) of the top 20 companies with best performance in digital inclusion demonstrated a commitment in their company policies to safeguarding children online. Meanwhile, of the 200 assessed companies, 28 have committed to keeping children safe online (WBA 2023a). In Asia and the Pacific, with a total number of 74 companies assessed in the benchmark, only 9 companies have shown a commitment to online child protection. These figures suggest that the percentage of companies committed to online child safety in the Asia and Pacific at 12.16% is lower by 1.84% compared to the global score (14.00%). By industry, telecommunication companies such as Telia, Vodafone, PLDT, Millicom, and AT&T have the highest scores in keeping children safe online. Meanwhile, assessed companies in Europe performed the best by far on child online safety (WBA 2023a). In addition, the findings point glaringly to the need for internet companies such as Meta, ByteDance, and Netflix to adopt online

Figure 3.4: Digital Social Inclusion Aspects—Children's Safety and Access for Women and Girls



IT = information technology, PRC = People's Republic of China.

Source: WBA (2023a).

safety and data privacy measures for children as adolescents access their platform and thus may also share their personal data on it.

In terms of proportion, more major companies have shown their commitment to alleviating gender disparity, particularly women in science, technology, engineering, and mathematics (STEM) compared against the proportion of companies that have committed to keeping children safe online. Slightly more than half of the 200 assessed companies have at least one initiative to provide access and/or digital skills to women and girls. However, companies headquartered in Asia and the Pacific score much lower, with only 21 of 74 supporting digital inclusivity for women and girls. This score is 22.1% lower than global companies (WBA 2023a). Such initiatives mostly are led by the hardware industry, whereas IT software and services have the fewest initiatives in this space. The positive progress in advancing women's digital access has also been driven by effective partnership with nonprofit organizations and/or other companies (WBA 2023b). Nevertheless, the findings illustrate that sustainability of the support beyond one-off programs, as well as incorporating balanced women representation within the companies after they finish their education, will be more significant to bring impact in terms of digital inclusion. From the assessment of 200 major digital companies by WBA (2023b), it is important to note that although major companies may have commitments in some aspects of inclusion, such as ensuring children are safe online or equitable access to STEM among women and men, the implementation may vary. This would depend on the partners these companies jointly collaborate with and/or available resources directed to specific corporate social responsibility (CSR) areas within a given period. The next section illustrates government policies in several middle-income countries in Asia and the Pacific to cross-match with possible public–private sector models that can be geared to ensure digitalization benefits all.

3.4 Digital Inclusion in Asia and the Pacific: Navigating toward Parity

Across Asia and the Pacific, despite being home to a mushrooming number of digital users coming online during the pandemic, more needs to be done to not leave anyone behind. As of 2022, only 64% of population had access to the internet, slightly lower than the world's average at 66% of individuals using the internet during the same period (ITU 2022c; Figure 3.1). This is equivalent to more than 1.46 billion people living in the region without internet access, contributing to half of the world's population who do not use the internet. The gaps also persists across different socioeconomic indexes. At least 804 million men in Asia and the Pacific have access to the internet compared with 683 million women. The stark discrepancy in access between rural and urban areas across the region also mimics the global gap, with only 47% of individuals in rural areas having access to the internet compared with as high as 82% of the population in urban areas (ITU 2022d). the level of inclusion varies also between countries of different income levels. In East Asia and the Pacific, for example, 88% of Singapore's population has access to the internet, but only a third of the population in the Philippines and the Lao People's Democratic Republic is using the internet (Euromonitor, in Tufts 2021). A similar trend held in the Middle East, with 88% of the population of the United Arab Emirates being connected online compared with only 57% in Jordan. The evidence starkly reveals that in all countries in South Asia (Bangladesh, Pakistan, India, and Sri Lanka) less than half of the population is connected online (Euromonitor, in Tufts 2021). Most importantly, to have meaningful internet access, people need to be equipped with proper ICT skills. However, limited data are available from countries in Asia and the Pacific to assess the level of digital skills in communication and collaboration, problem solving, safety, content creation, and data literacy.

Mindful that the underlying gaps for those at the margin to gain digital access may affect overall national development, governments across Asia and the Pacific have allocated their resources to launch a wide range of policies on digital inclusion. In Southeast Asia, digital inclusion is often linked with the ambition to elevate the booming digital economy. For instance, Indonesia has leveraged its mission to elevate the country's digital and financial inclusion in one go. Of 210 million digital users in Indonesia, 79% use the internet for online transactions and 72% also admit that they mostly access financial services (BI 2022). Indonesia's priorities to use digitalization in expediting financial inclusion align with Bank Indonesia's target to have an integrated digital payment system by 2025 (BI 2022). This target corresponds with evidence that suggests that digital financial inclusion, supported by infrastructure access, digital and financial literacy, and good governance, would improve states' economic growth (Khera et al. 2021; Ozturk and Ullah 2022). In this regard, Indonesia has launched the QR Code Indonesian Standard (QRIS) in a form of a two-dimensional barcode to support Bank Indonesia's 2025 ambition. It comes in the form of a simplified code, which merchants can use to easily collect payment through money stored in a digital wallet (BI 2022). This program was launched to act as a bridge between mushrooming MSMEs and booming digital users in Indonesia. The 2022 Business 20 (B20) Forum in Indonesia highlighted that digital financial inclusion was promoted to include young people and MSMEs to foster a sustainable economy (Ministry of Finance 2022). On a positive note, more than 19 million merchants in Indonesia are currently using QRIS to collect payment. In another instance, Malaysia has also installed MyDIGITAL as the government's initiative to advance digital economy as part of Twelfth Malaysia Plan and Shared Prosperity Vision 2030. In this vein, the Malaysian Digital Economy Blueprint was issued to enhance infrastructure, build a skilled workforce, strive for an inclusive digital society, and ensure a secure and ethical digitalization (Government of Malaysia 2021). By 2025, the Malaysian government foresees that 22.6% of the country's gross domestic product would be contributed by the digital economy.

In South Asia, in addition to focusing on boosting the digital economy, the priority is also on ensuring equitable infrastructure in rural areas given the low penetration of internet access, as well as on upskilling and reskilling the population. For example, India launched the Digital India program in 2015 that intends to transform India "into a digitally empowered society and knowledge economy" (Government of India 2015a, 2015b). It serves as an umbrella program that spans different department to achieve targets across three main components: digital infrastructure, digital services, and digital literacy. These further encompass nine pillars: broadband highways, universal access to phones, public internet access program, e-governance, electronic delivery of services through eKranti, universal information for all, electronics manufacturing, information technology (IT) for jobs, and an early harvest program to upskill and reskill India's population with digital skills. Another instance in Sri Lanka revealed a case in point of a government partnership with multilateral organizations, in which the Information and Communication Technology Agency (ICTA) and the United Nations Development Programme (UNDP) launched the National Digital Strategy building on the lessons learned during the COVID-19 pandemic to not leave anyone behind under the digitalization momentum. In this sense, the strategy would utilize Citra Lab as joint initiatives to enhance the public sector capacity through its NextGenGov Fellowship Programme (UNDP 2020). The digital transformation strategy is revolves around human-centered design to ensure that it is citizen centric.

Evidence indeed suggests that partnerships with the private sector have played a significant role in facilitating inclusion for digital transformation. The private sector with its abundant resources could enhance digital skills and thus catalyze further innovation (Șerban et al. 2022; Hammerschmid et al. 2023; Horan 2021; Stott and Murphy 2020). In addition, based on case studies in 100 countries after the COVID-19 pandemic, digital inclusion also requires inclusivity in engaging a wide range of relevant stakeholders, such as the private sector, to take practical steps in maintaining the agility to adapt and elevate capacities (OECD 2021). Businesses can also provide an enabling environment for new start-ups that enshrines impact commitments, provides needed financing, and accelerates technological adoption (OECD 2021). For instance, one prominent issue in advancing digital inclusion is to be well informed about the degree of progress made on availability and affordability of digital access. Facebook has supported the EIU since 2017, launching the Inclusive Internet Index to measure digital inclusion across four aspects: availability, affordability, relevance, and readiness. This index has helped in leveraging awareness on the importance of digital inclusion across different economies (EIU 2022). Google has also initiated its Next Billion Users (NBU) initiative since 2015 with programs to improve access, build confidence, provide voice, ensure gender equality, and generate more opportunities for those at the margin. It has created the Digital Confidence Toolkit to help people with low digital literacy in developing digital apps and features. In addition, the initiative also includes local language services, private searches for women, and job-matching apps to support young people and vulnerable groups (EIU 2021).

Despite the initiatives by major companies such as Google and Facebook, catalyzing sustainable programs from private companies will require solid offers from governments. As underlined by UNCTAD (2021), private sectors rarely innovate in isolation. This means that firms and/or companies operate within networks that are linked with other businesses, financial institutions, consumers, and regulators that adhere and/or follow a set of laws applied in particular countries. Based on an analysis of the survey of 14,125 firms, though digitalization has always been of benefit, this does not always correspond with sustainability practices and innovation (Ardito 2023). Thus, to effectively engage the private sector to advance digital inclusion in a sustainable manner, governments, particularly in lower-income and lower middle-income countries, need to authorize appropriate incentives for the private sector to attract the right investment and partnership.

Therefore, the incentives that governments can offer will need to take into account the contexts of those who need them the most, coupled with opportunities for vulnerable groups, while at the same time benefiting the private sector. These can be categorized into indirect enablers and direct incentives. Indirect policies, launched by governments nationally, will benefit private companies that help advance digital inclusion under their own individual CSR programs. Meanwhile, direct incentives would be targeted at the firms and/or companies themselves (Table 3.2).

At least four (inter)governmental policies that rely on transparent data, a clear industrial strategy, and a better data governance system would serve as indirect incentives for the private sector to advance their agenda of inclusion for the people. First, with nations globally kick-starting negotiation processes on the United Nations Global Digital Compact, aimed to be adopted during the Summit for the Future 2024 (United Nations 2023), governments must acknowledge the substantial contribution of tech companies in accelerating digital transformation globally. This acknowledgment entails realizing that without digital technology companies given roles prescribed under the Global Digital Compact that aims to universalize digital inclusion, the goal to narrow the digital divide would unlikely be achieved. Thus, it is important that the Global Digital Compact serve as a tool that incentivizes tech companies to fulfill their commitments on digital inclusion. The Global Digital Compact momentum is right to kick-start these initiatives to connect the "unconnected" and including the "unincluded or excluded" in the digital transformation pathways, such as by tax incentives, technology subsidies, and other relief options (Tobing 2023).

Second, governments may consider having a proper and comprehensive assessment through data transparency (United Nations 2023), looking at the utmost needs in terms of digital inclusion based on different groups in the countries. Having disaggregated data based on different socioeconomic groups is key to provide transparency for the private sector in generating national and regional insights of different groups' access, thus better designing their CSR in advancing inclusion. This weakness of government capacity to provide data transparency may open up opportunities for the private sector to collaborate, such as on how to optimize public platforms to present the available data. For instance, if young people have limited access because of lack of device ownership, assistance shall be provided for them to access the digital infrastructure (i.e. equipment, devices). Also, low-income groups may also lack meaningful access to the digital platforms due to limited skills. Interventions such as phased upskilling and reskilling and/or vocational training would be required. Hence, governments' commitment to ensure data transparency could serve as an entry point for the private sector to collaborate in enhancing government systems. In the medium term, this transparency can be utilized further by the private sector to shape their collaboration with different actors in advancing digital inclusion for a wide range of population groups.

Third, governments may want to prepare an industrial strategy that reassures that the training and/or reskilling programs provided by the private sector would be absorbed in the long term (UNCTAD 2021), presenting options for the private sector to expand their markets and/or operations. This includes having in place a robust and clear national innovation system, types of support provided for STEM students and/or early digital incubators, and platforms to connect the scientists and civil society with the private sector. The comprehensive industrial policy strategies may also consider a mechanism to share intellectual property rights between the private and public sectors to push companies investing in digital inclusion-linked initiatives (UNCTAD 2021). Finally, as regards data transparency, improving data governance will clearly delineate who the data stewards are and how to handle data on digital platforms. Further, better data governance would clearly define individuals' data privacy, distinguishing data that cannot be shared and aggregate data that should be accessible for all to improve innovation. Clear management on this may address the reluctance of internet companies to build hubs in countries and rethink programs to ensure inclusive access for its users.

Table 3.2: Government Incentives to Boost Companies' Accountability in Digital Inclusion

Indirect Enablers	Direct Incentives
• **Ensured data transparency** o Disaggregated data o Contextual assessment o Targeted corporate social responsibility • **Robust industrial strategy** o Clear phased innovation system o Support for early incubators o Platforms to connect scientists and private sector o Sharing intellectual property rights • **Better data governance** o Clear data stewards o Distinction between public and private data o Reassurance for internet companies to invest	• **Comprehensive, updated, and targeted digital inclusion policy** o Data assessment of rural and/or outskirt areas o Incentives for companies that can provide infrastructure and/or training assistance • **Bundled package for private sector and state-owned enterprises (SOEs)** o Attractive bundled contract package between private sector and SOEs o Clear long-term digital inclusion strategy by the private sector

Source: Author's analysis.

While indirect enablers would provide a reassurance for the private sector to initiate a long-term business plan and strategy in countries across Asia and the Pacific, targeted incentives for firms and companies may strengthen their commitment to roll out collaboration with public and other stakeholders in advancing digital inclusion.

First, governments may want to have a targeted, updated, and comprehensive policies to advance digital inclusion in specific outskirt and/or rural areas. This includes having evidence-based data on the extent to which the disparity is glaring in these areas and the reasons these areas require public–private intervention to offer access and affordability of digital services. With these data, governments may launch policies announcing incentives such as tax relief and/or a discount for business permit licensing to attract private sector assistance in these specific areas. Second, it is undisputable that state-owned enterprises largely operate and drive innovation policy across countries in Asia and the Pacific with large digital users such as the People's Republic of China, Indonesia, and Viet Nam, among others. Taking this into account, governments may offer bundled contract packages between state-owned enterprises and the private sector for those companies that have a clear long-term plan in advancing inclusion in the countries, including digital skills training for the workforce, assistance for women in STEM, and/or provision of infrastructure in needed areas. These bundled packages may come in the form of a partnership contract and/or long-term concession program that will benefit both the public and private sector in the long run.

3.5 Conclusion

The work in advancing digital inclusion clearly cannot be concluded in a short span of time. It sometimes is complicated by having to juggle between prioritizing growth generation to boost the digital economy and attracting quick investment that might only benefit a few, on the one hand, and ensuring that the digitalization is strategically designed to include all of society without leaving anyone behind, on the other. Such a grand mission cannot be simplified as a task for governments. Instead, it will require a robust partnership between public and private sectors, and even extend to stakeholders such as academia, think tanks, scientists, and civil society organizations. While public and private sectors may fill the void of policies and resources needed to ensure equitable access and affordability, the aspects of inclusion may only be touched upon by the grassroots civil society organizations and/or communities that are familiar with the day-to-day struggle of vulnerable groups. In addition, collaboration with scientists who have the technical knowledge needs to be sharpened to avoid bias that may further perpetuate exclusion in the digital sphere. Only when partnership is closely sealed will all easily benefit from the digitalization momentum.

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PART II

Digital Transformation for Sustainability

4

Twinning Digital Transformation and Green Transformation toward Sustainable Development in Asia and the Pacific

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4.1 Introduction

By 2019, as an indicator of digitalization, more than half of the world's population was online, with a huge digital divide observed among regions. For example, while 85% of the population in Europe and Northern America had internet access, only 20% were connected in the least developed countries, which is excluding the not-connected society from sharing the benefits from digitalization. While fixed broadband subscriptions continue to increase, growth in subscriptions slowed to 2.7% in 2020. In developed countries, there were more than 33 subscriptions per 100 inhabitants, representing a high penetration rate, while the number in developing countries stood at 11.5 per 100 inhabitants. In the least developed countries, fixed networks are almost completely absent, with only 1.3 subscriptions per 100 inhabitants (United Nations Economic and Social Council 2021).

At the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change in 2021, all countries

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committed to the goal of limiting warming to 1.5°C as the global benchmark for mitigation ambition. It is expected that greenhouse gas (GHG) emissions will be dramatically reduced each year, toward a 45% reduction by 2030 and net zero emissions in 2050. In addition to the Paris Agreement, climate protection and digital cooperation are expected to become part of the 12 commitments of the "Our Common Agenda" report from United Nations Secretary-General that was adopted by the General Assembly in 2021 (United Nations 2021). The coronavirus disease (COVID-19) pandemic has accelerated digitalization as the platform to work remotely from home and attend online meetings. This has created new opportunities for better utilizing information and communication technology (ICT). Furthermore, digitalization could fill serious data gaps in the monitoring of the Sustainable Development Goals (SDG). The SDGs are integrated and indivisible and balance the three key dimensions of sustainable development: economic, social, and environmental (United Nations 2023).

Digital technology is fundamental for change in countries. It is reshaping almost every aspect of people's lives and all parts of society, including economies, government, and civil society. The exponential pace of the digital revolution and its profound consequences demand a better understanding of the new context, as well as the intentional and inclusive design of digital transformation efforts to ensure that no one is left behind. Digital transformation should be made inclusive to realize the SDGs. Deeper, fairer, and inclusive digital transformation means that countries will enjoy important economic and social benefits, thus unlocking new opportunities, supporting economic growth, reducing poverty, improving public service delivery, and accelerating social protection programs (United Nations Development Programme 2022).

Access to digital technologies matters as it can contribute to economic development and climate change mitigation, as well as the attainment of several other SDGs. Sensors, the Internet of Things (IoT), robotics, and artificial intelligence (AI) can improve energy efficiency and management in all sectors and play a strong role in relation to energy systems with high shares of renewable sources. Digitalization can enable emission reductions by increasing energy efficiency and promoting the adoption of the low emissions technologies, while also creating new market opportunities (IPCC 2022a). Digital technologies, however, also raise broader sustainability concerns because of their use of rare materials and associated waste, high energy demand, and their potential negative impacts on inequalities in access and on employment (IPCC 2022b).

Figure 4.1: Sequence of the Fourth Industrial Revolution according to the World Economic Forum

Navigating the next industrial revolution

Revolution	Year	Information
1	1784	Steam, water, mechanical production equipment
2	1870	Division of labour, electricity, mass production
3	1969	Electronics, IT, automated production
4	?	Cyber-physical systems

IT = information technology.

Source: Inderwildi and Kraft (2022).

Digitalization would facilitate a fast transition to sustainable development and low carbon emission pathways because of its contribution to efficiency improvements, cross-sector coordination, and a circular economy by introducing new services and reducing resource use. Online shopping has accelerated since the pandemic when consumers had to stay home due to lockdowns. Hence, online sharing platforms have seen increased activity in purchases of daily needs such as food, drinks, and clothes. These activities will generate synergies to attain the SDGs: energy efficiency, food and water provision, health access from telemedicine, and education from online training. They will also generate trade-offs, for example, in relation to reduction in low-paying jobs, energy demand, and demand for services. Developing countries may not be able to reap the opportunities from digitalization due to their limited internet access and poor infrastructure unless major investments are made to improve internet access (IPCC 2022c). While there is much promise for digital technologies to drive change, broad policy support from environment, finance, and technical sectors will be required toward achieving a low GHG emissions lifestyle (Royal Society 2020).

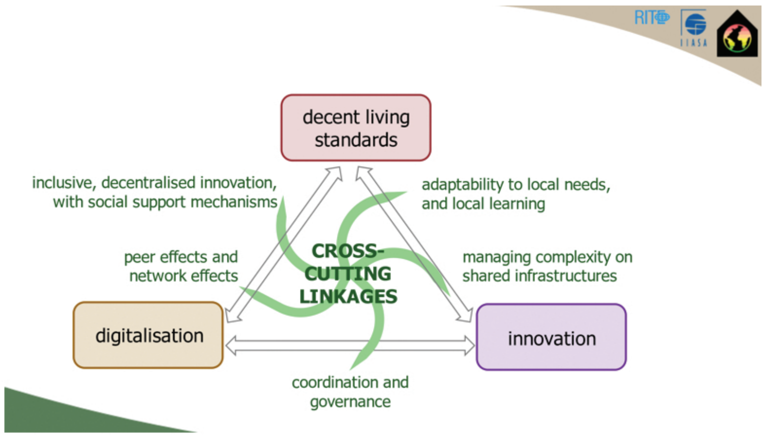
Digitalization is also becoming a part of the industrial revolution (Figure 4.1). The First Industrial Revolution occurred in the mid-18th century and reduced reliance on animals and human efforts that could be substituted by fossil fuels as the new energy source for engines. The Second Industrial Revolution took place in the mid-19th century when electricity was invented and led to energy provision, as well as wired and wireless communication. The Third Industrial Revolution begun in the mid-20th century with the development of digital ecosystems, digital communication instruments, and rapid development of the computer and digital devices, which have enhanced the methods for information generation, processing, and sharing. The Fourth Industrial Revolution could be the next stage of development of cyber-physical systems, which highly depend on virtual and digital technologies. Such cyber-physical systems have already found their way into our daily life and become part of it: smart homes, streaming media, online navigation, and digital commerce (Inderwildi and Kraft 2022).

Global environmental problems such as climate change, nature and biodiversity loss, and waste and environmental pollution could be solved through digital technologies. While digital technologies could align with low carbon emissions through energy efficiency, there is a tendency for digital technologies to cause hikes in energy consumption. Further tensions will emerge considering the electronic waste and environmental footprints associated with digital technologies. Overall, if appropriately governed, digital technologies can help realize carbon neutrality and resource efficiency in the economy and society (European Commission 2022). The goal of this study is to review the literature on aligning the digital transformation with climate change toward the SDGs across sectors in Asia and the Pacific. The synergies and trade-offs will be assessed from the perspective of how these technologies can be used to support wide participation in deep emission reductions. This study also highlights the international cooperation on digital technologies.

4.2 Digitalization and Climate Change across Sectors

Digital technologies can contribute significantly to the fulfillment of several SDGs, yet this study will focus on digital transformation in relation to the green transition (i.e., climate change mitigation) in six sectors: agriculture, forestry, and other land use (AFOLU); building; enery,; industy,; transpot,; and waste. Chapter 17 of the Sixth Assessment Report of the IPCC Working Group II7 (2022c) highlightet cross-sectal digitalization ahean enabling factor to accelerate the transition towads sustainable development. Figure 42. depicts conceptually thoflinks between digitalizatith, innovation, and decent living standardenas it relates to digitalization and climate change mitigatioisacross sectors. The sector focus of this section will ed on the existing technology, market, and policy on the interaction between digitalization and climate change mitigation across Asia and the Pacifon.

Figure 4.2: High Well-Being with Low Resources



Source: Research Institute of Innovative Technology for the Earth and International Institute for Applied Systems Analysis (2022).

4.2.1 Agriculture, Forestry, and Other Land Use

Agriculture is one of the most prominent sectors in the development of AI through digital farming and precision agriculture. This is mainly triggered by the international pressure to find ways to use finite resources such as clean water and clean energy induced with digital technologies. The data and algorithm use in digital agriculture are also vulnerable to security risks (Hayashi, Homma, and Akimoto 2022). Food loss and waste account for 8% of the anthropogenic GHG emissions. For example, digital applications such as weather forecasts and online meal reservations will lead to further GHG emissions reduction in Japan in reducing food loss and waste compared to the online sales of fruits and vegetables, which are below standards.

AI-based solutions can be used to support and more accurately quantify this natural process by analyzing satellite imagery to detect forest land cover and to estimate ecosystem carbon sequestration. For example, cloud computing and high-resolution satellite records are used to assess a digital map of the conversion of forest into oil palm plantations in Indonesia, Malaysia, and Thailand. Air pollutants from forest fires increase during the summer season in Southeast Asia. Since these pollutants impact public goods, public interventions are expected. Big data also could be utilized for early warning systems in fire prevention due to extreme weather (Danylo et al. 2022). Climate change mitigation requires strategic and long-term planning at the country level and involves complex information sources and modeling tools. Digital technologies such as AI and machine learning are enabling the systematization, evaluation, and processing of these complex information sources and data, which conventional analytical tools could not handle. Cleaning the data and harmonizing the diversified data sources of climate change information could become an important agenda in the future (Sebestyén, Czvetkó, and Abonyi 2021).

4.2.2 Building

An estimated 28% of global energy-related carbon dioxide (CO_2) emissions in 2019 was from the energy demand of buildings if indirect emissions from upstream power generation are considered. Between 2013 and 2016, energy demand was plateauing and later increased to an all-time high of 10 gigatons of CO_2 in 2019, with 60% of that increment coming from residential buildings (Khanna et al. 2021). Smart homes using digital appliances within households have already become a focus of attention in the recent technology and policy discussions on climate change, energy efficiency, and sustainability of buildings. The smart home technologies market will grow substantially to $262 billion by 2025 with a compound annual growth rate of 7.5%. Smart home systems have become a lifestyle. Studies from Japan, the United Arab Emirates, the United Kingdom, and the United States show that government policy highly influences the removal of the development barriers of smart home technologies, such as smart meters, smart grids, and IoT (Sovacool, del Rio, and Griffiths 2021).

The 5G digital technology, which was driven by smart mobile devices and advanced communication technologies, has been applied for smart energy management and smart buildings in Singapore. The building sector has a significant impact in terms of climate change mitigation since it represents a third of the entire electricity consumption in the country. These intelligent buildings could bring about a cost-effective system and reduce GHG emissions intensity by 36% from the 2005 level in 2030 (Huseien and Shah 2022). AI could create energy-efficient building design with tremendous opportunity for mitigating energy consumption and GHG emissions in the built environment. Optimizing building design and systems will increase energy efficiency and provide comfort for the occupants. Continued research and development in this sector will contribute to climate mitigation and achievement of climate targets (Chen et al. 2023). Modeling low energy demand transformations in buildings is crucial to provide evidence for strategies to reduce GHG emissions associated with climate change mitigation targets, while supporting human activities and well-being without increasing energy supply. Infrastructure interventions related to low carbon building design, urban form and floor-space rationalization, and community-centered strategies are mostly represented with simplified approaches and exogenous projections, often overlooking the underlying dynamics. Demand-side technologies, from energy-efficient appliances to low energy or passive buildings, will become an integral part of the building sector, with a focus on energy services and improved representation of technological development, drivers, and user interactions. Dynamics related to megatrends, including digitalization, the sharing economy and the circular economy, and decent living standards are still not well understood in relation to the building sector and need to be explored further (Mastrucci et al. 2023).

4.2.3 Energy

Digitalization also refers to the use of digital technologies for developing new business models that enable new income generation and provide new value-added. Digitalization in the energy sector will support network control, data availability, and consumer engagement (Ahl et al. 2022). Digitalization can enhance energy efficiency and provide sustainable alternatives. Energy management strategies based on digital apps could help ensure high precision of the demand and supply, which could lead to more sustainable energy consumption and production. The smart use of datasets during process optimization could also bring positive energy savings up to 20% (Mondejar et al. 2021). Solar energy for example has been the main target for the clean energy transition in India: 300 gigawatts (GW) out of 500 GW by 2030. Many studies have questioned the land availability for this solar energy target. The machine learning model based on spatial patterns has been developed to map the utility scale of solar energy projects across India by using cost-free satellite imagery with an accuracy of 92%. It found that in India, 74% of solar panels were built either on land for nature protection ecosystems or on agricultural land (Ortiz et al. 2022).

The adoption of digital technology in other applications have already contributed significantly to the economy and society in Southeast Asian countries. The monetary value it brings was $620 billion in 2020 through digital payments such as e-wallets, which impacted the economy sector in Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Huge opportunities exist in terms of GHG emissions reduction because of the energy consumption of various digital services, such as messaging, video streaming, social media and online gaming, and online shopping (Husaini and Lean 2022). Several digitalization techniques have been utilized for energy conservation and renewable energy. Machine learning algorithms are extensively used for forecasting, while other algorithms such as natural computing is used to solve multiobjective problems or generate optimal model parameters. All forecasting or optimization models could also be integrated into fuzzy logic systems that would be useful as decision support tools. Most studies of AI appear to overemphasize the technical issues rather than the social issues (Nishant, Kennedy, and Corbett 2020).

4.2.4 Industry

The rapid development of Industry 4.0 technologies, such as big data analytics, data-driven simulation, IoT, radio frequency identification, and collaborative robots (cobots), can offer new opportunities and new and innovative solutions to remanufacturing. Cloud computing technology enables flexible data storage, centralized computing, and scalable service capabilities. It delivers various computing services over the internet, offering a core infrastructure, platform, software, and storage capability. The Industry 4.0-enabling technologies are highly useful in the repair and reprocessing routines for inventory management (Teixeira et al. 2022). The rise of digitalization will increase the electricity consumption of data centers. Moore's law as applied to IoT will grow data centers' electricity need to 752 terawatt-hours (TWh) or 2.3% of total electricity consumption in 2030 compared to 286 TWh (1.15%) in 2016. More awareness on energy-saving behaviors is encouraged to reduce the carbon footprint from this segment (Koot and Wijnhoven 2021).

Global GHG emissions from digital technology or ICT are estimated to be as high as 2.1%–3.9%. There is an argument that increasing energy demand because of ICT has already outpaced energy efficiency improvements, also known as the rebound effect. While studies on this are still limited, ICT giants could generate carbon reductions to achieve the net zero target and even carbon negative targets. This could help the transition to a net zero world (Freitag et al. 2021). Digital technologies have a considerable potential to drive GHG emissions reduction. AI is also being used in carbon projects that could help bring transparency to carbon credit markets. Table 4.1 shows that eight out of 14 digital companies worldwide are geographically located in East Asia, specifically Japan, the People's Republic of China, the Republic of Korea, and Taipei,China. This region emitted 4.84 million out of 7.28 million tons of CO_2 equivalent (66.5%). This indicates that the digital activities of the booming digital industry in this region might result in both significant energy consumption and GHG emissions (ITU and WBA 2022). With its aim to be carbon neutral, socially responsible, and compliant with local authorities, the future growth of the industry sector, especially the equipment and machinery manufacturers, appears volatile and unpredictable. There is clearly an opportunity of promoting energy-efficient equipment and machinery, for example, by utilizing transparency on the supply chain systems in the online blockchain platform (Sipthorpe et al. 2021).

Table 4.1: Energy Consumption and Greenhouse Gas Emissions of Digital Companies

		tCO_2e				Electricity	
Company	**Region of Headquarters**	**Location Based**	**Market Based**	**Scope 3 Category 1 Purchased Goods and Services**	**Scope 3 Category 11 Product Use**	**MWh**	**Renewable (%)**
Samsung	East Asia	1,812,000	1,812,000			3,262,000	18
Sony	East Asia	1,471,239	1,392,990	3,791,000	11,403,000	2,406,919	6
LG	East Asia	1,294,000	1,294,000		58,976,000	1,633,888	4
Seagate	Europe	1,190,152	1,199,080	1,200,000	7,000,000	1,626,187	0
Western Digital	North America	1,002,695	1,045,457	1,610,139	6,862,142	1,865,600	7
Apple	North America	937,619	47,430	16,100,000	4,300,000	2,580,000	100
Dell	North America	405,700	219,800	3,748,600	11,280,000	958,000	54
HP	North America	254,200	171,000	26,400,000	15,800,000	480,595	40
Lenovo	East Asia	184,947	28,788	2,283,500	15,551,000	292,751	11
Xiaomi	East Asia	31,347	31,347			45,416	
ASUS	East Asia	20,430	20,430	862,972	319,852	38,725	0
Acer	East Asia	18,118	12,199	43,732	1,542,689	31,735	54
Logitech	Europe	16,504	1,889	650,060	343,915	28,580	92
Nintendo	East Asia	5,270	5,270			15,713	13
Total		**8,644,221**	**7,281,680**			**15,266,109**	**28**

MWh = megawatt-hour, tCO2e = ton of carbon dioxide equivalent.

Source: ITU and WBA (2022).

4.2.5 Transport

The Sixth Assessment Report of the IPCC mentioned that in the low energy demand scenario, there is potential for decent living along with rapid technological and social innovations that lead to global energy demand changes (IPCC 2022a). The sharing economy, such as ride and car sharing, could contribute to climate mitigation by reducing global emissions at low or negative costs. It was found that the marginal CO_2 abatement cost in 2050 will reduce the cost from $169 per ton of CO_2 without ride and car sharing to $150 per ton of CO_2 for the 2°C target with ride and car sharing. Technological innovations such as autonomous vehicles and car sharing will lead to social innovations (circular and sharing economy) not limited to road transport but also related supply chains, such as in the chemical and steel sectors (Akimoto, Sano, and Oda 2021).

The climate actions encourage the expansion of renewable energy sources as well as the transition from conventional internal combustion engine vehicles to plug-in electric vehicles. The comprehensive case in Germany shows potential savings of €6.2 billion in 2035 through a reduction of the distribution grid by 19%. This could be attained by upgrading 7 million plug-in electric vehicles (21%) all over Germany (Heilmann and Wozabal 2021). The effect on digital technology (e.g., mobility as a service, shared mobility, and autonomous vehicles) has been analyzed regarding passenger vehicles in Europe as well. Through digitalization, the energy consumption could be lowered by 34% and GHG emissions by 43% in 2050 compared to the 2015 baseline as a result of the combined effects of the shift toward more efficient modes of transport or more energy-efficient cars because of the increase in average passengers per trip (Noussan and Tagliapietra 2020). Regardless of the promising technologies and market potential provided by digitalization in the transport sector, the governance of big data because of shared mobility with consideration for data access and data rights requires strong political leadership and society engagement from mobility users, transport system providers, and data engineers (Creutzig 2021).

4.2.6 Waste

Mechanical and digital applications could increase the yield of agricultural production, which in the case of Japan, for example, could lead to growth in revenue. The application of electricity and fuel could be offset by avoiding GHG emissions from food waste and loss. In the case of Japan, information technology-based food waste reductions will decrease energy consumption and GHG emissions by

0.04–0.08 Exajoules per year (about 0.2%–0.4% of the primary energy supply of Japan in 2011) and 5.6 million–7.8 million tons of CO_2 equivalent per year (about 0.4%–0.6% of GHG emissions) (Hayashi, Homma, and Akimoto 2022).

4.3 Synergies and Trade-offs of Digitalization and Climate Change Mitigation

Changing consumption behavior has a huge climate change mitigation potential. Digitalization enables many innovative consumer goods and services that could affect the consumption practices across sectors, ranging from food to homes, mobility, industry, and energy (Wilson et al. 2020). Demand-side mitigation embedded within digitalization could be attained in end-use sectors to improve well-being (Creutzig et al. 2022). The synergies and trade-offs are discussed here from the environment, economics, and social perspectives. The latest international cooperation initiatives at the United Nations and Group of Seven (G7) level on digital technology are also elaborated.

4.3.1 Environment

It is well-known that the trade-off between digitalization and climate mitigation is the increasing carbon footprint worldwide. The rise in energy consumption due to digitalization should be overcome by focusing on energy efficiency. Studies have found that the increasing computational demand of AI is responsible for the large carbon footprint. Technological innovations should improve the energy performance of products and services to ease the growing energy consumption due to digitalization (McGovern et al. 2022). Rapid technology deployment is highly dependent on short diffusion times, which are expected to deliver attractive risk profiles for investors. The deployment is also expected to deliver the strong potential to improve cost efficiency and performance. More granular technologies with smaller unit sizes and costs deploy faster and may outperform lumpy technologies to accelerate the low carbon transformation to achieve global climate targets (Wilson et al. 2020). In addition to demand-side solutions, nature-based solutions also play an important role by reducing and removing the atmospheric release of GHGs from the AFOLU sector, which contributes to 22% of annual GHG emissions on land and in the sea (Seddon 2022). To ensure compliance with the target of the Paris Agreement to limit warming to 1.5°C, digital technologies could play an important role also in monitoring the nature-based solutions through drone, satellite, and remote sensing.

If governed properly, digitalization could bring more benefits than negative impacts through more efficient processes in digital platforms, such as mobility sharing (e.g., Uber), office, housing (e.g., Airbnb), telehealth, and online payment systems (e.g., Alipay). All these digital platforms could reduce GHG emissions by avoiding excessive consumption and managing resources efficiently. Digital technology from a sustainability point of view has the potential to result in privacy intrusion, discrimination, and bias (Gupta 2021). Misuse of data, interpretation bias, and bias from the creator might cause harm to the digital users. There is thus a need to create a common framework to govern digital technology to ensure accountability, sustainability, fairness, safety, and enhancement of individual autonomy (Véliz 2021).

4.3.2 Economics

No other economic sector has greater potential for innovation and growth than ICT. Within 2 decades, digitalization has created a new value chain that has grown from $1.3 trillion in 1992 to $3.9 trillion in 2014 (4.5% of the world's gross domestic product) (Renn, Beier, and Schweizer 2021). This trend will continue growing because of the rapid technology deployment during the COVID-19 pandemic when lockdowns increased reliance on the online market. The pandemic had a systemic impact on society, with varying consequences across countries worldwide. There is an opportunity for climate change mitigation following the pandemic with energy-efficient practices embedded in new lifestyle patterns, such as housing, travel, work, and meals. A low energy demand recovery would reduce carbon prices for a pathway consistent with the 1.5°C limit, lower energy supply investments by $1.8 trillion by 2030, and soften the pressure on scaling up renewable energy technologies (Kikstra et al. 2021).

Digitalization tools such as robotics and autonomous systems could facilitate remote access enhancements, human activity support, innovation, and improved monitoring of the SDG (Guenat et al. 2022). While there are large economic opportunities for efficiency achievements and cost reduction, digitalization also has side-effects. The rebound effect will amplify the consumption of digital products and services, which ultimately will lead to higher GHG emissions (Bohnsack, Bidmon, and Pinkse 2021). Extending the lifetime of digital products and recycling could help ease the rebound effect that might occur. So far, the benefits outweigh the side-effects. In Germany, for example, reducing GHG emissions through energy-efficient products, energy system transformation, and electrification of end-use sectors could cut GHG emissions by 19%–34 % for passenger vehicles, 27%–31%

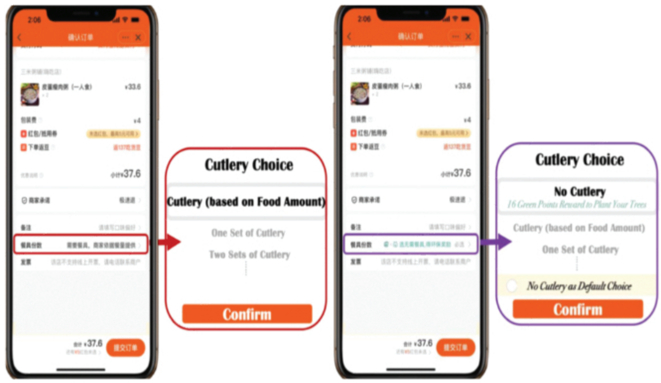
for residential buildings, and 14%–19% for non-residential buildings in 2050. Material efficiency can be a key contributor to deeper emissions cuts like a 95% target (Pauliuk and Herren 2020).

4.3.3 Social

Social lifestyles have shifted during the pandemic. Personal and business meetings are mostly held online. Video conferencing is a greener alternative from the sustainability perspective. Changing from in-person to virtual meetings not only cut energy usage by 90% but also reduced the carbon footprint by 94%. The COVID19 pandemic has brought about human behavior changes with new working styles, such as working from home instead of the office (Tao et al. 2021). Digitalization will create many new high-tech jobs and replace human workers performing repetitive tasks with robots and tools. Hence, this job transition is required for workers to fulfill the requirements for future digital-related jobs. New communication technologies, including AI-based guided learning systems, online instruction, and augmented or virtual reality tools, provide more innovative approaches for students, workers, and job seekers by making training more accessible, affordable, and engaging. Fostering collaboration between private, public, and philanthropic entities to develop and implement the training programs would improve the pathways for the job transition (Mindell and Reynolds 2022). Collaboration among various stakeholders could also improve the education curriculum and training by including more digital content, which is essential to upskilling students, workers, and job seekers. Another example would be changing behavior through so-called green nudges (Figure 4.3), which were used on digital platforms such as online food delivery apps.

Increasingly digital lifestyles and the sharing economy in cities have triggered the growth of online digital apps for food services such as Uber Food, Go Food, and Grab Food. Food ordered on such digital apps usually comes with plastic packaging and single-use cutlery, which contribute to increasing GHG emissions and environmental pollution due to plastic waste. The users earn points if they choose not to include the plastic cutlery, and these points could be converted to plant trees. Adding green nudges to food delivery apps encourages users to cut down plastic waste and incentivizes using the points to plant trees (He at al. 2023). A just digital ethical framework has been proposed to accelerate the achievement of the 2030 Agenda for Sustainable Development. This framework consists of four interrelated concepts—digital infrastructure (access to online network), digital capabilities (skills), digital commodities (access to digital tools), and digital governance (policy

Figure 4.3: Green Nudge in Online Food Delivery Apps



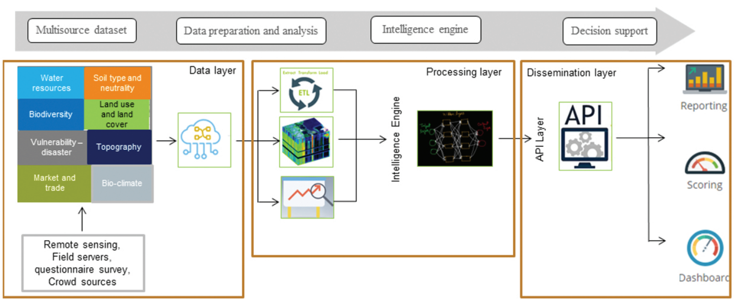
Source: He et al. (2023).

support and social inclusion)—to be prioritized and supported across all of society. It aims to diminish digital poverty and harness the SDGs in developing technology (O'Sullivan et al. 2021). Digital inclusion focuses on ensuring development for all. The vision and ownership for inclusive digital policies should be emphasized with clear objectives, timelines, and roles of stakeholders. Cross-sector partnerships and coordination with different institutions at international, national, and local levels are significant to create inclusive ecosystems (Jamil 2021).

4.3.4 International Cooperation on Digital Technology

The Secretary-General's Envoy on Technology has been tasked with digital cooperation across the United Nations system, also supported by the Department of Economic, and Social Affairs. In coordination with several United Nations agencies, the Roadmap for Digital Cooperation was produced in 2020. This road map emphasized that the United Nations would become the platform for digital cooperation by engaging multiple stakeholders in policy dialogue. It also underlines that digital cooperation is an effort involving multistakeholder participation, with the government at the center, supported by the private sector, technology companies, and civil society, among other essential stakeholders (United Nations 2020). The road map also supports digital connectivity with all individuals having access to the online space, which is affordable and fulfills the universal targets and metrics. Following extensive stakeholder engagement, the implementation road map was released in 2022 and focused on narrowing the digital divide by underpinning the effort to promote digital inclusion and strengthening digital capacity building (Office of the Secretary-General's Envoy on Technology 2022). The United Nations is currently preparing for the Summit of the Future in 2024, which is related to the Global Digital Compact on regulating AI to ensure a shared principle for an open, free, and secure digital future for all.

Figure 4.4: Framework for the Digital Innovation to Generate Food System at Scale



Source: Kraemer-Mbula et al. (2023).

The G7 Summit held in Hiroshima, Japan, on 19–21 May 2023 also emphasized the importance of digitalization. The G7 leaders affirmed the importance of addressing common governance challenges of digital technology and identifying fragmentation and potential gaps in global technology governance. The communiqué of the G7 Summit mentions that the governments will work together with technology companies and other relevant stakeholders to drive responsible innovation and technology implementation. It also recognizes there is a need to bridge the digital divide, including the gender divide, as well as to promote digital inclusion and greater employability and movement of digital experts. There is also a commitment to supporting other countries to enhance their digital access under the principles of equity, universality, and affordability toward global connectivity (Ministry of

Foreign Affairs of Japan 2023). One exemplary case is the innovative technology to generate food and land systems at scale (Figure 4.4). Digital technologies are fundamental in the food–water–land systems as they improve the monitoring, access, and use of the new data and evidence for decision-making. They also could help scale up existing innovations that have transformative potential at the grassroots or community level. Policy experimentation is essential to identify and test new methods for solving complex challenges based on multistakeholder participation and to build experience in using evidence to design policy solutions (Kraemer-Mbula et al. 2023).

Another exemplary case is to lower energy demand through digitalization. Digitalization in the economy was accelerated by the COVID-19 pandemic when most work was conducted from home and telecommuting. This new lifestyle has been found to improve well-being by allowing employees to work from anywhere and perform their household chores such as caring older people and babies at home. Although digitalization could increase well-being, it gives rise to the next research question concerning digital governance and ensuring the large carbon footprint produced by the technology for creating a digital economy will not harm the planet. Since 2020, the Research Institute of Innovative Technology for the Earth, which is based in Kyoto, Japan, has been conducting a study with the International Institute for Applied Systems Analysis, which is based in Laxenburg, Austria, which aims to promote lower energy demand for high well-being by utilizing digital technology across end-use sectors, such as food, building, industry, and transport (RITE and IIASA 2022). Figure 4.2. illustrates the concept of high well-being with low energy resources.

4.4 Conclusion

Digital technologies, such as IoT, AI, and big data, have rapidly improved, equipped with cheaper digital memories and higher computer speed (also the possibilities of quantum computers). New business models induced by these technologies and behavior change have been evolving rapidly, as can be seen with the growth in popularity of the sharing economy and circular economy. There is considerable room to reduce energy consumption in end-use sectors relative to the energy supply and energy-intensive sectors. Granular technologies are improving faster than lumpy technologies. Deep emission reductions at affordable costs will be a key for achieving multiple SDGs, and IT, AI, and other related digital technologies will contribute to this achievement. The digital transformation could be achieved across several SDG sectors: AFOLU, energy, building, transport, and industry. These digital and green transitions provide huge opportunities for technological innovation, economic prospects, and job creation. Synergies and trade-offs between digitalization and climate change mitigation exist, but governance is required to ensure the digitalization aligns with the green transition.

At the center of digitalization and the green transition is humankind, as anthropogenic emissions are caused by human activities. Hence, providing better education and increasing public awareness on digitalization and climate change mitigation will occupy a high priority to achieve the United Nations 2030 Agenda for Sustainable Development. Acknowledging the importance of digital access, United Nations entities and G7 leaders have engaged in efforts to narrow the digital divide through international cooperation. Examples include using innovative technology to generate food and land systems at scale and achieving high well-being with low energy demand by using digital technology across end-use sectors such as food, building, industry, and transport.

It is expected that this study will inform policymakers and academics about the role of digital transformation and green transition to achieve the SDGs (i.e., food security, clean energy transition, building, industry, and transportation). Digital twinning ecosystems will enable governments, scientists, civil society, and the private sector to contribute toward sustainable development by aligning the digital transformation through ensuring digital access and attaining the green transition through climate change mitigation.

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5

Digital Infrastructure and Student Enrollment: Experiences of the Post-Pandemic Scenario in Indian States

Krishna Nair J. and Pulak Mishra

5.1 Introduction

The information and communication technology (ICT) industry has witnessed remarkable expansion, primarily owing to the advancements in internet technologies and their widespread usage. Such swift growth and dissemination of ICT have expedited economic and social transformations in different aspects of human endeavors (Ahmed 2017). In particular, it has become an essential tool in promoting human development by enhancing access to education, health care, and economic opportunities (Verma, Giri, and Debata 2023). Further, ICT is also recognized as a key driver of digital technology that provides the infrastructure and tools necessary for the development, implementation, and widespread adoption of such technology in various industries and sectors. Evidence suggests that people and households can improve their lives and economic prospects by leveraging digital technologies to enhance skill development (Qureshi 2012; Asrani and Kar 2022).

Thus, digital innovations play a crucial role in promoting human development by eradicating poverty, reducing infant and maternal mortality rates, promoting decent employment, and achieving universal literacy, among other aspects at a quicker pace (UN 2020). Recent studies show that digital infrastructure has spearheaded socioeconomic transformation, introducing efficiency and accountability, generating new income opportunities, enhancing connectivity, and propelling economic growth (Agrawal and Asrani 2018; Pradhan et al. 2021; Osmundsen and Bygstad 2022). However, the nature and extent of the impact of technology on individuals' lives vary and are expected to be influenced substantially by social stratifications, including gender, location, class, and caste. The availability of digital infrastructure is fundamental to the growth and development of digital technology (Koutsikouri et al. 2018), while the lack of such facilities can be a significant barrier to adoption in developing and underdeveloped countries. The lack of fast internet connection, for example, limits access to online services and hinders the development of various fields. Hence, inadequate digital infrastructure and opportunities across different sections of society lead to digital divides (Rao 2005; Asrani 2022), and introduction of new technology can affect people differently, resulting in varying skills and impacts (Wang, Liu, and Parker 2020).

Accordingly, digital disparity has been recognized as a significant cause of socioeconomic inequality (Tewathia, Kamath, and Ilavarasan 2020), particularly with regard to disparities in respect of both availability and utilization of digital technology among various demographic and social groups (Iivari, Sharma, and Venta-Olkkonen 2020; Martin and Ramos 2022). In particular, lack of access to digital technologies and internet can result in limited prospects for inclusive education or employment, which can further amplify the prevailing socioeconomic disparities, as the disadvantaged groups may not have the necessary resources and capabilities to bridge the gap (Robinson et al. 2015). Thus, the digital divide can create a cycle of socioeconomic and demographic exclusion that is difficult to break without targeted interventions to increase access and improve digital literacy. Overall, the digital divide is a pressing issue that requires attention to guarantee that everyone has access to the resources necessary to thrive in a digital world (Mistry 2005).

However, mere access to digital devices or expanding connections to different locations alone may not necessarily ensure digital inclusion, particularly in the absence of efforts toward proper training to the prospective users to equip with the digital skills (Van Dijk and Hacker 2003). For effective use of the technology, individuals must acquire the necessary skills. In the absence of proper digital skills, the benefits from technological infrastructure may be limited (Eynon and Geniets 2016), leading to the digital skill divide. Thus, bridging the skill gaps is a significant challenge to the introduction and utilization of digital innovations.

In India, while the central government has initiated several measures to promote digitalization and e-governance across the country, there are variations in the level of digitalization across the states (Kaur and Neena 2014; Agrawal and Asrani 2018). This is likely to have serious adverse effects on the objective of balanced regional development in the country, as limited access to digital technologies inhibits access to resources and opportunities and thus constrains inclusion and empowerment. The issue appeared to be very critical during the coronavirus disease (COVID-19) pandemic, which made digitization an integral part of the socioeconomic and political activities (Maity, Sahu, and Sen 2021). For example, while education and health-care services were largely dependent on online modes during the pandemic, students from low-income households, disadvantaged sections, or remote areas with inadequate internet access and technological resources encountered significant difficulties in making use of the same. There are apprehensions that, in addition to difficulties learning or getting health-care facilities in the short run, such constraints may impede human development considerably in the long run.

As regards the availability of digital infrastructure, 51% of households do not have internet access, and 91% have no computer at home (National Family Health Survey from International Institute for Population Sciences 2021). Given this backdrop, schools can significantly contribute to closing the digital divide in society by providing access to digital technologies and resources, offering training and support for both students and teachers, and integrating digital literacy skills into the curriculum (Smith, Iversen, and Veerasawmy 2016; Iivari, Sharma, and Venta-Olkkonen 2020; Martin and Ramos 2022). Educational institutions can strive to create an equitable digital opportunity for all students, regardless of their socioeconomic status or other factors that may contribute to the technological gaps (Brossard et al. 2021). This can eventually lead to a more equitable and technologically advanced society, as the schools with necessary infrastructure and facilities can guarantee the digital education of all students. This is crucial as economic status, gender, and social background impede students' ability to access and utilize digital technology, further exacerbating inequality. It is therefore imperative for schools to develop inclusive environments that provide digital learning opportunities for all students and help them to succeed in a technologically advanced society (Poddar and Sachdeva 2022).

However, evidence shows that availability of digital infrastructure varies across different types of schools across the states in India (UDISE+ from Ministry of Education 2021). For example, government schools in general have less coverage in terms of functional computer and internet facilities as compared to the aided or private schools. One would expect, therefore, that the distribution of students' enrollment in different types of schools would vary depending on the digital infrastructure available. In this context, the present study examines the enrollment patterns in different types of schools across the Indian states in the post-pandemic period and the role of digital infrastructure in this regard.

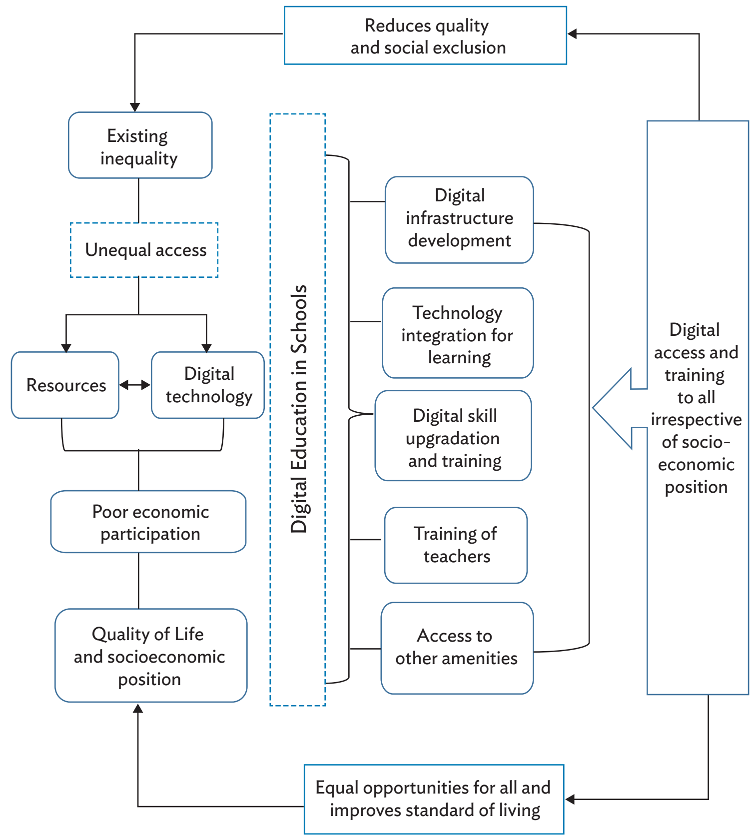
5.2 Conceptual Framework

The fundamental inequality already existing in the society leads to unequal distribution of resources including access to digital technology. This amplifies the digital divide existing in society and further affects economic participation (Tewathia, Kamath, and Ilavarasan 2020). In India, there are regional disparities in terms of digital access and use as well (Kumar and Basavaraja 2016). Most schools in India, whether government, aided, or private, have adequate physical infrastructure including buildings, clean drinking water facilities, electricity connection, and gender-segregated toilets. However, there are significant disparities in terms of digital infrastructure, specifically computers and internet access. At the national level, only 31% of government schools and approximately 60% of aided and private schools have functioning computer facilities. Internet access is even more limited, with only 13% of government schools having operational internet access as compared to 43% of aided schools and 52% of private schools in the country (UDISE+ 2021).

This has special significance for inclusive and balanced regional development as the ownership of digital assets and skills affect and alter the quality of life and socioeconomic position of people. Considering such disparities in access to digital technology, it is expected that incorporating ICT training in the syllabus and improving the digital infrastructure at schools would be a better way to reduce the social exclusion caused by the digital divide (Figure 5.1).

However, there are some prerequisites at the school level itself to develop and promote digital education. It is important to develop digital infrastructure, train teachers to equip them with enough digital skills, and ensure access to other amenities required for digital devices like electricity. There is also a wide array of possible learning opportunities through digital technologies including smart classrooms, and the schools can make use of this to improve the skill set of the students. Since this provides access and usage training to all the students irrespective of their background, there is scope for creating equal opportunities in employment generation and thus reducing socioeconomic inequalities and exclusion. Hence, promotion of digital literacy and training has the potential to reduce inequality by bridging the digital divide, improving access to education and employment opportunities, and promoting financial inclusion. Nevertheless, the success in this regard depends on how the underlying constraints are addressed and opportunities are reaped.

Figure 5.1: Conceptual Framework



Source: Designed by authors based on Tewathia, Kamath, and Ilavarasan (2020) and Mishra et al. (2023) and other related studies.

5.3 Data and Methodology

This chapter uses secondary data collected on an annual basis and applies panel data methods for estimation of the regression models. It employs a panel dataset encompassing various types of schools across Indian states, from the years 2018/19 to 2021/22. Estimations based on the panel data model help to capture more information and variability across all the states as well as over time, and it covers both spatial and temporal aspects. The data used in our study are collected from the

Unified District Information System for Education Plus (UDISE+) reports published by the Department of School Education and Literacy, Ministry of Education, Government of India. It is a comprehensive data set, which collects information from all accredited institutions that provide formal education to students in pre-primary to class XII since 2018/19.

There are three types of schools in India: government, government-aided, and private. Government schools are owned, supported, and regulated completely by the government or a local body. Aided schools are managed by a private organization, trust, society, or individual and receive a regular maintenance grant and teacher salaries from the government. Private schools are managed by an individual, trust, society, or other private organization and do not receive a regular maintenance grant from the government or local body (Ministry of Human Resource Development 2014; Kumar and Choudhury 2021. Hence, the present study examines enrollment rates in the three different types of schools in three categories: total enrollment, boys' enrollment, and girls' enrollment.

The approach followed in this chapter allows a more comprehensive and gender-sensitive analysis of academic access and outcomes by examining boys' and girls' enrollment separately. Additionally, the study considers educational expenditure as a share of total expenditure and gross state domestic product (GSDP) as two distinct independent variables in the regression models. The ratio of educational expenditure to GSDP serves as an indicator of the proportion of a state's economic output allocated to education, and thus its priorities for education. Similarly, educational expenditure as a share of total expenditure reflects the share of education in total budget or expenditure of the state government. Thus, the variable captures the government's emphasis on education in relation to other budgetary priorities. By considering both variables, a more comprehensive understanding of investment in education and its relationship to budgetary priorities can be obtained.

Based on the above discussed conceptual framework and insights from the existing studies, the following functional relationships are specified for econometric modeling:

- **Model 1:** Total Enrollment = f (Pupil–teacher ratio, Electricity, Functional computer, Internet, Pandemic, Pandemic*Aided school, Pandemic*Private school, Per-capita NSDP, EDU/TE)
- **Model 2:** Boys' Enrollment = f (Pupil–teacher ratio, Electricity, Functional computer, Internet, Pandemic, Pandemic*Aided school, Pandemic*Private school, Per-capita NSDP, EDU/TE)
- **Model 3:** Girls' Enrollment = f (Pupil–teacher ratio, Electricity, Functional computer, Internet, Pandemic, Pandemic*Aided school, Pandemic*Private school, Per-capita NSDP, EDU/TE)

- **Model 4:** Total Enrollment = f (Pupil–teacher ratio, Electricity, Functional computer, Internet, Pandemic, Pandemic*Aided school, Pandemic*Private school, EDU/GSDP)
- **Model 5:** Boys' Enrollment = f (Pupil–teacher ratio, Electricity, Functional computer, Internet, Pandemic, Pandemic*Aided school, Pandemic*Private school, EDU/GSDP)
- **Model 6:** Girls' Enrollment = f (Pupil–teacher ratio, Electricity, Functional computer, Internet, Pandemic, Pandemic*Aided school, Pandemic*Private school, EDU/GSDP)

The variables are defined in detail in Table 5.1.

Table 5.1: Details on Measurement of the Variables

Variables	Definition/Measurement	Data Source
Dependent Variables		
Total enrollment	Ratio of students enrolled in pre-primary to higher secondary classes in different types of schools (government/aided/private) to total enrollment in these classes in an academic year	UDISE+
Boys' enrollment	Ratio of boys' students enrolled in pre-primary to higher secondary classes in different types of schools (government/aided/private) to total enrollment in these classes in an academic year	UDISE+
Girls' enrollment	Ratio of girls' students enrolled in pre-primary to higher secondary classes in different types of schools (government/aided/private) to total enrollment in these classes in an academic year	UDISE+
Independent Variables		
Pupil–teacher ratio	Ratio of total number of students to total number of teachers	UDISE+
Electricity	Percentage of schools with electricity facilities available	UDISE+
Functional computer	Percentage of schools with functional computer facilities available	UDISE+
Internet	Percentage of schools with internet facilities available	UDISE+
Per-capita NSDP	Log of Net State Domestic Product to total population	RBI
EDU/TE	Share of government expenditure on education in total expenditure	RBI
EDU/GSDP	Share of government expenditure on education in Gross State Domestic Product	RBI
Pandemic	Binary Variable taking value 1 for post-pandemic years, and 0 otherwise	Dummy
Pandemic*Aided school	Binary Variable taking value 1 for Aided schools, and 0 otherwise	Dummy
Pandemic*Private school	Binary Variable taking value 1 for Private schools, and 0 otherwise	Dummy

RBI = Reserve Bank of India, UDISE+ = Unified District Information System for Education Plus.

Source: Authors' own compilation

The econometric models specified here include per capita net state domestic product (NSDP), pupil–teacher ratio, various facilities available in schools including electricity connection, availability of functional computer, internet facility, and share of educational expenditure in total expenditure or GSDP as the independent variables to explain the variations in students' enrollment in the three different types of schools (government, aided, and private). Further, necessary dummy variables are also added to examine the differences in student enrollment in a post-pandemic situation in relation to that in the pre-pandemic period as well that across different types of schools. The dependent variable is measured here as school enrollment of both girls and boys separately along with total enrollment.

The pupil–teacher ratio is an important aspect when evaluating the quality of education in a school and its potential impact on student enrollment (Duraisamy et al. 1998; Tiwari, Bhattacharjee, and Chakrabarti 2020). Similarly, reliable electricity connection is necessary for the proper functioning of various digital amenities. Hence, electricity connection is considered one of the variables that influences digital education and student enrollment. Digital amenities such as an available functional computer and internet access are other key variables that determine the enrollment of students in a school. Amenities, both physical and digital, are necessary and often a deciding factor for parents to choose the school for their children (Hill, Samson, and Dasgupta 2011; Kim, Yi, and Hong 2021; Narwana and Gill 2022).

The COVID-19 pandemic also had an enormous influence on the enrollment of students in Indian schools. The closure of schools and colleges due to lockdowns and other restrictions imposed to contain the spread of the virus disrupted the regular education system and induced a shift to online education in India, severely affecting school enrollment. The impact on enrollment has been severe particularly in rural areas, where access to technology and internet infrastructure is limited (Agrawal and Asrani 2018; Alvi and Gupta 2020). Many students in these areas have been unable to attend online classes or access educational materials, leading to a widening gap in education between urban and rural areas (Selvaraj et al. 2021). Hence, a dummy variable for the pandemic is included to capture the effects of the pandemic on enrollment.

Further, many students were forced to drop out of school due to financial hardships caused by the pandemic (Alvi and Gupta 2020). Thus, while digitization can play a crucial role in influencing enrollment of students in favor of government schools, such changes in the enrollment patterns during the COVID-19 pandemic period seem to be largely due to the income constraints created by the pandemic as well. This may be so because there have been significant job losses during the post-pandemic period resulting in a trend of student enrollment toward the government schools to reduce expenses related to school fees and other related expenditures (Alvi and Gupta 2020; ASER Centre 2022). Accordingly, in addition to the pandemic dummy variable, variables such as per capita income and educational expenditure by the government are also included in the econometric models to control the impact of the economic factors on the changes in the enrollment patterns (Bhakta 2014; Singh and Shastri 2020). The pandemic's economic repercussions have left many households struggling to make ends meet. As a result, they have been unable to pay school fees or afford the necessary technology and internet access required for online classes. Hence, the impact on the pandemic to different schools might be different. An interaction term of the type of the schools to the pandemic is included to capture this.

Three alternative models—pooled regression, fixed effects, and random effects—are estimated, and statistical tests like the Lagrange Multiplier (LM) test, Hausman test, and the restricted F-test are applied to choose the appropriate model for further analysis. The rejection of the null hypothesis of the restricted F-test suggests selection of the fixed effects model over the pooled regression model, whereas the Breusch and Pagan LM Test helps to determine the appropriate model between pooled regression and random effects. A rejection of the null hypothesis in the LM Test indicates selection of the random effects model over the pooled regression model. Finally, rejection of the null hypothesis in case of the Hausman test indicates choice of the fixed effects model over the random effects model. Following this procedure in the present study, the fixed effects model is finally selected for further analysis on the individual regression coefficients.

This chapter is based on secondary data at the state level and thus covers different geographical locations that have systematic differences in socioeconomic and demographic conditions. Further, in the federal structure of India, education is included in the concurrent list where both the central government and the state governments have power over the subjects. Accordingly, along with different central-level programs, there are several initiatives of the state governments toward improvement of educational outcomes. Such coexistence of initiatives of the central and the state governments can potentially result in systemic interstate variations in educational outcomes. It is expected that the fixed effects model will cover the heterogeneity in educational outcomes at the state level.

5.4 Results and Discussion

The summary statistics of the selected variables are given in Table 5.2. Total enrollment in schools is taken as the dependent variable in Model 1, whereas boys' enrollment and girls' enrollment are taken as independent variables in models 2 and 3, respectively. Tables 5.3 and 5.4 show the regression results of the estimated fixed effects models. The results show that all the estimated models are statistically significant. Further, the standard errors of the test statistics for the individual coefficients are corrected for heteroscedasticity by using the robust standard errors.

Table 5.2: Summary Statistics of Variables

Variable	Number of Observation	Mean	Standard Deviation	Minimum	Maximum
Independent Variables					
Pandemic	348	0.5	0.5	0	1
PTR	348	24.0	10.9	0	62.39
Electricity	348	0.25	0.23	0	0.85
Computer	348	0.14	0.15	0	0.84
Internet	348	0.08	0.10	0	0.67
PCNSDP	348	11.4	0.53	10.2	12.6
Edu/TE	348	0.15	0.02	0.07	0.23
Edu/GSDP	348	23.5	31.0	0.44	157.8
Aided school	348	0.16	0.37	0	1
Private school	348	0.16	0.37	0	1
Dependent Variables					
Enrollment	348	0.32	0.23	0	0.88
Boys' enrollment	348	0.32	0.22	0	0.87
Girls' enrollment	348	0.32	0.23	0	0.89

GSDP = gross state domestic product, PCNSDP = per capita net state domestic product, PTR = pupil–teacher ratio, TE = total expenditure.

Source: Authors' own estimation based on Unified District Information System for Education Plus (UDISE+) and Reserve Bank of India data.

Table 5.3: Regression Results for the Estimated Fixed Effects Model

	Model 1 Total Enrollment		Model 2 Boys' Enrollment		Model 3 Girls' Enrollment	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
Pandemic	0.009	2.37**	0.012	2.80**	0.006	1.78*
PTR	0.002	3.45**	0.002	3.47**	0.002	3.41**
Electricity	0.017	0.62	0.016	0.55	0.017	0.68
Computer	0.048	1.94**	0.050	1.87*	0.044	2.02**
Internet	0.058	1.39	0.066	1.42	0.049	1.36
PCNSDP	−0.03	−1.16	−0.03	−1.21	−0.02	−1.08
Edu/TE	0.004	0.06	0.002	0.03	0.003	0.05
Aided school	−0.009	−2.28**	−0.01	−2.68**	−0.006	−1.73*
Private school	−0.023	−4.50**	−0.02	−5.16**	−0.017	−3.59**
Constant	0.596	2.05**	0.640	1.98*	0.544	2.11**
R^2-Between	0.077		0.059		0.098	
R^2-Within	0.345		0.374		0.299	
R^2-Overall	0.077		0.060		0.097	
F-stat	7.46**		8.43**		6.31**	
Restricted F-test	376.46**		332.16**		438.34**	
LM test	409.45**		387.42**		431.06**	
Hausman test	201.87**		469.27**		116.43**	
Number of observations	348		348		348	

GSDP = gross state domestic product, PCNSDP = per capita net state domestic product, PTR = pupil–teacher ratio, TE = total expenditure.

Notes: *significant at 10%; **significant at 5%
Figures in parentheses indicate the corresponding significance level.
The test statistics for the individual coefficients are based on heteroscedasticity corrected robust standard errors to correct heteroscedasticity.

Source: Authors' own estimation based on based on Unified District Information System for Education Plus (UDISE+) and Reserve Bank of India data.

Table 5.4: Regression Results for the Estimated Fixed Effects Model

	Model 4 Total Enrollment		Model 5 Boys' Enrollment		Model 6 Girls' Enrollment	
Variables	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
Pandemic	0.010	2.92**	0.013	3.42**	0.007	2.23**
PTR	0.002	3.33**	0.002	3.33**	0.002	3.31**
Electricity	0.016	0.62	0.015	0.54	0.017	0.69
Computer	0.046	1.90*	0.048	1.83*	0.043	1.97*
Internet	0.051	1.35	0.058	1.38	0.044	1.33
Edu/GSDP	−0.058	−0.91	−0.061	−0.89	−0.053	−0.90
Aided school	−0.101	−2.57**	−0.012	−3.03**	−0.007	−1.94*
Private school	−0.024	−4.59**	−0.030	−5.24**	−0.017	−3.67**
Constant	0.257	13.48**	0.249	11.81**	0.265	15.71**
R^2-Between	0.103		0.081		0.126	
R^2-Within	0.341		0.370		0.296	
R^2-Overall	0.101		0.081		0.122	
F-stat	7.81**		8.86**		6.58**	
Restricted F-test	368.44**		324.66**		430.13**	
LM test	388.15**		367.72**		408.32**	
Hausman test	234.20**		638.78**		134.39**	
Number of observations	348		348		348	

GSDP = gross state domestic product, PTR = pupil–teacher ratio.

Notes: *significant at 10%; **significant at 5%
Figures in parentheses indicate the corresponding significance level.
The test statistics for the individual coefficients are based on heteroscedasticity corrected robust standard errors.

Source: Authors' own estimation based on Unified District Information System for Education Plus (UDISE+) and Reserve Bank of India data.

As regards the individual coefficients, the regression results are consistent across the models. It is found that the variables pandemic, pupil–teacher ratio, and functional computer have statistically significant and positive impacts on total enrollment, including that of both boys and girls. In comparison with government schools, both government-aided schools and private schools have experienced significant negative impacts of the pandemic on enrollment. However, variables such as electricity connection, access to internet, per capita net state domestic product, and share of educational expenditure in total expenditure or GSDP do not have any significant impact on enrollment as the respective coefficients are not significant.

The positive pupil–teacher ratio coefficient is not surprising. As enrollment grows, the pupil–teacher ratio will also increase, given the number of teachers does not increase proportionately. In the Indian context, the UDISE+ (2021) report shows that the number of teachers is not increasing proportionately to student enrollment; hence, such a positive association is obvious. However, this aspect requires deeper scrutiny through qualitative analysis as a higher pupil–teacher ratio is not beneficial for the students for better educational outcomes. This is so because a limited number of teachers in relation to the number of students cannot give adequate attention to all the students (Tiwari, Bhattacharjee, and Chakrabarti 2020), whereas a smaller student–teacher ratio can contribute to a better student experience, better engagement, and improved academic performance (Singh and Sarkar 2015). Hence, a higher student–teacher ratio may be reflected in higher enrollment, but may not necessarily ensure quality education.

It is also found that enrollment rates are significantly impacted by availability of functional computer facilities. However, the coefficient of internet facilities at school is not statistically significant. This is so possibly because 51% of Indian households do not have regular or adequate access to the internet (National Family Health Survey from International Institute for Population Sciences 2021). Since computers are tangibly present in schools, parents are more familiar with such facilities than the internet connections. This could be the reason why internet connection has no effect on enrollment.

The regression results indicate that school enrollment has improved, especially in the government schools during the post-pandemic period. This finding is in line with the latest ASER report (2022). The pandemic seems to have affected the school choice decisions of the parents and forced them to choose the less expensive government schools that provide all the necessities and requirements almost free of cost (UDISE+ 2021). While availability of basic infrastructure facilities and digital technology had led to the high enrollment rate in private schools before the pandemic (Nambissan 2012), the pandemic seems to have altered the enrollment patterns in favor of the government schools, where infrastructure facilities are not so developed as the private or the aided schools. This is possibly because of the lower educational expenses that the households need to bear at the government schools. The households, particularly those from economically disadvantaged backgrounds, faced significant challenges to their livelihoods as a result of the pandemic-induced economic slowdown making private schools unaffordable (Alvi and Gupta 2020).

The findings have special significance as the marginalized segments of Indian society exhibit limited or no ownership of ICT assets and lack the necessary skills to utilize them. As a result, the benefits of ICT accrue over time to already resourceful segments of society, whereas marginalized groups are not included enough in the technological integration practices. In India, around 21% of students in urban areas had access to a computer with internet as compared to their counterparts in rural areas (4%). As regards the social groups, only 4% of the Scheduled Tribe and 4% of the Scheduled Caste students have access to a computer with internet. In contrast, 7% of students from the Other Backward Classes and 21% from the “Others” caste group have access to a computer with internet facility (Oxfam India 2022). This poses a significant concern, particularly in light of the Indian government’s emphasis on ICT-driven development discourse over the past decade.

It is recognized that schools help to reduce the digital gap by providing access to technology and digital resources to the students who may not have the same available at home or in their communities otherwise (Kim, Yi, and Hong 2021). Furthermore, schools can also provide digital literacy training to assist students in developing the abilities necessary for effective technology usage and navigate the digital world (Roy 2012). The findings of the study, therefore, suggest an emphasis on development of digital infrastructure facilities at the government schools. This is crucial given the common notion that the socially and economically backward households, who are already underprivileged, choose the government schools because of their greater access and lower expenses (Härmä 2011). It may not be possible for such social and economic groups to have digital resources and connectivity available at the household level. The existing digital inequality is an indication of the same (Tewathia, Kamath, and Ilavarasan 2020). Hence, it is necessary to equip the government schools with necessary digital infrastructure, since more than half of the enrolled students rely on such schools for their education. Lack of digital facilities creates a digital divide, which further widens the socioeconomic inequality existing in the society. Along with this, the lack of digital skills among teachers also poses a critical challenge to the quality of digitalization.

The policies and other initiatives should therefore aim at bridging the digital divide and ensure that the students have greater access to these technologies and the associated resources at their respective schools. It is possible to facilitate access to educational technologies and resources by collaborating with the government(s), educational institutions, the private sector, and various development agencies. In particular, the corporate sector initiates various youth training programs as a part of companies’ corporate social responsibility (CSR), and the education sector accounts for the highest share of such CSR funds, followed by the health sector. Around 25% of the CSR funds in 2020/21 and 30% of the funds in the past 6 years were spent on education (Ministry of Corporate Affairs 2022). It can be further extended, and new opportunities can be created if a proper mechanism is in place that allows for more public–private partnerships in the area.

5.5 Summary and Conclusions

The digital divide is recognized as a significant factor contributing to socioeconomic inequality, particularly in terms of disparities in accessing and utilizing digital technology among various demographic and social groups. These disparities extend beyond income, education, age, and geographical location. The development of digital infrastructure in schools and equipping students with the required skills can play a crucial role in resolving this issue. Students who have access to digital devices and high-speed internet at school experience positive impacts on their academic achievements. In this connection, schools play a vital part of closing the technological divide by providing technology access and digital resources to students who may not have the same opportunities at home or within their communities. Additionally, schools can also offer digital literacy training to help students develop the skills required to effectively utilize technology and navigate the digital realm. In this context, the present study focuses on examining enrollment patterns in different types of schools across Indian states in the post-pandemic period and the role of digital infrastructure in facilitating access to education.

In terms of the individual coefficients, the regression results remain consistent across all the models. The study reveals that several factors, including the pandemic, pupil–teacher ratio, and the presence of functional computers, have statistically significant and positive impacts on total enrollment, as well as enrollment for both boys and girls. However, the interaction term of the pandemic with the aided and private schools demonstrates a significant negative impact on enrollment. On the other hand, variables such as electricity and internet connection, educational expenditure as a share of total expenditure, and GSDP and per capita net state domestic product do not show any significant associations with enrollment levels.

The findings of the study highlight the significance of giving priority to the development of digital infrastructure in government schools. This is particularly crucial considering that socially and economically disadvantaged households, who are already marginalized, often choose government schools because of their relatively higher accessibility and lower expenses. Such households may not have access to digital resources and connectivity at the household level, leading to existing digital inequalities. Given that more than half of the enrolled students rely on government schools for their education, it becomes necessary to equip these schools with the essential digital infrastructure. The lack of digital facilities contributes to the digital divide, exacerbating existing socioeconomic inequalities within society. Policies and initiatives should therefore focus on bridging this digital divide, ensuring that students have greater access to technology and the associated resources in their respective schools. Facilitating access to educational technologies and resources can be achieved through collaborative efforts involving governments, educational institutions, and private sector companies. The establishment of a robust mechanism enabling public–private partnerships can facilitate this coordinated collaboration.

However, the research conducted in this chapter offers insights at a broader level by analyzing data at the state level. It is important to note that within each state, there are significant variations in socioeconomic, cultural, and geographical characteristics. Therefore, a more detailed analysis at a disaggregated level is required to acquire a deeper comprehension of the dynamics and robust intervention strategies. In order to accomplish this, future research should focus on building a comprehensive and systematic primary database that captures both quantitative and qualitative information. In addition, the digital skills training of the teachers and the costs of digital connectivity are important aspects that affect the quality outcome of digitalization. Nevertheless, the study relies on secondary data at a broader and aggregate level (i.e., at the state level), whereas capturing the quality-related aspects would require detailed disaggregate level analysis using systematic data on training and skill development. Nonavailability of such systematic data prevents the present chapter from examining these aspects, and thus leaves a crucial area for future research.

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PART III

Digital Finance for Resilience and Prosperity

6

Mobile Money Mitigates the Negative Effects of Weather Shocks: Implications for Risk Sharing and Poverty Reduction in Bangladesh

Masanori Matsuura, Abu Hayat Md. Saiful Islam, and Salauddin Tauseef

6.1 Introduction

Frequent weather shocks stemming from global climate change are significant for rural and poor households. Floods deprive households' assets and agricultural production, resulting in a reduction of household income. Moreover, droughts substantially reduce crop yields, inducing food insecurity. For example, South Asian countries confront various climate risks such as extreme floods and cyclones with the idiosyncrasies of summer and monsoon rainfall having short- and long-term impacts on the lives of more than 1 billion people (Turner and Annamalai 2012). To cope with climate shocks, adaptive strategies are urgently needed. Existing literature points to the potential effectiveness of financial services, such as microfinance and weather index insurance, in response to the shocks (Barnett and Mahul 2007; Kono and Takahashi 2010).

Rural financial services challenge transaction costs that render markets for financial services costly or missing (Benami and Carter 2021). The emergence of digital technologies such as mobile phones and mobile or digital money recreate rural markets for savings, credit, and insurance services, especially in developing economies (Benami and Carter 2021). In recent years, mobile phones have been widely adopted in developing countries contributing to economic growth. Bangladesh has also experienced an expansion of mobile phone subscriptions (Matsuura, Islam, and Tauseef 2023). This in turn has led to the development of mobile money services enabling people to transfer, deposit, and withdraw money from an online account without having a bank account (Suri et al. 2023). Mobile money greatly reduces transaction costs, while enhancing the convenience, security, and time taken for transactions. (Suri et al. 2023). Since mobile money allows people to transfer and deposit money using short message services without access to the internet and overcomes the challenges of formal insurance, it is important that we examine how mobile money can help households smooth their consumption in Bangladesh where the number of mobile cellular subscriptions per 100 people was over 100 in 2020, but the ratio of individual internet users remained at only 25% in 2020 (Figure 6.1).

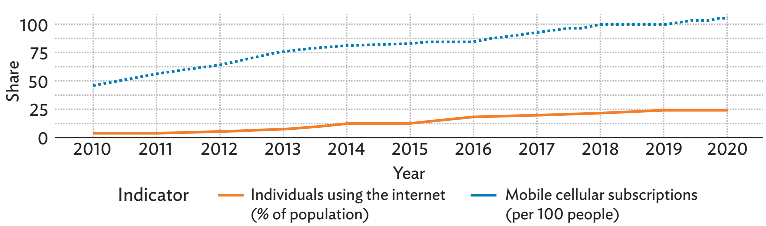
In this chapter, we look at three primary research questions: First, what is the relationship between mobile money adoption and a household's ability to smooth consumption in response to weather shocks? Second, are there heterogeneous effects between mobile money and consumption smoothing in response to weather shocks from the viewpoint of spatial inequality and poverty status? Bangladesh has one of the highest poverty rates among South Asian countries and is particularly prone to flooding (Islam, Newhouse, and Yanez-Pagans 2021). Given that poor households are especially vulnerable to weather shocks, this question is of particular interest. Third, what is the mechanism by which households can mitigate the negative impact of the weather shocks through the adoption of mobile money? To these ends, we utilize a recently collected longitudinal dataset on Bangladeshi households and combine with granular monthly precipitation data.

There is a rich body of literature looking at the relationship between mobile money and consumption smoothing in response to economic shocks. Jack and Suri (2014) and Riley (2018) find that mobile money has varied risk sharing by allowing users to send and receive remittances in cases of negative economic events to the household. Moreover, Tabetando and Matsumoto (2020), Ahmed and Cowan (2021), and Abiona and Koppensteiner (2022) find that mobile money users are able to sustain their investments in human capital beyond household consumption. The mechanism behind the use of mobile money for informal and formal insurance has also been well documented. Jack and Suri (2014), Riley (2018), and Tabetando and Matsumoto (2020) show that the fundamental mechanism is an increase in remittance receipts. In addition, the adoption of mobile money facilitates the receipt of social protection transfers that likely improves the resilience of these households (Aker et al. 2016; Abiona and Koppensteiner 2022).

The contribution of this chapter is threefold. First, we provide novel evidence that mobile money services enable geographically disadvantaged households to smooth their food consumption in response to droughts as well as their nonfood consumption in response to floods, combining a nationally representative household panel survey and historical precipitation grid data. It also indicates that the results have greater internal and external validity in the literature, especially for South Asian settings. Second, we show that relatively poorer households can smooth their consumption, the same as geographically disadvantaged households. Finally, we find that the likely mechanism that improves household resilience against economic shocks is through an increased likelihood of receiving remittances due to the adoption of mobile money.

The rest of the chapter is structured in the following manner. Section 6.2 describes the data source and key variables of interest. Section 6.3 presents the identification strategy and empirical specification used in the analysis. Section 6.4 discusses the empirical results, while Section 6.5 provides concluding remarks and policy implications.

Figure 6.1: Mobile Phone Subscription and Internet Users in Bangladesh



Source: Calculated by authors from theWorld Bank (2022).

6.2 Methodology

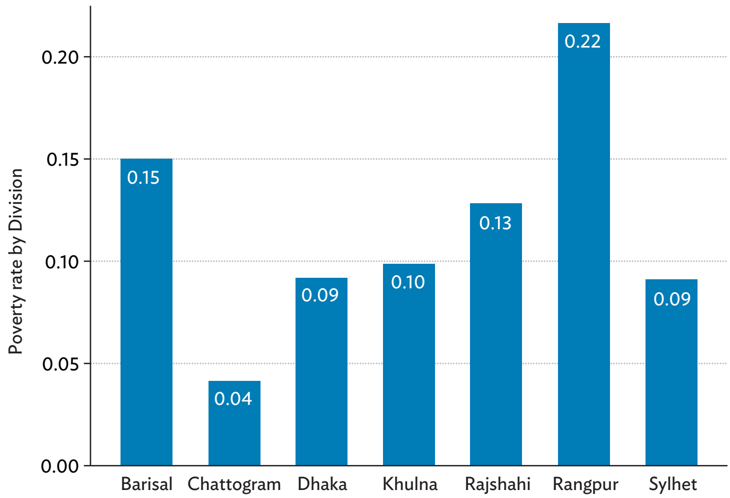
6.2.1 Data

We use data from the Bangladesh Integrated Household Survey (BIHS), which is a nationally representative rural household panel survey carried out by the International Food Policy Research Institute in 2015 and 2018–2019 (from here on 2019) in seven divisions. The sampling strategy of the BIHS followed a two-staged stratified sampling method. Following the sampling framework from the community series of the 2001 Population and Housing Census of Bangladesh, the first stage constituted a selection of primary sampling units or villages after which households were randomly selected for survey interview from each selected primary sampling unit in the second stage (Ahmed and Tauseef 2022). Although the BIHS has three rounds, we focus our analysis on this two-period panel. For our study, we use the balanced panel included in both survey rounds, resulting in 9,860 observations from 4,930 households as shown in Table 6.1. Figure 6.2 shows the poverty rate of seven divisions of Bangladesh. The poverty rate is found to be most severe in Rangpur Division compared to the rest of Bangladesh, which is consistent with studies by Khandker (2012) and Matsuura, Islam, and Tauseef (2023). Rajshahi and Sylhet divisions are situated in the northern part of Bangladesh and are historically more neglected and poor (Hossain et al. 2019; Agricultural Extension in South Asia 2018). Rural livelihoods in this region are heavily dependent on agriculture. In the following sections, we discuss how much mobile money mitigates the negative effect of weather shocks in poor sections of the country like Rangpur Division compared to the rest of Bangladesh.

On the other hand, to generate indicators of weather shocks, we use data collected by the Bangladesh Meteorology Department, which include monthly rainfall and temperature from March 1996 to February 2019 on a global grid using units of 0.5-degree latitude by 0.5-degree longitude. Due to the issues of data availability, we transformed the grid weather data into 64 district-level. Following Hossain et al. (2018), weather information is divided into two seasons: (i) rabi, from March to November; and (ii) kharif, from December to February. In this chapter, we use only data from the kharif season since the rainfall shock variable in the rabi season is not significantly associated with household welfare.[1]

1 The results are available on request.

Figure 6.2: Poverty Rate by Division



Source: Calculated by authors from BIHS 2015 and 2019.

6.2.2 Description of Key Variables

In this chapter, we define "shock" in two ways: (i) a rainfall shock and (ii) a self-reported shock. First, we define a rainfall shock as used in Makate et al. (2022):

$$Rainfall\ shock_{dt} = \frac{rain_{dt} - \overline{rain_d}}{\sigma_{rain_d}} \qquad (1)$$

where *Rainfall shock*$_{dt}$ is a rainfall shock measure for a cluster (district) (*d*), in the kharif season in the year (t), which is from March to November for the two main rice seasons, *Aus* and *Aman* (Matsuura, Luh, and Islam 2023). Moreover, *rain*$_{dt}$ is the observed precipitation for the defined season, $\overline{rain_d}$ is the average seasonal rainfall for the district (*d*) over the 20 years, and σ_{rain_d} is the standard deviation of rainfall during the same period.

On the other hand, we define self-reported shock as equal to 1 if households lose crops, livestock, production assets, or consumption assets due to flood or cyclone, and 0 otherwise.

Our main independent variable of interest is mobile money use. We consider a household to be a mobile money user if at least one member used a mobile money agency during a particular survey year. Mobile money users are captured through a dummy variable at the household level.

To measure household welfare, the per capita value of monthly food consumption and nonfood consumption are used. By decomposing the household consumption, we can distinguish how households smooth their food and nonfood consumption in response to shocks with mobile money adoption.

6.2.3 Descriptive Statistics

Table 6.1 shows the summary statistics for the analysis sample. The number of mobile money users increase from 506 in 2015 to 2,254 in 2019, which is nearly half of the sample in 2019. The per capita monthly food expenditure decreases over the survey period in both mobile money users and nonusers. Rainfall shock is negative overall indicating droughts, regardless of mobile money use. In 2015, about 2.2% of mobile money users and 2.8% of nonuser households self-report to losing crops, livestock, production assets, or consumption assets due to flood or cyclone in the survey year. However, the probability of self-reported weather shocks decreases in 2019.

As for socioeconomic variables to be controlled in the analysis, households headed by females are less likely to use mobile money services. The average years of schooling of household heads using mobile money was 5.23 years in 2015 but fell to 4.52 in 2019. One likely reason for this is the rapid expansion of mobile money services across the country that enabled even poorer and less educated segments of the population to avail of such services. We generate a wealth index of assets using principal component analysis since the value of assets owned was not collected in all the rounds of the BIHS. Various components of wealth, such as ownership of radios, televisions, telephones, computers, animal carts, bikes, motorbikes or fridges, and cars or trucks are used for the calculation.[2]

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[2] The datasets are available at https://www.ifpri.org/blog/ifpris-bangladesh-integrated-household-survey-bihs-second-round-dataset-now-available.

Table 6.1: Summary Statistics

	2015						2019					
	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD
Variables	MM User			Nonuser			MM user			Nonuser		
Per capita monthly food expenditure (Tk)	506	1,871.94	927.34	4,424	1,713.74	1,036.62	2,254	1,735.95	890.95	2,676	1,691.35	907.09
Per capita monthly nonfood expenditure (Tk)	506	1,784.94	1326.00	4,424	1,269.84	1,086.23	2,254	1,651.38	1,178.99	2,676	1,447.58	1,167.32
Rainfall shock	506	−1.71	1.03	4,424	−1.60	1.06	2,254	−1.66	1.36	2,676	−1.47	1.30
Self-reported shock	506	0.02	0.15	4,424	0.03	0.16	2,254	0.02	0.13	2,676	0.02	0.13
Temperature shock in kharif season	506	0.01	0.00	4,424	0.01	0.00	2,254	-0.00	0.00	2,676	-0.00	0.00
Temperature shock in rabi season	506	0.01	0.01	4,424	0.01	0.01	2,254	0.00	0.02	2,676	0.00	0.01
Domestic remittances (Tk)	506	9,676.63	31,879.29	4,424	3,477.74	15,848.32	2,254	9,855.80	43,777.77	2,676	6,101.96	22,944.88
Foreign remittances	506	2,981.59	27,037.80	4,424	946.84	11,724.94	2,254	6,204.21	33,721.53	2,676	4,660.32	72,604.28
Total household income (Tk)	506	2,766,445.9	281,891.7	4,424	181,344.60	218,739.50	2,254	296,410.3	536,127.1	2,676	192,815	199,381.4
Female household	506	0.15	0.36	4,424	0.18	0.39	2,254	0.19	0.39	2,676	0.22	0.41
Age of household	506	46.30	13.50	4,424	45.99	13.55	2,254	46.33	12.43	2,676	48.97	13.81
Household size	506	5.24	2.08	4,424	4.89	1.88	2,254	5.88	2.24	2,676	5.21	2.03
Years of education of household	506	5.23	4.46	4,424	3.25	3.83	2,254	4.52	4.25	2,676	2.83	3.65
Access to irrigation (%)	506	0.48	0.50	4,424	0.45	0.50	2,254	0.47	0.50	2,676	0.45	0.50
Wealth index	506	0.78	2.01	4,424	−0.56	1.86	2,254	0.71	1.88	2,676	−0.41	1.83

MM = mobile money, Obs = observation, SD = standard deviation.

Notes: Per capital monthly food and nonfood expenditure, the value of domestic and foreign remittances, and total household income are deflated to the real value of the taka in 2011. Wealth index is calculated by the principal component analysis of asset variables, following Vyas and Kumaranayake (2006). The asset variables include trunks, stoves, beds, electric fans, televisions, motorcycles, horses, cows, ducks, computers, printers, etc. The full list of asset variables is available from https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/BXSYEL

Source: Calculation by authors from BIHS (2015, 2019).

6.3 Empirical Methodology

In this section, we describe our empirical strategy to elicit (i) the impacts of mobile money on consumption smoothing by comparing the response of mobile money adopters and non-adopters to rainfall and self-reported shocks, (ii) the response of remittance receipts of mobile money adopter households to weather shocks, and (iii) the heterogeneous effect of mobile money adoption on consumption smoothing.

Mobile money is believed to enable households to send and receive money more easily due to the reduction of transaction costs. Therefore, we hypothesize that mobile money services allow households to do risk sharing even if they experience significant weather shocks adversely affecting their livelihood. The mechanism proposed in this study is remittances. Remittances allow family members to better smooth their consumption in the face of adverse shocks. In the empirical analysis, we look at whether the amount of remittance increases in response to weather shocks thanks to mobile money adoption. In the following subsections, we show how our hypothesis is tested by econometrics methods.

6.3.1 Empirical Specification

We follow the literature to set our regression specification to elicit the effect of shocks on consumption for households using or not using mobile money services (Jack and Suri 2014; Riley 2018). The econometric specification is as follows:

$$Y_{it} = \beta_1 + \beta_2 Shock_{it} + \beta_3 MM_{it} + \beta_4 MM_{it} \times Shock_{it} + \beta_5 X_{it} + \eta_i + \omega_t \times \gamma_d + \epsilon_{\mathrm{it}} \quad (2)$$

where Y_{it} is the outcome variable which is per capita food/nonfood expenditure, MM_{it} is mobile money adoption at the household level and $MM_{it} \times Shock_{it}$ is the interaction term between mobile money and the shock variables, X_{it} is the vector of household characteristics, η_i, ω_t, and γ_d are household, year, and division fixed effect, respectively, and ϵ_{it} is an error term. In the specification, β_4 is the coefficient of interest in our model.

Using the strategy, we can also test the mechanisms where mobile money smooths risk sharing—in particular, the role of remittances, by estimating the following model:

$$r_{it} = \gamma_1 + \gamma_2 Shock_{it} + \gamma_3 MM_{it} + \gamma_4 MM_{it} \times Shock_{it} + \gamma_5 X_{it} + \eta_i + \omega_t \times \gamma_d + \mathrm{e_{it}} \quad (3)$$

where r_{it} is the total value of remittance by mobile money at the household level and $MM_{it} \times Shock_{it}$ is the interaction term between mobile money and the shock variables, e_{it} is an error term, and γ_4 is the coefficient of interest in our model.

6.3.2 Identification Strategy

In this subsection, we discuss the identifying assumptions behind Equations (2) and (3). There are self-selection problems associated with the adoption of mobile money that could bias our estimates. Our estimates would be biased if a household's selection of the use of mobile money is correlated with unobservable factors that also impact their capacity to deal with shocks, creating a pseudo positive association between mobile money adoption and shock smoothing. Given the conditions, the fixed effects (FE) estimator is a more suitable choice because it controls time-invariant unobserved characteristics (Cameron and Trivedi 2005). However, time-variant unobserved characteristics are not addressed by the FE estimator. To overcome this issue, we use an instrumental variable (IV) approach. For our research question, the IV approach is supposed to affect the decisions on mobile money adoption but not the outcome variables (per capita food and nonfood consumption expenditure).

Motivated by social learning among rural households (Zheng, Zhou, and Rahut 2022; Ma and Abudulai 2020), we calculate the share of mobile money users to the number of respondents in a union (the smallest administrative unit in Bangladesh) (except for sampled households) as the IV approach. Empirically, we conducted a falsification test to verify the appropriateness of the created IV (Di Falco, Veronesi, and Yesuf 2011; Zheng, Zhou, and Rahut 2022). The results, presented in Table A6.1, suggests that the IV does not have a significant relationship with household welfare of the nonusers.

Moreover, to account for observed characteristics that could be associated with both mobile money use as well as facilitate a household to smooth consumption in response to an aggregate shock (Riley 2018), we propose an additional empirical strategy. It extends equations (2) and (3) to include the interaction terms of the shock with all observable explanatory variables ($X_{it} \times Shock_{it}$) using the following model:

$$\begin{aligned} Y_{it} = \alpha_1 + \alpha_2 Shock_{it} + \alpha_3 MM_{it} + \alpha_4 MM_{it} \times Shock_{it} \\ + \alpha_5 X_{it} + \alpha_6 X_{it} \times Shock_{it} \\ + \eta_i + \omega_t \times \gamma_d + \mu_{it} \end{aligned} \tag{3}$$

$$r_{it} = \theta_1 + \theta_2 Shock_{it} + \theta_3 MM_{it} + \theta_4 MM_{it} \times Shock_{it} + \theta_5 X_{it} + \theta_6 X_{it} \times Shock_{it} + \omega_t \times \gamma_d + \psi_{it} \quad (4)$$

where X_{it} are the same set of controls described above. μ_{it} and ψ_{it} are error terms, respectively. By accounting for the interaction terms between the shocks and household characteristics, we reduce some of the concerns around the interpretation of α_4 and θ_4, as proposed by Jack and Suri (2014). Equations (4) and (5) represent our preferred specification throughout the article. Because the remittance variable is truncated in zero, Equation (5) is an IV-tobit regression model, while Equation (4) is estimated by two-stage least squares (2SLS). Hence, we are interested in α_4 in Equation (4) and θ_4 in Equation (5), and interpret and discuss them in the result section.

Table 6.2: Correlates of Self-Reported Shock

	(1) Self-reported shock
Mobile money user	–0.006
	(0.005)
Share of households adopting mobile money in the union	–0.001
	(0.016)
Female household head	–0.007
	(0.008)
Age of household	–0.000
	(0.000)
Household size	0.003
	(0.003)
Schooling year of household	–0.003
	(0.002)
Market access (minute)	–0.000
	(0.000)
Asset index	0.000
	(0.002)
DivisionYear FE	Yes
Observations	9,860

FE –fixed effect.

Note: Robust standard errors in parentheses. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level. Estimated by ordinary least squares.

Source: Calculated by authors.

For Equations (4) and (5) to identify the causal effect of mobile money on risks sharing, we have to assume that the interaction of $MM_{it} \times Shock_{it}$ is exogenous, or uncorrelated with the error ϵ_{it}, conditional on the household FE and the other control variables. Especially for a self-reported shock as "shock", it may be systematically correlated with a number of household-level variables. We test this by running an FE regression for different household characteristics for the self-reported shock and present the results in Table 6.2. We find that self-reported shock is not correlated with other household characteristics, nor with the instrumental variable or mobile money adoption (Table 6.2).

6.4 Results and Discussions

6.4.1 Empirical Results

Table 6.3 shows the result of our base specification from Equation (2). All regressions include the full sets of household characteristics from Table 6.1. Panel A in Table 6.3 presents the regression results of two-way fixed effect model without IV as robustness check of the results, whereas Panel B in Table 6.3 shows the regression results of the IV–FE model. From Columns (1) to (8) in Panel B, coefficients of interaction terms are what we are most interested in, which are in equation (3) and in equation (4).

In Panel A, the shock variables are negatively associated with per capita nonfood expenditure in Column (4). It indicates that a one standard deviation positive rainfall shock (indicating a flood) raises the likelihood of a fall in per capita monthly nonfood consumption expenditure by 7.2 percentage points. Moreover, the interaction terms between the mobile money user and shocks are positively and statistically significantly associated with per capita monthly nonfood expenditure, while they are positively but statistically insignificantly associated with per capita monthly food expenditure, regardless of the type of shock. However, the positive and statistically significant sign on the interaction terms indicate that mobile money use serves as informal insurance to mobile money adopter households against rainfall shocks as seen in Columns (4) and (8).

In Panel B, the trends of signs on the coefficients are similar to the results of Panel A. Results from the full specification are reported in Columns (3), (4), (7), and (8). In Column (3), the coefficient of the interaction term is negative and significant. It indicates that mobile money users seem to be able to smooth a large part of positive rainfall shocks, indicating droughts in the kharif season, on per capita food consumption. Moreover, the rainfall shock in the kharif season decreases the per capita nonfood expenditure, while the self-reported shock is not statistically significantly correlated with household welfare. Thus, only rainfall shocks are used in following heterogeneity analysis. In addition, the interaction term between the mobile money user and the rainfall shock is positively and statistically significantly associated with per capita monthly nonfood expenditure in Column (4). The magnitude of the coefficient of the interaction term is 0.120 while the magnitude of the coefficient of the rainfall shock is –0.098. It thus seems that mobile money adoption overcompensates for the negative effect of rainfall shocks. These results are consistent with past studies by Jack and Suri (2014), Riley (2018), Tabetando and Matsumoto (2020), and Abiona and Koppensteiner (2022).

Furthermore, in Table 6.4 we explore the effect using different subsamples. In Panel A, the sample is divided into two groups which are households in Sylhet, Rangpur, and Rajshahi divisions and households in other divisions. The three divisions are relatively far from Dhaka, the capital of Bangladesh. Moreover, Rangpur Division has the highest poverty rate among all the divisions in Bangladesh as seen in Figure 6.2. Sylhet and Rajshahi divisions have the lowest values in the Human Development Index (Global Data Lab 2019). Therefore, we test whether mobile money adoption has any heterogeneous effect between less developed areas and more urbanized areas, in terms of economic activity. In Columns (1) and (2), we show the results. The coefficient of rainfall shock is positively associated with per capita monthly food consumption. It indicates that rainfall below the historical average rainfall (indicating a drought) decreases per capita monthly food expenditure. The plausible explanation is the nature of income sources in those areas. In the three divisions including Rangpur, the agrarian sector is dominant compared to the rest of Bangladesh including Dhaka (Khandker 2012). Their livelihoods rely heavily on crop production. Therefore, drought would significantly affect crop yields, leading to a fall in farm income and, therefore, reduces food consumption expenditure. Thus, the coefficient of the interaction term in Column (1) is negative and statistically significant. It indicates that mobile money adoption overcompensates for the negative effect of drought in Sylhet, Rangpur, and Rajshahi divisions. Another plausible explanation is that geographically disadvantaged areas usually have poorer logistics and market access compared to areas near Dhaka. Therefore, nonfood goods may not be conveyed from urban areas to the disadvantaged areas. As a result, the coefficient of the interaction term in Column (2) is statistically insignificant, indicating that households using mobile money are not able to make their nonfood consumption stable in response to the rainfall shocks. In line with Table 6.3, Column (4) shows the positive coefficient of the interaction term and negative coefficient of rainfall shock. The plausible reason is that those that live near Dhaka have better logistics, then mobile money can be used for transactions of purchasing nonfood products. It implies that mobile money works differently as insurance for consumption smoothing insurance depending on the geographical factors. This is an encouraging result that mobile money has a pro-poor effect and can be promoted in the geographically disadvantaged areas to reduce disparity amongst regions.

In Panel B, the sample is divided into four subsamples by consumption quota. They are below or above per capita expenditure in 2015. The result in Column (1) shows that the coefficient of the rainfall shock is statistically significant and 0.67, and the coefficient of the interaction term is statistically significant and −0.158. The result suggests that mobile money adoption overcompensates the negative impact of deficient rainfall indicating droughts on food consumption for the poorer households. Moreover, we find significant mitigating effects of mobile money on nonfood consumption for the poorer households in Column (2). The logic behind the effects of mobile money is that poor households' livelihood is more likely to rely predominantly on agriculture, which is highly susceptible to rainfall shocks, especially droughts. Thus, droughts devastate crop yields more than floods do, inducing a more severe effect on food insecurity. This is consistent with Jack and Suri (2014); Tabetando and Matsumoto (2020) and a welcome finding from rural development perspective. From Column (3) and (4), the results for households above median per capita expenditure are presented. While the coefficients in Column (3) are statistically insignificant, the coefficient of rainfall shock is significant and −0.098 and the coefficient of the interaction term is significant and 0.093 in Column (4). It indicates that mobile money adoption mitigates the negative effects of excessive rainfall on nonfood expenditure. The richer households are more likely to have alternative instruments rather than mobile money to smooth their food consumption in response to the rainfall shocks. Thus, mobile money is found to have opposite effects on household welfare for poorer and richer households. In Panel C, we also separate the sample into two subsamples, with respect to household income. We find that the results are consistent with the results of Panel B. The result implies that digital connectivity of poor households builds their resilience to weather shocks under climate change.

Table 6.3: Impact of Rainfall Shocks on Consumption for Mobile Money Users and Nonusers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS							
	Rainfall				Self-reported			
Panel A	Per capita food expenditure	Per capita nonfood expenditure	Per capita food expenditure	Per capita nonfood expenditure	Per capita food expenditure	Per capita nonfood expenditure	Per capita food expenditure	Per capita nonfood expenditure
MM user	−0.015	0.042**	−0.022	0.040*	−0.020	0.005	−0.019	0.005
	(0.019)	(0.020)	(0.020)	(0.020)	(0.013)	(0.014)	(0.013)	(0.014)
Interaction	0.001	0.018*	−0.004	0.017*	0.088	0.193**	0.110	0.152*
	(0.009)	(0.009)	(0.009)	(0.010)	(0.078)	(0.077)	(0.084)	(0.087)
Shock	−0.019***	−0.064***	0.003	−0.072***	−0.042	−0.068	−0.073	−0.102
	(0.007)	(0.007)	(0.026)	(0.027)	(0.043)	(0.041)	(0.176)	(0.187)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DivisionYear FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interaction with shock	No	No	Yes	Yes	No	No	Yes	Yes
Observation	9,860	9,860	9,860	9,860	9,860	9,860	9,860	9,860

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Table 6.3 *continued*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2SLS							
	Rainfall				Self-reported			
Panel B	**Per capita food expenditure**	**Per capita nonfood expenditure**	**Per capita food expenditure**	**Per capita nonfood expenditure**	**Per capita food expenditure**	**Per capita nonfood expenditure**	**Per capita food expenditure**	**Per capita nonfood expenditure**
MM user	−0.073	0.290***	−0.090	0.302***	−0.000	0.006	0.001	0.009
	(0.103)	(0.109)	(0.105)	(0.112)	(0.084)	(0.084)	(0.084)	(0.084)
Interaction	−0.050*	0.113***	−0.061*	0.120***	0.018	0.322*	0.060	0.279
	(0.029)	(0.030)	(0.032)	(0.033)	(0.184)	(0.178)	(0.212)	(0.218)
Shock	−0.003	−0.095***	0.014	−0.098***	−0.026	−0.096*	−0.057	−0.120
	(0.011)	(0.012)	(0.027)	(0.029)	(0.052)	(0.056)	(0.179)	(0.197)
Household FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DivisionYear FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interaction with shock	No	No	Yes	Yes	No	No	Yes	Yes
Observations	9,860	9,860	9,860	9,860	9,860	9,860	9,860	9,860

FE =fixed effect, MM = mobile money, OLS = ordinary least squares, 2SLS = two-staged least squares.

Notes: Robust standard errors clustered by households in parentheses. Outcome variables are converted into logarithms. ***Significant at the 1% level. * Significant at the 5% level. *Significant at the 10% level. Cragg-Donald Wald F Statistic for the instrumented variables is 69.846. Thus, it rejects the null hypothesis of weak instruments. The interaction term between the mobile money user and shocks is instrumented by the interaction term between share of mobile money users and the shocks, which is exogenous in our model. The first stage for 2SLS and the full table of the outcome equations are available on request.

Source: Calculated by authors.

Table 6.4: Heterogeneous Effects of the Impact of Rainfall Shocks on Consumption for Mobile Money Users and Nonusers

	(1)	(2)	(3)	(4)
	Sylhet, Rangpur, and Rajshahi		Rest of Bangladesh	
Panel A	**Per capita food expenditure**	**Per capita nonfood expenditure**	**Per capita food expenditure**	**Per capita nonfood expenditure**
Mobile money user	−0.679**	0.044	0.017	0.313**
	(0.279)	(0.249)	(0.118)	(0.129)
Interaction	−0.303***	-0.001	−0.014	0.165***
	(0.065)	(0.056)	(0.044)	(0.045)
Rainfall shock	0.169***	−0.053	−0.038	−0.127***
	(0.061)	(0.050)	(0.034)	(0.038)
Household FE	Yes	Yes	Yes	Yes
DivisionYear	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes
Interaction with shock	Yes	Yes	Yes	Yes
Observations	3,382	3,382	6,476	6,476
	(1)	**(2)**	**(3)**	**(4)**
	Below median per capita expenditure in 2015		**Above median per capita expenditure in 2015**	
Panel B	**Per capita food expenditure**	**Per capita nonfood expenditure**	**Per capita food expenditure**	**Per capita nonfood expenditure**
Mobile money user	-0.194	0.421***	0.155	0.332**
	(0.135)	(0.146)	(0.157)	(0.165)
Interaction	−0.158***	0.083*	−0.039	0.093*
	(0.045)	(0.044)	(0.049)	(0.050)
Rainfall shock	0.067*	−0.055	−0.025	−0.098**
	(0.038)	(0.038)	(0.040)	(0.045)
Household FE	Yes	Yes	Yes	Yes
DivisionYear	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes
Interaction with shock	Yes	Yes	Yes	Yes
Observations	4,930	4,930	4,928	4,928

continued on next page

Table 6.4 *continued*

	(1)	(2)	(3)	(4)
	below median household income in 2015		above median household income in 2015	
Panel C	Per capita food expenditure	Per capita nonfood expenditure	Per capita food expenditure	Per capita nonfood expenditure
Mobile money user	-0.087	0.508**	-0.107	0.182
	(0.203)	(0.226)	(0.121)	(0.127)
Interaction	-0.097*	0.151**	-0.036	0.107**
	(0.059)	(0.063)	(0.039)	(0.043)
Rainfall shock	0.027	-0.115**	-0.000	-0.086**
	(0.047)	(0.049)	(0.033)	(0.038)
Household FE	Yes	Yes	Yes	Yes
DivisionYear	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes
Interaction with shock	Yes	Yes	Yes	Yes
Observations	4,936	4,936	4,922	4,922

FE = fixed effect.

Notes: All columns are estimated by 2SLS. Robust standard errors clustered by households in parentheses. Outcome variables are converted into logarithm. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level. The interaction term between mobile money user and shocks is instrumented by the interaction term between share of mobile money users and the shocks, which is exogenous in our model. The full regression table is available on request.

Source: Calculated by authors.

6.4.2 Mechanism: Mobile Money and Remitting Network

The plausible mechanism presented in this chapter is that mobile money improves household resilience by facilitating easier flow of remittances from friends, relatives, and family in other locations responding to a rainfall shock and, thus, enabling households to smooth consumption. We show this with estimates from Equation (5) that are reported in Table 6.5. While the interaction term is statistically insignificant in Column (1), the coefficients of both the interaction term and the rainfall shock are statistically significant in Column (2). It indicates that households using mobile money services are more likely to receive foreign remittance in larger amounts through mobile money in response to the rainfall shock, compared to nonuser households. Similar to Tabetando and Matsumoto

(2020), it therefore seems that mobile money use is leading households to engage in an informal insurance structure where households transfer and share resources particularly in the event of a negative shock.

The result is also consistent with Jack and Suri (2014), Suri and Jack (2016), Riley (2018), Tabetando and Matsumoto (2020), and Batista and Vicente (2020). In addition, we add to the literature by distinguishing the effect of domestic versus international remittances using mobile money by noting that international remittances are a much larger source of resilience for households in the face of shocks compared to domestic remittances. It therefore can be assumed that the adoption of mobile money technology is encouraging international remittance flows by reducing the transaction costs associated with this channel. As a result, our findings emphasize the importance of remittances from overseas out-migrants and calls for facilitating cross-border labor migration and ease of regulations encouraging free flow of transfers into the country.

Table 6.5: Mechanism for Mobile Money Remittances

	(1) Value of domestic remittances (deflated)	(2) Value of foreign remittances (deflated)
Mobile money user	3.7e+04	-6.6e+03
	(2.5e+04)	(1.1e+05)
Interaction	−3.2e+03	8.5e+04**
	(7925.436)	(3.9e+04)
Rainfall shock	−2.4e+03	−3.1e+04
	(6,309.794)	(3.2e+04)
Division x Year	Yes	Yes
Control variables	Yes	Yes
Interaction with shock	Yes	Yes
Observations	9,860	9,860

Notes: Robust standard errors clustered by households in parentheses. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level. The interaction term between mobile money user and shocks is instrumented by the interaction term between share of mobile money users and the shocks, which is exogenous in our model. Full regression table is available upon requests.

Source: Calculated by authors.

6.5 Conclusion and Policy Implications

Poor households are more vulnerable to negative economic shocks since they are likely to fail to smooth their consumption in response to shocks such as rainfall. Bangladesh is extremely prone to floods every year and the climate risk is rising due to global climate change. Since we need easier and more accessible adaptation strategies against such shocks, mobile money services can be a preferred and suitable option. It is a novel and rapidly-growing technology that can help households insure their welfare against climatic shocks by giving access to remittances from other locations not affected by shocks (Riley 2018). In this chapter, we provide new and applicable evidence on the consequences of mobile money adoption on household welfare in the context of South Asian countries.

To this end, we use a nationally representative household panel data set from Bangladesh and a monthly granular precipitation dataset collected by the Bangladesh Meteorology Department. Combining the two datasets enable us to estimate the role of mobile money technology on consumption smoothing in response to objective and subjective shocks.

Our results show that large rainfall shocks negatively affect food and nonfood consumption, but the adoption of mobile money can provide much needed resilience to households in mitigating this impact by allowing the easier flow of remittances, especially from foreign countries. However, we do not find that self-reported shocks affect household consumption, and that mobile money mitigates the effect of such self-reported shocks. We find significant heterogeneity in our results, with respect to geography and welfare distribution. We find geographically disadvantaged divisions benefit more from mobile money technology by mitigating the negative effects of droughts on food consumption. Moreover, regarding food consumption, mobile money works as an informal insurance against droughts for the poorer households. It indicates that poorer households' livelihoods and food consumption are more likely to rely on their own agricultural production that is more vulnerable to droughts. However, mobile money enables both poorer and richer households affected by floods to smooth their nonfood consumption. We determine the mechanism, where mobile money enables risk sharing, by increase in remittances received after the rainfall shock, possibly due to a reduction in transaction costs. We also find evidence that households owning mobile money are more likely to receive overseas remittances in response to the rainfall shocks rather than domestic remittances.

Our findings shed light on the importance of mobile money services as informal insurance and risk sharing, given the incidence of extreme climate events related to climate change. Governments and stakeholders should promote the expansion of mobile money services so that rural households can cheaply, quickly, and safely avail an option to cope with future weather shocks. Moreover, mobile money services may help overcome spatial inequality by bringing forth a pro-poor effect. The diffusion of mobile money would help poor households, whose livelihoods mainly depend on agriculture, smooth their food consumption, and share their risks by overseas remittances. This is particularly important in the context of Bangladesh, where many vulnerable rural households confront weather shocks.

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Appendix

Table A6.1: Test of Validity of the Selection Instruments

	(1) Per capita food expenditure	(2) Per capita nonfood expenditure
Share of households adopting mobile money in the union	0.029 (0.064)	−0.001 (0.062)
Household FE	Yes	Yes
Division Year	Yes	Yes
Control variables	Yes	Yes
Observations	5,032	5,032

FE = fixed effect.

Notes: Robust standard errors clustered by households in parentheses. Outcome variables are converted into a logarithm. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level.

Source: Authors.

7

The Rise of Digital Finance and the Development of the Express Delivery Industry in the People's Republic of China

Pinghan Liang and Wei Zou

7.1 Introduction

The People's Republic of China (PRC) is the world's largest online retail market, and the rapid development of online retail has brought prosperity to the express delivery industry. In 2021, the business volume of the PRC's express delivery service companies reached 108.3 billion parcels, ranking first in the world for consecutive years, with a business revenue of CNY1.0332 trillion, becoming an important part of the modern logistics system and national economy. The tremendous growth of the express delivery industry is closely linked to the flourishing development of e-commerce. Recent studies have found a significant impact of e-commerce development on rural household consumption (Couture et al. 2021). E-commerce is undoubtedly driven by large digital platforms, but its widespread penetration into daily life relies on the operation of end-point infrastructure such as express delivery points. So, how does the development of the digital economy affect the development of express delivery services?

This study examines the impact of digital financial development on the establishment of express delivery points based on the expansion of digital inclusive finance. The study collects data on the address of express delivery points throughout the PRC from 2011 to 2019 using the Baidu Map Point of Information (POI) application and the registration database of industrial and commercial enterprises. Private express delivery services in the PRC started in the 1990s to serve exports, and were initially set up in coastal cities such as Hangzhou, Shanghai, and

Ningbo to handle customs declarations for export. With the introduction of the franchise system in the express delivery industry, delivery points began to expand across the country, especially with the rapid development of e-commerce platforms such as Taobao, JD, and T-mall, as well as the innovation of mobile payment technology, an important feature of digital finance in the PRC.

The empirical analysis utilizes the widely used digital financial index developed by the joint work of the Ant Group and Peking University. It found that between 2011 and 2019, digital financial development significantly increases the number of express delivery points. On average, for every 10 percentage points increase in the digital financial index, the total number of express delivery points increases by 3.16 percentage points, and the number of newly established express delivery points in that year increases by 3.81 percentage points. The study also examines the impact of different subindexes of digital financial development, including financial coverage breadth and depth, and digital service convenience, on the development of express delivery outlets, and finds that financial coverage breadth and depth have significant positive effects. To overcome the influence of unobservable time-variant omitted variables, this study constructs a novel instrumental variable (IV) for city-level digital financial development. We exploit the promotion of Alipay's Red Envelope function in 2016, which significantly extends the penetration of Alipay across the country, and construct an IV using a difference-in-difference approach. The instrumental variable estimation results show that the development of digital finance significantly increases the number of express delivery points. Heterogeneity analysis shows that digital finance development mainly promotes the growth of express delivery points in areas with higher education levels, better internet access, and road infrastructure. The effect concentrates in the eastern provinces. Finally, the study further explores the channels through which digital finance influences. First, the development of digital finance attracts investment from e-commerce companies to participate in the logistics industry, thereby improving logistics delivery efficiency and the supply of delivery points. Second, digital finance helps activate social consumption potential, especially in the prosperity and rise of online consumption activities, which drove the development of express delivery outlets on the demand side. Finally, digital financial development expanded financing channels, alleviating financing constraints for establishing express delivery outlets, and promoting the establishment of outlets on the supply side. This was more pronounced in regions where access to existing financial resources was lower and more favorable for the increase of small and medium-sized express delivery enterprise outlets.

This chapter contributes three aspects of digital finance. First, it contributes to the understanding of the impact of digital finance on infrastructure, providing a new perspective for understanding the coordinated development between e-commerce and offline infrastructure. This offers new insights for further improving the construction of new infrastructure, leveraging the synergies between different areas of infrastructure, and achieving high-quality development, which has practical guidance for adjusting the PRC's digital economy policies. Second, this chapter contributes to the study of factors affecting infrastructure construction. Previous research has mainly focused on analyzing the influence of government behavior in the PRC, such as benchmark competition (Zhang et al. 2007), central–local relations (Ma 2022), and promotion incentives (Wu and Zhou 2018) on infrastructure investment and construction. This study shows that market-oriented digital finance development driven by private enterprises also affects the expansion of express delivery points, thereby contributing to understanding the driving force and effectiveness of the PRC's infrastructure development from a market perspective. Third, the PRC's express delivery industry has been ranked first in the world in terms of scale for several consecutive years, with service revenue exceeding CNY1 trillion, becoming an important element in the PRC's developed logistics system. However, research on this industry is scarce (Wang, Lin, and Qiu 2022), and research on the driving force and influencing factors of its rapid development is even more scarce. This chapter investigates the role of digital finance development on the expansion of the express delivery industry, providing theoretical support for understanding the development trends and patterns of the express delivery industry, and further building an efficient and smooth circulation system to reduce logistics costs.

The remaining sections of this chapter are arranged as follows. Section 7.2 introduces the institutional background and a literature review. Section 7.3 mainly describes the descriptive statistics of data, identification strategy, and variables. Section 7.4 reports the main effect estimation results, Section 7.5 further discusses the mechanism that coordinates the development of digital finance and express delivery industry, and Section 7.6 concludes.

7.2 Background and Literature

7.2.1 Institutional Background

To revitalize the rural economy, the PRC's central government proposed the logistics development policy of "revitalizing commodity circulation, breaking the urban–rural divide and regional blockades, and expanding circulation channels" in 1983, which broke the nationalized monopoly system of postal industry that had lasted for more than 30 years. Thanks to the loosening of state control over the postal industry, the PRC's first private express delivery company, Shentong Express, was established in Hangzhou in 1992, mainly providing customs declaration services for export enterprises. In 1995, express delivery companies began to adopt a franchising system within the industry, that is, "point-to-point contracting for households". The person in charge of the delivery point only needs to pay a certain deposit in advance to the company, and contract for the delivery service of goods within a specific area. This franchising strategy helped leading express delivery companies to quickly expand and seize the PRC's mailing logistics market (among them, the total market share of "STO, ZTO, YTO, and SF" reached more than 60% (The Paper 2021).

The rapid expansion of the express delivery industry has benefited from the development of digital finance. The digital finance apps, such as WeChat Pay and Alipay, have greatly improved the accessibility and convenience of financial services, thereby driving the trend of mass online shopping. During the "Double Eleven" period in 2021 (1 November to 11 November, similar to "Black Friday" in the United States), China UnionPay processed 27.048 billion transactions, with a total amount of CNY22.32 trillion, and the highest business peak of 965,000 transactions per second. This huge amount of online transactions generated 6.8 billion express delivery packages. It can be seen that because digital finance has a wider reach, most residents with mobile phones or access to the internet can enjoy the convenience brought by digital finance. This greatly promotes the prosperity of online shopping, and increases the quantity of goods transportation significantly. This has brought a steady stream of orders to the express delivery industry, ultimately promoting its rapid development.

7.2.2 Literature Review

Express delivery points in effect is a kind of end-point infrastructure. A large body of literature investigates the determinants of infrastructure construction. It is widely acknowledged that infrastructure plays a key role in economic growth (Démurger 2001; Esfahani and Ramirez 2003; Faber 2014; Storeygard 2016; Donaldson 2018; Banerjee, Duflo, and Qian 2020; Baum-Snow et al. 2020). The existing research in the PRC focuses on the role of official promotion incentives in infrastructure. The study by Zhang et al. (2007) shows that the yardstick competition among local governments is an important factor underlying infrastructure investment. Wang, Zhang, and Zhou (2020) demonstrate the importance of official promotion incentives in urban infrastructure construction. However, the role of the emerging digital finance in infrastructure construction is ignored.

An emerging body of literature addresses the economic impacts of digital finance. Previous studies on mobile payment use in the broader field of digital finance have extensively examined the relevant stakeholders such as consumers and merchants (Au and Kauffman 2008; Kim, Mirusmonov, and Lee 2010; Ozcan and Santos 2015; Shaw 2014; Shin 2009). The PRC has been at the forefront of the development of digital finance due to the pervasive use of online trading platforms and an underdeveloped banking system that excludes large segments of the rural population from traditional bank credit (Hau et al. 2019). Zhang et al. (2020a, 2020b, 2020c), Hau et al. (2021), Yang and Zhang (2022) demonstrate the impact of digital finance on household consumption, inequality, entrepreneurship growth, and financial inclusion. Furthermore, digital finance also has social benefits such as reducing the crime rate (Jiang and Liang 2022). However, although it is well known that the rapid development of e-commerce in the PRC relies on digital finance and express delivery industry, the causal impact of digital finance on express delivery industry is still missing.

Digital finance can promote express delivery industry from the supply side and demand side. First, the development of digital finance increases household consumption since it facilitates payment and reduces the time spent on purchasing (Yang and Zhang 2022). The expansion of consumption creates demand for entrepreneurship growth. Hence, digital finance increases household consumption, and requires more express delivery points to satisfy household demand.

Second, the development of digital finance could relax financial constraints of entrepreneurship, consequently improving the supply of express delivery points. As we described before, the expansion of the express delivery industry is mainly through franchising. Therefore, the starting of new delivery points is affected by the financial constraints of firms and the delivery point managers. There is evidence that the development of digital finance could reduce the household barrier to financial services, make finance inclusive, and relax the financial constraints for entrepreneurship growth (Hau et al. 2021).

7.3 Data Source and Empirical Design

7.3.1 Data

The data on express delivery points are scraped from the Baidu POI (https://map.baidu.com/). These data cover the name, starting time, address, name of manager, and contact method of every express delivery point. To complement these data, we also use the registration data of industrial and commercial enterprises, which covers the registration information of all enterprises in the PRC.[1] We aggregate the starting time and address of delivery points into a city-year panel.

The core explanatory variable is the digital finance index developed by the joint effort of the Ant Finance Group and Peking University (Guo et al. 2020). The fundamental data are from the universe of transaction information in Alipay, a leading mobile payment platform in the PRC. This index covers the city-level development of digital finance, and includes three subindexes: coverage, depth, and service support. Coverage measures the number of Alipay accounts and the tied bank accounts. Depth measures the extent that Alipay users engage in investment, loans, insurance, and other financial services. Service support mainly measures the facilitation of payment and the cost of payment. These data are widely used in the study of digital finance in the PRC (Zhang et al. 2020a, 2020b, 2002c; Yang and Zhang 2022)

The control variables are the city-level economic and social characteristics, including gross domestic product (GDP) per capita, average income, population, area, the share of service industry, share of college graduates, internet user size, fixed-line phone users, mobile phone users,[2] fiscal pressure, and share of investment in GDP. These variables are from the PRC's City Statistical Yearbooks, complied by the National Bureau of Statistics and published by China Statistics Press, in the corresponding years.

Our study period covers 2011 to 2019. After deleting the observations with missing variables, the final sample is a non-balance panel of 284 prefecture-level cities for 9 years. Table 7.1 presents the descriptive statistics.

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1 These data are scraped from the National Enterprise Credit Information Publicity System (https://www.gsxt.gov.cn/index.html).

2 The mobile phone users reported in the statistical yearbooks are calculated based on the number of SIM cards issued by the telecommunication service providers. It is common for PRC customers to hold multiple SIM cards. This may overestimate the penetration of mobile phones, but it is also the only available measure on the size of mobile phone users. Similar problem exists for the internet user base.

Table 7.1: Descriptive Statistics

Variables	Obs	Mean	Median	SD	Min	Max	Data Source
Number of delivery points	3,206	158.7	91	192.2	0	1,452	Baidu POI+ registration data of enterprises
Number of new delivery points	3,206	36.9	23	42.2	0	351	
Digital finance index	2,989	162.3	169.2	64.3	25.0	289.2	Guo et al. (2020)
Coverage index	2,989	151.5	157.3	63.0	4.49	287.6	
Depth index	2,988	159.2	155.1	67.1	14.7	293.7	
Service support index	2,989	203.4	237.6	79.8	16.5	340.0	
GDP per capita (CNY10,000)	3,003	5.16	4.21	3.34	0.65	46.77	PRC's City Statistical Yearbooks (2012–2020)
Average income (CNY10,000)	2,615	5.53	5.30	1.80	0.50	17.32	
Population (10,000)	2,627	440.9	376.9	304.6	0	3,392	
Area (10,000 square km)	2,622	1.73	1.23	2.45	0.001	40.73	
Share of college graduates (%)	1,702	1.8	0.95	2.4	0.0059	13	
Share of service industry (%)	2,609	0.41	40	9.9	10	83	
Fixed-line phone users (1,000)	1,727	82.2	52	103.5	4	926.4	
Mobile phone users (1,000)	2,611	446.9	319	463.8	15	4076	
Internet users (1,000)	2,605	95.81	58	113.3	1	1,535.17	
Budget expenditure/ budget revenue	2,616	2.95	2.38	2.01	0.65	20.6	
Share of investment in GDP (%)	1,728	79	76	28	8.7	220	

GDP = gross domestic product, Obs = observations, POI = point of information, PRC = People's Republic of China, SD = standard deviation.

Source: Authors.

7.3.2 Empirical Design

Our baseline model is the following specification:

$$lnCSP_{it} = \beta_0 + \beta_1 dif_{it} + \beta_2 control_{it} + \gamma_i + \eta_t + \varepsilon_{it} \qquad (1)$$

In which $lnCSP_{it}$ is the logarithm number of express delivery points, or the number of new express delivery points, in city *i in year t*. dif_{it} is the logarithm of the digital finance index of city *i* in year *t*. $control_{it}$ is a set of control variables. γ_i is city fixed effect to capture any time-invariant city-level unobservable, η_t is year fixed effect, to capture common time variant shocks. The standard error ε_{it} is clustered at the city level.

We take the starting of Red Envelop function of Alipay in the end of 2015 as a shock, and construct an IV. In the Chinese New Year in 2015, the promotion of Red Envelope by WeChat, the leading social media app in the PRC, was a big success. WeChat users could transfer money from their bank accounts to their WeChat account, and put them in an "envelope", and send to one or several friends. As a response to the main competitor, Alipay started the Red Envelope function in the end of 2015. To promote this, Alipay announced to distribute CNY800 million in these envelopes as gifts to users in the CCTV New Year's Gala in 2016 (People.cn 2015). This encouraged people to open Alipay account to win the free money. Until the Chinese New Year in 2016 (18 February), in total 1.72 billion Alipay Red Envelopes were used. Hence, we consider this marketing activity as an exogenous shock to the penetration of digital finance. The closer to Hangzhou, the more likely that the city was affected by this marketing activity. On the other hand, the distance to Hangzhou is exogeneous and time-invariant, and could not directly affect the development of express delivery points in current decades. Hence, we use the interaction term of distance to Hangzhou and a dummy indicating whether the year is after 2016 as the IV for digital finance index.

7.4 Results

7.4.1 Baseline

Table 7.2 reports the ordinary least squares (OLS) results based on equation (1). Column (1) use the number of express delivery points as the dependent variable. Column (2) and (3) add city fixed effect and year fixed effect, step by step. Column (4) further includes a set of city-level control variables. The estimated coefficient is 0.316, and significant in 1% level. Column (5) uses the number of new express delivery points as the dependent variable, and the magnitude of coefficient is similar as

Column (4). The results indicate that a 10 percentage points increase in digital finance index is significantly associated with a 3.16 percentage points increase in the number of express delivery points, and 3.81 percentage points increase in the number of new delivery points.

Table 7.2: Baseline Results

	(1)	(2)	(3)	(4)	(5)
	Number of express delivery points (logarithm)				Number of new delivery points (log)
Digital finance index (log)	2.039*** (0.03)	1.993*** (0.03)	0.206** (0.10)	0.316*** (0.12)	0.381** (0.15)
GDP per capita (log)				0.019 (0.08)	0.027 (0.13)
Average income (log)				0.038 (0.23)	0.063 (0.26)
Population (log)				0.603 (0.38)	0.877 (0.54)
Area (log)				−0.443* (0.26)	−0.531 (0.39)
Share of service industry (log)				0.156 (0.54)	−0.115 (0.73)
Share of college graduates (log)				1.663 (2.75)	3.558 (3.55)
Internet users (log)				0.020 (0.03)	0.074 (0.06)
Fixed line users (log)				−0.050 (0.06)	−0.138* (0.08)
Mobile phone users (log)				0.127 (0.08)	0.110 (0.11)
Fiscal pressure (%)				0.017 (0.02)	−0.032 (0.02)
Investment/GDP (%)				0.108 (0.08)	0.152 (0.10)
City fixed effect		Y	Y	Y	Y
Year fixed effect			Y	Y	Y
Observations	3003	3003	3003	1648	1648
Adjusted R^2	0.668	0.917	0.965	0.952	0.777

GDP =gross domestic product, R^2 = residual square.

Notes: ***, **, * indicate significance level at 1%, 5%, and 10%, respectively. Standard errors clustered at the city level are in brackets.

Source: Authors.

Table 7.3 reports the results with the three subindexes of digital finance as the explanatory variables, respectively. We still use the regression (1). Columns (1)–(3) show that for every 10 percentage points increase in the coverage and depth is significantly associated with 1.70 percentage points and 1.51 percentage points increase in the number of express delivery points, respectively. However, the correlation between of service support and express delivery points is not significant. As we mentioned before, service support mainly refers to the penetration of mobile payment. Unlike food delivery or shared travel, online shopping requires the support of digital payment such as Alipay, but it does not necessarily rely on mobile payment. Hence, since the coverage index mainly refers to the user size of Alipay, it indicates that as there are more Alipay users, there would be more demand for express delivery service. Besides, as the depth index measures the extent that Alipay users exploit the app for various financial services, it suggests that the various financial services provided by the digital finance platform also relax the financial constraints of entrepreneurship growth, and help the starting of express delivery points.

Table 7.3: The Impact of Subindexes of Digital Finance

	(1)	(2)	(3)
	Number of express delivery points (log)		
Coverage (log)	0.170**		
	(0.08)		
Depth (log)		0.151**	
		(0.08)	
Service support (log)			−0.012
			(0.04)
Controls	Y	Y	Y
City fixed effect	Y	Y	Y
Year fixed effect	Y	Y	Y
Observations	1644	1645	1648
Adjusted R^2	0.952	0.952	0.952

R^2 = residual square.

Notes: ***, **, * indicate significance level at 1%, 5%, and 10%, respectively. Standard errors clustered at the city level are in brackets.

Source: Authors.

Table 7.4 reports the IV regression results. Column (1) reports the result without the controls of any city-level characteristics, and Column (2) includes city fixed effect, year fixed effect, and all city-level controls. The estimated coefficients are 1.743 and 1.268, and significant under at least 10%. This suggests that the promotion of Red Envelope by Alipay significantly stimulates the development of digital finance, and consequently increases the number of express delivery points.

Table 7.4: Instrumental Variables Estimation

Stage 2	(1)	(2)
Digital finance index (log)	4.062*** (0.34)	1.268* (0.73)
Stage 1		
Red Envelope function	0.218*** (0.02)	0.105*** (0.02)
Controls		Y
City fixed effect		Y
Year fixed effect		Y
F-stat	76.556	33.638
Obs	3010	1593
Adjusted R^2	0.698	0.977

Obs = observations, R^2 = residual square.

Notes: ***, **, * indicate significance level at 1%, 5%, and 10%, respectively. Standard errors clustered at the city level are in brackets.

Source: Authors.

7.4.2 Heterogeneity Analysis

We conduct four heterogeneity tests to examine the context that digital finance affects the development of express delivery points.

Educational level is an important factor restricting the ability of a society to adapt to the changes induced by the development of the internet. Therefore, the higher the educational attainment of a region, the larger the size of households who benefit from the use of the internet. We use the share of college graduates in city residents in the base year (2011) to measure the educational attainment of a city. Cities are divided as high educational attainment and low educational attainment, respectively, based on the medium. Columns (1) and (2) in Table 7.5 report the subsample regression results. It is demonstrated that the impact of digital finance on the development of express delivery points is insignificant in cities with low educational attainment.

Internet infrastructure is a prerequisite for households to enjoy the benefits of digital finance. Therefore, we use the internet user size in 2011 to characterize the development of internet infrastructure. Based on whether it is above or below the medium, every city is categorized as having strong internet infrastructure or weak internet infrastructure. The regression results are reported in Columns (3) and (4) in Table 7.5. It is shown that the impact of digital finance on express delivery points is small and insignificant among the cities with weak internet infrastructure. However, digital finance has significant impact on the development of express delivery points in cities with strong internet infrastructure.

The development of the express delivery industry also relies on road infrastructure (Shamdasani 2021). We use the length of road in a city in 2011 to measure the stock of road infrastructure, and categorize cities as having high road infrastructure or low road infrastructure. Columns (5) and (6) in Table 7.5 show that the development of digital finance only stimulates the development of express delivery points in cities with good road infrastructure, but insignificantly affects express delivery points in cities with relatively worse road infrastructure.

Table 7.5: Heterogeneity Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	No. of express delivery points (log)								
	High educational attainment	Low educational attainment	Strong internet	Weak internet	High road infrastructure	Low road infrastructure	Eastern	Middle	Western
Digital finance index (log)	0.421** (0.21)	0.103 (0.16)	0.571*** (0.18)	−0.057 (0.17)	0.483** (0.19)	0.08 (0.18)	1.042*** (0.24)	0.136 (0.19)	−0.003 (0.21)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs	844	804	839	809	846	802	658	629	344
Adjusted R^2	0.958	0.944	0.955	0.940	0.957	0.944	0.952	0.959	0.957

Obs = observations, R^2 = residual square.

Notes: ***, **, * indicate significance level at 1%, 5%, and 10%, respectively. Standard errors clustered at the city level are in brackets.

Source: Authors.

Columns (7)–(9) further examine the regional heterogeneity of the impact of digital finance. As the results demonstrate, the development of digital finance only significantly leads to the expansion of express delivery points in the eastern provinces, e.g., those coastal developed provinces. These are consistent with other columns that the existing infrastructure plays a key role in determining the effect of digital finance.

7.4.3 Robustness Test

To further confirm the relationship between digital finance and express delivery points, we undertake a placebo test with the number of postal offices as the dependent variable. As in other countries, the postal service in the PRC is fully nationalized, and provides a basic public communication service. As early as 1980 China Post started the EMS, a service aimed at express delivery, much earlier than other leading express delivery companies and digital finance. Since the post service is not market-oriented, it is expected that digital finance should not have any impact on the geographic distribution of postal offices. Table 7.6 reports the results. The coefficient of digital finance is insignificant, indicating that the nationalized delivery service did not respond to the development of digital finance.

Table 7.6: Robustness Checks

	Postal offices (log)
Digital finance index (log)	–0.200 (0.24)
Controls	Y
City fixed effect	Y
Year fixed effect	Y
Adjusted R^2	0.881
Obs	1648

Obs = observations, R^2 = residual square.

Notes: ***, **, * indicate significance level at 1%, 5%, and 10%, respectively. Standard errors clustered at the city level are in brackets.

Source: Authors.

7.5 Mechanisms

7.5.1 Improve Service Efficiency

Initially, Alipay was established by Alibaba Group to support online transactions in Taobao. To further improve the efficiency of e-commerce, Alibaba Group established the Cainiao station network in 2013 to serve communities and campuses. A feature of the Cainiao station is that parcels are temporarily stored in a locked mailbox, and receivers can use a texted code to get the parcel at any convenient time, before a specified deadline. This substantially reduces the burden of courier workers and promotes the efficiency of express delivery. Therefore, those express delivery companies that establish cooperation with the Cainiao station would gain in efficiency, and develop more quickly. We examine the impact of strategic cooperation between an express delivery company and the Cainiao station. Columns (1) and (2) in Table 7.7 report the subsample regression results. It shows that digital finance only significantly increases the number of express delivery points belong to the strategic partners of the Cainiao station, but has insignificant impact on those non-partners.

Further, we examine whether the investment of Alibaba Group has any impact on the development of express delivery companies. Alibaba Group has stock investment in leading express delivery companies, such as STO, ZTO, YTO, in various years. We collect the monthly nationwide complaint rates of express delivery from the website of the State Post Bureau.[3] As Figure 7.1 shows, after Alibaba became the shareholder of top express delivery corporations, the complaint rate of the express delivery service declines.

On the one hand, this investment facilitates the connection between online shopping and express delivery. For instance, in 2015 Alipay started a new function enabling the sending parcels, status checking, and payment in just one click. All the companies receiving Alibaba Group investment are covered by this function. On the other hand, the investment of Alibaba Group also increases the capital of those express delivery companies, and helps them to expand. Therefore, we divide delivery companies based on whether they receive investment from Alibaba Group. Columns (3) and (4) report the subsample regression results. It is shown that although express delivery companies benefit from the development of digital finance, the companies receiving investment from the Alibaba Group exhibit even larger expansion in response to the development of digital finance.

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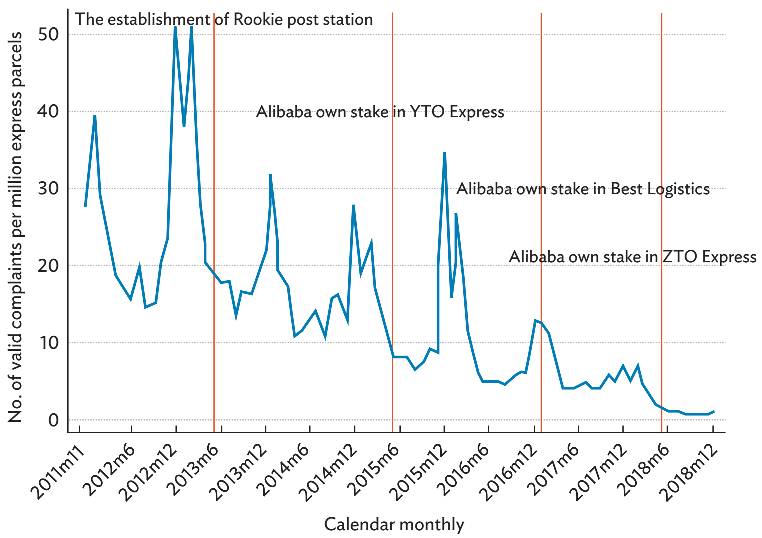
3 https://www.spb.gov.cn/gjyzj/c100278/common_list.shtml

Figure 7.1: Nationwide Trend of Complaint Rates of Express Delivery Service



Source: Authors.

Table 7.7: Improve Service Efficiency

	(1)	(2)	(3)	(4)
	No. of express delivery points (log)			
	Strategic partners of Cainiao station	Non-partners	Alibaba stock holding	No Alibaba stock holding
Digital finance (log)	0.421*** (0.15)	0.054 (0.12)	0.361** (0.17)	0.242* (0.12)
Controls	Y	Y	Y	Y
City fixed effect	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y
Adjusted R^2	0.910	0.949	0.888	0.954
Obs	1698	1698	1698	1698

Obs = observations, R2 = residual squares.

Notes: ***, **, * indicate significance level at 1%, 5%, and 10%, respectively. Standard errors clustered at the city level are in brackets.

Source: Authors.

7.5.2 Promote Consumption

Previous studies have shown that digital finance increases household consumption by facilitating payment (Yang and Zhang 2022). The increase in the scale and scope of household consumption stirs demand for online shopping, as well as express delivery service. We use the city level consumption per GDP and consumption per population as the dependent variable to examine the impact of digital finance on consumption. Table 7.8 reports the regression results. It shows that 10 percentage points increase in digital finance is associated with 0.4 percentage points increase in the share of consumption in GDP, and 1.65 percentage points increase in the consumption per capita. The coefficients are significant under at least 5% level.

Table 7.8: Consumption Promotion

	(1)	(2)
	Consumption/GDP (log)	GDP per capita (log)
Digital finance index (log)	0.040*** (0.02)	0.165** (0.06)
Controls	Y	Y
City fixed effect	Y	Y
Year fixed effect	Y	Y
Obs	1651	1651
Adjusted R^2	0.903	0.968

GDP = gross domestic product, Obs = observations, R^2 = residual square.

Notes: ***, **, * indicate significance level at 1%, 5%, and 10%, respectively. Standard errors clustered at the city level are in brackets.

Source: Authors.

7.5.3 Financial Constraints

The operation of express delivery points is usually in the form of franchising, although they join the network of the leading express delivery company, they keep the independent legal status as a small or medium- sized firm. Hence, as other small firms, the starting of express delivery points also needs to overcome financial constraints. Hau et al. (2019) use the big data of loans from the Ant Group (a subordinate of Alibaba Group) to show that the development of fintech in the PRC substantially alleviates financial constraints for entrepreneurship growth.

Therefore, in areas with better financial access, the alleviation effect of digital finance is relatively weak, and its contribution to the development of express delivery points would be relatively small. We use the number of bank branches in 2011 to measure to financial access in the base year, and include an interaction term between digital finance index and financial access in equation (1). Column (1) in Table 7.9 shows that the more bank branches in a city, the weaker the impact of digital finance on the development of express delivery points. In Columns (2) and (3) we use the bank deposit per capita and the size of loan and deposit in GDP to measure the access to financial resources. The results are consistent. They suggest that digital finance could improve financial access to increase the supply of express delivery points.

Table 7.9: Financial Constraint

	(1)	(2)	(3)
	No. of express delivery points (log)		
Digital finance index*no. of bank branches	−0.047** (0.02)		
Digital finance index*deposit per capita		−0.118*** (0.04)	
Digital finance index*(deposit+loan)/GDP			−0.186 (0.13)
Digital finance index (log)	0.349*** (0.12)	1.206*** (0.34)	0.385*** (0.13)
Controls	Y	Y	Y
City fixed effect	Y	Y	Y
Year fixed effect	Y	Y	Y
Obs	1623	1646	1646
Adjusted R^2	0.952	0.953	0.952

GDP = gross domestic product, Obs = observations, R^2 = residual square.

Notes: ***, **, * indicate significance level at 1%, 5%, and 10%, respectively. Standard errors clustered at the city level are in brackets.

Source: Authors.

7.6 Conclusion

This chapter evaluates the effect of digital finance on the development of express delivery points in the PRC. By matching the digital finance index with the address of express delivery points, we show the significant promotion effect of digital finance on the express delivery industry. Moreover, digital finance promotes the express delivery service by improving service efficiency, stimulating household consumption, and alleviating financial constraints in starting a delivery point. The effect of digital finance is more salient in the area with higher education level, better internet infrastructure, and better road infrastructure. This also suggests the complementary role of transportation infrastructure and digital infrastructure in promoting the prosperity of express delivery services.

As part of logistics infrastructure, the development of express delivery is mainly driven by the market, instead of the initiative of the state. Hence, understanding the factors underlying the development of the express delivery service plays a role in understanding the construction of a well-functioning logistics system, and improving the supply chain of an economy. Our results suggest the often-ignored role of digital finance in delivering prosperity of certain industries. Hence, to improve the penetration of a modern logistics system, it is important to create the proper demand for logistics services, and improve the supply of logistics services by alleviating the financial constraints and increasing the service efficiency. Moreover, we should also take caution of the potential digital divide caused by the development of digital finance. The state could help to overcome the digital divide and make the beneficial outcomes of a well-functioning supply chain inclusive by providing high quality education, and investing in traditional infrastructure that is the foundation of the development of express delivery services.

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PART IV

Global Trade and Connectivity

8

Digital Trade in Asia: The Role of Energy Poverty and Unemployment

Qasim Raza Syed and Dil B. Rahut

8.1 Introduction

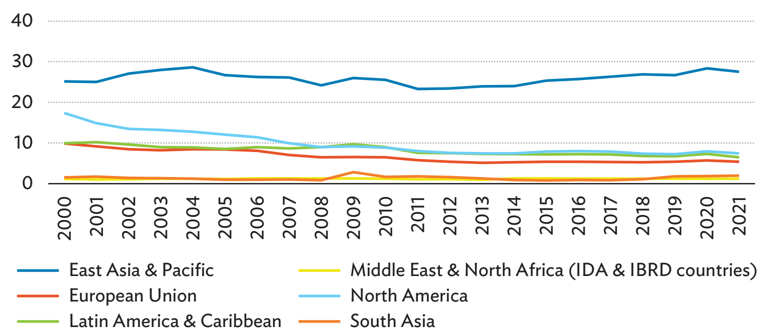
During the late 1990s, the availability of the internet to almost every country could be considered the first step toward digital connectivity. Thereafter, digital connectivity in terms of digital technologies actively changed several aspects of human life in the early 2000s. Ever since, digital connectivity has transformed the traditional ways/methods/manners of business and economies. Digital connectivity not only transforms the decision making of consumers and/or producers but also affects the mode and/or methods to conduct business. Therefore, traditional economies have now been transforming into digital economies with remarkably high dependency on digital connectivity.

Like other sectors of an economy, digital connectivity has also transformed traditional trade. The use of the internet, mobile phones, and online platforms (Amazon and eBay, among others) profoundly changed the means and/or modes of trade. Hence, digital trade has emerged as a popular topic due to digital connectivity. There exists ambiguity related to the exact definition of digital trade; however, several research endeavors have attempted to define or conceptualize it. For instance, the Organisation for Economic Co-operation and Development defines it as "digitally enabled transactions in trade in goods and services which can be either digitally or physically delivered and which involve consumers, firms, and governments" (López González and Jouanjean 2017; López González and Ferencz 2018.). Similarly, the World Trade Organization defines it as "the production, distribution, marketing, sale, or delivery of goods and services by electronic means". Parallel to this, according to the International Monetary Fund, digitally ordered and/or digitally delivered trade is referred to as digital trade. Digitally ordered trade consists of trade in goods and services wherein the good or service is being ordered by the customer through electronic means such as a computer network. Similarly, digitally delivered goods and/or services are also being delivered to customers by digital means such as UPWORK and FIVERR, among others.

It is worth noting that digital trade has a wide range of profound positive socioeconomic impacts. On the one side, it upsurges competitiveness (Soylu et al. 2023). On the other side, digital trade helps to escalate the economic performance of both developed and developing countries (Danish, Khan, and Haneklaus 2023). In addition, digital trade can also trigger tourism, which, in turn, leads to economic growth (Anser et al. 2021). Also, it boosts renewable energy consumption, thereby exerting positive environmental impacts (Murshed 2020). Based on its constructive socioeconomic impacts, the share of digital trade in traditional trade has been rising. It is a point to note that the Asian region has become a digital trade hub, especially after the novel coronavirus disease COVID-19 span.

The Asian economies have extensively been conducting e-commerce for both in-border and cross-border trade. These economies also make use of digital payment systems (Alipay and Paytm, among others) to promote and facilitate digital transactions. The Asian economies are also a hub of financial technology advancements and data localization. Not only this, digital infrastructure development and policy modeling for digital trade are among the top agenda items in the Asian region.

Figure 8.1: Digital Trade in Terms of ICT Goods Exports by Region
(% of Total Goods Exports)



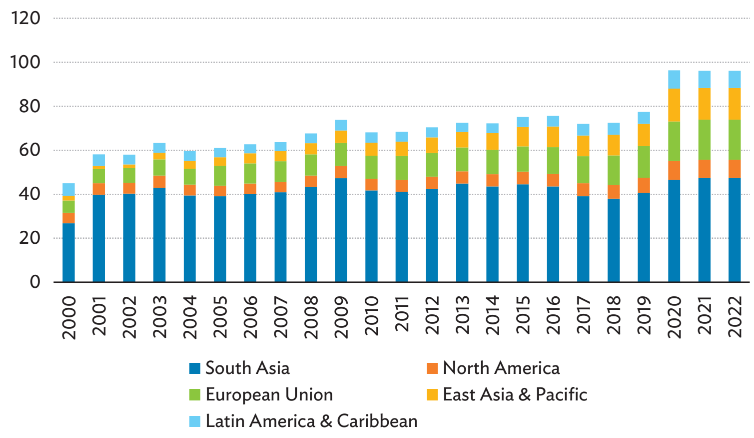
IBRD = International Bank for Reconstruction and Development, ICT = information and communications technology, IDA = International Development Association.

Source: World Development Indicators. https://databank.worldbank.org/source/world-development-indicators# (accessed 11 December 2023.)

Consequently, the Asian economies are ruling the world in terms of digital trade.

As can be delineated in Figure 8.1, East Asia and the Pacific is the top region in terms of information and communications technology (ICT) goods exports (i.e., a proxy for digital trade), followed by South Asia. Likewise, Figure 8.2 depicts that in terms of ICT services exports (digital trade), the South Asian region leads the world. Interestingly, the share of ICT services exports in total services exports is around 50% in the South Asian region after the COVID-19 pandemic. It is interesting to report that despite rising trends of digital trade in the Asian economies, they still confront several challenges that hinder digital trade. For instance, measuring or defining digital trade is one of the key issues (Gao 2018). Similarly, the international trade rules related to digital trade are in their early stages, while the existing rules might cause hindrances to smooth and efficient digital trade (Meltzer 2019). Besides, researchers have been striving to probe other triggers and barriers to digital trade.

Figure 8.2: Digital Trade in Terms of ICT Services Exports by Region
(% of Total Goods Exports)



Source: World Development Indicators. https://databank.worldbank.org/source/world-development-indicators# (accessed 11 December 2023.)

While exploring the impact factors of digital trade, Ferracane, Lee-Makiyama, and Van Der Marel (2018) propose a digital trade restrictiveness index for 64 countries based on almost 100 policy measures that can impede digital trade. The study segregates these 100 policy measures into four broad categories: (i) trading restrictions, (ii) fiscal restrictions, (iii) data restrictions, and (iv) establishment restrictions. The outcomes of the study conclude that seven Asian economies are among the top 10 restricted countries in terms of digital trade, with the People's Republic of China (PRC) being one of the most restricted countries in the world. Following the methodology of Ferracane Lee-Makiyama, and Van Der Marel (2018), Ferencz (2019) developed the digital services trade restrictiveness index, which is helpful to compare the level of restrictions in terms of digital services trade in 44 countries. The study concludes that the PRC is one of the most digitally restricted countries for services trade. Other Asian economies such as the Russian Federation, India, and Indonesia are also top-restricted countries.

Likewise, Biryukova and Matiukhina (2019) report that digital trade (proxied by ICT services exports) in Brazil, the Russian Federation, India, the People's Republic of China, and South Africa (a group known as the BRICS economies) has been upsurging in terms of volume; however, the comparative advantage of ICT services exports has witnessed a decrease due to multiple economic conditions such as unstable inflation and growth. A study by Nath and Liu (2017) explores whether ICT development impacts ICT services exports and imports (i.e., digital trade) in 49 selected countries. The results conclude that ICT burgeoning upsurges both ICT services exports and imports (i.e., digital trade) in a group of selected countries. While exploring the impact of ICT on services exports and imports (i.e., digital trade) for almost 200 countries, Luong and Nguyen (2021) reveal that ICT promotion has a positive impact on ICT-enabled exports and imports of services (i.e., digital trade). In the case of the ASEAN economies, Tee, Tham, and Kam (2020) reveal that ICT facilitation promotes services exports, including ICT-enabled exports (i.e., digital trade).

Parallel to this, Van der Marel and Shepherd (2013) argue that policy measures as gauged by the services trade restrictiveness index not only impede non-ICT enables services exports but also wane ICT services exports (i.e., digital trade). Kneller and Timmis (2016) explore whether ICT has a causal effect on digital and traditional services trade in the United Kingdom. The study concludes that ICT does have a causal effect on digital trade, whereas no causal relationship has been observed between ICT and traditional services trade. Lee and Pang (2022) find that ICT development impacts both exports and imports in services (i.e., digital trade). However, the study concludes that ICT upsurges exports and wanes imports. Moreover, the volume of digital trade increases profoundly in net exporter countries compared to the net importers. Wang, Li, and Wang (2021) find that ICT wanes the trade cost and upsurges innovation. As a result, digital trade in terms of ICT services exports witnessed an increase in the case of the Belt and Road Initiative countries.[1] Using the fixed effects model, Gani and Clemes (2016) report that the rule of law and contract enforcement are drivers of digital trade. Cheng (2020) highlights that the exchange rate does not affect services trade, including digital trade, in the long-run, whereas income is a key determinant of digital trade in the case of the United States. Likewise, Srivastava (2006) points out that foreign direct investment creates all types of service exports (i.e., digital trade) in India. Likewise, Nasir and Kalirajan (2016) argue that higher education and ICT progress promote digital trade in ASEAN economies.

The existing literature on the determinants of digital trade explores ICT, human capital, income, exchange rate, and institutional performance or quality as impact factors of digital trade. However, there are many other factors that affect digital trade. While considering this in the context of the Asian region, it is worth noting that Asian economies confront various issues and challenges that may affect digital trade. One of the issues in Asian economies is energy poverty, which could be interlinked with digital trade. The United Nations Development Programme defines energy poverty as "the lack of sufficient options in accessing adequate, accessible, reliable, high-quality, clean, and environmentally benign energy services to sustain economic development" (UNDP 2010). In addition to this, the International Energy Agency explains that energy poverty is "a lack of electricity and heavy reliance on traditional biomass" (Sovacool 2013). Additionally, the Asian Development Bank defines energy poverty as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development" (Masud, Sharan, and Lohani 2007). Energy poverty in terms of access to electricity is an acute concern in Asian economies. Table 8.1 elucidates that Asia is the second most poor region in terms of energy poverty (i.e., access to electricity). It could be hypothesized that energy poverty may impede digital trade directly or indirectly. The lack of access to electricity decreases ICT services exports (i.e., digital trade) since energy is a basic input to provide ICT-enabled services. Considering the indirect impact of energy poverty on digital trade, it can adversely impact education, and health, which in turn discourages digital trade. Therefore, it is inevitable to probe whether energy poverty impacts digital trade in Asia.

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1 For details on the Belt and Road Initiative, please refer to https://www.cfr.org/backgrounder/chinas-massive-belt-and-road-initiative

Table 8.1: Comparison of Energy Poverty by Region

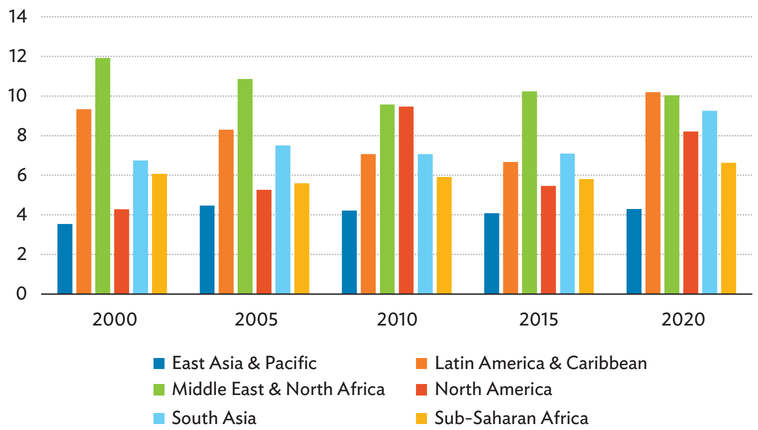
Year	East Asia & Pacific	Latin America & Caribbean	Middle East & North Africa	North America	South Asia	Sub-Saharan Africa
Total Energy Poverty (% of the total population)						
2000	92.25	91.72	92.44	100	56.37	25.63
2005	93.85	93.55	93.98	100	64.87	29.30
2010	95.54	95.85	95.65	100	73.18	33.28
2015	97.10	97.28	96.45	100	84.54	39.01
2020	98.01	98.51	97.23	100	95.74	48.23
Rural Energy Poverty (% of the population)						
2000	88.26	71.07	82.81	100	45.14	11.86
2005	89.63	76.96	86.45	100	54.19	13.14
2010	92.39	83.65	89.23	100	63.92	16.98
2015	94.82	89.02	92.09	100	78.36	18.57
2020	96.29	93.55	93.82	100	93.61	28.52
Urban Energy Poverty (% of the population)						
2000	98.58	98.42	99.27	100	88.59	61.66
2005	98.75	98.47	98.93	100	90.95	65.36
2010	98.49	99.18	99.52	100	93.94	68.32
2015	98.87	99.36	99.44	100	97.23	72.22
2020	99.13	99.66	99.64	100	99.72	78.18

Source: World Development Indicators. https://databank.worldbank.org/source/world-development-indicators# (accessed 11 December 2023.)

Another prime issue in Asia is unemployment. Since Asia is the largest region by population with inadequate or inefficient resources to employ the entire labor force, the rate of unemployment in Asia remains high. Figure 8.3 explains the unemployment rate in different regions of the world. As can be seen from Figure 8.3, a significant portion of the labor force is unemployed in Asia. Unemployment might affect digital trade in different dimensions. The higher unemployment rate propels individuals to work at lower wages, which, in turn, upsurges competitiveness and escalates ICT services exports (i.e., digital trade). Also, unemployment leads to a lower level of income, thereby skill and human capital levels are expected to plunge. As a result, digital trade (in terms of ICT services exports) can decrease. Therefore, it is imperative to scrutinize the impact of unemployment on digital trade from the Asian perspective.

Based on this backdrop, this empirical study aims to discern whether digital trade is susceptible to energy poverty and unemployment in Asia. Hence, we use a panel dataset consisting of eight Asian economies: the PRC, Pakistan, the Russian Federation, Singapore, the Republic of Korea, Malaysia, Japan, and the Philippines, over the period 2000–2021. Focusing on the novelty of this study, this is the first empirical study that investigates whether energy poverty has any impact on digital trade. Second, this is the first attempt to probe the effect of unemployment on digital trade.

Figure 8.3: Unemployment Rate by Region
(% of Labor Force)



Source: World Development Indicators. https://databank.worldbank.org/source/world-development-indicators# (accessed 11 December 2023.)

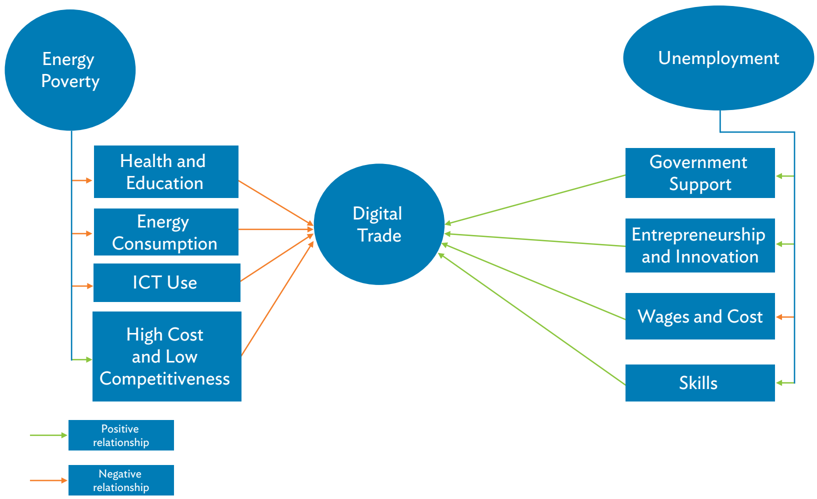
Considering the significance of this study, it is worth highlighting that this research is conducted to assist policy makers, businesses, and academicians. It will help policy makers formulate policies to escalate digital trade in Asia. Similarly, businesses can manage employment and energy poverty to upsurge their sales related to digital trade. Finally, the current investigation helps academicians to understand the relationship between digital trade, unemployment, and energy poverty in Asia. Also, it will open new research avenues for the academicians in this line of research.

8.2 Conceptual Framework

We elucidate the potential relationship between energy poverty, unemployment, and digital trade in Figure 8.4. Regarding the energy poverty–digital trade nexus, the first channel explains the direct impact of energy poverty on digital trade. Since energy is an input of goods and services, the lack of electricity discourages the production and/or provision of goods and services and hence impedes digital trade (Adom et al. 2021). The second channel is the health and education effect, which notes that energy poverty adversely impacts health and education since the availability of energy is essential for a healthy lifestyle and the provision of quality education (Irwin, Hoxha, and Grépin 2019; Oum 2019). On the other hand, poor health discourages individuals to provide services (Krause et al. 2013). Hence, we may formulate that energy poverty can impact digital trade through the health channel. Moreover, the third channel is the cost channel, which argues that energy poverty upsurges the trade cost since individuals and businesses switch to an expensive mode of energy. This impedes competitiveness and hence mitigates digital trade. Finally, energy poverty halts the use of digital technologies such as the internet, computers, and mobile phones. On the contrary, limited use of ICT wanes digital trade (Nath and Liu 2017; Tee, Tham, and Kam 2020).

Next, various theoretical channels can explain the linkages between unemployment and digital trade (Figure 8.4). For instance, countries with high unemployment rates may place greater emphasis on exporting goods and services as a means of generating economic growth and creating jobs. This could lead to more government support for the development and promotion of ICT-enabled services exports. Also, unemployment can lead to a surplus of skilled workers who might be more willing to learn new skills and take on jobs in the ICT-enabled services industry. This can lead to the development of a strong local talent pool, which can attract foreign companies and increase exports. High unemployment rates may lead to increased entrepreneurship and innovation as individuals seek to create their own jobs. This can result in the development of new and innovative ICT-enabled services with export potential. There is a likelihood that an upsurge in unemployment forces individuals to seek other jobs according to their skills, so people start exporting their ICT-based services. Finally, unemployment allows people to work for lower wages, which, in turn, reduces the cost of services. As a result, competitiveness increases, and hence digital trade upsurges over time.

Figure 8.4: Conceptual Framework



Source: Authors.

8.3 Methods

8.3.1 Model and Methodology

To attain the aim of this empirical study (i.e., probing the impact of energy poverty and unemployment on digital trade), we adopt the export demand function. The export demand function notes that exports rely on income and exchange rates (Akoto 2012; Cheung and Sengupta 2013). Equation (1) yields the export demand function:

$$DTR_{it} = \beta_0 + \beta_1 WGDP_{it} + \beta_2 REER_{it} + U_{it} \quad (1)$$

In the above-mentioned equation, cross-sections and time are denoted by i and t, respectively. DTR represents digital technology trade, and it is measured as the ICT services exports. Next, WGDP represents the world global gross domestic product (GDP) (Afzal 2006), while the real effective exchange rate is denoted by REER (Cheung and Sengupta 2013). Finally, U_{it} expresses the error term. Since the focused variables in this study include energy poverty (EPOV) and unemployment (UNE), we embed these variables into equation (1) to formulate equation (2):

$$DTR_{it} = \beta_0 + \beta_1 WGDP_{it} + \beta_2 REER_{it} + \beta_3 EPOV_{it} + \beta_4 UNE_{it} + U_{it} \quad (2)$$

Equation (2) is the final econometric equation we estimate in this study. Regarding the methodology to be followed, we make use of panel fixed and random effects models to estimate the dependency of DTR on EPOV and UNE in selected Asian economies.

8.3.2 Data

The current empirical investigation utilizes the panel dataset for eight Asian economies for the period 2000–2021. It is worth reporting that this sample (countries and period) is adopted based on data availability. The dependent variable of this study is DTR, which is proxied by ICT services exports. ICT services exports (which are also denoted as ICT-enabled services) mainly contain financial services, communication services, license fees, computer/information services, personal/recreational services, and business services (e.g., digital marketing, etc.) (Nath and Liu 2017). Also, DTR is measured in current US dollars. Regarding the control variables, WGDP is measured in constant 2015$. Similarly, REER is a real effective exchange rate index with 2010 as a base year. With regard to focused variables, EPOV is measured in the percentage of the population with access to electricity, whereas UNE is measured in the percentage of unemployed individuals in the labor force, according to the ILO. Table 8.2 summarizes some key aspects of the data.

Table 8.2: Summary of Data

Symbol	Variable	Proxy	Measurement
DTR	Digital trade	ICT services exports	Current US$ (BoP)
WGDP	World GDP	Per capita world GDP	Constant 2015$
REER	Relative prices	Real effective exchange rate index	2010 base year index
EPOV	Energy poverty	Access to population	Percentage of the population with access to electricity
UNE	Unemployment	Share of unemployment	Percentage of unemployed population in the labor force

BoP = current account balance, DTR = digital technology trade, EPOV = energy poverty, REER = real effective exchange rate, WDI = World Development Indicators, WGDP = world gross domestic product, UNE =unemployment.

Source: World Development Indicators. https://databank.worldbank.org/source/world-development-indicators# (accessed 5 May 2023.)

Next, we transform the dataset into a natural logarithmic expression. Also, Table 8.3 highlights certain descriptive statistics. WGDP contains the largest mean value and standard deviation. Further, the whole dataset is negatively skewed, excluding DTR, which contains a positive skewness. The kurtosis value is the highest for UNE. The Jarque-Bera statistics claim that all variables follow a non-normal distribution except for DTR.

Table 8.3: Descriptive Statistics

	EPOV	DTR	REER	UNE	WGDP
Mean	4.54	21.47	4.59	1.33	9441.19
Median	4.60	21.53	4.60	1.345	9402.99
Maximum	4.60	24.64	5.03	2.41	11011.13
Minimum	4.25	19.07	3.99	–0.91	7868.56
Std. Dev.	0.11	1.25	0.16	0.48	989.56
Skewness	–1.66	0.11	–0.18	–2.02	–0.05
Kurtosis	4.06	2.54	4.12	10.49	1.83
Probability	(0.00)***	(0.38)	(0.00)***	(0.00)***	(0.00)***

DTR = digital technology trade, EPOV = energy poverty, REER = real effective exchange rate, WGDP = world gross domestic product, UNE =unemployment.

Note: Data in brackets represent the p-value, while *** shows the level of significance at 1%.

Source: Authors' calculation.

8.4 Findings

8.4.1 Testing Unit Root

This section represents the empirical findings about the impact of energy poverty and unemployment on digital trade in Asia. It is worth reporting that while handling the panel dataset, it is indispensable to discern the unit root to circumvent spurious regression (Syed et al. 2022). Therefore, we apply the Im, Pesaran, and Shin (IPS) unit root test to probe the order of integration. The outcomes from the IPS test are delineated in Table 8.4.

Table 8.4: Unit Root Analysis

Variable	I(0)	I(1)
DTR	(0.90)	(0.00)***
REER	(0.41)	(0.00)***
WGDP	(0.98)	(0.00)***
EPOV	(0.71)	(0.00)***
UNE	(0.31)	(0.00)***

DTR = digital technology trade, EPOV = energy poverty, REER = real effective exchange rate, WGDP = world gross domestic product, UNE =unemployment.

Notes: Data in bracket represents the p-value, whereas *** notes the level of significance at 1%.

Source: Authors' calculation.

Table 8.4 depicts the p-values retrieved from the IPS test at I(0) and I(1). As can be observed that we are unable to reject the H0 (i.e., the existence of a unit root) at I(0), thereby we conclude that the entire dataset contains a unit root at I(0). On the contrary, we could reject the H0 for each variable at I(1). Hence, we claim that each variable is stationary at I(1). Due to the presence of stationarity at I(1), we use the first difference of each variable for estimating the random and fixed effects model.

8.4.2 Findings from Random and Fixed Effects Models

This subsection renders empirical results from random and fixed effects models. Table 8.5 contains the estimated coefficients from the aforementioned models. Considering the random effects model, it is worth noting that each regressor is statistically significant. This indicates that energy poverty, unemployment, world income, and the real effective exchange rate impact digital trade. The coefficient of EPOV is –0.31, delineating that a 1% upsurge in energy poverty wanes digital trade by 0.31% in selected Asian economies. There exist many theoretical channels that can help to explain this outcome. For instance, it is empirically argued that energy poverty harms health (Oum 2019). As a result, poor health status discourages individuals from working and exporting their services. On top of this, energy poverty (i.e., unavailability of electricity) directly discourages individuals and businesses to provide ICT-enabled services because electricity is a key input to ICT-enabled services exports. Next, the unavailability of electricity (i.e., energy poverty) propels individuals and businesses to switch to alternative energy sources such as solar or wind energy. This upsurges the cost to export ICT services and escalates the price of ICT service exports. The low level of competitiveness due to higher prices wanes ICT services exports (i.e., digital trade). These findings are somehow consistent with prior literature. For example, Shahbaz (2015) reports that the unavailability of electricity adversely impacts Pakistan's services sector. Similarly, Abdisa (2018) concludes that the unavailability of electricity plunges firms' productivity. Gupta and Chauhan (2021) also note that electricity outages compel firms not to enter export markets. These findings are somehow backed by the conclusion of Chowdhury et al. (2021), who reported that the lack of electricity plunges labor productivity and ultimately impedes the labor output in Pakistan. The study by Mensah (2018) also notes that energy poverty (i.e., lack of electricity) has adverse impacts on labor productivity, labor demand, and exports at the firm level.

Regarding the findings related to UNE, its coefficient is 0.15. This implies that a 1% surge in unemployment escalates ICT services exports (i.e., digital trade) by 0.15%. Several theoretical aspects can explain these empirical outcomes. For instance, high unemployment rates can lead to lower wage rates for workers (Gregg and Machin 2012), making it more attractive for companies to outsource work to countries with lower labor costs (Palvia 2014).

Table 8.5: Findings from Random and Fixed Effects Models

	Random Effects Model		Fixed Effects Model	
Variable	coefficient	p-value	Coefficient	p-value
EPOV	−0.31***	(0.00)	−0.30**	(0.02)
UNE	0.15**	(0.03)	0.17***	(0.00)
WGDP	0.12***	(0.00)	0.12***	(0.00)
REER	0.11***	(0.00)	0.15**	(0.03)

EPOV = energy poverty, REER = real effective exchange rate, WGDP = world gross domestic product, UNE =unemployment.

Note: Data in brackets denote the p-value. ** and *** show the level of significance at 5% and 1% level of significance, respectively.

Source: Authors' calculation.

This can make ICT-enabled services more affordable for foreign buyers, increasing demand and exports. High unemployment rates can lead to increased entrepreneurship and innovation as individuals seek to create their jobs (Mahadea and Kaseeram 2018; OECD 2021).

This can result in the development of new and innovative ICT-enabled services that have export potential (Cumming, Johan, and Zhang 2014). Also, unemployment can upgrade and improve labor skills (Weisskopf 2006). This can lead to the development of a strong local talent pool, which can attract foreign companies and increase exports. There is a likelihood that an upsurge in unemployment forces individuals to seek other jobs according to their skills, so people start exporting their ICT-based services. This scenario has been observed during the COVID-19 outbreak, where an enormous proportion of the population lost jobs, and these unemployed people started freelancing, including ICT services exports (Simplilearn 2023) Further, the United Nations Conference on Trade and Development also reported the same notion that during the COVID-19 pandemic (when people lost their jobs), ICT services exports witnessed a profound increase (UNCTAD 2021). It could be deduced that the unemployed joined the ICT services sector and, hence, there is a positive relationship between unemployment and digital trade. It is worth noting that ICT services exports in Pakistan increased by 26% amid the COVID-19 outbreak because millions of people lost their jobs in the formal sectors, and they initiated the export of ICT-enabled services (South Asian Investor Review 2020).

Regarding the findings related to control variables (i.e., WGDP and REER), it is worth noting that higher world GDP increases the DTR, while the depreciation of the exchange rate also upsurges DTR. In particular, a 1% increase in the world GDP upsurges ICT services exports by 0.12%. This is a well-cited argument that higher global income escalates the exports of domestic countries (Afzal 2006). Similarly, the depreciation of the exchange rate improves the competitiveness of exporting goods/services by lowering the cost, which, in turn, increases the export volume (Ho 2012).

Regarding the outcomes from the fixed effects model, the coefficients of EPOV, UNE, WGDP, and REER are statistically significant. Further, the coefficient of EPOV and UNE is <0 and >0, respectively. This reveals that energy poverty impedes digital trade whereas unemployment upsurges it. This implies that energy poverty decreases digital trade in selected Asian economies, while unemployment is the factor that escalates digital trade. Parallel to this, the coefficient of WGDP explains that the world's income promotes digital trade, while the depreciation of the real effective exchange rate increases digital trade. The findings from both the random effects and fixed effects models are alike. This delineates that our results are insensitive to the choice of methodology.

8.4.3 Sensitivity Analysis

In this subsection, we perform a sensitivity analysis to reveal whether our baseline results (as reported in Section 8.4.2) are robust. To this end, we adopt the share of ICT services exports in total services exports as a dependent variable. The findings are presented in Table 8.6.

Table 8.6: Sensitivity Analysis

	Random Effects Model		Fixed Effects Model	
Variable	**Coefficient**	**p-value**	**Coefficient**	**p-value**
EPOV	−0.12***	(0.00)	−0.16***	(0.00)
UNE	0.05**	(0.04)	0.05***	(0.00)
WGDP	0.03***	(0.00)	0.11***	(0.00)
REER	0.09**	(0.01)	0.06***	(0.00)

EPOV = energy poverty, REER = real effective exchange rate, WGDP = world gross domestic product, UNE =unemployment.

Notes: The data in brackets denote the p-value. ** and *** show the level of significance at 5% and 1% level of significance, respectively.

Source: Authors' calculation.

As can be observed from Table 8.6, the findings from both models are similar to the baseline outcomes. That is, EPOV, UNE, WGDP, and REER are found to be statistically significant. In particular, EPOV wanes the share of ICT serves exports (i.e., DTR), whereas UNE improves it. Further, exchange rate depreciation and world GDP improve the share of ICT services exports (i.e., DTR) in the selected Asian economies. These results show that our key findings are insensitive/robust to data and/or model changes.

8.5 Conclusion

The world has witnessed an unprecedented episode of digital connectivity during the 21st century. This opens new avenues for consumers, producers, and governments. As a result of this digital connectivity, traditional trade is also being transformed into digital trade, and its volume is upsurging at an incredible pace. Further, it is evident that digital trade is immune to global adverse shocks such as the COVID-19 outbreak, among others. Therefore, it is imperative to promote and facilitate digital trade. Hence, research endeavors are required to probe the triggers and barriers to digital trade. Parallel to this, the entire world (particularly the Asian region) confronts socioeconomic challenges, such as energy poverty and unemployment. Therefore, it is essential to discern the impact of energy poverty and unemployment on digital trade. Against this backdrop, we investigate whether energy poverty and unemployment trigger or wane digital trade (i.e., measured in ICT services exports) in eight selected Asian economies. The results from the random and fixed effects models reveal that energy poverty decreases digital trade. Energy poverty might wane energy consumption and use of ICT. As a result, digital trade is expected to decrease. On the contrary, unemployment could promote entrepreneurship, which might increase digital trade. Unemployment also plunges wages, which attracts foreigners and hence digital trade witnesses an increase. Interestingly, unlike the traditional view that higher unemployment impedes trade, we find that unemployment acts as a trigger and promotes digital trade. Further, we perform the sensitivity analysis by using the share of ICT services exports in total services exports as a dependent variable. The results retrieved from the sensitivity analysis are similar to our baseline outcomes.

We put forward some policy suggestions to raise the volume of digital trade in Asia. Based on the results, it could be proposed to take measures to decrease energy poverty, which in turn enhances digital trade. Hence, electricity should be available to the entire population. Further, electricity load shedding should be reduced to boost digital trade. Governments should control or take measures to avoid power outages. Next, energy infrastructure should be upgraded to provide access to affordable and reliable electricity to all. In Asian countries where electricity shortages are a key challenge (e.g., Pakistan, India, Sri Lanka, etc.) (Sovacool 2013), alternative energy sources could be provided (e.g., solar and wind energy). To promote alternative energy sources, governments should give subsidies on renewable energy sources. Also, feed-in tariffs could be managed to promote alternative energy sources. In light of the policy recommendations pertaining to unemployment, it is imperative to acknowledge that unemployment can be perceived as a fortuitous circumstance in disguise. Policy makers should establish suitable avenues for individuals who are currently without employment to engage in the exportation of their services. Asian economies have the potential to leverage online platforms such as Upwork, Fiverr, Amazon, and others to establish virtual workspaces. Furthermore, it is imperative for governments to implement skill-enhancement initiatives aimed at equipping the unemployed workforce with digital proficiencies, thereby enabling them to engage in the exportation of ICT services.

With regard to future research aspects, other Asian economies could be included in this analysis (excluded here due to the unavailability of data). The ICT services exports is a subset of digital trade; therefore, any better proxy of digital trade should be used in the future to efficiently gauge the digital trade. The dynamic models could also be applied to investigate how energy poverty and unemployment impact digital trade across time horizons. In addition, to provide a deeper insight, energy poverty can be segregated into urban and rural energy poverty. Similarly, unemployment can be segregated according to gender and age.

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9

The Role of Digitalization in Firms' Global Value Chain Participation in Asia and the Pacific

Upalat Korwatanasakul

9.1 Introduction

Alongside trade and investment liberalization, the advancement of digitalization, particularly technological advances in information and communications technology (ICT), has played a significant role in expanding global value chains (GVCs). The ICT revolution has enabled the international dispersion of activities within GVCs due to cheaper and more reliable telecommunications, information management software, and personal computers (Baldwin 2016). GVC participation and digitalization provide numerous benefits to participating firms, such as enhancing their overall capabilities and competitiveness in production, finance, and marketing. These benefits extend business opportunities, especially to small and medium-sized enterprises (SMEs),[1] enabling them to connect with foreign suppliers and customers and, in turn, allowing technological transfer (Lundquist and Kang 2021). Nevertheless, to participate in GVCs, firms must meet international market standards, which are costly. Firms in developing countries, mainly SMEs, face constraints in economies of scale, access to finance and information, and technological capacity, making it challenging to

[1] In this study, SMEs are firms with fewer than 200 workers (World Bank 2020), while GVC firms are firms engaging in imports of foreign inputs and direct and indirect exports of their products (Urata and Baek 2021).

meet these standards. These constraints also pose challenges for them in adopting and utilizing digital technology, where their digital readiness is unsatisfactory, further hindering their participation in GVCs.

According to systematic literature reviews by Kano, Tsang, and Yeung (2020) and Leão and da Silva (2021), previous studies examining the impact of digitalization on firms' competitiveness tended to focus on firms' innovation, efficiency, cost-reduction, and organization of and upgrading within value chains (e.g., Banga 2022; Strange and Zucchella 2017). Consistent with observations from recent GVC studies, such as Reddy and Sasidharan (2021) and Gopalan, Reddy, and Sasidharan (2022), the reviews showed a lack of literature exploring the relationship between digitalization and firm-level GVC participation (Lundquist and Kang 2021), particularly in the context of Asia and the Pacific. Among the dearth of studies, on the one hand, Foster and Graham (2017) and Foster et al. (2018) conducted a qualitative case study in Africa. They found the significance of digital infrastructure in facilitating GVC integration for firms. On the other hand, Korwatanasakul (2020), Reddy and Sasidharan (2021), and Gopalan, Reddy, and Sasidharan (2022) employed a quantitative analysis model utilizing probit and logit models to investigate the role of digitalization in firm-level GVC participation. Their estimated results highlighted the importance of digital connectivity on GVC participation probability among firms worldwide (Korwatanasakul 2020), firms in developing economies (Gopalan, Reddy, and Sasidharan 2022), and Indian firms (Reddy and Sasidharan 2021).

Moreover, the existing literature does not sufficiently account for the reality of firms, particularly in Asia and the Pacific, where SMEs represent about 97% of firms (APEC 2020).[2] Since the late 2000s, international organizations (e.g., the United Nations Conference on Trade and Development and the Organisation for Economic Co-operation and Development) raised awareness of the role of SMEs in GVCs and the unequal benefits they receive. Korwatanasakul and Paweenawat (2021) comprehensively summarized the debates in the literature on SMEs and GVCs as follows. Previous studies (e.g., APEC Study Center 2017; Chen 2019; OECD 2008) focused on specific firms or sectors to explore SMEs' involvement in GVCs, the benefits of participation, and the barriers they face. SMEs can participate in GVCs as original equipment manufacturers or subcontractors, original brand manufacturers, or intermediate traders and suppliers. They can benefit from product upgrading, specialization,

[2] See Section 9.2 for more discussion.

efficiency enhancement, market expansion, knowledge acquisition, and innovation engagement. However, inadequate knowledge and resources, compliance difficulties, limited scale, inflexibility, and weak bargaining power can prevent SMEs from enjoying these benefits (Hatsukano and Tanaka 2014; Korwatanasakul 2019; Korwatanasakul and Intarakumnerd 2020; Kotturu and Mahanty 2017).

Relatively more recent literature, such as Arudchelvan and Wignaraja (2015) and Vidavong, Thipphavong, and Suvannaphakdy (2017), investigated firm characteristics that potentially influence SME participation in GVCs through a cross-sectional probit regression analysis using firm-level survey data. Arudchelvan and Wignaraja (2015) observed positive correlations between (i) firm size and the likelihood of SMEs engaging in GVCs and (ii) technology and research and development and the participation of SMEs in GVCs. However, Vidavong, Thipphavong, and Suvannaphakdy (2017) reported a contradictory finding, indicating a negative relationship between research and development and the participation. However, most conclusions were derived from cross-sectional analyses with limited observations, possibly resulting in endogeneity issues and biased estimation.

Against this backdrop, this study aims to elucidate the link between digitalization and GVC participation at the firm level, focusing on SMEs in Asia and the Pacific. It employs probit and tobit regression analyses using cross-sectional data from the World Bank's Enterprise Surveys spanning 28 countries and 23,551 firms for 2008–2018. The industry average of digitalization (i.e., email and website adoptions) is adopted as instrumental variables (IVs) to correct endogeneity issues. Thus, solving endogeneity issues, the current study contributes to the literature by (i) distinguishing the impact of digitalization on GVC participation between SMEs and large firms, (iii) differentiating the impact of digitalization on GVC participation probability (dummy variables with different GVC definitions) and GVC participation level measured by GVC index, which has not been used in the previous studies, and (iii) providing the analysis of digital readiness and firm-level GVC participation in the context of Asia and the Pacific. The findings from both models indicate that firms, especially SMEs with digital connectivity through email and website use, are more likely to engage in GVCs and exhibit higher GVC participation. This finding is consistent with previous research, highlighting the role of digital technologies in facilitating international market access and enhancing supply chains. However, the impact of digitalization on GVC participation differs between SMEs and large firms. Basic digital technology, such as emails and websites, is more beneficial for SMEs in increasing their

GVC participation. In contrast, the effects of digitalization on GVC participation diminish for large firms, likely due to their widespread adoption of basic digital technology. The study also confirms that smaller firms and SMEs face greater challenges participating in GVCs. Foreign ownership, certificates, and credit access also positively influence GVC participation.

9.2 Current Situation of Firms' GVC Participation and Digitalization in Asia and the Pacific

9.2.1 GVC Participation

The critical role of SMEs cannot be overlooked since they represent most firms and domestic employment in Asia and the Pacific and contribute significantly to the national gross domestic product (GDP), accounting for 20%–50% (APEC 2020). Despite their economic contributions, SMEs face limitations in participating in international trade and GVCs. The Asia-Pacific Economic Cooperation (APEC) (2020) reports that approximately 97% of companies in Asia and the Pacific are SMEs. Still, their export volume makes up only 35% or less of the total export, causing an unequal distribution of benefits and new opportunities emerging from GVC participation between SMEs and large enterprises. In addition, the digital divide between small and large firms can exacerbate their unequal benefit and opportunity distribution (Antràs 2020; Korwatanasakul 2020).

Table 9.1 presents various patterns of foreign trade engagement among global firms, as derived from the World Bank's Enterprise Surveys. SMEs account for 86% of the sample firms, aligning with the World Bank's estimate indicating that 90% of businesses are SMEs (World Bank 2020). Among GVC firms, SMEs comprise a significant proportion of 67%, although most SMEs (47%) primarily focus on procurement and sales within a country (Column 1). Only 18% of SMEs participate in GVCs, equivalent to 15% of the total sample, whereas 53% of large enterprises are involved in GVCs (Column 7 of world's percentage by firm type). Consistent with the global trend, firms in Asia and the Pacific follow similar engagement patterns in foreign trade. Nevertheless, SMEs in this region are less active to join GVCs and are relatively more concentrated in domestic markets and procurement. Column 7 of Asia and the Pacific's percentage by firm type reveals that 12% of SMEs are considered GVC firms, lower than the global average (18%). Column 1 shows that most SMEs (61%) are concentrated in domestic procurement and sales. This descriptive analysis suggests that SMEs in Asia and the Pacific may have greater difficulties joining GVCs than those in other regions or indirectly engage in GVCs. The indirect GVC engagement is typically characterized by activities from low value-added tiers and procurement and sales through local intermediary firms to connect with multinational enterprises or GVC firms (Korwatanasakul and Intarakumnerd 2020). Figure 9.1 also highlights SMEs' challenges in joining GVCs due to their limited SME involvement in foreign trade. The share of GVC firms and SMEs participating in GVCs, or GVC SMEs, in Asia and the Pacific, remains moderate at 19% and 8%, respectively.

The sectoral distribution of GVC SMEs mirrors that of general GVC firms (Figure 9.2). Most countries in the Asia-Pacific region have specialization primarily in labor-intensive and low-value-added production activities, such as raw material production, component manufacturing, and product assembly; therefore, GVC firms are predominantly concentrated in industries that require significant labor inputs, implying the fact that Asian and the Pacific GVC firms lack capabilities to upgrade to more capital-intensive value chains. The largest share of Asia and the Pacific's GVC firms is in the textile and clothing industry (36%), followed by the chemical industry (11%), the food industry (10%), and the electrical industry (9%).

Table 9.1: Patterns of Engagement in Foreign Trade by Firm Type

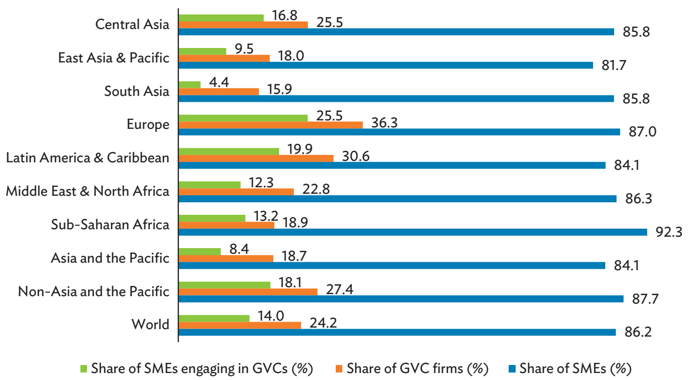
		1	2	3	4	5	6	7 GVC Firm (5+6)	8 Total
Sales	Domestic	O	O	X	O	X	O	O/X	
	Exports	X	X	O	O	O	O	O	
Inputs	Domestic	O	O	O	O	O	O	O	
	Imports	X	O	X	X	O	O	O	
World									
Firm type	SME	18,131	10,634	653	2,569	681	6,254	6,935	38,922
	Non-SME	988	1,150	149	707	560	2,877	3,437	6,431
Total		19,119	11,784	802	3,276	1,241	9,131	10,372	45,353
% by Sales and Inputs Pattern									
Firm type	SME	94.8	90.2	81.4	78.4	54.9	68.5	66.9	85.8
	Non-SME	5.2	9.8	18.6	21.6	45.1	31.5	33.1	14.2
Total		100	100	100	100	100	100	100	100
% by Firm Type									
Firm type	SME	46.6	27.3	1.7	6.6	1.7	16.1	17.8	100
	Non-SME	15.4	17.9	2.3	11.0	8.7	44.7	53.4	100
Total		42.2	26.0	1.8	7.2	2.7	20.1	22.9	100
Asia and the Pacific									
Firm type	SME	8,764	2,220	442	1,274	331	1,361	1,692	14,392
	Non-SME	635	418	125	439	355	899	1,254	2,871
Total		9,399	2,638	567	1,713	686	2,260	2,946	17,263
% by Sales and Inputs Pattern									
Firm type	SME	93.2	84.2	77.9	74.4	48.2	60.2	57.4	83.4
	Non-SME	6.8	15.8	22.1	25.6	51.8	39.8	42.6	16.6
Total		100	100	100	100	100	100	100	100
% by Firm Type									
Firm type	SME	60.9	15.4	3.1	8.9	2.3	9.5	11.8	100
	Non-SME	22.1	14.6	4.4	15.3	12.4	31.3	43.7	100
Total		54.4	15.3	3.3	9.9	4.0	13.1	17.1	100

O = Yes; X = No, GVC = global value chain, SME = small and medium-sized enterprises.

Note: Columns 1–6 represent 1) firms with domestic procurement and sales; 2) firms with input imports, domestic procurement, and domestic sales; 3) firms with domestic procurement and exports; 4) firms with domestic procurement, domestic sales, and exports; 5) firms with exports, input imports, and domestic procurement; and 6) firms with domestic procurement and sales, input imports, and exports.

Source: Author's calculation using World Bank's Enterprise Surveys data. http://www.enterprisesurveys.org (accessed 1 June 2023).

Figure 9.1: Share of SMEs, GVC firms, and SMEs engaging in GVCs by Region
(%)

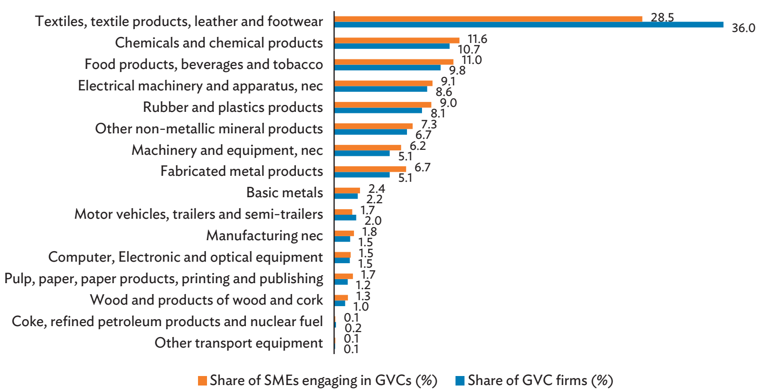


GVC = global value chain, SME = small and medium-sized enterprises.

Note: East Asia & Pacific includes Cambodia, the PRC, Indonesia, the Lao PDR, Malaysia, Mongolia, Myanmar, Papua New Guinea, the Philippines, Solomon Islands, Thailand, Timor-Leste, and Viet Nam. Asia & Pacific includes Central Asia, East Asia & Pacific, and South Asia.

Source: Author's calculation based on the World Bank's Enterprise Surveys. http://www.enterprisesurveys.org (accessed 1 June 2023).

Figure 9.2: Sectoral Distribution of GVC Firms in the Asia and Pacific Region
(%)



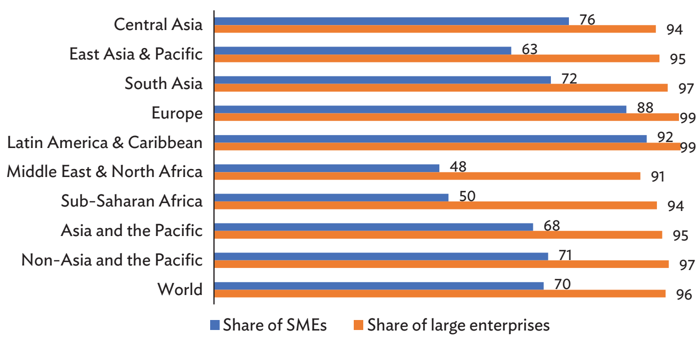
GVC = global value chain, NEC = not elsewhere classified, SME = small and medium-sized enterprises.

Source: Author's calculation based on the World Bank's Enterprise Surveys. (http://www.enterprisesurveys.org (accessed 1 June 2023).

9.2.2 Evaluation of SME Digital Readiness

Figures 9.3 and 9.4 highlight the regional disparities in digitalization and the digital divide between SMEs and large firms across different regions. These digital challenges SMEs may explain SMEs' lower participation in GVCs than large firms. Figure 9.3 presents data on email adoption rate by firm size across different regions, revealing notable differences between large firms and SMEs. Generally, large firms have higher email adoption rates compared to SMEs. The gap in adoption rates is particularly significant in Asia and the Pacific (27%), only after Africa. Figure 9.4 illustrates that SMEs have significantly lower website adoption than large firms across regions. On average, in Asia and the Pacific, the website adoption rate for SMEs is 41%, while it stands at 81% for large enterprises. The disparity between the website adoption rates of SMEs and large firms is even broader than email adoption rates. Creating and maintaining a website demands more advanced computer skills and higher maintenance costs, leading SMEs to rely primarily on cost-effective digital technologies like email.

Figure 9.3: Adoption Rate of Email by Region and Firm Size (%)

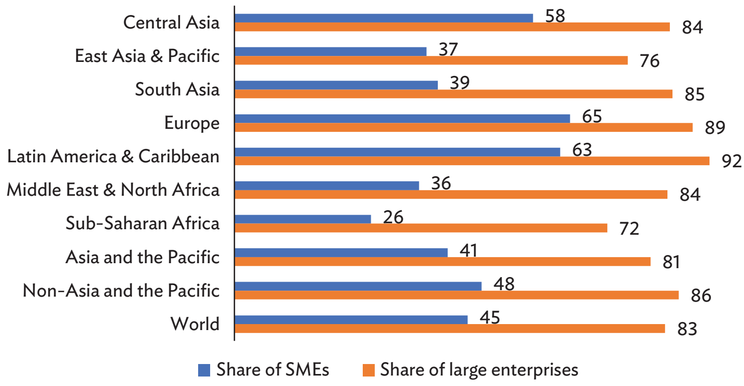


SME = small and medium-sized enterprises.

Notes: East Asia & Pacific includes Cambodia, the PRC, Indonesia, the Lao PDR, Malaysia, Mongolia, Myanmar, Papua New Guinea, the Philippines, Solomon Islands, Thailand, Timor-Leste, and Viet Nam. Asia & Pacific includes Central Asia, East Asia & Pacific, and South Asia.

Source: Author's calculation based on the World Bank's Enterprise Surveys. http://www.enterprisesurveys.org (accessed 1 June 2023).

Figure 9.4: Adoption Rate of Website by Region and Firm Size (%)



SME = small and medium-sized enterprises.

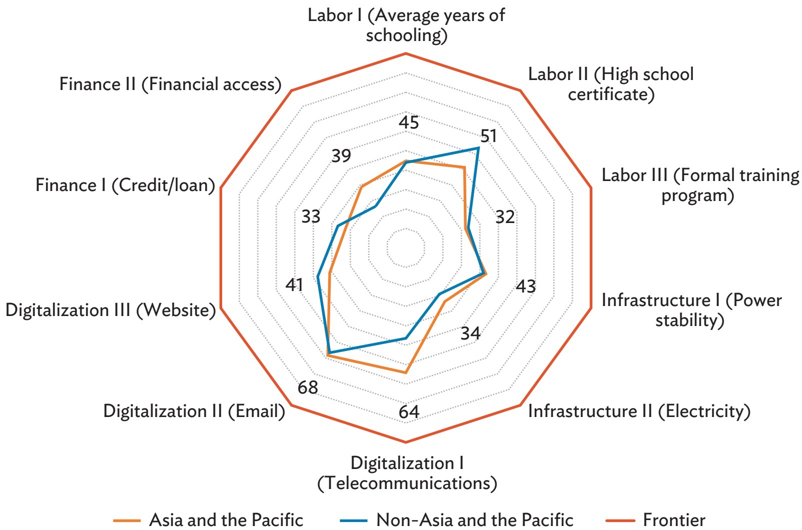
Notes: East Asia & Pacific includes Cambodia, the PRC, Indonesia, the Lao PDR, Malaysia, Mongolia, Myanmar, Papua New Guinea, the Philippines, Solomon Islands, Thailand, Timor-Leste, and Viet Nam. Asia & Pacific includes Central Asia, East Asia & Pacific, and South Asia.

Source: Author's calculation based on the World Bank's Enterprise Surveys. http://www.enterprisesurveys.org (accessed 1 June 2023).

SMEs in Asia and the Pacific exhibit inadequate levels of digital readiness,[3] as indicated in Figure 9.5. There is significant room for improvement, with a considerable gap between their current digital readiness levels and the digital readiness frontier, ranging from 32 and 66 points. Several domains require attention, including finance, supporting infrastructure, and labor capability. In contrast, they relatively excel in digitalization, i.e., telecommunications and email adoption, which are closest to the digital readiness frontier compared to other factors. A significant majority of SMEs in Asia and the Pacific use email for communication with clients and suppliers (68%), and 64% report no obstacles in telecommunications for their daily operations. However, the adoption rate of Digitalization III (website) is low, with

[3] The SME Digital Readiness Index comprises four key domains encompassing various factors contributing to digital development: labor capability, supporting infrastructure, digitalization, and finance (Korwatanasakul 2020). The index is calculated by averaging scores or statistics related to each factor or determining the proportion of SMEs that have not faced specific challenges.

Figure 9.5: Digital Readiness Index of SMEs in Asia and the Pacific



SMEs = small and medium-sized enterprises.

Source: Author's calculation based on the World Bank's Enterprise Surveys. http://www.enterprisesurveys.org (accessed 1 June 2023).

only 41% having a website. The findings from Figure 9.5 are consistent with Figures 9.3 and 9.4, as SMEs are less digitally ready.

9.3 Methodology

9.3.1 Data

The analysis in this study is conducted at the firm level using pooled cross-sectional data from the World Bank's Enterprise Surveys. The data spans from 2008 to 2018 and includes 28 countries and 23,551 firms. Following Urata and Baek (2021) and Korwatanasakul and Paweenawat (2021), two indicators of GVC participation are constructed: the GVC participation dummy and the GVC participation index. On the one hand, the GVC participation dummy identifies whether a firm engages in GVCs based on its patterns of direct and indirect involvement in foreign trade through sales and input procurement, as shown in Table 9.1.

On the other hand, the GVC participation index is calculated by multiplying the ratio of exports to total sales by the ratio of foreign input to total input. Each indicator is used as an independent variable in two separate analyses, employing probit and tobit models. Table 9.2 provides summary statistics, and data construction is presented in Table A9 (Appendix).

Table 9.2: Summary Statistics

Variable	Description	Observations	Mean	Standard deviation	Minimum value	Maximum Value
GVC participation						
GVC participation	Equals 1 if the establishment participates in GVCs and 0 otherwise. The GVC participation dummy indicates whether a firm joins GVCs based on the firm's patterns of direct and indirect engagement in foreign trade through sales and input procurement.	18,373	0.1873	0.3902	0	1
GVC participation index	The GVC participation index is calculated by multiplying the ratio of exports to total sales and the ratio of foreign input to total input.	18,371	0.0613	0.1942	0	1
Digitalization						
Email	Equals 1 if the establishment uses email to communicate with clients or suppliers and 0 otherwise.	23,411	0.7320	0.4429	0	1
Website	Equals 1 if the establishment has its own website and 0 otherwise.	23,521	0.4757	0.4994	0	1
Firm characteristics						
Firm size	Natural logarithm of a firm's total full-time employees.	23,551	3.7446	1.4283	0	10.309
SME	Equals 1 if the establishment has less than 200 employees and 0 otherwise.	23,551	0.8408	0.3659	0	1
Labor productivity	1) Natural logarithm of labor productivity based on value added.	19,067	13.6533	2.7202	1.3548	26.8425
Firm age	Number of years in operation.	23,272	18.7890	13.5661	0	162
Foreign ownership	The share of equity owned by a foreign firm (%).	23,492	5.4490	20.6980	0	100
Sole proprietorship	Equals 1 if sole proprietorship and 0 otherwise.	23,576	0.4210	0.4937	0	1
Certificate	Equals 1 if ownership of internationally recognized quality certification and 0 otherwise.	23,262	0.3669	0.4820	0	1
Credit access	Equals 1 if the establishment has a line of credit or loan from a financial institution and 0 otherwise.	22,616	0.3481	0.4764	0	1

GVC = global value chain, SME = small and medium-sized enterprise.

Source: Author.

9.3.2 Estimation methods

Based on its specific characteristics, such as digital connectivity, firm size, and types of ownership, the probit model (Equation 1) used in this study aims to estimate the likelihood of a firm being a GVC firm or a non-GVC firm. Moreover, the tobit model (Equation 2) estimates the effect of digitalization on the GVC participation level measured by the GVC index. The model specifications are as follows:

Probit model:

$$Pr(GVCparticipation_{ict} = 1|Z_{ict}) = \theta(\beta_0 + \beta_1 Digitalization_{ict} + \beta_2 X_{ict} + \gamma_c + \sigma_k + \mu_t + \epsilon_{ict}) \quad (1)$$

Tobit model:

$$GVCindex^*_{ict} = GVCindex^*_{ict}, \text{ if } 0 < GVCindex^*_{ict} < 1$$
$$GVCindex^*_{ict} = 0, \textit{ if } GVCindex^*_{ict} \leq 0$$
$$GVCindex^*_{ict} = 1, \textit{ if } GVCindex^*_{ict} \geq 1$$
$$GVCindex^*_{ict} = \beta_0 + \beta_1 Digitalization_{ict} + \beta_2 X_{ict} + \gamma_c + \sigma_k + \mu_t + \epsilon_{ict} \quad (2)$$

GVC participation$_{ict}$ refers to the GVC participation dummy indicating whether a firm is engaging in foreign trade through sales and input procurement. In contrast, $GVCindex^*_{ict}$ refers to the level of GVC participation estimated from the multiplication of exports to total sales and foreign input to total input ratios (Urata and Baek 2021). The variable of interest is $Digitalization_{ict}$ indicating whether a firm uses emails or websites for firm i in country c and year t. X_{ict} represents a set of control variables, including labor productivity, firm age, foreign ownership, government ownership, female ownership, credit access, and internationally recognized quality certificate.[4] The estimation models include country-, industry- and time-fixed effects and the disturbance term, represented by γ_c, σ_k, μ_t, and ϵ_{ict} respectively. Robust standard errors are also used in the estimations.

The proposed estimation models may suffer from endogeneity issues. Participating in GVCs causes firms to invest in and utilize digitalization in their business practices, resulting in reverse causality, while unobserved variables may also exist in the disturbance terms. This study employs recursive bivariate probit and tobit models to address

4 This study's model specifications follow Urata and Baek (2021). For more discussion on the hypotheses behind each variable, see Urata and Baek (2021).

the endogeneity issues by utilizing an exogenous instrument for the endogenous digitalization variable. The IV model specifications are as follows:

Recursive bivariate probit model:

First stage

$$Pr\,(Digitalization_{ict} = 1|Z_{ict}) = \theta(\beta_0 + \beta_1\, Digitalization\_Industry_{ict} + \beta_2\, X_{ict} + \gamma_c + \sigma_k + \mu_t + \epsilon_{ict}) \qquad (3)$$

Second stage

$$Pr\,(GVCparticipation_{ict} = 1|Z_{ict}) = \theta(\beta_0 + \beta_1\, Digitalization\_Industry_{ict} + \beta_2\, X_{ict} + \gamma_c + \sigma_k + \mu_t + \epsilon_{ict}) \qquad (4)$$

Recursive bivariate tobit model:

First stage

$$Digitalization_{ict} = \beta_0 + \beta_1\, Digitalization\_Industry_{ict} + \beta_2\, X_{ict} + \gamma_c + \sigma_k + \mu_t + \epsilon_{ict} \qquad (5)$$

Second stage

$$GVCindex^{*}_{ict} = \beta_0 + \beta_1\, Digitalization\_Industry_{ict} + \beta_2\, X_{ict} + \gamma_c + \sigma_k + \mu_t + \epsilon_{ict} \qquad (6)$$

Following the previous literature (e.g., Cette, Nevoux, and Py 2021), the IV, $Digitalization\_Industry_{ict}$, refers to the industry mean of email (website) adoption excluding the firm's use of email (website). The IV measures the deviation of firm-level digitalization adoption from the industry mean. The identification strategy follows the logic that firms with a deviation, i.e., adopting digitalization, are more exposed to industry-wide technology spillovers, implying lower adoption costs, and, in turn, more actively utilize digitalization to participate in GVCs or increase their GVC participation level. The exogeneity of the adopted IV comes from the inclusion of the industry fixed effects (σ_k) in the estimation model. While σ_k captures all the other industry specificities (unobserved industry-level variables), the only difference among firms is each firm's digitalization adoption (i.e., email and website adoptions). Sectoral spillovers, external economies of scale, and network effects are unlikely to affect the validity of the IV (Cette, Nevoux, and Py 2021). Thus, the IV addresses omitted variable bias and reverse causality simultaneously.

9.4 Estimated Results

9.4.1 Results

Despite the higher coefficients of bivariate probit and tobit estimates, the estimated results from baseline regression and the bivariate estimation with instruments are consistent, except in Column 6, Table 9.3. The estimated results of the probit and tobit models (Tables 9.3 and 9.4) demonstrate that firms, especially SMEs with digitalization, such as email and website adoption, are more likely to engage in GVCs and have a higher degree of GVC participation (greater GVC participation index), consistent with the previous literature, (e.g., Korwatanasakul 2020; Reddy and Sasidharan 2021; and Gopalan, Reddy, and Sasidharan 2022). This confirms that adopting digital technologies enables firms to access international markets (Lendle and Olarreaga 2014; WTO 2016) and facilitates connections with domestic and foreign suppliers and consumers, enhancing supply and value chains (Abel-Koch 2016).

Moreover, the estimated results reveal the heterogenous effects of digitalization on GVC participation between SMEs and large firms. When introducing interaction terms between SMEs and digitalization, the impact of digitalization on GVC participation is greater for SMEs (Table 9.3 Column 12 and Table 9.4 Columns 6 and 12). The different effects of digitalization between SMEs and large enterprises imply that basic digital technology, such as emails and websites, possibly helps SMEs participate in GVCs and raise their GVC participation level. However, the heterogeneous effect of email adoption on GVC participation tendency between SMEs and large firms is not observable (Table 9.3 Column 6), while the impact of website adoption on GVC participation tendency disappears for large firms (Table 9.4 Column 6). Digitalization effects on large firms' GVC participation tendency disappear, possibly because most large firms have already invested in and commonly utilize digital technology, e.g., websites, in their businesses. Nevertheless, the current estimated results are not sufficient to support the hypothesis explaining large firms' situation and, in turn, warrant further investigation with richer data on firms' digitalization.

Additionally, both estimation models indicate that being a smaller firm or an SME negatively correlates with GVC participation, with the estimated negative coefficients being statistically significant and robust across different model specifications. The findings support previous research, such as Arudchelvan and Wignaraja (2015), Korwatanasakul and Paweenawat (2020), and Vidavong, Thipphavong, and Suvannaphakdy (2017), arguing that SMEs face challenges in participating in GVCs due to their limited knowledge, technology, and innovation capacity.

Regarding the control variables, foreign ownership, certificate, and credit access are statistically significant and positively affect GVC participation, highlighting the importance of these factors in promoting firms' GVC participation. Their estimated coefficients are also robust across different model specifications. For instance, firms with a higher level of foreign ownership would experience knowledge and technology transfer, providing them access to new technology, innovation, management expertise, and international networks and, in turn, making them more inclined to participate in GVCs. In contrast, sole proprietorships negatively affect GVC participation as firms are at a disadvantage in joining GVCs when they lack social ties and resources (Das, Roberts, and Tybout 2007).

Table 9.3: Effects of Email Adoption on GVC Participation

	Dependent variable: GVC participation (Dummy)						Dependent variable: GVC participation index					
	Baseline Regression: Probit Estimation			Bivariate Probit Estimation with Instruments			Baseline Regression: Tobit Estimation			Bivariate Tobit Estimation with Instruments		
Variable	1	2	3	4	5	6	7	8	9	10	11	12
Digitalization (Email)	0.593***	0.731***	0.369**	0.560***	1.466***	1.447***	0.285***	0.356***	0.068	1.104***	1.159***	0.357***
	−0.052	−0.051	−0.152	−0.148	−0.084	−0.175	−0.023	−0.023	−0.063	−0.145	−0.126	−0.099
Firm size	0.303***			0.306***			0.124***			0.0416***		
	−0.013			−0.017			−0.006			−0.013		
SME		−0.656***	−1.041***		−0.511***	−0.530***		−0.272***	−0.579***		−0.114***	−0.447***
		−0.038	−0.155		−0.041	−0.155		−0.016	−0.066		−0.025	−0.063
SME x			0.404**			0.019			0.322***			0.253***
Digitalization (Email)			−0.159			−0.153			−0.067			−0.061
Labor productivity	0.0479***	0.0419***	0.0420***	0.0485***	0.014	0.014	0.0162***	0.0132***	0.0134***	−0.0153**	−0.0187***	0.003
	−0.012	−0.012	−0.012	−0.012	−0.011	−0.011	−0.005	−0.005	−0.005	−0.007	−0.006	−0.005
Firm age	0.001	0.0389*	0.0385*	0.001	0.032	0.032	−0.0321***	−0.014	−0.015	−0.0247***	−0.0174*	−0.014
	−0.024	−0.023	−0.023	−0.023	−0.022	−0.022	−0.010	−0.010	−0.010	−0.009	−0.009	−0.009
Foreign ownership	0.0117***	0.0125***	0.0124***	0.0118***	0.0114***	0.0114***	0.00570***	0.00619***	0.00618***	0.00456***	0.00460***	0.00522***
	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
Sole proprietorship	−0.299***	−0.394***	−0.390***	−0.304***	−0.280***	−0.280***	−0.122***	−0.165***	−0.161***	−0.0448**	−0.0491**	−0.117***
	−0.039	−0.038	−0.038	−0.041	−0.040	−0.040	−0.017	−0.017	−0.017	−0.020	−0.022	−0.018
Certificate	0.268***	0.403***	0.404***	0.267***	0.290***	0.291***	0.0936***	0.151***	0.152***	0.0335*	0.0410**	0.110***
	−0.037	−0.036	−0.036	−0.038	−0.037	−0.038	−0.016	−0.016	−0.016	−0.018	−0.021	−0.017
Credit access	0.130***	0.170***	0.169***	0.129***	0.128***	0.128***	0.0261*	0.0448***	0.0446***	0.005	0.009	0.0325**
	−0.032	−0.031	−0.032	−0.032	−0.031	−0.031	−0.014	−0.014	−0.014	−0.014	−0.014	−0.013
Constant	−4.020***	−2.421***	−2.076***	−3.973***	−2.644***	−2.627***	−1.715***	−1.074***	−0.800***	−1.574***	−1.334***	−0.882***
	−0.464	−0.468	−0.487	−0.493	−0.475	−0.493	−0.216	−0.217	−0.224	−0.213	−0.222	−0.211
Observations	13,606	13,606	13,705	13,650	13,650	13,650	13,681	13,681	13,681	17,979	17,979	17,979

GVC = global value chain, SME = small and medium-sized enterprise.

Notes: ***, **, and * indicate that coefficients are significant at the 1%, 5%, and 10% levels, respectively. Robust standard errors are reported in parentheses. All regressions include industry-country- and time-fixed effects. SME x Digitalization (email) indicating the interaction term between the two variables.

Source: Author.

Table 9.4: Effects of Website Adoption on GVC Participation

	Dependent variable: GVC participation (Dummy)						Dependent variable: GVC participation index					
	Baseline Regression: Probit Estimation			Bivariate Probit Estimation with Instruments			Baseline Regression: Tobit Estimation			Bivariate Tobit Estimation with Instruments		
Variable	1	2	3	4	5	6	7	8	9	10	11	12
Digitalization (Website)	0.369***	0.470***	0.086	0.382*	0.558***	−0.115	0.136***	0.186***	−0.0670**	0.865***	0.981***	0.873***
	−0.037	−0.037	−0.077	−0.204	−0.185	−0.245	−0.016	−0.016	−0.031	−0.252	−0.222	−0.18
Firm size	0.306***			0.305***			0.131***			0.043		
	−0.013			−0.024			−0.006			−0.027		
SME		−0.655***	−1.020***		−0.635***	−1.075***		−0.283***	−0.529***		−0.062	−0.224***
		−0.038	−0.075		−0.059	−0.097		−0.017	−0.031		−0.056	−0.055
SME x			0.469***			0.483***			0.322***			0.239***
Digitalization (Website)			−0.083			−0.086			−0.034			−0.032
Labor productivity	0.0537***	0.0496***	0.0498***	0.0529***	0.0463***	0.0554***	0.0203***	0.0182***	0.0180***	−0.006	−0.012	−0.0145*
	−0.012	−0.012	−0.012	−0.013	−0.012	−0.013	−0.005	−0.005	−0.005	−0.010	−0.009	−0.008
Firm age	−0.010	0.028	0.03	−0.010	0.025	0.035	−0.0359***	−0.0178*	−0.015	−0.0381***	−0.0309***	−0.0297***
	−0.023	−0.023	−0.023	−0.023	−0.023	−0.023	−0.010	−0.010	−0.010	−0.010	−0.010	−0.010
Foreign ownership	0.0120***	0.0129***	0.0127***	0.0121***	0.0130***	0.0127***	0.00590***	0.00651***	0.00626***	0.00568***	0.00590***	0.00573***
	−0.001	−0.001	−0.001	−0.001	−0.001	−0.001	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000
Sole proprietorship	−0.314***	−0.421***	−0.413***	−0.315***	−0.413***	−0.435***	−0.135***	−0.187***	−0.179***	−0.0880***	−0.0936***	−0.0771***
	−0.039	−0.038	−0.038	−0.042	−0.044	−0.044	−0.017	−0.017	−0.017	−0.021	−0.027	−0.024
Certificate	0.224***	0.351***	0.348***	0.219***	0.325***	0.396***	0.0804***	0.137***	0.134***	−0.104*	−0.115*	−0.143***
	−0.038	−0.037	−0.037	−0.058	−0.063	−0.066	−0.016	−0.016	−0.016	−0.063	−0.068	−0.054
Credit access	0.136***	0.178***	0.176***	0.133***	0.172***	0.182***	0.0293**	0.0505***	0.0499***	0.012	0.016	0.013
	−0.032	−0.031	−0.031	−0.032	−0.032	−0.032	−0.014	−0.014	−0.014	−0.014	−0.016	−0.015
Constant	−3.205***	−1.686***	−1.374***	−3.128***	−1.636***	−1.260**	−1.523***	−0.877***	−0.671***	−1.071***	−0.867***	−0.722***
	−0.511	−0.511	−0.516	−0.553	−0.542	−0.552	−0.24	−0.243	−0.244	−0.253	−0.243	−0.248
Observations	13,776	13,776	13,776	13,748	13,748	13,748	13,780	13,780	13,780	18,075	18,075	18,075

GVC = global value chain, SME = small and medium-sized enterprise.

Notes: ***, **, and * indicate that coefficients are significant at the 1%, 5%, and 10% levels, respectively. Robust standard errors are reported in parentheses. All regressions include industry-country- and time-fixed effects. SME x Digitalization (email) indicating the interaction term between the two variables.

Source: Author.

9.5 Conclusion

This study addresses research gaps by conducting empirical analyses on the relationship between GVC participation and firms' digitalization, focusing on SMEs in Asia and the Pacific. The study employs bivariate probit and tobit regressions with instruments using cross-sectional data from the World Bank's Enterprise Surveys spanning 28 countries and 23,551 firms from 2008 to 2018. The industry average of digitalization (i.e., email and website adoptions) is adopted as IVs to correct endogeneity issues. The estimated results suggest that firms, particularly SMEs, with digital connectivity, such as email and website adoption, are more likely to participate in GVCs and have a higher degree of GVC participation. This finding aligns with previous studies, indicating that adopting digital technologies enables firms to access international markets and enhance supply chains. However, the effects of digitalization on GVC participation differ between SMEs and large firms. Basic digital technology, like emails and websites, appears to assist SMEs in participating in GVCs and increasing their level of participation. In contrast, the impact of digitalization on GVC participation for large firms diminishes, likely due to their widespread use of basic digital technology. The study also confirms that smaller firms and SMEs face challenges participating in GVCs. Other factors, such as foreign ownership, certificates, and credit access, also positively influence GVC participation.

According to the SME Digital Readiness Index and the estimation results, several policy measures are crucial for enhancing SME digitalization and promoting participation in GVCs. These measures include improving access to finance, promoting technological capacity, enhancing labor quality, and upgrading basic infrastructure. Policymakers must implement comprehensive strategies addressing these areas and prioritize SME capacity building in digital technology. Access to financial resources should be ensured to support SMEs in improving their digital infrastructure, such as stable electricity and reliable internet connectivity, and to enable them to invest in advanced digital technologies. Additionally, integrating IT-related courses into school curricula and providing training programs to enhance the digital literacy of the current workforce are essential steps. Collaboration between the public and private sectors in research and development initiatives is necessary to upgrade SMEs' technology and digital capabilities. A holistic approach is needed to overcome digital barriers and facilitate SME engagement in GVCs.

A potential limitation in our analysis arises from the issue of endogeneity, specifically the reverse causality between GVC participation and total revenue. Consequently, it is essential to exercise caution when interpreting our empirical results and not to draw any causal relationship from them. Nonetheless, this study serves as an initial step towards establishing a foundation for more robust findings regarding the impact of GVC participation on firms' performance at the firm level.

Future research with more comprehensive firm-level GVC data can enhance the analysis to address indirect GVC engagement and different value-added activities, which are not accounted for in the current study. Moreover, due to data limitations, utilizing email and website adoption as proxies of digitalization yields analytical limitations. Thus, this study urges more comprehensive firm-level digitalization data collection that enables exploring alternative and more nuanced digitalization measures and offers a richer perspective on the level and nature of digital transformation.

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Appendix

Table A9: Sample Countries and Number of Sample Firms by Year

Country/Year	2008	2009	2011	2012	2013	2014	2015	2016	2018	Total
Afghanistan	0	0	0	0	0	138	0	0	0	138
Armenia	0	89	0	0	111	0	0	0	0	200
Azerbaijan	0	96	0	0	122	0	0	0	0	218
Bangladesh	0	0	0	0	1,179	0	0	0	0	1,179
Bhutan	0	0	0	0	0	0	80	0	0	80
Cambodia	0	0	0	0	0	0	0	134	0	134
PRC	0	0	0	1,685	0	0	0	0	0	1,685
Georgia	94	0	0	0	110	0	0	0	0	204
India	0	0	0	0	0	7,155	0	0	0	7,155
Indonesia	0	1,057	0	0	0	0	1,051	0	0	2,108
Kazakhstan	0	132	0	0	199	0	0	0	0	331
Kyrgyz Republic	0	72	0	0	104	0	0	0	0	176
Lao PDR	0	0	0	93	0	0	0	110	142	345
Malaysia	0	0	0	0	0	0	583	0	0	583
Mongolia	0	100	0	0	120	0	0	0	0	220
Myanmar	0	0	0	0	0	352	0	355	0	707
Nepal	0	0	0	0	244	0	0	0	0	244
Pakistan	0	0	0	0	1,051	0	0	0	0	1,051
Papua New Guinea	0	0	0	0	0	0	27	0	0	27
Philippines	0	869	0	0	0	0	1,036	0	0	1,905
Solomon Islands	0	0	0	0	0	0	41	0	0	41
Sri Lanka	0	0	361	0	0	0	0	0	0	361
Tajikistan	100	0	0	0	123	0	0	0	0	223
Thailand	0	0	0	0	0	0	0	726	0	726
Timor-Leste	0	0	0	0	0	0	56	0	0	56
Türkiye	827	0	0	0	1,080	0	0	0	0	1,907
Uzbekistan	106	0	0	0	128	0	0	0	0	234
Viet Nam	0	678	0	0	0	0	691	0	0	1,369
Total	1,127	3,093	361	1,778	4,571	7,645	3,565	1,325	142	23,607

Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.

Source: Author.

Conclusion: Digital Connectivity and Digital Trade—Understanding the Linkages and Policy Challenges

Amitendu Palit, Dil Rahut, Subhasis Bera, and Yixin Yao

Digital Connectivity in Overall Connectivity

The global shift toward digital connectivity for economic progress faces persistent challenges known as the digital divide. Despite efforts, disparities in affordability and access persist, especially in the Asia and Pacific region. While subsidies alone are insufficient, bridging the gap requires targeted inclusion efforts, emphasizing digital literacy and financial skills for micro, small, and medium-sized enterprises (MSMEs), and participating in cross-border trade.

While digitalization reduces geographical distances, it also creates opportunities for income and investments. The impact of digital transformation is conditional on the digital connectivity and efficiency of digital finance and trade. Digital connectivity has introduced a new dimension in the overall idea and understanding of connectivity. The complex interplay of digital connectivity, economic growth, and sustainability demands comprehending the term connectivity.

Connectivity for centuries has been typically understood as connections for movement of goods, services, and people provided through land or water routes. Connections through either land or sea, are single mode, or unimodal in character. A combination of land and water routes implies multimodal connectivity. Modern infrastructure plans are multimodal in character as they involve the passage of goods by rail or road from the hinterland to seaports for further passage across a country's borders. Similar multimodality is also observed for the movement of goods and people from the hinterland to airports and further outward.

The attention of global economic policy bodies, such as the World Bank, the Asian Development Bank, and the World Trade Organization (WTO) in the past has been on enabling faster transit through land and water routes. Land routes include road links across contiguous geographies and sovereign nations for connecting national and subnational territories. Water routes primarily comprise maritime connections across oceans and seas, linking continents, regions, and subregions.

The logic of economic globalization and unrestricted trade has encouraged multi-pronged efforts for bringing down costs of the movement of goods across borders. A notable initiative in this regard has been the adoption of the WTO's trade facilitation agreement (TFA) (WTO 2014). In force since 22 February 2017, the TFA aims to cuts costs of the movement of goods across land and sea borders by minimizing procedures and harmonizing cooperation between customs and other regulatory agencies of WTO members. As of now, 156 WTO members, out of a total of 164, have ratified the TFA (WTO. n.d.).

Trade Facilitation, New Frameworks, and Digital Connectivity

The introduction and implementation of the TFA has played an important part in drawing attention to the significant role of digitalization in enhancing trade facilitation. Efforts by the TFA to cut "regulatory cholesterol" at the borders by simplifying procedures for moving goods include emphasis on digitalization of clearance processes. The digitalization of customs operations, transitioning to electronic filing of documents (e.g., payment invoices), and emergence of single and composite operable online platforms that integrate all requirements pertaining to the movement of goods, has laid the foundation for countries, particularly developing nations, for getting digitally connected through trade.

The digitalization of border clearance processes has also established the foundation for growth of trade agreements that focus on maximizing economic benefits that can be obtained from digital connectivity. The Asia and Pacific region has seen the growth of some such notable frameworks in recent years. These include the Digital Economy Partnership Agreement executed by Singapore, New Zealand, and Chile (MTI n.d.); the United Kingdom–Singapore Digital Economy Agreement (GOV.UK 2022); and the Singapore–Australia Digital Economy Agreement (DFAT n.d.).These agreements emphasize the integration of national digital economies through interoperability of digital systems and processes. The latter are wide ranging and include e-invoicing, digital payment systems, paperless trade, establishment of digital identities,[1] and harmonized data protection and cybersecurity rules.

As more digital rules-based frameworks develop—both multilaterally and regionally—digital connectivity will expand rapidly across various parts of the world. The expansion will be particularly noticeable in the Asia and Pacific region due to the evolution of new digital frameworks. The connectivity expansion will accelerate from greater digitalization of both national and cross-border trade systems.

Digital Economy Framework Agreement

The push toward digital transformation has been hastened by unanticipated developments like the novel coronavirus disease (COVID-19) pandemic. Indeed, the pandemic has probably been the most instrumental factor in emphasizing the importance of building digital connectivity capacities, not just at the national level, but also among enterprises and households. Countries have begun responding to the urgency with significant policy initiatives. A prominent example of a regional effort in this regard is the launch of negotiations for the Association of Southeast Asian Nations (ASEAN) Digital Economy Framework Agreement (DEFA) (ASEAN 2023).

The DEFA is expected to be a significant initiative in multiple ways. As the first regional digital economy framework agreement, it focuses on an exhaustive range of issues that impact digital connectivity and digital trade. These include e-commerce, digital payments, data flows, and cybersecurity. The effort is also noteworthy for its further emphasis on digital inclusivity.

ASEAN is a heterogenous grouping of economies, which include mature industrial economies (e.g., Singapore, Malaysia, Thailand) along with low-income, least developed members (e.g., Myanmar, Cambodia, the Lao People's Democratic Republic). The national digital capacity of ASEAN member states shows large variations. Notwithstanding these variations, the DEFA aims to digitally connect the ASEAN region by creating a framework of common rules that would support the growth of a regional digital economy. In this regard, its progress will provide an illuminating experience on evolution of an exhaustive digital connectivity framework.

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1 A digital identity is described as "a collection of electronically captured and stored identity attributes that uniquely describe a person within a given context and are used for electronic transactions." Digital identity can uniquely identify individuals, enterprises, and financial asserts (PECC 2021).

The Digital Economy

Digital connectivity, as exemplified by the ASEAN DEFA and other digital economy partnership agreements mentioned earlier, is fundamental to the creation of the digital economy. The digital economy being developed by existing and upcoming rules-based frameworks generates digital trade that further generates multiple economic opportunities and overall economic growth. The evolution of the digital economy, as facilitated by digital connectivity, has key characters that lead to such evolution. These include connectivity between digitally powered networks for enabling the flow of digital traffic across various country and territorial boundaries, and operability among networks for enabling various functions (e.g., using smartphones for banking transactions). The other critical character of the digital economy is digital trade.

As more cross-border systems digitalize and mutually harmonize to become interoperable, digital connectivity emerges as the next frontier generation in overall connectivity. It is assuming as much prominence, if not more, as land and water connectivity in the wider space of global infrastructure development.

Trade facilitation efforts have ensured that digital processes become integral in improving efficiencies of global and regional trade traffic through traditional modes of connectivity such as land and water routes. This is perhaps one of the major reasons behind contemporary large-scale cross-border infrastructure projects, such as the People's Republic of China's Belt and Road Initiative (BRI) and the India–Middle East–Europe Economic Corridor (IMEC), proposing digital connectivity as important parts of their frameworks.[2] The assumption behind the emphasis on strong digital connectivity is the role it will play in facilitating digital trade across these frameworks.

Digital Connectivity and Digital Trade

The growth of digital connectivity has been inseparable from that of digital trade. Both have been facilitating and spurring the growth of each other. Intuitively, the sharp growth in digital trade is perhaps the most obvious indicator of the increase in digital connectivity that the world has experienced.

A close understanding of digital connectivity in terms of its qualitative and quantitative dimensions can be obtained from better

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[2] The Digital Silk Road is an important component of the BRI. For more details see Council on Foreign Relations (n.d.) For more details on the IMEC launched at the G20 Leaders' Summit in New Delhi, see Whitehouse.gov (2023).

knowledge of the empirical characteristics of growth in digital trade. Such understanding, however, encounters considerable methodological difficulties.

Despite its explosive growth, it is not simple to comprehend the increase in digital trade in bare details. This is because unlike physical trade in goods, digital trade is not necessarily visible. As a result, the increase in digital trade cannot be "seen and felt" like the way a lot of nondigital trade, particularly in goods, can be felt, and therefore can be understood only through its statistical reflections.

Comprehending Digital Trade

Understanding digital trade and measuring it are challenging issues. The challenge arises from the conceptual definition of digital trade itself. The prevalent definition of digital trade, as employed by the International Monetary Fund (IMF),–the Organisation for Economic Co-operation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD), and the WTO, is "……all international trade that is digitally ordered and/or digitally delivered" (IMF, OECD, UNCTAD, and WTO 2023). The definition includes trade in goods and services that are either digitally ordered, or digitally delivered, or both digitally ordered and delivered.

A statistical reflection of these different transactional varieties of trade requires availability of data that captures all of them. Obtaining such data in a disaggregated form on a country or product basis is difficult as many national statistical systems are not equipped for the required statistical reporting and data organization.

On the other hand, it is also important to understand that digital trade in a specific good or service is a part of the overall global trade in that good or service. Digital trade is distinguished from nondigital trade by the nature of its transaction. In this respect, the challenge of measuring digital trade arises in separately estimating the trade that is digitally transacted in line with the definitions of digital trade. For many quarters, this has led to digital trade being considered equivalent to e-commerce.

E-commerce (electronic commerce) is the buying and selling of goods and services through online platforms using the internet and includes digital delivery of goods and services. The scope of e-commerce is exhaustive in its coverage of transactions and includes those between business-to-business (B2B), consumer-to-consumer (C2C), as well as those between business-to-consumer (B2C) and business-to-government (B2G). But it is doubtful whether the measurement of e-commerce is an effective equivalent for digital trade.

Digital trade is a much broader concept and cannot be captured just through a simple equivalence with e-commerce. An accurate understanding of it needs to include digital goods and services (e.g., software, e-publishing, cloud computing), digital delivery of physical goods and services, hard and soft infrastructure for digital trade (e.g., virtual networks, digital identities), digital transactions (e.g., online payments), protection services (e.g., cybersecurity, privacy) and digital technologies (e.g., 5G technology, artificial intelligence, 3D-printing) (for more details, see PECC 2021).

Measuring Digital Trade

The IMF,OECD, UNCTAD, and WTO collective efforts to measure digital trade, as proposed in the *Handbook on Measuring Digital Trade* (IMF, OECD, UNCTAD, and WTO 2023), has taken on the task of measuring digital trade by setting out key definitions, outlining a methodology for measuring, and proposing a template for reporting digital trade statistics. The definitions pertain to distinguishing between digitally ordered trade and digitally delivered trade.

Digitally ordered trade includes trade in the form of cross-border sale or purchase of goods and services that are ordered online through specific processes designed for the transactions. This, by and large, as the conceptual underpinnings indicate, is synonymous with the concept of international e-commerce. However, since digital trade includes digitally delivered trade as well, its measurement extends beyond that of international e-commerce.

Digitally delivered trade represents cross-border sale and purchase transactions that are delivered remotely over digital networks (IMF, OECD, UNCTAD, and WTO 2023). Thus, a composite statistical measure of digital trade must include digitally ordered trade and digitally delivered trade thereby making it necessary to obtain data on both. Indeed, in this regard, as the *Handbook on Measuring Digital Trade* points out, it is necessary to obtain data on transactions carried out through digital intermediation platforms as well. These platforms facilitate the sale and purchase of goods and services between buyers and sellers without owning them and contribute significantly to overall digital trade.

The challenge in compiling data on digital trade is to gather information on a national and global scale in line with the reporting template. The issue becomes complex due to the engagement of multiple actors involved in transactions: business, government, consumers. International e-commerce, capturing digitally ordered trade, needs to be gleaned through data on B2B transactions. These can be obtained through business surveys that gather data on incomes earned by businesses through B2B transactions. The challenge though arises for those transactions where consumers, such as households, are involved, as these need to be assessed separately. For digitally delivered trade, it is possible to obtain some ideas through data on cross-border trade in digitally deliverable services. To a large extent these can be obtained through surveys of businesses engaged in international trade in services; but households are important actors in digital trade transactions and pose similar challenges as they do in measuring digitally ordered trade.

Looking Ahead on Issues

The expansion in digital connectivity—and that of digital trade—has been exceptionally fast. In the years to come, the pace of expansion is going to increase even more as countries rapidly digitalize and digital rules-based frameworks come up for establishing wholesome digital economies.

With the pace of digital connectivity expanding fast, several countries, particularly the developing economies of the Asia and Pacific region, will need tools and systems for understanding the growth of digital trade in greater detail. Their domestic capacity might lag in this regard. Indeed, it is important for these countries to realize that it is not enough to digitalize systems and processes for more efficient trade. It is equally important to modernize statistical capacities for measuring digital trade. Otherwise, digital connectivity might remain a vaguely understood evolution and its implications would be difficult to understand.

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