Digital Divide on Financial Development in Asia-Pacific Region: The Role of Contextual Factors

Bao Trung Phan[*] , **Dao Le-Van**[**] , **Dinh Van Nguyen**[***] , **Thi Kim Duyen Nguyen**[§]

Abstract: This study delves into the influence of the digital divide on financial development, considering contextual factors, particularly institutional frameworks. The Asia-Pacific region, chosen for its diverse variables across countries, was pivotal in elucidating this relationship. This research reveals that the impact of the digital divide on financial development becomes evident about two years post-implementation by addressing time lag and endogeneity concerns with instrumental variables. Notably, the study highlights how the digital divide affects financial inclusion advancements, with institutional quality moderating the strength of this relationship but not altering its trajectory. Monopoly is recognized as a constraint on financial development, supporting previous research. Policymakers in transitioning economies should heed the delayed effects of digital transformation, emphasizing long-term strategies considering multifaceted impacts on financial development.

Keywords: digital divide; financial development; Asia-Pacific Region; institutional quality.

JEL classification: O16; O33; G2; E44.

[*] International School, Vietnam National University Ha Noi, 10000, Hanoi, Viet Nam; e-mail: *trungpb@vnuis.edu.vn* (corresponding author).

[**] Vietnam National University Hanoi's International School and RMIT University, Ho Chi Minh, Vietnam; e-mail: *daolv@vnuis.edu.vn*.

[***] International School VNU Hanoi, Vietnam; mail: *dinhnv@vnuis.edu.vn*.

[§] International School, Vietnam National University, Hanoi (VNU-IS), Vietnam; mail: *duyenntk@vnuis.edu.vn*.

1. INTRODUCTION

The Asia-Pacific region, home to a highly significant proportion of the world's population, more than half of the global workforce, and diverse economies provides a compelling case for studying the digital divide and financial development (Vo *et al.*, 2021; ESCAP, 2025). This region exhibits tremendous heterogeneity in terms of economic development, technological infrastructure, and levels of financial inclusion. Additionally, the Asia-Pacific region has witnessed a rapid proliferation and diversity of digital technologies and the emergence of innovative digital financial solutions, which was massively widening during the recent global pandemic. The region's diverse economic landscape, ranging from advanced economies (e.g., Australia) to emerging markets (e.g., Vietnam), brings a fertile ground for studying the impacts of digital technologies on financial development and understanding the potential for streamlining institutional quality to foster inclusive growth (Nguyen *et al.*, 2019). Examining the digital divide within the context of financial development in the Asia-Pacific is the most digitally divided region in the world (Kim *et al.*, 2022), therefore, offers valuable insights into the unique challenges and opportunities that arise from the interplay of diverse socioeconomic factors and technological advancements (Hutton, 2003).

Financial development in the rapidly evolving landscape of global economics has emerged as a critical field of open inquiry (Sethi *et al.*, 2020). With the intricate interplay between financial systems and economic growth becoming increasingly evident, governments and policymakers alike recognize the pressing need to comprehend the intricate dynamics and underlying mechanisms that shape financial development (World Bank, 2012; Prochniak and Wasiak, 2017). More importantly, in an era defined by rapid technological advancements and the digital transformation of various sectors, the study of financial development has taken on new dimensions (Svirydzenka, 2016; Mignamissi and Djijo T, 2021). For example, Shiller (2013) has observed that the use of big data collected from customers by large companies has enabled them to achieve near-perfect price discrimination at the first-degree level, while the increasing difficulty in controlling the new algorithms has led to an asymmetry of information between big techs and their customers, widening the gap with suppliers as the winners (Cherbib *et al.*, 2021; Dinh *et al.*, 2023; Van Le and Tran, 2024). Thus, as societies embrace digital technologies, the importance of understanding the relationship between financial development and the digital divide referring to the disparities in access to and utilization of digital technologies has become progressively obvious (Lythreatis *et al.*, 2022; Nam and Lee, 2023).

Although extensive research explores the digital divide and financial development, the role of institutional quality in this relationship, particularly in the Asia-Pacific region, remains underexplored. Existing studies often overlook regional diversity, the moderating role of governance and regulatory quality, and cross-country variations in institutional strength. Additionally, empirical evidence using robust econometric methods is scarce, limiting insights into how digital divide influence financial development. Addressing these gaps will provide a nuanced understanding of the topic and inform targeted policy interventions to enhance financial development in diverse institutional contexts. This study delves into providing insights into strategies that can promote inclusive financial ecosystems and bridge the digital divide to pursue sustainable development goals in the Asia-Pacific region (Azmeh, 2025). By examining the role of institutional quality, it highlights how governance, regulatory frameworks, and policy effectiveness shape digital financial development. First, it would assess the relationship between the digital revolution and the financial development of 31

countries in the Asia-Pacific region under the influence of contextual factors. There would be prominent characteristics of the Asia-Pacific region in terms of research and measuring suitable indices for financial development (FD) and the digital divide (DD) in the Asia-Pacific region and second, utilizing the generalized method of moments (GMM) estimator with instrumental variables to assess the causal relationship, which allows for effective resolution of endogeneity issues. Third, this study offers an explanation for how the digital divide influences financial development, both in linear and non-linear forms. Therefore, for the academic community, this research introduces a more comprehensive perspective and fresh insights to researchers and scholars in economics, finance, and technology-related disciplines who have been actively investigating the effects of digital d on financial systems, all while taking into account the influence of contextual factors in shaping this connection. Additionally, researchers could have a reference for further examining the importance of institutional quality in creating an enabling environment for digitalization to thrive and contribute to financial development (Beck *et al.*, 2016; Khan *et al.*, 2019).

The paper is structured as follows: Section 2 reviews recent literature on digital divide, financial development, and institutional quality, and applies the DOI theory, focusing on the complex economic landscape of Asia Pacific economies. Section 3 explains the methodology and data used, while Section 4 presents the findings. Section 5 discusses these findings and concludes with final remarks.

2. LITERATURE REVIEW

2.1 Digital divide is a driven force for financial development

Financial development encompasses the evolution of financial systems, institutions, and policies that facilitate economic growth, resource allocation, and risk management (World Bank, 2019b; Wade, 2023), while the digital divide represents the disparities in access to information and communication technologies (ICTs), including internet connectivity, mobile devices, and digital literacy (Mignamissi and Djijo T, 2021; Raihan *et al.*, 2024). These concepts may initially appear distinct, but they are intrinsically linked as digital technologies increasingly streamline the landscape of paperless financial services, inclusive growth, and socioeconomic well-being.

The diffusion of innovation (DOI) theory provides a valuable framework for understanding the role of digital divide as a driving force for financial innovation (Rogers, 2010; Chien *et al.*, 2020; Drori *et al.*, 2024). According to DOI theory, the adoption and diffusion of new technologies follow a predictable pattern, influenced by various factors such as the characteristics of the innovation itself, the communication channels used to promote it, and the social system in which it is introduced (García-Avilés, 2020; Drori *et al.*, 2024). In the context of financial development, digital divide improvement represents the innovation that has the potential to reshape financial systems and promote inclusive growth. In particular, DOI theory describes the dissemination of technology-enabled business procedures, undeliberately at times, within a group or nation (Bara, 2016). In terms of paperless business procedures, DOI supports technology-backed innovation in the technology-based business transactions (Ong and Chong, 2023), digitized operation processes and paperless financial services (Kaur *et al.*, 2020), expedites digitizing and digital transforming (Wójcik *et al.*, 2021). Launching digitized business innovation has improved enterprise value and boosted user attraction (Kaur *et al.*, 2020).

Notably, digital divide will reinforce access to the government's online services, strengthen investment buildout, and enrich public-private sector ties (Legowo *et al.*, 2021b). Furthermore, previous studies have investigated into the spread of financial innovations and their effects on financial development. For instance, Allen *et al.* (2014) did a study analyzing mobile money in Kenya, Tanzania, and Uganda and found it enhanced financial inclusion for the previously unbanked, leading to increased savings, better risk management, and improved economic opportunities. Another study by Aghion *et al.* (2017) on credit information-sharing systems across countries revealed that their adoption positively influences financial development by enabling the sharing of credit data among financial institutions.

The development of financial technology (Fintech), the most observable space presenting digital transformation's impact on financial development with faster and more efficient financial transactions, with real-time processing and instant access to funds (Agarwal and Chua, 2020; Badra *et al.*, 2025), greater convenience through mobile and digital platforms, allowing users to access financial services anytime, anywhere (Hwang *et al.*, 2021; Duc *et al.*, 2024), and lowers costs for both consumers and businesses by reducing transaction fees and overhead expenses associated with traditional banking services (Demirguc-Kunt *et al.*, 2018). Additionally, Fintech promotes financial inclusion by reaching previously underserved populations, such as the unbanked and underbanked, through innovative solutions like mobile banking and digital wallets (Demirguc-Kunt *et al.*, 2018). However, digitalization-based effects on financial development to each country in the Asia-Pacific area are diversely distinct as a result of differences in culture, ICT level, national resources, and quality of governance (Bukht and Heeks, 2017; Ozili, 2018; Rhee *et al.*, 2022).

By contrast, digitalization can lead to financial exclusion when certain populations, such as the elderly, low-income groups, or those in rural areas, lack access to digital infrastructure, digital literacy, or the necessary technology. Barriers like limited internet connectivity, high costs of digital services, cybersecurity concerns, and complex digital banking systems can prevent these groups from fully participating in financial markets. Without inclusive policies and support systems, the shift to digital finance may widen the financial gap rather than close it (Weber, 2024; Shaban, 2025).

2.2 Digital divide and financial development under contextual conditions

Some studies indicate that in the context of developing countries versus developed ones whose impact lies in the internal conditions, adopter's heterogeneity, and external influences (Owusu-Agyei *et al.*, 2020; Runtev, 2020; Ekinci, 2021; Horobet *et al.*, 2022; Ong *et al.*, 2023). Another point is that external disturbances such as Remittance inflows to GDP and External loans and deposits can also affect the application of technology in the financial development (Fromentin, 2017; Alam *et al.*, 2019; Sobiech, 2019; Azizi, 2020; Bindu *et al.*, 2022; Van *et al.*, 2023). These factors should be controlled in the empirical model.

Digital divide has emerged as a pivotal force reshaping financial landscapes, with its evolving impact proving both substantial and complex over time. Studies by several researchers highlight digitalization's potential to revolutionize financial development, citing its ability to enhance financial inclusion and efficiency (Machkour and Abriane, 2020). However, this transformative journey is dynamic. As emphasized by some studies, certain aspects exhibit a non-linear relationship, such as the proliferation of ATMs or bank branches initially fueling rapid growth but potentially reversing impact upon transitioning into a

trajectory of digital divide's influence on financial development, thus unveiling a nuanced narrative, characterized by both progressive advancements and intermittent plateaus, illustrating a dynamic relationship necessitating comprehensive evaluation across temporal domains (Kumari and Khanna, 2017; Ramya *et al.*, 2017; Fujiki, 2021; Urhie *et al.*, 2021).

In the context of inefficient institutions, such as a monopoly or a former authoritarian regime, the government can utilize technological development to exert control over its citizens. This is evident in countries like North Korea, where the government restricts access to external financial resources and tightly regulates financial services to maintain a monopoly and exercise control (Carlin and Lee, 2021; Da-gyum, 2022). Similarly, in former authoritarian regimes, technology is used for surveillance, censorship, and repression to suppress dissent and maintain power (Dragu and Lupu, 2021). These control mechanisms have wide-ranging implications, stifling innovation, and limiting individual freedoms (Michaelsen, 2018). Monopolistic or authoritarian regimes create barriers to competition in financial services, business processes, and financial market development, preventing the full realization of the benefits of technological progress and digital dividends. Likewise, countries with poor institutional quality, such as some developing economies in South Asia, face challenges in fully harnessing the potential of digitalization for financial development due to inadequate regulations, weak enforcement mechanisms, and insufficient consumer safeguards (Sudan, 2020). Addressing these challenges requires promoting transparency, accountability, supportive investment, and good governance to prevent the concentration of power while fostering an enabling environment for digital transformation, innovation, and competition, which is crucial for financial resilience and sustainability. Conversely, countries with better institutional quality, such as Singapore and Hong Kong, have witnessed accelerated digitalization and experienced remarkable progress in their financial sectors (Son, 2022).

The impact of digitalization on financial development can vary significantly depending on the contextual conditions in a given country or region. For example, institutional factors, such as regulatory frameworks, legal systems, and governance structures, shape the environment in which digitalization unfolds and influences financial development outcomes. Barth *et al.* (2013) examine the impact of digital financial services on financial inclusion in a sample of countries and find that the effectiveness of digitalization in promoting financial inclusion depends on the quality of a country's legal and regulatory environment. They argue that well-functioning institutions are necessary to establish trust, protect consumer rights, and ensure the stability and security of digital financial services. Similarly, a study by Claessens *et al.* (2018) explores the role of institutional factors in driving fintech adoption and financial development. The researchers found that countries with more supportive regulatory frameworks and stronger institutional environments experience higher fintech adoption rates and greater financial development. In the same vein, Demirgüç-Kunt and Singer (2017) find that the adoption of digital financial services (e.g., mobile money and electronic payments) positively correlates with financial inclusion and economic development.

From the discussions above regarding (i) institutional influence, (ii) diverse specificities leading to distinct impact channels, and (iii) spatial and temporal effects, it becomes evident that simplifying research contexts solely into categories of developing versus developed nations risks overlooking crucial factors. This oversight could result in significant biases within studies, prompting us to examine these impacts within a highly dynamic region to accentuate the role of contextual factors, taking Asia-Pacific as an example. This region presents significant differences in stakeholders' involvement in adaptation and rapid changes

across variables among nations and within individual countries (e.g., ongoing transitions, digital financial services, and institutional quality). Furthermore, existing experimental studies have predominantly focused on the digital divide using conventional indices (e.g., internet user numbers and ICT indices), neglecting various facets of the digital divide's impact on distinct aspects of financial development. Therefore, this experimental study aims to provide a more comprehensive explanation of the digital divide's influence on different dimensions of the financial development index.

2.3 Asia-Pacific's context

Digitalization in Asia Pacific countries has emerged as a transformative force, shaping various aspects of society, economy, and governance. The region has witnessed rapid advancements in technology adoption, digital infrastructure development, and innovative digital solutions, seeing mobile internet subscribers increase by 20% to 1.29 billion users from 2019 to 2022 (GSMA, 2022). Governments and regulatory authorities in the region have been proactive in fostering a conducive environment for digital financial innovation, including implementing supportive regulations, promoting collaboration between traditional financial institutions and fintech companies, and investing in digital infrastructure (ESCAP, 2022).

Asia-Pacific has emerged as a global leader in digitalization, with countries like China, Japan, South Korea, and Singapore at the forefront of this transformation. These countries have witnessed significant growth in digital financial services, such as mobile payments and e-commerce. For example, China's digital payment ecosystem, led by mobile payment platforms like Alipay and WeChat Pay, has revolutionized how people conduct financial transactions. The rapid adoption of these digital payment solutions has transformed China into a predominantly cashless society, with mobile payments accounting for a substantial share of total transactions.

Good institutions are vital for maximizing the positive impact of digitalization on financial development in the Asia-Pacific region. By providing a conducive regulatory environment, protecting consumer rights, and ensuring stability and trust in the financial system, these institutions contribute to the growth and sustainability of digital financial services (Keane *et al.*, 2020; Corning, 2022).

3. METHODOLOGY AND DATA

3.1 Theoretical framework and basic setup

The Diffusion of Innovations (DOI) theory provides a valuable framework for understanding how digital financial technologies spread across different institutional contexts in the Asia-Pacific region. According to Rogers (2010), the successful adoption and diffusion of new technologies depend on institutional factors such as perceived relative advantage, compatibility, complexity, trialability, and observability. These factors shape how digital financial services are integrated into existing financial systems and influence their accessibility across different economies. Institutional governance, regulatory effectiveness, and legal frameworks directly impacts these DOI attributes by either facilitating or hindering the adoption process. Thus, institutional factors play a crucial role in determining both the uptake and long-term impact of digital financial services. By applying DOI theory, this study examines how variations in institutional quality affect the diffusion of digital financial

innovations, ultimately identifying key barriers and enablers. The methodological motivation of this paper is driven from the diffusion of innovations (DOI) theory; which elucidates the stages and factors influencing the adoption and diffusion of innovation in a social system and explains how the adoption of innovative digitized services foster a more inclusive financial ecosystem (Rogers, 2010; Kingiri and Fu, 2020; Legowo *et al.*, 2021a, 2021b; Mignamissi and Djijo T, 2021). Indeed, the DOI theory extends our understanding of technological-based business transactions, digitalized financial services, and the overall process of digitalization (Blakstad and Allen, 2018).

Digitalization affects financial development through various mechanisms and different components within the economy. To illustrate, Das (2022) categorizes the factors into three main groups: (i) adopters' characteristics (i.e., communication among adopters and adopter heterogeneity), (ii) external factors (i.e., innovation continuity, shocks, price structure, and promotional communication), and (iii) contextual factors (i.e., infrastructure development and the role of institutions). These factors determine the adaptation of new technologies in both spatial and temporal dimensions (Rao and Kishore, 2010). Figure no. 1 illustrates the basic analytical framework in this study, with the institutional aspect governing the relationship between digitalization and financial development as the primary focus. Therefore, to assess the impact of digitalization on financial development while focusing on contextual conditions, studies need to shut down the remaining channels by managing control variables.
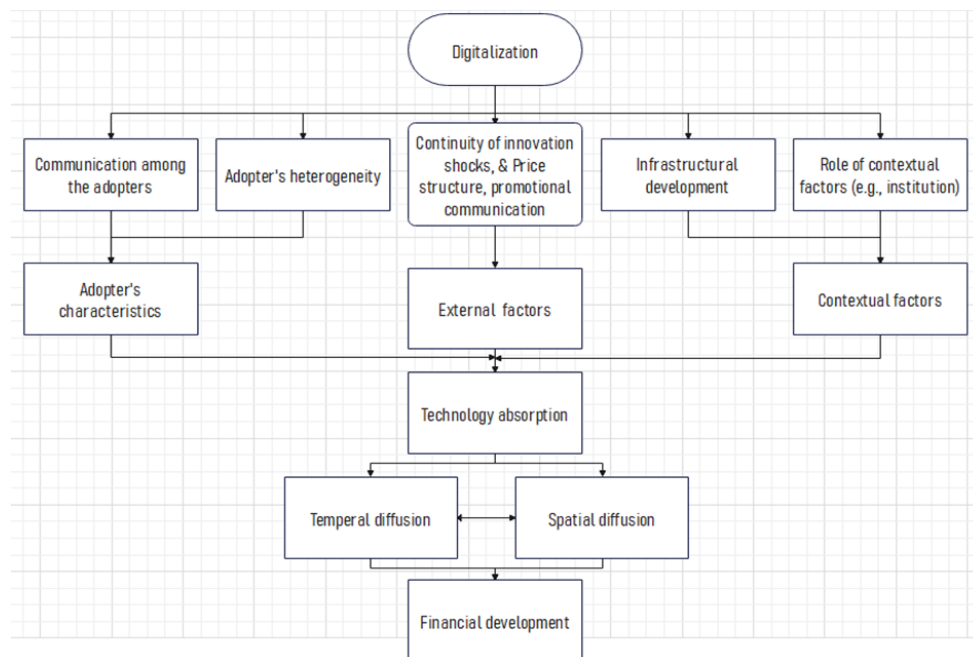
Note: The framework show the process of how Digitalization impacts on Financial development through the Adopter's characteristics, External Factors, and acontextual factors in both temporal and spatial diffusion.

Figure no. 1 – Theoretical framework
Source: author synthesized and adapted from Rao and Kishore (2010); Das (2022)

Based on this theory, there is substantial empirical evidence that elucidates the impact of digital divide on the development of financial systems through various mechanisms (Mignamissi and Djijo T, 2021). *First*, it stimulates the financial efficiency of financial enterprises, thereby expanding the number of businesses operating within this domain (Bunje *et al.*, 2022). *Second*, it reduces costs associated with remittance, thus enhancing personal financial flexibility through this source of funds (Jemiluyi and Jeke, 2023). *Third*, it promotes the participation of nations in the global value chain, consequently fostering the development of accompanying financial services for facilitating payments related to significant and systemic contracts (Ha, 2022). *Fourth*, it enhances market performance (Oladunjoye and Tshidzumba, 2023; Yu *et al.*, 2023). The DOI theory also explains how the adoption of innovative digitized services in the financial sector increases accessibility to government services, fostering a more financial ecosystem (Nchofoung and Asongu, 2022). Thus, the empirical model in this framework will be estimated using the following equation:

$$Y_{ijt} = \beta_0 + \beta_1.DD_{ijt} + \sum_{k=2}^{K} \beta_k Z_{ijkt} + \delta_i + \varphi_j + \lambda t + u_{ijt} \qquad (1)$$

where Y_{ijt} represents the financial development (FD) level in the ith country, the jth geographical specific region, in year t. DD_{ijt} represents the digital divide, which reflects the level of digital transformation in the ith country, jth geographical specific region in a given year, denoted as t. Z refers to selected control variables that are derived from previous studies. These control variables are structured based on the analytical framework, categorizing them into adopter's characteristics (e.g., bank-specific attributes) and external factors (e.g., external financial shocks or flows). In other words, these control variables are primarily designed to mitigate the influences stemming from external factors and the characteristics of the adopters, specifically banks. δ_i refers to the unchanging and unobservable variables in each country, encompassing elements such as its historical background, cultural heritage, geographical attributes, and various ethnic components. φ_j and λ represent the invariant-unobservable variables specific to each economic region and factors that are not directly measurable and subject to changes over time (e.g., the structure of the economy across different years), while u_{ijt} denotes the error term.

It should be noted that equation (1) only allows for examining correlation rather than causal relationships. Thus, in the next part of the study, the research will further set the methodology to establish causal relationships using instrumental variables. The impact of digital divide on financial development under the role of institutional settings across Asia-Pacific countries will be empirically assessed by utilizing interaction variables; accordingly, the empirical model will be transformed as follows.

$$Y_{ijt} = \beta_0 + \beta_1.DD_{ijt} + \sum_{k=2}^{K} \beta_k Z_{ijkt} + \gamma DD_{ijt} \times IQ_{ijt} + \delta_i + \varphi_j + \lambda t + u_{ijt} \qquad (2)$$

where, IQ_{ijt} represents the variable indicating the institutional quality of country i within geographical region j in year t, the estimated coefficient γ reflects the impact of digital divide on financial development under the influence of institutional quality. Accordingly, if γ is statistically significant positive, it implies that improving institutional quality contributes to enhancing the impact of digital divide on financial development. It is also important to note that the institutional quality index in the model (2) can be used as either a continuous variable or a set of dummy variables representing different levels of institutional quality.

3.2 Endogeneity

One major concern in this study is the issue of endogeneity arising from reverse causal effects (Ong and Chong, 2023) and confounding factors. According to Ong and Chong (2023), increased adoption of cashless payments promotes internet and mobile banking, which, in turn, encourages businesses to invest more in developing new digital services. Financial development stimulates customer demand for faster, lower-cost, and lower-risk payment methods. It should be noted that the fintech industry faces lower risks of losing customers and lower profit risks than traditional banking, approximately two times and 1.5 times, respectively (Feyen *et al.*, 2021). These factors contribute to the occurrence of reverse causal effects in this paper.

Furthermore, the confounding factor highlights other factors influencing simultaneous improvements or declines in digital divide and financial levels. For instance, the ideological shift facilitating access to the global financial market economy and new technologies led to rapid expansion and digital divide changes. In such cases, using ordinary least squares (OLS) with fixed effects would result in biased and inconsistent estimates. To solve the endogeneity problem, the study concentrates on examining the shifts in exogenous factors (identified as instrumental variables) that affect financial development exclusively through the digital divide channel. In other words, in the first stage, we identify factors that are more likely to be exogenous and lead to fluctuations in the digital divide. The prediction derived from this stage are then used to assess their impact on outcomes in the second stage (Van Le *et al.*, 2022; Van Le and Tran, 2024, 2025). Accordingly, DD_{ijt} can be decomposed into several terms: (i) digital level at the graphical regional-specific (DD_{jt}), (ii) speed of internet download in each regional area (Dengler *et al.*, 2022; Wu and Shao, 2022; Chen and Kim, 2023), and (iii) idiosyncratic component (η_{ijt}). Mathematically,

$$DD_{ijt} = DD_{jt} + IV_{jt} + \eta_{ijt} \tag{3}$$

where, DD_{jt} represents the (average) amount of digital level to regional-location j, determined by the local endowments, while η_{ijt} denotes an idiosyncratic component. In this study, the regional geographical location is assumed to be determined by geopolitical and historical factors (*), making it exogenous to the nations and uncorrelated with any omitted variables in the model (1). This ensures that the exclusion condition of the instrumental variable is satisfied, mathematically $cov(DD_{jt}, u_{ijt} | X, Z) = 0$. IV_{jt} reflects the speed of internet download in each regional area. According to Dengler *et al.* (2022); Chen and Kim (2023), this variable significantly influences the level of digital transformation at the current time, while assuming that IV_{jt} is independent of the model's error term (u_{ijt}), which can be ensured (**).

Given two assumptions (*) and (**), using the 2-stage least square (2SLS) with fixed effect (i.e., the IVXTREG option in Stata) ensures that the coefficients obtained from the estimation are consistent. Notably, to optimize the estimation and address the potential issue of dynamic endogeneity – occurs when past levels of financial development influence the current level of digital divide, the study suggests using the generalized method of moments (GMM) estimator alongside external instrumental variables. By incorporating lagged variables as internal instruments, the GMM estimator aims to generate optimal results in the estimation process (Blundell and Bond, 1998; Van Le and Tran, 2022, 2025).

3.3 Data

Data collection depends on the definition and measurement of financial development and digital divide during the period 2014-2021. There are various definitions of financial development for different countries, particularly in regions with disparities in financial development levels, especially the Asia-Pacific region. Commonly used definitions in empirical studies include financial system deposits to GDP, deposit monay banks assets to GDP, and liquidity liability to GDP. These simplistic definitions partly stem from data limitations in less developed regions where data availability needs to be completed.

In this work, we adopt a financial development index based on the works of Svirydzenka (2016), considering (i) data availability and (ii) scientific appropriateness in index design. Specifically, the new FD index is structured hierarchically, consisting of two sub-indexes: the financial intermediaries' development index (FIDI) and the financial markets development index (FMDI). Each index comprises two dimensions measuring the accessibility and efficiency. The dataset builds upon previous efforts, including the World Bank's *"Financial Development and Structure"* database (World Bank, 2024).

Measuring digital divide also encounters challenges regarding definition, measurement methodology, and data availability (Thordsen *et al.*, 2020). One widely cited work in classifying digitalization levels is the World Bank (2016) publication; accordingly, it categorizes digital technologies into (i) the digital divide and (ii) digital dividends. Although measuring digital dividends holds significance in this study, we approach digitalization as the digital divide due to data availability (see more in Figure no. A1).

In this study, the study aimed to collect data for all 48 countries (as classified by the United Nations) in the Asia-Pacific region. However, due to data availability issues, only 31 out of the 48 countries could be included in the analysis. The details of the countries included in the dataset are listed in Table no. A1. The final dataset is a balanced panel consisting of 31 countries in the Asia-Pacific region, covering the period from 2014 to 2021 (8 years). Additionally, we collected additional data on each country's economic and geographic characteristics to examine the relationship between digital divide and financial development across different geographical/ economic groups. Table no. 1 summarizes the components, proxies/descriptions, and sources for measuring the two indices: financial development and digital divide.

Table no. 1 – Methodology of measuring digital divide and financial development

Index	Sub-index	Components (Weight)	Description/proxy	Sources
Digital divide	Accessible Infrastructure	Network coverage (30%)	The proportion of the population covered by 2G, 3G, and 4G networks. Percentage of people covered by 5G networks (only from 2019 to 2021)	GSMA Intelligence
		Network performance (30%)	Average download and upload speeds for mobile broadband. Latencies in mobile broadband on average	Ookla's Speedtest Intelligence
		Other enabling infrastructure (20%)	Percentage of people who have access to electricity	World Bank
			Per internet user, international internet bandwidth	ITU

Index	Sub-index	Components (Weight)	Description/proxy	Sources
			Secure Internet Servers per 1 million people	World Bank
			Internet Exchange Points (IXPs) per 10 million people	Packet Clearing House
		Spectrum (20%)	Per operator, digital dividend spectrum	GSMA Intelligence
			Other sub-1GHz, 1GHz-3GHz, above 3GHz, and mmWave spectrum per operator	
	Affordability	Mobile tariffs (30%)	Cost of 100MB, 500MB, 1GB, and 5GB data (% of monthly GDP per capita)	Tarifica
		Handset prices (30%)	Cost of the cheapest internet-enabled device (as a percentage of monthly GDP per capita)	Tarifica
		Taxation (20%)	Tax as a percentage of overall cost of mobile ownership	GSMA Intelligence
			Sector-specific tax as a percentage of overall mobile ownership cost	
		Inequality (20%)	Income inequality (%)	UNDP
	Open & safe	Local Relevance (40%)	Per individual, one generic top-level domain (gTLD) and one country code top-level domain (ccTLD).	ZookNIC
			E-Government Online Service Index score	UN
			Mobile social media penetration	Datareportal
		Availability (40%)	Mobile apps developed per person	Apps
			The number of mobile apps accessible in the country's native language(s).	Apps and Ethnologue
			The availability of the most popular smartphone apps	
		Security (20 %)	ITU Global Cybersecurity Index	ITU
Financial develop-ment	Financial intermediaries' development	Accessibility (PCA Weight)	Bank branches per 100,000 adults	Global financial development index
			ATMs per 100,000 adults	
		Efficiency (PCA Weight)	Liquid Liabilities To GDP	
			Domestic credit to private sector (% of GDP)	
	Financial markets development	Accessibility (PCA Weight)	Financial System Deposits To GDP	
		Efficiency (PCA Weight)	Bank Deposits To GDP	

Note: Weighting the components of the digital divide index is based on GSMA Intelligence (GSMA, 2022), while the weighting for the financial development index is calculated using the principal component analysis (PCA) technique (World Bank, 2024).

Sources: author's synthetic.

Utilizing a PCA methodology, we compute the financial development index from two sub-indices: financial intermediaries and financial markets development. As a result, this index exhibits considerable variation between and within Asia-Pacific countries, with a standard deviation approximating the mean, while the digital divide demonstrates comparatively lower variability. Detailed statistical descriptions are presented in Table no. 2.

**Table no. 2 – Descriptive statistics**

	UNITS	SOURCES	MEAN	SD	MIN	MAX
Dependent variables						
Financial Development Index	[0,1]	using PCA	0.257	0.216	0.000	1.000
Bank Branches Per 1000 Adults	1 bank branch	Global Financial Development Index	0.167	0.140	0.015	0.712
ATMs Per 1000 Adults	1 ATM		0.482	0.435	-0.171	1.854
Deposit Money Banks Assets To GDP	/100 (%)		0.934	0.684	0.027	3.747
Liquid Liabilities To GDP	/100 (%)		0.976	0.791	0.228	4.547
Financial System Deposits To GDP	/100 (%)		0.829	0.722	0.146	4.157
Bank Deposits To GDP	/100 (%)		0.828	0.722	0.146	4.157
Independent variables						
Digital divide $= \frac{1}{3}\sum_{i=1}^{3} sub - index_i$	[0,1]	Authors	0.558	0.168	0.234	0.917
$Sub - index_1$: Accessible Infrastructure	[0,1]	GSMA Intelligence	0.561	0.175	0.210	0.941
$Sub - index_2$: Affordability	[0,1]		0.570	0.141	0.281	0.894
$Sub - index_3$: Open and safe	[0,1]		0.542	0.219	0.080	0.965
Institutional quality & control variables						
Institutional Quality	z-score	WDI	-0.028	0.832	-1.681	1.859
Covariates 1: Internal controls						
Central Bank Assets To GDP	%	"Financial Development and Structure" WB database	5.742	14.140	0.013	92.239
Bank Net Interest Margin	%		3.191	1.547	0.521	7.703
Bank Overhead Costs To Total Assets	%		1.869	1.180	0.442	14.419
Bank Return On Equity, After Tax	%		10.921	4.917	-3.244	39.314
Bank Concentration	%		56.811	21.205	16.144	100.000
Covariates 2: External controls						
Liquid liabilities, 2000 constant	billion USD	"Financial Development and Structure" WB database	1325.99	4425.66	0.19	28700.00
Remittance inflows to GDP	%		5.206	7.697	0.000	38.981
External loans and deposits of reporting banks	%		20.294	26.489	0.277	119.813
Instruments and mechanism tests						
Regional Digital Development (2 year-lagged)	[0,100]	(Dengler et al., 2022; Wu and Shao, 2022; Chen and Kim, 2023)	55.775	8.391	35.162	76.773
Regional Average Mobile Broadband Download Speeds (2 year-lagged)	[0,100]		32.080	14.576	7.055	56.987
Digital Financial Consumer Protection	[0,1]	Dinh et al. (2023)	0.535	0.243	0.000	0.937

Sources: conducted by authors.

4. RESULTS

4.1 Descriptive statistics

In examining the suitability of our case study (i.e., Asia-Pacific region), this section presents several demonstrations. To begin with, Figure no. 2 exemplifies the linear association between the digital divide and financial development in the Asia-Pacific region from 2014 to 2021; accordingly, initial findings validate a positive correlation between these variables. Notably, some countries with a high level of digital divide (i.e., Singapore, Australia, and New Zealand) remain at an intermediate level of financial development, relatively lower than that of China and Japan. This phenomenon can be attributed to these nations' proclivity for prioritizing the quality of financial services (digital dividends) over the sheer quantity of services (digital divide). In contrast, Laos demonstrates a rapid increase in financial services while experiencing limited digitalization, primarily due to international financial growth, mainly emanating from China (Stuart-Fox, 2009). This underscores the imperative need for controlling external factors once again.
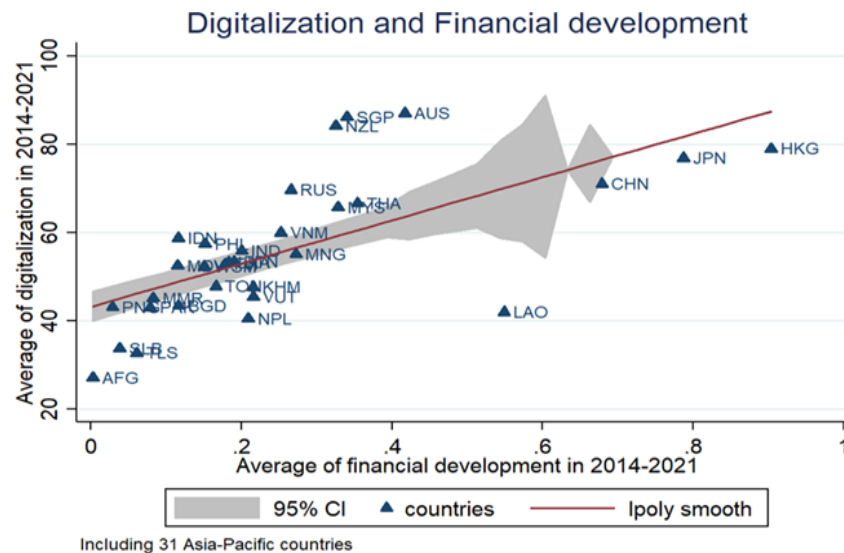
Note: A line graph shows the relation between Digitalization and Average financial development with triangle dots presenting each observed nation from 2014 to 2021

Figure no. 2 – Linear relationship between digitalization and financial development, Asia-Pacific region
*Sources:* conducted by authors
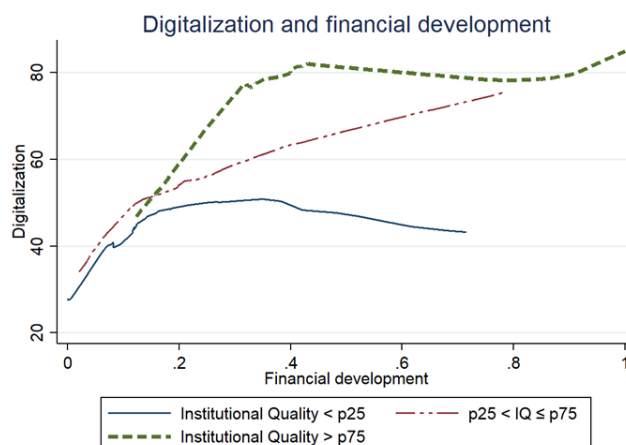
Note: A three-line graph compares the non-linear correlation between the digital divide and financial development in different institutional quality level including 3 groups: below 25th percentile, above 75th percentile and the middle of those. Observation includes 31 Asia Pacific countries from 2014 to 2021.

Figure no. 3 – Digital divide and financial development nexus, classified by institutional quality
Source: author's own work.

Figure no. 3 illustrates the non-linear correlation between the digital divide and financial development among a cohort of 31 Asia-Pacific nations from 2014 to 2021. These countries are classified based on their varying institutional contexts and categorized explicitly into three groups: those falling below the 25th percentile, those between the 25th and 75th percentile, and those exceeding the 75th percentile regarding institutional quality. Preliminary results also indicate that countries with lower institutional quality (below the 25th percentile) exhibit a shallower intercept. Countries within the 25th-75th percentile of institutional quality display the steepest slope, while the highest and lowest institutional levels have a similar slope. These results imply that regions positioned at a middling level of institutional development, typically encompassing transitioning nations such as Vietnam and China, hold the potential to achieve the most rapid enhancements in their financial performance when they embark on improvements in their digitalization processes.

Third, one of the criteria for selecting an appropriate research region is the presence of heterogeneity among the countries concerning both variables of interest. Figure no. 4 portrays the current state of digitalization and financial development across the 31 countries within the Asia-Pacific region. This visual representation suggests substantial disparities in the levels of financial development and digital divide among these nations in comparison to the global map (see more in Figures no. A2 and A3), underscoring the region's suitability for analysis aimed at discerning the relationship between the two variables. Of equal importance, the figure presented below provides a visual depiction of the progress and regressions in the status of financial development and digitalization across the 31 Asia-Pacific countries during the period spanning from 2014 to 2021. Accordingly, Figure no. 5 elucidates that the significant shifts in financial performance predominantly transpired within the southeast Asian region, marked by the continuous growth in Cambodia, Nepal, and Bhutan over time, while Malaysia experienced a slight decline in 2018 before rebounding in 2021. In Figure no. 6, the discernible color shift (from yellow to red) distinctly reflects the rapid upsurge in digital processes across most regions.

Financial Development   Digital Divide
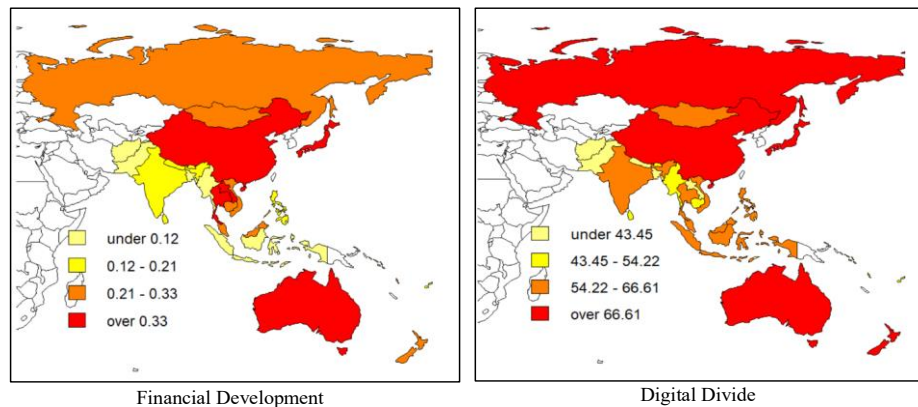
Note: 2 maps of Asia-Pacific region portray the current state of digital divide and financial development across the 31 countries with 4 colors of development showing each country level

Figure no. 4 – Financial and digital level, Asia Pacific region 2014-2021
Source: author's own work.

Financial development 2014   Financial development 2018   Financial development 2021
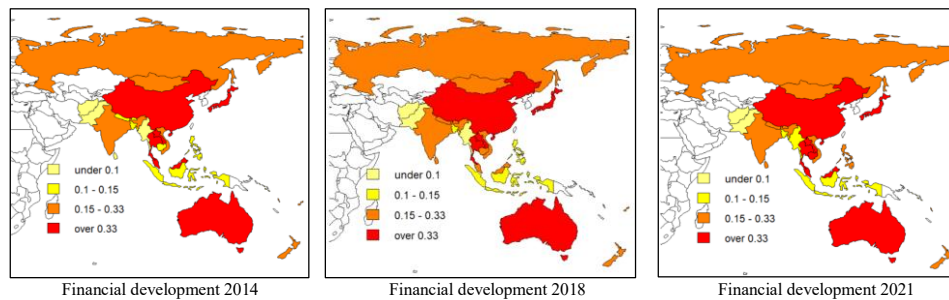
Note: three maps of Asian Pacific conuntries demonstrate the changes of Financial development in 2014, 2018 and 2021 with four colors presenting different level for each nation.

Figure no. 5 – Financial evolution in Asia Pacific countries, 2014-2021
Source: author's own work.

Digital Divide 2014   Digital Divide 2018   Digital Divide 2021
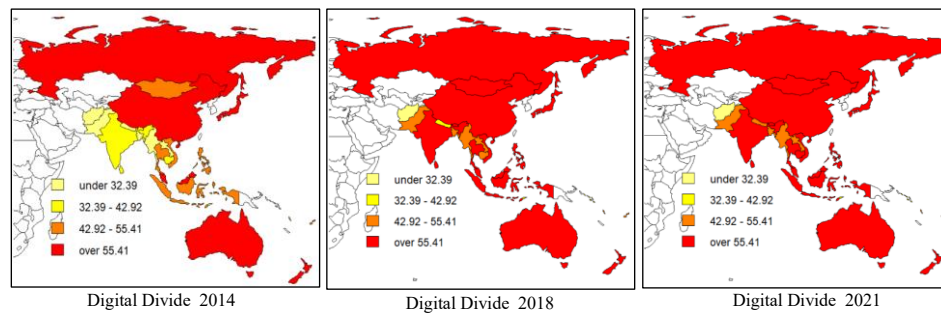
Note: three maps of Asian Pacific conuntries demonstrate the changes of Digital Divide in 2014, 2018 and 2021 with four colors presenting different level for each nation. It does not include islands and archipelagos.

Figure no. 6 – Digital evolution in Asia Pacific countries, 2014-2021
Source: author's own work.

4.2 Basic results

Using a fixed-effect model, Table no. 3 presents the regression results concerning the linear nexus between the digital divide and its lag effect on the financial development (FD) index. In columns [1]-[3], we observe the current effects of the digital divide on the dependent variable. To shut down the channel of adopter characteristics and external shocks, the study controls for additional internal banking variables (e.g., banking structure and bank costs and profits) in column [2] and for external factors (i.e., the size of liquid liabilities, remittance inflows, and external loans and deposits) in column [3]. The reduction in the magnitude of the coefficients aligns with the theoretical framework, indicating that the heterogeneity among adopters and external factors significantly moderates the nexus (Rao and Kishore, 2010; Demirguc-Kunt *et al.*, 2018; Das, 2022). It should be noted that controlling these variables helps clarify the impact of institutional quality on the relationship in question, directly related to research examining influences on financial development, such as remittance inflows (Donou-Adonsou *et al.*, 2020), financial structure (Ruiz-Porras, 2009), and degree of banking concentration (Michaelsen, 2018; Sudan, 2020; Dragu and Lupu, 2021). This strand also accounts for the divergence in research outcomes when scholars conducted within different contexts, particularly between developing and developed nations.

Regarding the lagged effects, columns [4]-[6] in Table no. 3 reveal consistent results, indicating a lag of approximately two years. In other words, the effects of the digitalization process become most discernible after approximately two years. To further validate this finding, our study employs the local projection technique offered by Jordà (2005); accordingly, as illustrated in Figure no. 7, the results confirm the two-year delayed impact of the digital divide (DD) on financial development. In subsequent analyses, we examine the current effects of the digital divide on financial development for several reasons. One reason is data availability; employing the 2-year lag of DD reduces the number of observations in the sample, particularly when controlling for relevant factors, resulting in just 112 observations across 23 countries (column [6]). Another reason is the emphasis on the present-day impact of the digital divide, which holds more significant policy implications for the countries in the Asia-Pacific region, given that policies are typically based on current data. To minimize potential underestimation of the current effects, if any, we employ the two-system generalized method of moments (GMM) estimator with two external instruments (i.e., regional digitalization and regional average mobile broadband download speeds) with a 2-year lag, as outlined in the study design in sub-section 3.3. The study design, therefore, ensures optimal observations while maintaining the consistency of the estimated results.

Table no. 3 – Basic regression results

Dependent variable:	Financial development index					
	Fixed effect model					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Digital divide$_t$	0.348***	0.200***	0.119***			
	(0.035)	(0.045)	(0.038)			
Digital divide$_{t-1}$				-0.041	-0.057	-0.058
				(0.124)	(0.134)	(0.106)
Digital divide$_{t-2}$				0.349***	0.266**	0.198**
				(0.109)	(0.114)	(0.092)
Institutional quality	-0.013	0.064*	0.036	-0.003	0.054	0.022

Dependent variable:	Financial development index					
	Fixed effect model					
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	(0.025)	(0.036)	(0.028)	(0.029)	(0.044)	(0.035)
Central bank assets to GDP		0.001**	0.001		0.001	0.001**
		(0.001)	(0.001)		(0.001)	(0.001)
Bank net interest margin		-0.008*	-0.010**		-0.004	-0.004
		(0.005)	(0.004)		(0.009)	(0.007)
Bank overhead costs to total assets		0.002	-0.001		0.002	-0.007
		(0.003)	(0.002)		(0.015)	(0.015)
Bank return on equity (after tax)		-0.001*	-0.001*		-0.002**	-0.001**
		(0.001)	(0.000)		(0.001)	(0.001)
Bank concentration		-0.000	-0.002***		0.000	-0.001
		(0.001)	(0.001)		(0.001)	(0.001)
Liquid liabilities			0.000***			0.000***
			(0.000)			(0.000)
Remittance inflows to GDP			-0.004			-0.007*
			(0.003)			(0.004)
External loans and deposits of reporting banks			-0.000			0.000
			(0.000)			(0.000)
ID controls	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.063***	0.197***	0.298***	0.103***	0.144**	0.264***
	(0.020)	(0.056)	(0.053)	(0.026)	(0.065)	(0.072)
Observations	248	171	154	186	129	112
R-squared	0.325	0.397	0.597	0.307	0.388	0.586
Number of countries	31	23	23	31	23	23

Note: The numbers in parentheses represent the standard errors, with *** indicating significance at $p<0.01$, ** at $p<0.05$, and * at $p<0.1$.

Source: author's own work.

Following the argument above, in Table no. 4, columns [1]-[3], this study employs a two-stage regression with instrumental variables (XTIVREG option in Stata), while columns [4]-[6] present the results utilizing GMM estimator. The coefficients in Table no. 4 are consistent with previous studies and align with our expectations; accordingly, these results consistently indicate that the impact of the digital divide on financial development is statistically significant and positive. The coefficients obtained with XTIVREG are similar to the previous Table, while those from the two-system GMM estimator are approximately three times larger. This can be attributed to (i) the consideration of local average treatment effects (LATE) and (ii) the GMM design allowing for an examination of the impact of the regional digital divide with a lag of 2 years on financial development, which, as discussed, tends to be larger than the current effects.
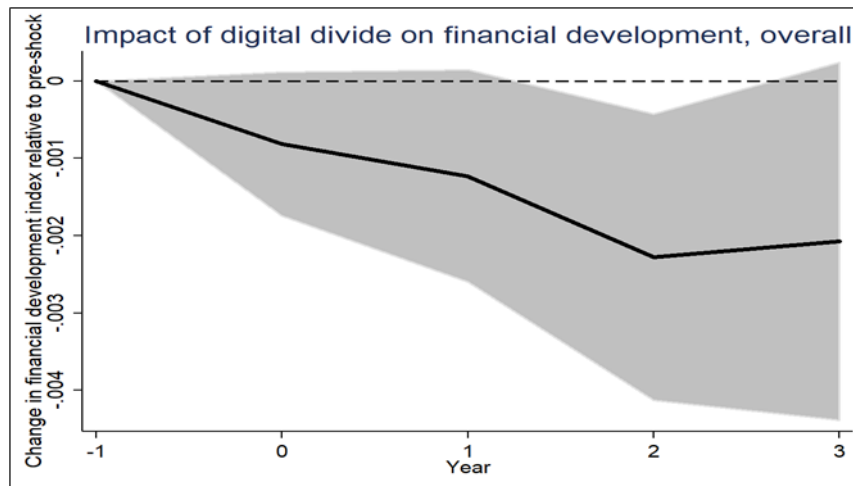
Note: a line graph covered with a grey area shows the year-delayed impact of Digital divide on Financial development through the change in the financial development index.

Figure no. 7 – Change in financial development index relative to pre-shock
Source: author's own work.

Both XTIVREG and GMM estimators yield consistent coefficients when the instruments are valid. In our case, the instrumental variables are assessed for theoretical validity based on previous research applications (Dengler *et al.*, 2022; Wu and Shao, 2022; Chen and Kim, 2023) and for technical validity through four tests (i.e., AR(1), AR(2), Hansen test of overidentification restrictions, and Difference-in-Hansen tests of the exogeneity of instruments (Wintoki *et al.*, 2012; Van Le and Tran, 2022). However, in cases where the changes in instruments are uncorrelated with the fixed effects (δ), or in mathematical terms, $E(\Delta Instruments_{it}, \delta i) = 0$ for all i and t, the GMM estimators effectively account for unobservable heterogeneity, simultaneity, and potential endogeneity. Conversely, if the additional assumptions are not met, this estimator can produce spurious results, which can be challenging to discern due to the complexity of this technique.

Table no. 4 – XTIVREG and 2-system GMM estimators results

Dependent variable:	Financial development index					
	IVREG	IVREG	IVREG	GMM 2-sys	GMM 2-sys	GMM 2-sys
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Digital divide	0.368***	0.194***	0.110***	0.874**	0.696**	0.693***
	(0.037)	(0.047)	(0.040)	(0.351)	(0.333)	(0.197)
Institutional quality	-0.017	0.066*	0.038	0.048	0.055	0.044
	(0.025)	(0.036)	(0.027)	(0.073)	(0.076)	(0.035)
Central bank assets to GDP		0.001**	0.001		0.002	0.002
		(0.001)	(0.001)		(0.003)	(0.004)
Bank net interest margin		-0.008*	-0.010**		0.013	0.005
		(0.005)	(0.004)		(0.037)	(0.016)
Bank overhead costs to total assets		0.002	-0.002		-0.009	-0.004

Dependent variable:	Financial development index					
	IVREG	IVREG	IVREG	GMM 2-sys	GMM 2-sys	GMM 2-sys
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
		(0.003)	(0.002)		(0.046)	(0.012)
Bank return on equity (after tax)		-0.001*	-0.001*		-0.001	-0.002
		(0.001)	(0.000)		(0.005)	(0.002)
Bank concentration		-0.000	-0.002***		-0.002	-0.003
		(0.001)	(0.001)		(0.002)	(0.004)
Liquid liabilities			0.000***			0.000
			(0.000)			(0.000)
Remittance inflows to GDP			-0.004			0.002
			(0.003)			(0.013)
External loans and deposits of reporting banks			-0.000			0.000
			(0.000)			(0.001)
ID controls	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant				-0.176	0.002	0.058
				(0.160)	(0.191)	(0.407)
Observations	248	171	154	248	171	154
R-squared	0.324	0.396	0.597			
Number of countries	31	23	23	31	23	23
Year lagged instruments				2-year lagged	2-year lagged	2-year lagged
Exogeneous instruments	2	2	2	2	2	2
Cragg-Donald Wald F statistic:	789.491	373.000	290.793			
Sargan statistic (overidentifi–cation test of all instruments):	0.0358	0.0410	0.5354			
AR(1)				0.955	0.918	0.461
AR(2)				0.030	0.083	0.076
Hansen test of overid. Restrictions (p-value)				1.000	1.000	1.000
Difference-in-Hansen tests of exogeneity of instrument (p-value)				1.000	1.000	1.000

Note: The numbers in parentheses represent the standard errors, with *** indicating significance at $p<0.01$, ** at $p<0.05$, and * at $p<0.1$.

Source: author's own work.

4.3 Contextual factors & mechanism tests

One of the crucial contextual factors influencing the relationship under examination is the quality of institutional frameworks. The Asia-Pacific region is characterized by a diverse range of institutional regimes, spanning from the institutional framework in Australia to the centrally-planned socialist economy in Vietnam. Accordingly, Table no. 5 presents results derived from Equation (3), wherein institutional quality is divided into three categories based on percentiles: 25th and 75th. Columns [2]-[4] examine the impacts of various sub-indices of the digital divide, while column [1] investigates the impact of the composite index. While variations in the intercept are observed under the influence of institutional quality on the

nexus, there are no discernible differences in the slopes between them, as indicated by the lack of statistical significance in the interaction term coefficients. Furthermore, concerning the effects of control variables, it should be noted that the degree of banking concentration, representing banking market monopoly, has a negative influence on financial development, consistent with findings from previous studies (Michaelsen, 2018; Sudan, 2020; Dragu and Lupu, 2021).

Table no. 5 – The nexus under the institutional condition

Dependent variable:	Financial development index Fixed effect model			
Independent variable (DD)	Digital divide	Sub-index: Infrastructure	Sub-index: Affordability	Sub-index: Open and safe
	(1)	(2)	(3)	(4)
Independent variable (*DD*)	0.167***	0.067*	0.157***	0.188***
	(0.052)	(0.039)	(0.054)	(0.050)
Middle level of institutional quality	0.045	0.014	**0.063***	**0.064****
	(0.032)	(0.025)	(0.036)	(0.032)
High level of institutional quality	0.081	**0.070***	0.119	0.055
	(0.052)	(0.037)	(0.079)	(0.043)
Middle level of institutional quality × *X*	-0.043	0.020	-0.063	-0.080
	(0.057)	(0.044)	(0.065)	(0.053)
High level of institutional quality × *X*	-0.107	-0.074	-0.160	-0.070
	(0.086)	(0.056)	(0.135)	(0.070)
Central bank assets to GDP	0.001	0.001*	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Bank net interest margin	-0.009**	-0.011**	-0.012***	-0.008**
	(0.004)	(0.004)	(0.004)	(0.004)
Bank overhead costs to total assets	-0.000	-0.001	-0.002	-0.001
	(0.002)	(0.003)	(0.002)	(0.002)
Bank return on equity (after tax)	-0.001*	-0.001*	-0.001*	-0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
Bank concentration	-0.001**	-0.002***	-0.002***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Liquid liabilities	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Remittance inflows to GDP	-0.002	-0.003	-0.001	-0.001
	(0.003)	(0.003)	(0.003)	(0.003)
External loans and deposits of reporting banks	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
ID controls	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Constant	0.240***	0.320***	0.271***	0.240***
	(0.063)	(0.059)	(0.061)	(0.057)
Observations	154	154	154	154
R-squared	0.608	0.595	0.592	0.619
Number of countries	23	23	23	23

Note: The numbers in parentheses represent the standard errors, with *** indicating significance at p<0.01, ** at p<0.05, and * at p<0.1. In Table no. A2, we present results with a lag of 2, where the impact is more clearly demonstrated, with statistical significance at the 1% alpha level.
Source: author's own work.

In terms of the operative mechanisms, Table no. 6 examines the impact of the digital divide on the following channels: financial market boost (e.g., number of bank branches and ATMs, deposit money banks' assets) and intermediate market expand (e.g., liquid liabilities and financial system deposits). The research results are in line with prior findings; accordingly, column [3] confirms the findings of Demirguc-Kunt *et al.* (2018) that the integration of digital technologies, such as online banking and digital payment systems, enhances the efficiency and reach of deposit money banks (DMBs) assets, enabling them to expand their services and customer base. Similarly, Ping (2014) emphasizes that digitalization streamlines operations reduces administrative costs, and enhances the overall profitability of DMBs.

Column [4] aligns with Aziz and Naima (2021), who suggest that digitalization is pivotal in reshaping a nation's economic landscape, particularly concerning its liquid liabilities. Indeed, digitalization has various mechanisms that facilitate a positive impact; for instance, integrating digital payment systems and online banking channels reduces reliance on physical cash as digital financial transactions become more prevalent in this era. As the demand for physical currency in circulation diminishes, there is potential for a change in liquid liabilities as a proportion of GDP. Moreover, digitalization fosters greater financial inclusion, making credit and financial services more accessible to underserved populations (Demirguc-Kunt *et al.*, 2018). The expanded access to credit can facilitate a more efficient allocation of financial resources, thus, in turn, reducing the necessity for excessive liquidity. Notably, automating and streamlining financial processes through digital technologies can result in expedited settlements and fewer payment delays (Claessens *et al.*, 2018), reducing the cash reserves businesses need to maintain for transaction purposes.

Columns [5] and [6] verify that digitalization also exerts a transformative influence on the financial landscape and, consequently, enhances accessibility to the financial system, increasing deposit mobilization across various financial institutions, including banks (Demirguc-Kunt *et al.*, 2018). Digital banking platforms, online payment systems, and mobile banking applications facilitate convenient deposit-taking, transcending geographical constraints. Notably, a recent study by Dinh *et al.* (2023) asserts that information and communication technology (ICT) can enhance the protection of digital customers in a global sample, thereby improving consumer trust. In other words, the digital divide can enhance financial demand by improving trust in the financial system, particularly in countries undergoing transitions (such as Vietnam), given that their payment behavior relies sizably on cash (World Bank, 2019a). We corroborate these findings in the Asia-Pacific region in Table no. 7, and the results are consistent with our expectations.

Table no. 6 – Mechanism results

Dependent variables:	Bank branches per 1000 adults	ATMs per 1000 adults	Deposit money banks assets to GDP	Liquid liabilities to GDP	Financial system deposits to GDP	Bank deposits to GDP
			Fixed effect model			
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Digital divide$_t$	0.072	-0.045	0.550***	0.458***	0.352***	0.354***
	(0.056)	(0.129)	(0.157)	(0.145)	(0.125)	(0.125)
Institutional quality	0.010	0.248**	0.095	0.061	0.069	0.069
	(0.042)	(0.096)	(0.118)	(0.108)	(0.094)	(0.094)
Central bank assets to GDP	-0.001	-0.003	-0.005**	0.010***	0.006***	0.006***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)

Dependent variables:	Bank branches per 1000 adults	ATMs per 1000 adults	Deposit money banks assets to GDP	Liquid liabilities to GDP	Financial system deposits to GDP	Bank deposits to GDP
			Fixed effect model			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Bank net interest margin	-0.005	-0.034**	-0.019	-0.038**	-0.024*	-0.023*
	(0.006)	(0.014)	(0.017)	(0.016)	(0.014)	(0.014)
Bank overhead costs to total assets	0.007*	0.003	-0.008	-0.011	-0.016*	-0.016*
	(0.004)	(0.008)	(0.010)	(0.009)	(0.008)	(0.008)
Bank return on equity (after tax)	-0.001	0.001	-0.005**	-0.001	-0.004**	-0.004**
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Bank concentration	-0.001	-0.006***	-0.004*	-0.006***	-0.004**	-0.004**
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Remittance inflows to GDP	-0.011***	-0.006	-0.019*	0.002	0.003	0.003
	(0.004)	(0.009)	(0.011)	(0.010)	(0.009)	(0.009)
External loans and deposits of reporting banks	-0.000	0.000	-0.000	0.000	0.000	0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ID controls	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.240***	1.023***	0.997***	1.037***	0.852***	0.850***
	(0.080)	(0.183)	(0.224)	(0.206)	(0.178)	(0.178)
Observations	154	154	154	154	154	154
R-squared	0.177	0.257	0.425	0.493	0.407	0.408
Number of countries	23	23	23	23	23	23

Note: The numbers in parentheses represent the standard errors, with *** indicating significance at $p<0.01$, ** at $p<0.05$, and * at $p<0.1$.

Source: author's own work.

**Table no. 7 – Mechanism test: Digital financial consumer protection channel**

Dependent variable:	Digital financial consumer protection			
	Fixed effect model			
VARIABLES	(1)	(2)	(3)	(4)
Digital divide	0.491***			
	(0.070)			
Sub-index 1: Infrastructure		0.260***		
		(0.044)		
Sub-index 2: Affordability			0.211*	
			(0.107)	
Sub-index 3: Open and safe				0.458***
				(0.065)
Institutional quality	-0.055	-0.050	0.028	0.005
	(0.049)	(0.053)	(0.065)	(0.047)
Central bank assets to GDP	0.001	0.001	0.001	0.001
	(0.001)	(0.002)	(0.002)	(0.001)
Bank net interest margin	0.007	0.012	0.002	0.008
	(0.008)	(0.009)	(0.011)	(0.008)
Bank overhead costs to total assets	-0.004	-0.005	-0.011***	-0.006**
	(0.003)	(0.003)	(0.004)	(0.003)
Bank return on equity (after tax)	0.000	-0.000	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)

Dependent variable:	Digital financial consumer protection			
	Fixed effect model			
VARIABLES	(1)	(2)	(3)	(4)
Bank concentration	-0.001	-0.001	-0.002**	-0.001*
	(0.001)	(0.001)	(0.001)	(0.001)
Liquid liabilities	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Remittance inflows to GDP	0.007	0.003	-0.002	0.007
	(0.007)	(0.007)	(0.009)	(0.007)
External loans and deposits of reporting banks	-0.002	-0.002*	-0.001	-0.002*
	(0.001)	(0.001)	(0.002)	(0.001)
ID controls	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Constant	0.208**	0.361***	0.521***	0.282***
	(0.091)	(0.084)	(0.117)	(0.082)
Observations	75	75	75	75
R-squared	0.669	0.616	0.390	0.671
Number of countries	15	15	15	15

Note: The numbers in parentheses represent the standard errors, with *** indicating significance at $p<0.01$, ** at $p<0.05$, and * at $p<0.1$.

Source: author's own work.

Last but not least, the impact of the digital divide on financial development may exhibit non-linear characteristics. Indeed, in some sub-indexes of financial development, such as financial infrastructure, the increasing level of digitalization can alter the modes of utilizing financial services, for example, shifting from online payments through ATMs to integrated payment methods. Consequently, this can give rise to a parabolic curve in lieu of linear trends (Aterido *et al.*, 2011). Regression results with this non-linear form are presented in the Table no. A3 and illustrated in Figure no. 8. Accordingly, the impact of the digital divide on the bank branches component adheres to parabolic trends and is consistent with the expectations of previous studies.
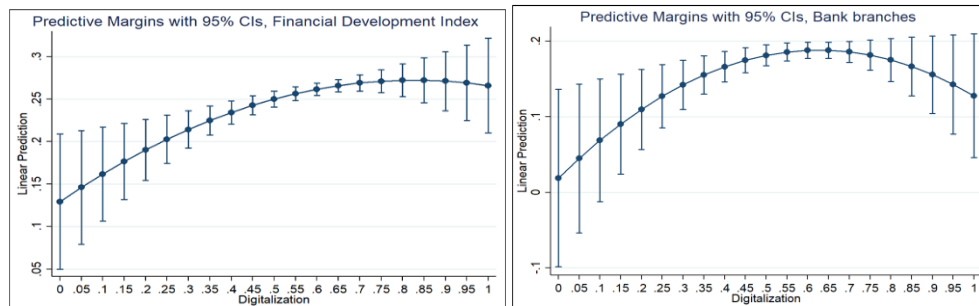
Note: 2 graphs show the near parabolic curves of predictive margins with 95% confidence intervals for Financial Development and its component as Bank branches.

Figure no. 8 – Digital divide on financial development and its components
Source: author's own work.

5. DISCUSSION AND POLICY IMPLICATION

This study provides insight into the impact of the digital divide on financial development while considering contextual factors, such as institutional frameworks. Several key highlights emerge from this investigation. First, we chose the Asia-Pacific region due to its favorable characteristics for determining the relationship under study, including significant variability among variables between and within countries. Second, we took into account the time lag in the impact of the digital divide on financial development and addressed endogeneity issues by employing appropriate instrumental variables. Third, we elucidated the impact of the relationship through various mechanisms. The research results affirm the role of the digital divide in a nation's financial development, which becomes observable after approximately two years of implementation. This is particularly evident through the channels of (i) expanding the scale of the financial market, (ii) the scale of intermediate financial markets, and (iii) increasing consumer financial demand due to improved consumer protection (Dinh *et al.*, 2023).

Notably, given the shutdown of the adopter's characteristic and external channel, we confirm the significant role of contextual factors in the digital divide's impact on financial development. Institutional quality, as expected to be a key moderator of the relationship, can influence the intercept of the relationship but does not alter its slope. In other words, a better institutional framework does not determine the effectiveness of absorbing digital advancements, as we control for adopter's characteristics and external factors. Additionally, this study validates the notion that monopoly is a constraint on the financial development process, as predicted by numerous prior studies. Therefore, this study implies that future research on the digital divide's impact on financial development should emphasize the control of contextual factors.

Indeed, in the initial phases, a lack of digital services leads to an increase in physical bank branches to maintain financial accessibility. However, as digital infrastructure improves, especially in urban areas, the need for numerous physical branches diminishes, reflecting the declining phase of the parabol. This trend is evident as urban centers stabilize or reduce branch numbers in response to widespread digital banking adoption, while rural areas may experience a similar, albeit delayed, pattern – see a case in Vietnam (Van Le and Tran, 2023). This dynamic aligns with theories predicting that technological advances lead financial institutions to adapt their physical presence towards a more efficient, digital-first approach (Sardana and Singhania, 2018). In Table no. A4, we summarize the main findings of this study.

For policymakers, especially in transitioning countries, the digital transformation process may exhibit delayed effects through various intermediary financial market channels and the enhancement of consumer trust in the digital era. Consequently, digital transformation policies require a long-term strategy, considering their multifaceted impact rather than focusing solely on specific aspects. To bridge the digital divide and enhance financial development in the diverse institutional and economic landscape of the Asia-Pacific region, targeted policy measures are essential. Governments should prioritize strengthening digital infrastructure and connectivity by expanding broadband access, fostering public-private partnerships, and promoting regional cooperation to share best practices. Enhancing institutional and regulatory frameworks is equally critical, requiring adaptive regulations that balance innovation with consumer protection, stronger cybersecurity measures, and the implementation of regulatory sandboxes to facilitate fintech experimentation. Additionally, promoting financial and digital literacy through nationwide education programs, school curriculums, and interactive mobile content can empower individuals to confidently engage with digital financial services.

Supporting inclusive fintech innovation by providing incentives for startups, developing localized financial solutions, and fostering collaborations between traditional banks and fintech firms can further drive financial accessibility. Given the region's institutional diversity, policies should be tailored to different economic contexts developed economies should refine fintech regulations, emerging markets should focus on digital infrastructure and financial education, while low-income economies should prioritize mobile banking and microfinance initiatives. Lastly, leveraging emerging technologies such as AI, big data, blockchain, and central bank digital currencies (CBDCs) can optimize financial inclusion strategies and drive sustainable economic growth. By implementing these targeted and context-specific policies, governments and financial institutions can effectively promote the diffusion of digital financial innovations and foster inclusive financial ecosystems across the Asia-Pacific region.

ORCID

Bao-Trung Phan 🆔 http://orcid.org/0009-0004-8223-8676
Dao Le-Van 🆔 http://orcid.org/0000-0001-5044-0264
Dinh Van Nguyen 🆔 http://orcid.org/0000-0001-5149-1370
Thi Kim Duyen Nguyen 🆔 http://orcid.org/0009-0002-0996-6947

References

Agarwal, S., & Chua, Y. H. (2020). FinTech and household finance: A review of the empirical literature. *China Finance Review International, 10*(4), 361-376. http://dx.doi.org/10.1108/CFRI-03-2020-0024

Aghion, P., Akcigit, U., Hyytinen, A., & Toivanen, O. (2017). The social origins of inventors. *NBER, 24110.*

Alam, N., Gupta, L., & Zameni, A. (2019). Digitalization, Development and Disruption, *Fintech and Islamic finance*: Palgrave Macmillan Cham. http://dx.doi.org/10.1007/978-3-030-24666-2

Allen, F., Carletti, E., Cull, R., Qian, J., Senbet, L., & Valenzuela, P. (2014). Resolving the African financial development gap: Cross-country comparisons and a within-country study of Kenya. *In African Successes, III: Modernization and Development*, 13-62.

Aterido, R., Hallward-Driemeier, M., & Pagés, C. (2011). Big constraints to small firms' growth? Business environment and employment growth across firms. *Economic Development and Cultural Change, 59*(3), 609-647. http://dx.doi.org/10.1086/658349

Aziz, A., & Naima, U. (2021). Rethinking digital financial inclusion: Evidence from Bangladesh. *Technology in Society, 64*, 101509. http://dx.doi.org/10.1016/j.techsoc.2020.101509

Azizi, S. (2020). Impacts of remittances on financial development. *Journal of Economic Studies (Glasgow, Scotland), 47*(3), 467-477. http://dx.doi.org/10.1108/JES-01-2019-0045

Azmeh, C. (2025). Bridging divides: The role of Fintech and financial inclusion in reducing poverty and inequality in developing countries. *Innovation and Development*, 1-20. http://dx.doi.org/10.1080/2157930X.2025.2467515

Badra, S., Jain, S., & Vichore, S. (2025). Fintech and financial inclusion: conceptual foundations and research landscape. *Global Knowledge, Memory and Communication*. http://dx.doi.org/10.1108/GKMC-07-2024-0443

Bara, A. (2016). Diffusion and adoption of bank financial innovation in Zimbabwe: An external factor analysis. *African Journal of Science, Technology, Innovation and Development, 8*(4), 357-368. http://dx.doi.org/10.1080/20421338.2016.1156839

Barth, J. R., Caprio, G., & Levine, R. (2013). Bank regulation and supervision in 180 countries from 1999 to 2011. *Journal of Financial Economic Policy, 5*(2), 111-219. http://dx.doi.org/10.1108/17576381311329661

Beck, T., Chen, T., Lin, C., & Song, F. M. (2016). Financial innovation: The bright and the dark sides. *Journal of Banking & Finance, 72*, 28-51. http://dx.doi.org/10.1016/j.jbankfin.2016.06.012

Bindu, S., Sridharan, P., Swain, R. K., & Das, C. P. (2022). Causal linkage between remittances and financial development: Evidence from the BRICS (Brazil, Russia, India, China, and South Africa). *Journal of East-West Business, 28*(2), 117-149. http://dx.doi.org/10.1080/10669868.2021.1976348

Blakstad, S., & Allen, R. (2018). Universal Inclusion in the New Financial Ecosystem, *FinTech Revolution*: Palgrave Macmillan Cham. http://dx.doi.org/10.1007/978-3-319-76014-8

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*(1), 115-143. http://dx.doi.org/10.1016/S0304-4076(98)00009-8

Bukht, R., & Heeks, R. (2017). Defining, conceptualising and measuring the digital economy. *Development Informatics working paper*(68).

Bunje, M. Y., Abendin, S., & Wang, Y. (2022). The multidimensional effect of financial development on trade in Africa: The role of the digital economy. *Telecommunications Policy, 46*(10), 102444. http://dx.doi.org/10.1016/j.telpol.2022.102444

Carlin, R., & Lee, R. M. (2021). Understanding Kim Jong-un's Economic Policymaking: Defense versus Civilian Spending. *Bulletin of the Atomic Scientists, 91*. Retrieved from https://www.38north.org/2021/09/understanding-kim-jong-uns-economic-policymaking-defense-versus-civilian-spending

Chen, P., & Kim, S. (2023). The impact of digital transformation on innovation performance – The mediating role of innovation factors. *Heliyon, 9*(3). http://dx.doi.org/10.1016/j.heliyon.2023.e13916

Cherbib, J., Chebbi, H., Yahiaoui, D., Thrassou, A., & Sakka, G. (2021). Digital technologies and learning within asymmetric alliances: The role of collaborative context. *Journal of Business Research, 125*, 214-226. http://dx.doi.org/10.1016/j.jbusres.2020.11.064

Chien, M. S., Cheng, C. Y., & Kurniawati, M. A. (2020). The non-linear relationship between ICT diffusion and financial development. *Telecommunications Policy, 44*(9), 102023. http://dx.doi.org/10.1016/j.telpol.2020.102023

Claessens, S., Frost, J., Turner, G., & Zhu, F. (2018). Fintech credit markets around the world: size, drivers and policy issues. *BIS Quarterly Review September*.

Corning, G. P. (2022). ASEAN and the Regime Complex for Digital Trade in the Asia-Pacific. *Journal of World Trade, 56*(6). http://dx.doi.org/10.54648/trad2022038

Da-gyum, J. (2022). Past, present, future of S. Korea's first homegrown KF-21 fighter jet. *The Korea Herald*. Retrieved from https://www.koreaherald.com/article/2933112

Das, B. (2022). Diffusion of innovations: Theoretical perspectives and empirical evidence. *African Journal of Science, Technology, Innovation and Development, 14*(1), 94-103. http://dx.doi.org/10.1080/20421338.2020.1814517

Demirguc-Kunt, A., Klapper, L., Singer, D., & Ansar, S. (2018). The Global Findex Database 2017: Measuring financial inclusion and the fintech revolution. *World Bank*. http://dx.doi.org/10.1596/978-1-4648-1259-0

Demirgüç-Kunt, A., & Singer, D. (2017). Financial inclusion and inclusive growth: A review of recent empirical evidence. *World bank policy research working paper*(8040).

Dengler, K., Hiesinger, K., & Tisch, A. (2022). Digital transformation: The role of computer use in employee health. *Economics and Human Biology, 46*, 101137. http://dx.doi.org/10.1016/j.ehb.2022.101137

Dinh, V., Le, D. V., Duong, D., & Pham, D. (2023). Determinants affecting digital financial consumer protection: Evidence from 135 countries. *Journal of Economic Asymmetries, 27*, e00301. http://dx.doi.org/10.1016/j.jeca.2023.e00301

Donou-Adonsou, F., Pradhan, G., & Basnet, H. C. (2020). Remittance inflows and financial development: Evidence from the top recipient countries in Sub-Saharan Africa. *Applied Economics, 52*(53), 5807-5820. http://dx.doi.org/10.1080/00036846.2020.1776834

Dragu, T., & Lupu, Y. (2021). Digital authoritarianism and the future of human rights. *International Organization, 75*(4), 991-1017. http://dx.doi.org/10.1017/S0020818320000624

Drori, N., Alessandri, T., Bart, Y., & Herstein, R. (2024). The impact of digitalization on internationalization from an internalization theory lens. *Long Range Planning, 57*(1), 102395. http://dx.doi.org/10.1016/j.lrp.2023.102395

Duc, D. A., Hoi, L. Q., Van Dao, L., Lien, V. T. P., Hang, N. T., & Huong, T. L. (2024). Corporate environmental responsibility and the business risk of Vietnamese SMEs: The mediating role of internal control. *Risk Management, 26*(1), 2. http://dx.doi.org/10.1057/s41283-023-00133-1

Ekinci, R. (2021). The impact on digitalization on financial sector performance. The Impact of Artificial Intelligence on Governance. *The Impact of Artificial Intelligence on Governance, Economics and Finance, I*, 99-119. http://dx.doi.org/10.1007/978-981-33-6811-8_6

ESCAP. (2022). *Asia-Pacific digital transformation report 2022: shaping our digital future*. Retrieved from https://repository.unescap.org/bitstream/handle/20.500.12870/4725/ESCAP-2022-IDD-Flagship-Asia-Pacific-Digital-Transformation-Report.pdf?sequence=1&isAllowed=y

ESCAP. (2025). *Asia and the Pacific SDG Progress Report 2025: engaging communities to close the evidence ga*. Retrieved from https://repository.unescap.org/handle/20.500.12870/7736

Feyen, E., Heffernan, R. R., Natarajan, H., Saal, M., & Sarkar, A. (2021). World Bank group global market survey: digital technology and the future of finance. *World Bank Group Fintech and the Future of Finance report*.

Fromentin, V. (2017). The long-run and short-run impacts of remittances on financial development in developing countries. *The Quarterly Review of Economics and Finance, 66*, 192-201. http://dx.doi.org/10.1016/j.qref.2017.02.006

Fujiki, H. (2021). Will the widespread use of cashless payments reduce the frequency of the use of cash payments? *Review of Economic Analysis, 13*(3), 89-120. http://dx.doi.org/10.15353/rea.v13i3

García-Avilés, J. A. (2020). *Diffusion of innovation*: The international Encyclopedia of media psychology. http://dx.doi.org/10.1002/9781119011071.iemp0137

GSMA. (2022). *GSMA Mobile Connectivity Index*. Retrieved from: https://www.mobileconnectivityindex.com/connectivityIndex.html#year=2014&dataSet=indicator

Ha, L. T. (2022). Impacts of digital business on global value chain participation in European countries. *AI & Society*, 1-26. http://dx.doi.org/10.1007/s00146-022-01524-w

Horobet, A., Mnohoghitnei, I., Zlatea, E. M. L., & Belascu, L. (2022). The interplay between digitalization, education, and financial development: A European case study. *Journal of Risk and Financial Management, 15*(3), 135. http://dx.doi.org/10.3390/jrfm15030135

Hutton, T. A. (2003). Service industries, globalization, and urban restructuring within the Asia-Pacific: New development trajectories and planning responses. *Progress in Planning, 61*(1), 1-74. http://dx.doi.org/10.1016/S0305-9006(03)00013-8

Hwang, Y., Park, S., & Shin, N. (2021). Sustainable development of a mobile payment security environment using fintech solutions. *Sustainability (Basel), 13*(15), 8375. http://dx.doi.org/10.3390/su13158375

Jemiluyi, O. O., & Jeke, L. (2023). How Catalytic Is Digital Technology in the Nexus between Migrants' Remittance and Financial Development in Sub-Saharan African Countries? *Economies, 11*(3), 74. http://dx.doi.org/10.3390/economies11030074

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *The American Economic Review, 95*(1), 161-182. http://dx.doi.org/10.1257/0002828053828518

Kaur, P., Dhir, A., Bodhi, R., Singh, T., & Almotairi, M. (2020). Why do people use and recommend m-wallets? *Journal of Retailing and Consumer Services, 56*, 102091. http://dx.doi.org/10.1016/j.jretconser.2020.102091

Keane, M., Yu, H., Zhao, E. J., & Leong, S. (2020). *Chinas Digital Presence in the Asia-Pacific: Culture, Technology and Platforms*: Anthem Press. http://dx.doi.org/10.2307/j.ctv20pxxzt

Khan, M. A., Khan, M. A., Abdulahi, M. E., Liaqat, I., & Shah, S. S. H. (2019). Institutional quality and financial development: The United States perspective. *Journal of Multinational Financial Management, 49*, 67-80. http://dx.doi.org/10.1016/j.mulfin.2019.01.001

Kim, J. Y., Park, J., & Jun, S. (2022). Digital transformation landscape in Asia and the Pacific: Aggravated digital divide and widening growth gap. *ESCAP working papaer series*.

Kingiri, A. N., & Fu, X. (2020). Understanding the diffusion and adoption of digital finance innovation in emerging economies: M-Pesa money mobile transfer service in Kenya. *Innovation and Development, 10*(1), 67-87. http://dx.doi.org/10.1080/2157930X.2019.1570695

Kumari, N., & Khanna, J. (2017). Cashless payment: A behaviourial change to economic growth. *Qualitative and Quantitative Research Review, 2*(2).

Legowo, M. B., Indiarto, B., & Prayitno, D. (2021a). *Digital economy inclusiveness information system model to encourage national economic recovery: Recover together, recover stronger.* Paper presented at the In Conference Towards ASEAN Chairmanship 2023 (TAC 23 2021).

Legowo, M. B., Indiarto, B., & Prayitno, D. (2021b). *Digitalization for business model innovation: Create, change, and improve for values*. Paper presented at the In 2021 4th International Conference of Computer and Informatics Engineering (IC2IE).

Lythreatis, S., Singh, S. K., & El-Kassar, A. N. (2022). The digital divide: A review and future research agenda. *Technological Forecasting and Social Change, 175*, 121359. http://dx.doi.org/10.1016/j.techfore.2021.121359

Machkour, B., & Abriane, A. (2020). Industry 4.0 and its Implications for the Financial Sector. *Procedia Computer Science, 177*, 496-502. http://dx.doi.org/10.1016/j.procs.2020.10.068

Michaelsen, M. (2018). Transforming Threats to Power: The International Politics of Authoritarian Internet Control in Iran. *International Journal of Communication*(19328036), 12.

Mignamissi, D., & Djijo T, A. J. (2021). Digital divide and financial development in Africa. *Telecommunications Policy, 45*(9), 102199. http://dx.doi.org/10.1016/j.telpol.2021.102199

Nam, Y., & Lee, S. T. (2023). Behind the growth of FinTech in South Korea: Digital divide in the use of digital financial services. *Telematics and Informatics, 81*, 101995. http://dx.doi.org/10.1016/j.tele.2023.101995

Nchofoung, T. N., & Asongu, S. A. (2022). ICT for sustainable development: Global comparative evidence of globalisation thresholds. *Telecommunications Policy, 46*(5), 102296. http://dx.doi.org/10.1016/j.telpol.2021.102296

Nguyen, T. V., Simioni, M., & Van Le, D. (2019). Assessment of TFP change at provincial level in Vietnam: New evidence using Färe–Primont productivity index. *Economic Analysis and Policy, 64*, 329-345. http://dx.doi.org/10.1016/j.eap.2019.09.007

Oladunjoye, O., & Tshidzumba, N. (2023). Technology Adoption and the Financial Market Performance in Nigeria and South Africa. *In Applied Research Conference in Africa*, 935-952. http://dx.doi.org/10.1007/978-3-031-25998-2_72

Ong, H. B., & Chong, L. L. (2023). The effect of cashless payments on the internet and mobile banking. *Journal of Financial Services Marketing, 28*(1), 178-188. http://dx.doi.org/10.1057/s41264-022-00145-0

Ong, H. B., Wasiuzzaman, S., Chong, L. L., & Choon, S. W. (2023). Digitalisation and financial inclusion of lower middle-income ASEAN. *Heliyon, 9*(2), e13347. http://dx.doi.org/10.1016/j.heliyon.2023.e13347

Owusu-Agyei, S., Okafor, G., Chijoke-Mgbame, A. M., Ohalehi, P., & Hasan, F. (2020). Internet adoption and financial development in sub-Saharan Africa. *Technological Forecasting and Social Change, 161*, 120293. http://dx.doi.org/10.1016/j.techfore.2020.120293

Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review, 18*(4), 329-340. http://dx.doi.org/10.1016/j.bir.2017.12.003

Ping, H. W. (2014). Banking regulation in China: Why, what, and how? *Banking Regulation in China: The Role of Public and Private Sectors* (pp. 51-69): Springer. http://dx.doi.org/10.1057/9781137367556_3

Prochniak, M., & Wasiak, K. (2017). The impact of the financial system on economic growth in the context of the global crisis: Empirical evidence for the EU and OECD countries. *Empirica, 44*, 295-337. http://dx.doi.org/10.1007/s10663-016-9323-9

Raihan, M. M., Subroto, S., Chowdhury, N., Koch, K., Ruttan, E., & Turin, T. C. (2024). Dimensions and barriers for digital (in) equity and digital divide: A systematic integrative review. *Digital Transformation and Society*. http://dx.doi.org/10.1108/DTS-04-2024-0054

Ramya, N., Sivasakthi, D., & Nandhini, M. (2017). Cashless transaction: Modes, advantages and disadvantages. *International Journal of Applied Research, 3*(1), 122-125.

Rao, K. U., & Kishore, V. (2010). A review of technology diffusion models with special reference to renewable energy technologies. *Renewable & Sustainable Energy Reviews, 14*(3), 1070-1078. http://dx.doi.org/10.1016/j.rser.2009.11.007

Rhee, T., Wood, J., & Kim, J. (2022). Digital Transformation as a Demographic and Economic Integrated Policy for Southeast Asian Developing Countries. *Sustainability (Basel), 14*(5), 2857. http://dx.doi.org/10.3390/su14052857

Rogers, E. M. (2010). *Diffusion of innovations* Retrieved from https://www.simonandschuster.com/books/Diffusion-of-Innovations-4th-Edition/Everett-M-Rogers/9781451602470

Ruiz-Porras, A. (2009). Financial structure, financial development and banking fragility: International evidence. *Análisis Económico, 24*(56), 147-173.

Runtev, M. (2020). The impact of digitization on financial markets and their tendency on global growth. *Економски Развој-Economic Development, 22*(1-2), 133-145.

Sardana, V., & Singhania, S. (2018). Digital technology in the realm of banking: A review of literature. *International Journal of Research in Finance and Management, 1*(2), 28-32. http://dx.doi.org/10.33545/26175754.2018.v1.i2a.12

Sethi, P., Chakrabarti, D., & Bhattacharjee, S. (2020). Globalization, financial development and economic growth: Perils on the environmental sustainability of an emerging economy. *Journal of Policy Modeling, 42*(3), 520-535. http://dx.doi.org/10.1016/j.jpolmod.2020.01.007

Shaban, A. (2025). Digitalization and exclusion - digital divides and development. *In Digital Geographies - Theory, Space, and Communities: A Machine-Generated Literature Review*, 255-496.

Shiller, B. R. (2013). *First degree price discrimination using big data* Retrieved from https://www.researchgate.net/profile/Benjamin-Shiller/publication/358940523_First-Degree_Price_Discrimination_Using_Big_Data_for_very_useful_feedback_suggestions_and_advice_I_would_also_like_to_thank/links/621e7052395296023159b47d/First-Degree-Price-Discrimination-Using-Big-Data-for-very-useful-feedback-suggestions-and-advice-I-would-also-like-to-thank.pdf

Sobiech, I. (2019). Remittances, finance and growth: Does financial development foster the impact of remittances on economic growth? *World Development, 113*, 44-59. http://dx.doi.org/10.1016/j.worlddev.2018.08.016

Son, C. Y. (2022). Digital connectivity: Bolstering technical development and shaping the digital economy in South. *East Asia (Piscataway, N.J.)*.

Stuart-Fox, M. (2009). Laos: the Chinese connection. *Southeast Asian Affairs, 2009*(1), 141-169.

Sudan, F. K. (2020). Regional institutions in Europe and Southeast Asia: Lessons for economic integration in South Asia. Retrieved from http://hdl.handle.net/10419/238447

Svirydzenka, K. (2016). *Introducing a new broad-based index of financial development*: International Monetary Fund. http://dx.doi.org/10.5089/9781513583709.001

Thordsen, T., Murawski, M., & Bick, M. (2020). *How to measure digitalization? A critical evaluation of digital maturity models.* Paper presented at the In Responsible Design, Implementation and Use of Information and Communication Technology: 19th IFIP WG 6.11 Conference on e-Business, e-Services, and e-Society, I3E 2020, Skukuza, South Africa.

Urhie, E., Amonu, O. C., Mbah, C., Ewetan, O. O., Matthew, O. A., Adediran, O., . . . Adekeye, A. (2021). Banking technology and cashless economy in selected Sub-Saharan African countries: Does education matter? *Journal of Money Laundering Control, 24*(3), 584-595. http://dx.doi.org/10.1108/JMLC-10-2020-0122

Van, H. V., Van Dao, L., Hoang, L. K., & Van Hien, N. (2023). The efficiency of government finimical expenditures before and during the COVID-19 pandemic: A cross-country investigation. *Finance Research Letters, 54*, 103697. http://dx.doi.org/10.1016/j.frl.2023.103697

Van Le, D., & Tran, T. Q. (2022). Does the private sector increase inequality? Evidence from a transitional country. *Structural Change and Economic Dynamics, 62*, 451-466. http://dx.doi.org/10.1016/j.strueco.2022.06.005

Van Le, D., & Tran, T. Q. (2023). Heterogenous effects of ICT application on local tourism development: A quantile regression approach. *Journal of Policy Research in Tourism, Leisure & Events*, 1-23. http://dx.doi.org/10.1080/19407963.2023.2196727

Van Le, D., & Tran, T. Q. (2024). Economic growth and quality of education: Evidence from the national high school exam in Vietnam. *International Journal of Educational Development, 104*, 102947. http://dx.doi.org/10.1016/j.ijedudev.2023.102947

Van Le, D., & Tran, T. Q. (2025). Central budget allocation regime and total factor productivity in Vietnam: A decomposition approach. *Economía, 26*(1), 67-88. http://dx.doi.org/10.1108/ECON-11-2023-0187

Van Le, D., Tran, T. Q., & Doan, T. (2022). The private sector and multidimensional poverty reduction in Vietnam: A cross-province panel data analysis. *International Journal of Social Welfare, 31*(3), 291-309. http://dx.doi.org/10.1111/ijsw.12524

Vo, D. H., Nguyen, N. T., Vo, A. T., Ho, C. M., & Nguyen, T. C. (2021). Does the Kuznets curve apply for financial development and environmental degradation in the Asia-Pacific region? *Heliyon, 7*(4), e06708. http://dx.doi.org/10.1016/j.heliyon.2021.e06708

Wade, R. H. (2023). The world development report 2022: Finance for an equitable recovery in the context of the international debt crisis. *Development and Change, 54*(5), 1354-1373. http://dx.doi.org/10.1111/dech.12796

Weber, A. M. (2024). Digitalizing the commercial banking business model: vanishing bank branches and the risks of financial exclusion of the elderly *Commercial Banking in Transition: A Cross-Country Analysis* (pp. 87-107): Springer. http://dx.doi.org/10.1007/978-3-031-45289-5_5

Wintoki, M. B., Linck, J. S., & Netter, J. M. (2012). Endogeneity and the dynamics of internal corporate governance. *Journal of Financial Economics, 105*(3), 581-606. http://dx.doi.org/10.1016/j.jfineco.2012.03.005

Wójcik, M., Dmochowska-Dudek, K., & Tobiasz-Lis, P. (2021). Boosting the Potential for GeoDesign: Digitalisation of the System of Spatial Planning as a Trigger for Smart Rural Development. *Energies, 14*(13), 3895. http://dx.doi.org/10.3390/en14133895

World Bank. (2012). Global financial development report 2013: Rethinking the role of the state in finance. *World Bank.* Retrieved from https://documents.worldbank.org/en/publication/documents-reports/documentdetail/853761468326979957/global-financial-development-report-2013-rethinking-the-role-of-the-state-in-finance

World Bank. (2016). World development report 2016: Digital dividends. Retrieved from https://www.worldbank.org/en/publication/wdr2016

World Bank. (2019a). The Digital Economy in Southeast Asia: Strengthening the Foundations for Future Growth. World Bank. Retrieved from

https://documents1.worldbank.org/curated/en/328941558708267736/pdf/the-digital-economy-in-southeast-asia-strengthening-the-foundations-for-future-growth.pdf

World Bank. (2019b). Global financial development report 2019/2020: Bank regulation and supervision a decade after the global financial crisis. *World Bank.* Retrieved from https://openknowledge.worldbank.org/entities/publication/71ec90e9-08f3-52be-b0be-63f136719243

World Bank. (2024). *DataBank Global Financial Development*. Retrieved from: https://databank.worldbank.org/source/global-financial-development

Wu, T., & Shao, W. (2022). How does digital economy drive industrial structure upgrading: An empirical study based on 249 prefecture-level cities in China. *PLoS One, 17*(11), e0277787. http://dx.doi.org/10.1371/journal.pone.0277787

Yu, M., Jin, H., Zhang, H., & Chong, A. Y. L. (2023). ICT, financial development and renewable energy consumption. *Journal of Computer Information Systems, 63*(1), 190-203. http://dx.doi.org/10.1080/08874417.2022.2049017
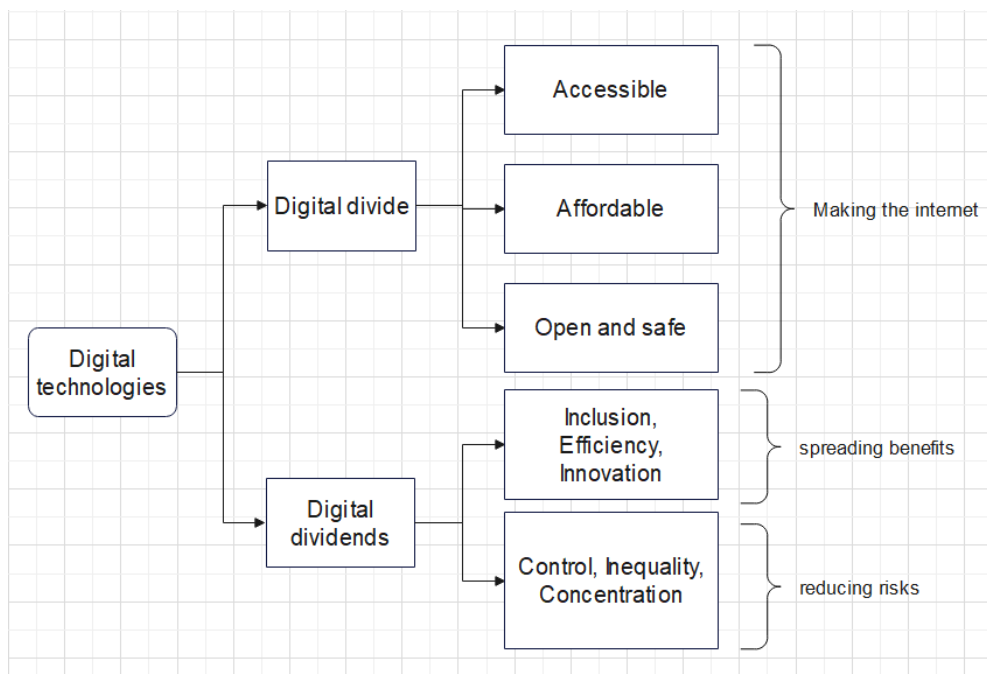
ANNEXES

Figure no. A1 – Digital divide and digital dividends

Source: authors' synthetic from World Bank (2016).

Table no. A1 – List of 31 Asia-Pacific countries in the sample from 2014 to 2021

Country name	Frequency	Country name	Frequency	Country name	Frequency
Afghanistan	8	Japan	8	Philippines	8
Australia	8	Laos	8	Russian Federation	8
Bangladesh	8	Malaysia	8	Samoa	8
Bhutan	8	Maldives	8	Singapore	8
Cambodia	8	Mongolia	8	Solomon Islands	8
China	8	Myanmar	8	Sri Lanka	8
Fiji	8	Nepal	8	Thailand	8
Hong Kong	8	New Zealand	8	Timor-Leste	8
India	8	Pakistan	8	Tonga	8
Indonesia	8	Papua New Guinea	8	Vanuatu	8
Vietnam	8	Total	248		
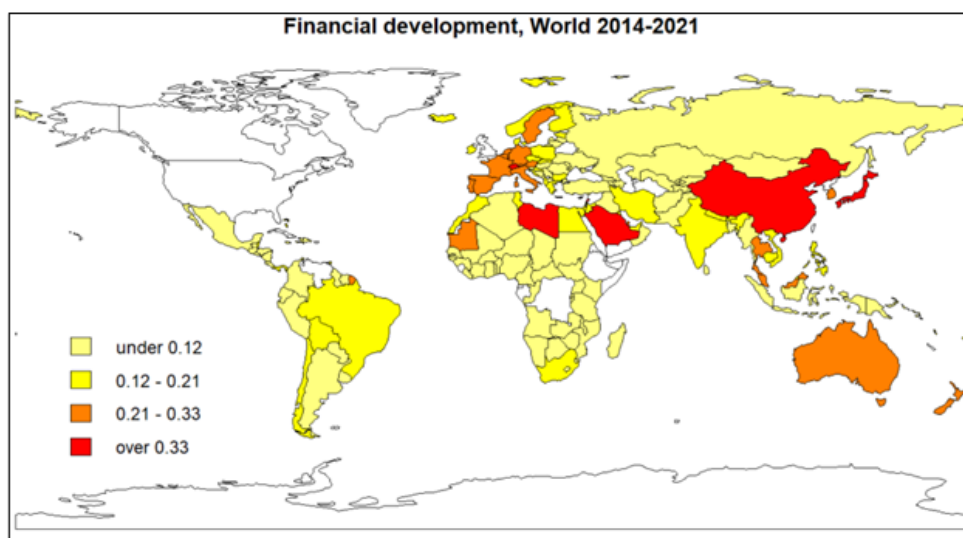
Figure no. A2 – Financial development, World 2014-2021

Source: authors' own work
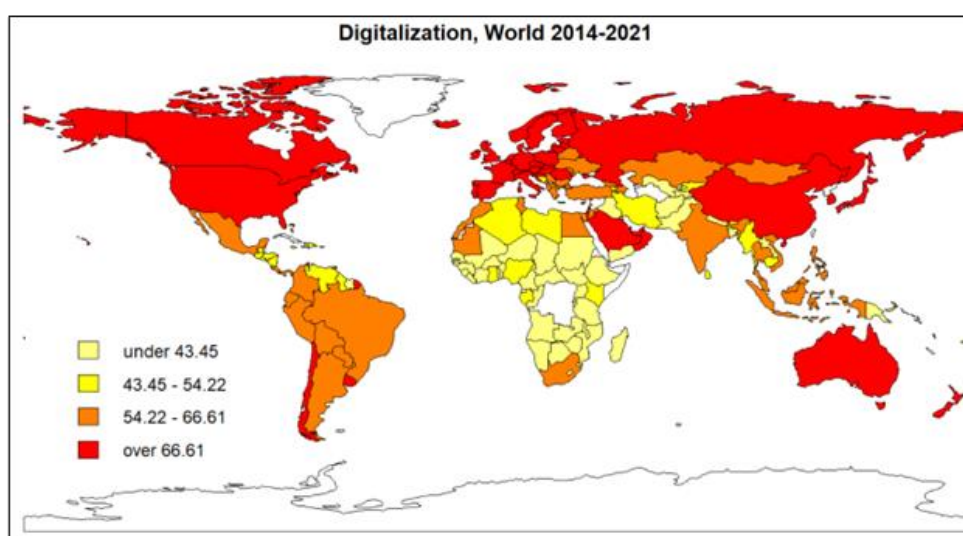
Figure no. A3 – Digitalization, World 2014-2021

Source: authors' own work

Table no. A2 – The nexus under the institutional condition (2-years lag)

Dependent variable:	Financial development index Fixed effect model			
Independent variable (DD)	Digital divide	Sub-index: Infrastructure	Sub-index: Affordability	Sub-index: Open and safe
	(1)	(2)	(3)	(4)
Independent variable [Equation]	0.002***	0.105**	0.223***	0.261***
	(0.001)	(0.042)	(0.059)	(0.093)
Middle level of institutional qualityt-2	0.082**	0.067**	0.104***	0.113**
	(0.035)	(0.027)	(0.039)	(0.049)
High level of institutional qualityt-2	0.110**	0.090**	0.165*	0.141**
	(0.055)	(0.038)	(0.085)	(0.060)
Middle level of institutional quality t-2 [Equation]	-0.001	-0.047	-0.117	-0.152
	(0.001)	(0.050)	(0.094)	(0.104)
High level of institutional qualityt-2 [Equation]	-0.001	-0.035	-0.177	-0.153
	(0.001)	(0.063)	(0.149)	(0.120)
Central bank assets to GDP	0.001**	0.001**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Bank net interest margin	-0.001	0.002	-0.005	-0.003
	(0.007)	(0.007)	(0.007)	(0.007)
Bank overhead costs to total assets	-0.004	-0.012	-0.004	-0.008
	(0.016)	(0.016)	(0.015)	(0.016)
Bank return on equity (after tax)	-0.001**	-0.001**	-0.001**	-0.001**
	(0.001)	(0.001)	(0.001)	(0.001)
Bank concentration	-0.001	-0.000	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Liquid liabilities	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Remittance inflows to GDP	-0.008**	-0.009**	-0.005	-0.008**
	(0.004)	(0.004)	(0.004)	(0.004)
External loans and deposits of reporting banks	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
ID controls	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Constant	0.164**	0.215***	0.141*	0.180**
	(0.072)	(0.069)	(0.076)	(0.074)
Observations	112	112	112	112
R-squared	0.646	0.622	0.650	0.631
Number of countries	23	23	23	23

Note: standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table no. A3 – Regression on FDI and its components

Dependent variables:	Financial development index	Bank branches per 100,000 adults	ATMs per 100,000 adults	Deposit money banks assets to GDP	Liquid liabilities to GDP	Financial system deposits to GDP	Bank deposits to GDP
			Fixed effect model				
VARIABLES	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Digital divide [Equation]	0.346**	0.541**	0.693	0.736	0.654	0.834*	0.819*
	(0.145)	(0.214)	(0.496)	(0.613)	(0.563)	(0.486)	(0.486)
[Equation]	-0.209	-0.432**	-0.681	-0.171	-0.180	-0.444	-0.430
	(0.129)	(0.191)	(0.442)	(0.546)	(0.502)	(0.433)	(0.433)
Institutional quality	0.030	-0.002	0.229**	0.090	0.056	0.057	0.057
	(0.028)	(0.042)	(0.097)	(0.119)	(0.110)	(0.095)	(0.095)
Central bank assets to GDP	0.001*	-0.001	-0.002	-0.004*	0.011***	0.006***	0.006***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Bank net interest margin	-0.008**	-0.003	-0.030**	-0.018	-0.037**	-0.021	-0.021
	(0.004)	(0.006)	(0.014)	(0.018)	(0.016)	(0.014)	(0.014)
Bank overhead costs to total assets	-0.002	0.006*	0.003	-0.008	-0.011	-0.016**	-0.016**
	(0.002)	(0.003)	(0.008)	(0.010)	(0.009)	(0.008)	(0.008)
Bank return on equity (after tax)	-0.001*	-0.001	0.001	-0.005**	-0.001	-0.003**	-0.003**
	(0.000)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Bank concentration	-0.001**	-0.000	-0.006***	-0.004	-0.006**	-0.004*	-0.004*
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Liquid liabilities	0.000***	0.000	0.000***	0.000***	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Remittance inflows to GDP	-0.003	-0.010**	-0.004	-0.019*	0.003	0.004	0.004
	(0.003)	(0.004)	(0.009)	(0.011)	(0.010)	(0.009)	(0.009)
External loans and deposits of reporting banks	0.000	-0.000	0.001	-0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.222***	0.083	0.776***	0.935***	0.972***	0.691***	0.695***
	(0.071)	(0.104)	(0.242)	(0.300)	(0.275)	(0.238)	(0.237)
Observations	154	154	154	154	154	154	154
R-squared	0.606	0.211	0.271	0.425	0.494	0.412	0.413
Number of ID	23	23	23	23	23	23	23

Note: standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table no. A4 – Summary of Research Findings

Type of Effects	Description	Empirical Results
Direct (linear) impact of DD on FD	DD causally influences the aggregated financial development index, with a lag of about 2 years	Supported
Direct impact of Institutional quality on FD	Institutional quality is positively correlated with the financial development index	Supported
Moderator effects of Institutional quality: interaction effects	Institutional quality affects the DD-FD nexus	No
Impact mechanisms of DD on FD: mediation effects	The impact is manifested through mechanisms improving Digital financial consumer protection	Supported
Impact mechanisms of DD on FD: mediation effects	The impact is manifested through mechanisms boosting the financial market and expanding the intermediate market	Supported
Non-linear impact of DD on sub-index of FD	The impact of the digital divide on the bank branches component follows parabolic trends and aligns with the expectations of previous studies	Supported

Source: authors.

Limitations: The selection of the Asia-Pacific region, while advantageous for research design, is constrained by the limited number of observations. Moreover, the additional control of adopters' characteristics and external factors led to excluding 31 countries from this region, leaving only 23 countries in the analysis. Therefore, future research with more extensive data may further solidify the research findings with richer datasets. Given the post-COVID-19 context, there is increased interest in how digitalization has shaped financial markets differently. However, given the limitations of the observations and the countries included in this study, we encourage future research to explore this relationship with sub-group analyses based on the periods before, during, and after COVID-19. Additionally, we acknowledge that using national-level data may introduce inevitable noise into the analysis, especially when considering the impact of external factors. Therefore, more insights may be gained from examining this relationship using individual or sub-national level data that combines multiple countries within the region (e.g., Vietnam, China, Australia, New Zealand, and India).