Effects of Information and Communication Technology on Financial Inclusion: Evidence Across Emerging and Developing Countries

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This study assesses the impact of information and communication technologies (ICT) on financial inclusion across countries. Panel data of 35 emerging and developing countries from 2009 to 2018 is gathered and analyzed with a two-step system GMM estimator. The results highlight the significance of ICT development, particularly mobile phones, internet users, and ATMs, to promote financial inclusion across countries. As more people join the financial system, bank accounts and deposits will increase to support their economic activities. Hence, while the banking industry has generally utilized the ICT to serve the well-off customers, it can be expanded to reach the unbanked population. Furthermore, we test the effects of macroeconomic and socioeconomic variations on the estimation results. We find that both factors play an essential role in increasing financial inclusion. Hence, it is important for emerging and developing countries to construct specific policies that can facilitate better access and usage of financial products and services, as well as enhance macroeconomic and socioeconomic development to further accelerate financial inclusion efforts. Finally, it is of utmost importance for the public sector to provide the basic infrastructure needed to facilitate secure and sustainable ICT growth for a more inclusive financial sector.

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1. Introduction

Information and communication technology (ICT) is prevalent in many socio-economic activities, from households to office and government activities. Those activities include the financial services sector, which has increasingly use ICT in providing various financial products and services. In the banking industry, ICT is particularly used as a delivery channel that can be accessed anytime and anywhere to fulfill customers need. The use of ICT in banking has broad characteristics in which customers can access all banking services and products from one location through e-banking (digital branch) or a bank/customer device (omnichannel). With e-banking, customers can obtain information, communicate, and make transactions through various electronic media, such as Automated Teller Machines (ATM), SMS banking, electronic fund transfers, internet banking, and mobile banking, in a multichannel manner.

Technology-based product and service innovations in banking is seen as an innovative technology to provide financial products and services for existing customers. However, it is also important to expand banking products and services to those who do not have a bank account (unbanked). According to McKinsey Global Institute (Manyika et al., 2016), digital finance is used in various financial inclusion programs by providers of financial services that are not only banks, but other non-bank financial institutions, payment providers, telecoms companies, financial technology (fintech) start-ups, retailers, and other businesses.

The ability to access financial products and services easily (accessibility) is one of the main drivers for financial inclusion. Hence, accessibility is reflected when people are close to access points – branches, agents, ATMs, outlets, or other devices – so that it enables them to easily select and use various financial products and services to meet their needs. Ozili (2018) illustrates that digitalization, when applied to the lives of low income and/or poor people, can increase their access to basic financial products and services, leading to greater financial inclusion. Kanobe et al. (2017) finds digitalization particularly beneficial in rural areas because mobile devices are becoming an essential tool for financial inclusion in developing countries.

The McKinsey Asia Personal Financial Services survey in 2017 shows that approximately 55 to 80% of customers in Asia consider opening an account with a branchless digital-only bank. In addition, customers will be willing to shift between 35 to 40% of their money to digital accounts (Barquin et al., 2019). Their finding implies that the more accounts opened in a branchless digital-only bank, the more opportunities for saving, borrowing, and transferring money can be executed through branchless banking services. The benefits of

increasing financial inclusion are not only significant for individuals or societies but also the economy as a whole. Many studies confirm that one of the positive impacts of financial inclusion is on economic growth. Loukoianova et al. (2018) illustrates that an increase of 1% in the financial inclusion index in low income developing countries can raise GDP per capita growth by 0.14%. Hariharan and Marktanner (2012) find an increase of 10% in financial inclusion has the potentials to raise income per worker by 1.34% on average.

Beyene Fanta and Makina (2019) conclude that the most significant driver for financial inclusion is the technology in which ATMs and internet technology affect financial access and use for financial services. Mushtaq and Bruneau (2019) specify that using information and technology as an instrument to increase financial inclusion can accelerate economic growth and reduce poverty as well as inequality. The increase in financial inclusion will also positively contribute to sustainable economic development at local and national level, as well as support the stability of the financial system (Robert et al., 2014).

This study contributes to examine the relationship between ICT and financial inclusion in banking in emerging countries. The analysis particularly assesses the impact of ICT, socio-economic, and bank network related factors towards two indicators that are commonly used to measure financial inclusion, i.e., access and usage.

The rest of the paper is organized as follows. Section 2 discusses some literature reviews on ICT in the banking industry and financial inclusion. Section 3 explains the theoretical framework for the basis of the study, followed by data and methodology in section 4. Section 5 discusses the results, and section 6 concludes the paper.

2. Literature Review

2.1 ICT in Banking

ICT is consisted of two aspects: (1) information technology that covers all matters relating to information processing; and (2) communication technology that is related to tools for processing data and transferring data from one device to another. Both aspects cannot run properly without the support of ICT infrastructure, including telecommunication network. In banking industry, the ICT infrastructure plays a vital role as the backbone in data and information processing and delivery with the customers.

The use of technology in socio-economic activities can facilitate the exchange of data and information. The most visible development in the use of information technology is processing the data into information in a fast and accurate way. Tcheng et al. (2007) illustrates that ICT development is increasingly considered as an engine for growth, in which the technology is omnipresent in most business sectors for continuous improvement process, cost reduction, as well as new product and processes innovation.

The needs for digital devices and their penetration in various aspects of human life have created large technology industries around the world with their business values increasing significantly over time. People can now shop anywhere at any time without leaving home by using electronic commerce (e-commerce) platform. For purchase and selling products through e-commerce platforms, the payment system has its origin in the banking sector. Over the last three decades, banks have transformed their business from paper-based system to fully integrated ICT-enabled system to serve various customers' need, including payment services. Since e-commerce has become so ubiquitous in some countries, cash has now become almost superfluous.

In a cashless ecosystem where people purchase goods and send money from their bank accounts to the recipients' accounts through various delivery channels, money is used for only the smallest transactions. Even the small money cash transactions are poised to be replaced by a micropayment service in some countries where consumers pay for small items through their mobile phone or a value-carrying smart card. Consequently, ICT has been positively associated with higher productivity growth, as previous studies conclude in both developed (Dedrick et al., 2013; Yousefi, 2011) and emerging economies (Sassi and Goaied, 2013).

European Banking Federation (2015) finds that the rapid uptake of digitalization in the banking industry has led banks to accelerate the rethinking of their traditional business model, including their brick-and-mortar branches. IT systems have become more important, and it is clear that banks need to respond quickly and efficiently to customer demands while keeping services safe and simple to use. The development of digitization in many areas has brought banks to understand that banking is no longer about saving and lending, but about data and keeping it secure for customers' protection while satisfying their need. However, there is clearly a need to define certain effects of the use of technology on the products and services used by customers as well as potential customers.

IT system has become more important for banks to align their goals with the way they operate their businesses. ICT is no longer a supporting factor for bank's going concern. Banks are enhancing their application platforms to enable customers to do their financial transactions independently through mobile and internet banking. Some of them even create online onboarding system to grab potential customers. The end state is to give customers and potential customers complete autonomy for actions, allowing customers and potential customers to provide services for themselves, increase perceptions of control, and increase the speed of access to available services.

The front-end experiences provided by either the bank, or its third-party partners can be used by both customers and potential customers to increase access to services and save costs incurred while using the services. At the same time, banks using integrated technology within their bank-wide operation can reduce labor costs and/or the ability to move employees to more productive activities, reduce branch network costs and expand market share even in remote areas. This expansion can be done through an electronic delivery channel used by customers and potential customers, or by the bank's agents.

For some banks, by implementing new technology in their IT architecture, more parties are involved in servicing their customers and potential customers. For example, an application programming interface (API) will allow the bank to acquire new customers from people who registered through the e-commerce platform. Collaborations between bank and fintech start-ups in electronic know-your-customer (e-KYC) and digital signature will bring down cost and time through a more simplified authentication phase. At the same time, it will increase the ability of customers and potential customers to grasp access and obtain faster transactions processing.

Due to the democratization of financial services and collaborations with fintech start-ups, banks have performed better in reducing the cost of transactions and fostering the development of innovative services. Unfortunately, most banks tend to have only one channel, which is a branch network. The ATM, call center, mobile channels, and internet channels are all built as additions while the physical bank branch has remained the foundation (Skinner, 2014). This condition brings difficulty to some countries that obliged to accommodate their citizens who live in remote and isolated areas, which can lead to high cost for the bank to have a physical branch in those areas. Ultimately, it is crucial to build the right framework to facilitate financial

inclusion and innovation in banking, while ensuring that consumer protection, trust, security, and competition are maintained in the industry.

2.2 Financial Inclusion

Being excluded from the formal financial system means that individuals and businesses who do not have bank accounts need to rely on informal mechanisms, such as saving money under their pillow/bed mattress, sending money through a remittance company or relatives, and borrowing money from pawnbrokers or loan sharks that are often unsafe, unreliable, and extremely expensive. Moreover, their socio-economic activities might be hampered by their positions, which are outside the formal financial system. This condition depicts what is actually occurring in today's world: the people with the most limited resources pay the highest fees for financial products and services. Therefore, providing access to affordable financial products and services to unbanked and underbanked people will have a tremendous impact for them to conduct financial transactions that support their socio-economic activities. Studies show that when people participate in the financial system, they can better start and expand the business, invest in education, manage risk, and absorb economic shocks (Demirguc-Kunt et al., 2015).

According to the World Bank Global Findex Survey in 2011 and 2014, financial inclusion has been measured in many countries based on account ownership by adult population (above 15 years old), in which the account that can be used to store money and receive payments (Demirguc-Kunt et al., 2015). From survey questions, it is known that accounts should be within formal institutions, which is different from one country to another depending on the laws and regulations for the formal institutions. Using this definition, approximately 2 billion adults in 2014 and 1.7 billion adults in 2017 remain unbanked, or without an account at any financial institution nor mobile money provider. In terms of global financial inclusion rate (Findex), the World Bank's surveys have shown an increase from 51% of adults owning an account in 2011 to 62% in 2014 and 69% in 2017.

Many countries have their own definition of financial inclusion and specific goal to increase inclusion. Each has attempted to expand account ownerships among the unbanked to increase financial inclusion rate. Hence, in 2018 the World Bank has improved the Findex approach to measure financial inclusion using access to financial products and services that are useful and affordable in meeting the consumers' need, such as transactions, payments, savings, credit, and insurance that are used responsibly and sustainably (World Bank, 2018). The purpose of financial inclusion is to include all consumers of the country's financial system to

enable all financial transactions to be carried out quickly and accurately. The consumers' ability to easily access financial products and services (accessibility) is one of the main drivers of financial inclusion.

Consequently, financial inclusion is a key enabler to reduce poverty and boost prosperity. The World Bank study shows that an inclusive financial system can help increase economic capacity and pave the way out of poverty and reduce economic inequality. In most emerging and developing countries, financial inclusion is intended to provide financial services to people who do not have access. It can be done by opening accounts in formal financial institutions so that individuals can carry out financial activities that ultimately eradicate poverty and accelerate economic growth (Beck et al., 2007a). This means an inclusive financial system can be achieved by increasing access as well as usage to financial services. Thus, the increasing financial inclusion is an essential component in social inclusion and economic inclusion that plays a role in promoting economic growth, creating financial system stability, supporting poverty reduction programs, and reducing gaps between individuals and regions.

An inclusive financial system has several merits. It facilitates the efficient allocation of productive resources and can potentially reduce the cost of capital. Besides, access to appropriate financial services can significantly improve the day-to-day management of finances. It helps reduce the growth of informal credit sources, e.g., money lenders, which are often to be exploitative (Sarma and Pais, 2008). Massey (2010) concludes that financial institutions in a developing country are vital in promoting financial inclusion.

As emerging and developing countries reveal potential development benefits from financial inclusion, governments implement many of their public policies through the use of account ownership as a vehicle to deliver their programs, such as digitizing cash transfers in government assistant program to poor people among others. Hence, there are two broad categories of opportunities for expanding financial inclusion. First, expanding account ownership among the unbanked; secondly, increasing the use of accounts among those who already have one.

Using the Word Bank Findex data, account ownerships in some emerging and developing countries have increased significantly, but stagnated in others. For example, the Findex for India and Indonesia in 2011, 2014, and 2017 are 35, 53, 80% and 20, 36, 49%, respectively. Meanwhile, the Findex for Pakistan and Philippines are 12, 13, 21% and 26, 31, 34% for the

same respective years. Based on Patwardhan et al. (2018), the common limitations and frictions in expanding financial inclusion are as follow:

1. Access, where the availability of financial services can be limited by basic problems in access. For example, services are only distributed through branches that are not available in rural areas.
2. Product market fit, where existing and available financial products do not address the need of the large segments of consumer demography.
3. Affordability, where prices need to be affordable; hence, the cost to the providers must be sufficiently low so that services can be offered at a profit despite limited revenues.

2.3 Banking ICT for Financial Inclusion

The advancement in ICT has revolutionized the business of commercial banks, particularly in delivering financial products and services. Technology has allowed banks to provide existing customers with easy access to financial services while expanding product supplies and banking services to the unbanked population. Technology can help overcome barriers that prevent them from accessing financial services. Demirgüç-Kunt et al. (2018) concludes that a well-developed payments system, good physical infrastructure, appropriate regulations, and vigorous consumer protection safeguards are required to ensure benefits from the digital financial services.

Koivo (2002) states that appropriate banking environment must be considered as a key pillar and enabler for financial inclusivity. Internet and mobile banking have made possible for financial institutions to provide online banking products and services for their customers through mobile phone. Garg and Pandey (2006) views an increase in the adoption of ATMs, EFT, smart cards, electronic home, office banking and telephone banking. He concludes that the adoption of ICT improves bank's image that can lead to broader, faster, and more efficient market. Jenkins (2008) shows that reduced transaction costs from highly innovated ICT can enhance trade, which provides opportunities for emerging and developing countries to tap into global markets and remittances that can increase their financial inclusion landscape.

Kendall et al. (2010) investigate the relationships between deposit, loan, and bank branch penetration with other variables. He finds significant associations for deposits and loan penetration with per capita income, physical and financial infrastructure, and macro-economic stability. However, he finds no significant relationship with policies that have financial

inclusion as a central goal. Oruo (2013) finds that economic growth is strongly correlated with financial inclusion, especially through bank branch networks, mobile money accounts, and customers as users. Mushtaq and Bruneau (2019) illustrate a positive association of ICT diffusion with financial inclusion, but a negative one with poverty and inequality. The result of the study also indicates poverty-reducing effects of the financial inclusion.

Andrianaivo and Kpodar (2012) confirm that mobile phone development contributes significantly to the economic growth of the African countries. Part of the positive effect of mobile phone penetration on growth comes from greater financial inclusion. Musango (2015) finds that mobile money transfer services have a positive impact on financial inclusion in Kenya. The study further finds that mobile banking services have contributed significantly to the deepening of financial markets, mostly from financial products related to mobile money. Mobile banking services have also been found to have contributed significantly to financial access in Kenya. As reported by the World Bank (2012), three-quarters of the world population have access to mobile phones, which have been widely accessed by the poor population in emerging and developing countries.

Besides mobile phones, there are many other electronic devices that banks can use to expand their services in reaching unbanked and underserved people, such as "EDC mini-ATM" and web site or internet banking. With electronic devices, banks – directly or through bank agents – are able to serve people in remote, isolated areas that have not been reached previously with existing physical branches. The utilization of ICT has enhanced the bank's ability to conduct financial transactions anytime and anywhere using computer or mobile device that can save both time and money by eliminating the need to visit a physical branch (Lenka and Barik, 2018).

Initiatives to accelerate financial inclusion in emerging and developing countries have increasingly relied on the use of technology, e.g., mobile banking, electronic payments, or financial technology start-ups (De Koker and Jentzsch, 2013). According to Mushtaq and Bruneau (2019), a growing literature in ICT and economic development has indicated the significance role of ICT in social and economic uplifting in the last decade. The study concludes that the ICT can accelerate economic growth and reduce poverty as well as inequality when used as instruments for financial inclusion.

The result of Beyene Fanta and Makina (2019) study shows the impact of ATM and internet technologies on the access and usage of financial services. The study concludes a

significant positive relationship between financial inclusion and technology. Andrianaivo and Kpodar (2012) utilizes only one dimension of financial inclusion, which is usage. They find that the combination of IT and mobile telephone have emerged as a viable solution for greater financial inclusion because they minimize the need to set up physical bank branches. Higher mobile phone penetration increases financial access, while better ICT infrastructure favors financial markets, economic growth, and poverty reduction (Alter, 2015).

Furthermore, in some countries banks are not the sole provider for financial transactions. Fintech companies have now played an increasing role in the financial sector. Digital finance terminology is used for financial inclusion instead of digital banking. Manyika et al. (2016) define digital finance as financial services delivered over digital infrastructure—including mobile phones and the internet—with low use of cash and traditional bank branches. Mobile phones, computers, or cards used over point-of-sale (POS) devices connect individuals and businesses to a digitized national payments infrastructure, enabling seamless transactions across all parties. Based on many reports on the implementation of financial inclusion program in various countries, the utilization of ICT favors financial inclusion through better access and higher usage of financial services, which can eventually drive economic growth and poverty reduction.

Asare and Sakoe (2015) examine the effects of electronic banking on the financial services in Ghana using qualitative research method. The study finds that the advent of electronic banking in the country has enhanced accessibility to a wide range of banking products. The delivery of banking services has been done more rapidly to cover a wide range of existing as well as new customers. The study also reveals that the availability of electronic banking facilities – the ATM, online banking, and telephone banking – does not influence customers' bank choice decision significantly.

The McKinsey Global Institute study illustrates that financial inclusion can boost the output of emerging economies by $3.7 trillion in 2025 and cut the costs of financial services by 80 to 90 percent (Manyika et al., 2016). However, some constraints have remained and hampered the efforts of banks and fintech companies to utilize technologies as an enabler in their broad-based financial inclusion program. Digital finance needs to be supported by a sustainable business environment that includes banks, other financial institutions, telecom companies, fintech start-ups, and other businesses such as retailers. Better collaboration between government, telecommunication providers, and institutions in the financial sector will

likely improve digital/mobile banking (Ozili, 2018). Digital finance can be enhanced through promoting policies that increases the use of ICT in providing various financial products and services in emerging and developing countries.

3. Variables, Data, and Methodology

3.1 Dependent Variables

Sarma and Pais (2008) refers financial inclusion to a process that ensures the ease of access, availability, and usage of the formal financial system for the whole population within the economy. The World Bank Global Financial Index in 2014 confirms three main types of indicators for measuring financial inclusion. The first indicator is access, which reflects the depth of outreach of financial services, e.g., the penetration of bank branches, point of sale (POS) devices in rural areas, and demand-side barriers that customers face to access financial institutions such as cost or information. The second indicator is usage, which measures how clients use financial services, such as the regularity and duration of the financial product and services over time. The third indicator is quality, which describes whether financial products and services match the need of the customers, such as the range of options available to customers and their awareness and understanding of the financial products (Demirgüç-Kunt et al., 2015). Similarly, the Consultative Group to Assist the Poor (CGAP) defines the three measurements of financial inclusion through access, usage, and quality. Accessibility to financial services can be measured by the percentage of adults with an account at a formal financial institution. Thus, the usage for financial services can be measured by the percentage of adults who have used mobile phone to make a payment. Finally, the quality of financial services can be measured by the average monthly cost to have a basic bank account, based on the official minimum wage.

Following Beyene et al. (2019), this paper measures financial inclusion with two indicators, that is, access and usage. Both indicators will serve as the dependent variables in our estimation model. Access will be measured by the number of bank deposit accounts, while usage will be measured by the ratio of deposits to the country's output (GDP) since electronic fund transfers (EFT) data is very limited in many emerging and developing countries.

3.2 Independent Variables

3.2.1 Socio-economic Variables

Social welfare determines the way people behave and make decisions on financial markets (Robert et al., 2014). The socio-demographic characteristics of the less developed countries' population is more likely to avoid using financial services and prefer old-fashioned cash, or even barter. The number of people with bank account will be small (Kabakova and Plaksenkov, 2018).

Furthermore, many studies have shown empirical evidences of significant causal relationships between financial development and economic growth. Social welfare influences the depth of usage of financial services, which can affect the demand side of financial inclusion and hamper its development (Dev, 2006). Many financial inclusion reports find that financial products and services that can put people at ease in making payment of their transactions can eventually boost economic growth. As a result, growth can stimulate financial development, and vice versa (Beck and Levine, 2002). Empirical study done by Ardic et al. (2011) confirms that higher deposit and/or loan correlation is significantly associated with higher economic and financial development as measured by GDP per capita, the amount of electricity use, the availability of explicit deposit insurance, and better credit environment. Oruo (2013) has investigated the relationship between financial inclusion and economic growth in Kenya and finds that growth has a strong positive association with the financial inclusion, especially through the bank branch networks, mobile money accounts, and bank customers as users.

Furthermore, Chithra and Selvam (2013) have identified the determinants of financial inclusion and find that socio-economic factors such as income, literacy, and population have significant associations with the level of financial inclusion. Kelly and Rhyne (2013) state that higher-income population can cause people to demand and utilize financial services. Hence, GDP per capita can drive financial inclusion (Evans and Alenoghena, 2017). Meanwhile, Iqbal and Sami (2017) find that factors such as population density (i.e., the number of individuals per unit of geographic area), rural and remote areas, and mobility of the population (i.e., highly mobile people with no fixed or formal address) can affect financial access services.

At the aggregate level, the index of financial inclusion and the human development index (HDI) are positively associated, as found by Gupta et al. (2014). The HDI summarizes the measurement of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable, and have a decent standard of living (Morse and Morse,

2019). World Bank (2018) states that population density and per capita income are two key factors that are systematically correlated with financial inclusion.

Following previous findings in literature, this study will first focus on the socio-economic impact population density, the country's aggregate output, and Human Development Index on financial inclusion across emerging and developing countries (Ali Said and Rihab Grassa, 2013; Beyene et. al., 2019; Kendall et. al., 2010; Musango, 2015; Mushtaq and Bruneau, 2019; Ozili, 2018; Sarma and Pais, 2008). Our first hypothesis in this study is that socio-economic variables have a positive impact on financial inclusion.

3.2.2 Banking ICT Variables

ATMs and mobile phone transactions have been in existence for some time to facilitate electronic banking. Nevertheless, electronic banking has been transformed by the internet— a new delivery channel that has facilitated banking transactions for both banks and their customers. E-banking implies the provision of banking products and services through electronic delivery channels (Nitsure, 2003). In this study, instead of classifying ATM as the independent variable that proxies banking information technology, it has frequently been treated as an independent variable to represent banks' network. This treatment controls and maintains the availability and readiness of the ATMs to be used by customers at banks' discretion, but not in customers' choice.

Furthermore, existing and potential customers can use mobile phone if relevant application to open bank account with mobile phone is made available. The use of the mobile application is relatively easy for targeted people. The wider prevalence of mobile phones in some emerging and developing countries can explain that people in those countries have no access to alternative communication modes such as the internet and fixed-line telephones. Hence, using mobile phones and the internet to provide financial services have become a new way to offer unbanked people more opportunities to participate in the formal financial system. Jenkins (2008) shows that reduced transaction costs from highly innovated ICT favor trade because it can give emerging and developing countries the opportunities to tap into global markets and remittances, as well as increase the country's financial inclusion landscape. Many empirical studies indicate that if efficient way of transactions continues, increasing access and usage to finance will help poverty reduction and economic growth. This study will focus on ICT diffusion as measured by mobile cellular subscriptions, internet users, and fixed telephone line subscriptions (Andrianaivo and Kpodar, 2012; Beyene Fanta and Makina, 2019; Sarma

and Pais, 2008; Sassi and Goaied, 2013). Our second hypothesis in this study is that ICT has a positive impact on financial inclusion.

3.2.3 Bank Network Variables

While new technologies in principle are available globally, their adoption and use for financial inclusion may have been uneven across countries. There has also been significant variation in whether technologies have been pioneered by the traditional financial sector or other players. Financial access can surely improve the financial condition and living standards of the poor and the deprived section. Hence, the banking sector has continued to extend its network by setting up new branches and installing new ATMs (Dangi and Kumar, 2013).

In a cross country study, World Bank (2018) finds that financial inclusion that is measured in terms of access to bank accounts is an increasing function of the country's per capita income. Economies of scale has largely explained the findings in countries such as Bangladesh, India, and Indonesia. High population densities have also been an enabling condition for financial inclusion through traditional bank branches despite low per capita income levels. Nkuna et al. (2018) finds some suggestive evidence that transaction costs and distance barriers limit the usage of banking accounts in Malawi. Meanwhile, in exploiting reasons for dormancy in a no-frills account, distance is a major barrier for financial inclusion in which respondents are more willing to pay for convenient banking services closer to their homes in Tamil Nadu (Alphina et al., 2011). Hence, in developing countries people still feel more convenient to go to a bank's channel that can reveal the bank's identity in a real form to facilitate their financial transactions.

The measurement of financial inclusion worldwide has focused on density indicators, such as the number of bank branches, or ATMs per capita (Beck et al., 2007). In addition, the Global Partnership for Financial Inclusion (GPFI) has a basic set of financial inclusion indicators to assist countries in setting up the financial inclusion targets and monitoring progress (World Bank, 2015). For example, bank branches can measure geographical access to formal financial providers, such as the average number of people having access to financial services as counted from each bank's physical outlet. This gives reason to why ATMs and bank branches are among the factors surveyed periodically by the IMF Financial Access Survey (FAS). Two FAS indicators – the number of commercial bank branches per 100,000 adults and the number of ATMs per 100,000 adults – have been adopted to monitor Target 8.10 of the United Nations Sustainable Development Goals (SDG) for 2030. The SDG Target 8.10

strengthens the capacity of domestic financial institutions to encourage and expand access to banking, insurance, and financial services for all. In specifics, the indicators 8.10.1 are comprised of the number of commercial bank branches per 100,000 adults and number of ATMs per 100,000 adults. Hence, bank's network is measured through the number of bank branches and ATMs (Beyene Fanta and Makina, 2019; Demirgüç-Kunt et al., 2015; Demirgüç-Kunt et al., 2018; Nkuna et al., 2018). Our third hypothesis in this study is that bank's network variables have a positive impact on financial inclusion.

4. Data and Methodology

The sample data in this study is comprised of 35 emerging and developing countries from the S&P Dow Jones Index and the IMF World Economic Outlook as shown in table 1. The countries are Argentina, Bangladesh, Brazil, Brunei Darussalam, Chile, China, Colombia, Czech Rep, Egypt, Greece, Haiti, Hungary, India, Indonesia, Kenya, Malaysia, Mexico, Morocco, Mozambique, Myanmar, Nigeria, Pakistan, Peru, Philippines, Poland, Qatar, Rwanda, Saudi Arabia, South Africa, Thailand, Turkey, Uganda, Ukraine, United Arab Emirates, and Vietnam. Two panel data are constructed to determine the effects of ICT and macro-socioeconomic development on financial inclusion through two indicators, i.e., financial access and financial usage. The first indicator uses bank account as a measurement for access, while the latter uses financial deposits-to-GDP ratio as a measurement for usage. A complete list of the variables and their respective definitions and data sources is shown in table 2. A summary of the linkage between all of variables is summarized in figure 1.

We conduct our analysis using annual data from 2009 to 2018 in the first model to estimate the effects of ICT as well as macroeconomic and socioeconomic conditions on financial access. To analyze the effects on financial usage in our second model, we use the observation data from 2009 to 2017.

Following Beyene Fanta and Makina (2019) with some modifications of the variables, our study employs two panel data models to assess the impact of ICT on financial inclusion. We eliminate secondary school enrolment and inflation in the model, but add new independent variables consisting of the gross domestic product and human development index to further analyze the impact of macroeconomic and socioeconomic conditions. The specification of the two panel data models used in this study is as follows:

Model 1 for Financial Access:

$$LnBankACC_{i,t} = \alpha_0 + \beta_1 \text{LnBankACC}_{i,t-1} + \beta_2 TELE_{i,t} + \beta_3 MOB_{i,t} + \beta_4 INT_{i,t} + \beta_5 DENS_{i,t} + \beta_6 ATM_{i,t} + \beta_7 LnGDP_{i,t} + \beta_8 HDI_{i,t} + \varepsilon_{i,t}$$

Model 2 for Financial Usage:

$$DEPtoGDP_{i,t} = \alpha_0 + \beta_1 DEPtoGDP_{i,t-1} + \beta_2 TELE_{i,t} + \beta_3 MOB_{i,t} + \beta_4 INT_{i,t} + \beta_5 DENS_{i,t} + \beta_6 ATM_{i,t} + \beta_7 LnGDP_{i,t} + \beta_8 HDI_{i,t} + \beta_9 BBRANCHES_{i,t} + \varepsilon_{i,t}$$

where LnBankACC denotes the number of bank deposit accounts per 1.000 adults, and DEPtoGDP is the ratio of the number of financial deposits (i.e., demand, time, and saving deposits) with respect to the gross domestic product of the respective country i at year t. For independent variables, TELE denotes the number of fixed-telephone lines per 100 people, MOB is the rate of mobile cellular subscription per 100 people, INT is the number of internet users as a percentage of the population, DENS is the number of people per square kilometer of land area, ATM is the number of ATMs per 100.000 people, BBRANCHES is the number of bank branches per 100,000 adults, LnGDP denotes the annual growth rate of the gross domestic product, and HDI represents the human development index of the respective country. Note that BBRANCHES variable is not used in model 1 since the number of bank branches can be used as an indicator to measure financial access and bank account (World Bank, 2015).

The two panel data models use the two-step system generalized method of moments (GMM) approach. According to Arellano and Bond (1991) and Blundell and Bond (1998), dynamic panel GMM is better than conventional estimators (i.e., multiple regression estimator) due to its ability to correct potential endogeneity, heteroscedasticity, and autocorrelation problem in a panel data. The model is appropriate to analyze the problem in this study since the relationship between the variables used in the model is dynamic. Hall (2007) states that by minimizing the criterion function through a weighted matrix, GMM is the right methodology used in a study when the time dimension is characterized by the use of time-series data and cross-sectional data.

Furthermore, efficiency is one of the most critical problem in econometrics. Hence, in a GMM framework, the standard practice is to employ two-step procedure to improve the GMM estimator's efficiency and the associated tests' power (Hwang and Sun, 2018). Based on finite-sample correction to the reported standard of errors in two-step estimation, the two-step system GMM introduces adequate control over the instrument matrix (Windmeijer, 2005). It offers

automatic difference in Sargan/Hansen testing for the validity of the instrument subsets and supports for observation weights and the forward orthogonal deviations transform, which is an alternative to differencing proposed by Arellano and Bover (1995) that preserves sample size in panels with gap. To overcome the estimator's potential downward bias, our study use the two-step robust standard error system GMM by Windmeijer (2005).

5. Results

Table 3 shows the descriptive statistics of the data. We note the relatively high standard deviation for density (DENS) due to the broad sample of 35 emerging and developing countries that show large variations in their geographical size and population base. Bhattacharyay (2012) states that countries with different characteristics generate very high data distribution. Table 4 and table 5 exhibit the correlations of the variables in the model, none of which exceed |0.9| as a rule of thumb to detect problem of multi-collinearity following Gujarati (2009). Meanwhile, the results of the two-step system GMM estimation for both financial access and financial usage are presented in table 6 and summarized in table 7, in which all variables show robust standards of error.

The estimation results indicate that fixed-line telephone has no significant impact on financial access across countries, but has a negative effect on financial usage. These results are in line with Beyene Fanta and Makina (2019), in which higher penetration for fixed-line telephone over mobile telephone in emerging and developing countries tend to have lower use of financial products and services and, therefore, less financial inclusion. It follows that population with higher mobile telephone penetration can conduct more frequent financial transactions from various locations at their own convenient time. The results indicate that mobile telephone penetration has a strong positive relationship on both financial access and financial usage. Higher penetration of mobile telephone corresponds to higher bank account ownership and usage of financial services. Hence, the shift of monetary transactions in society from cash payments to cashless through the banking services represents an enormous opportunity for emerging and developing countries to increase the use of online bank accounts and payments for their customers. The use of ICT such as mobile telephones, or point-of-sale terminals can increase payments' efficiency on both sides (Demirgüç-Kunt et al., 2015).

Internet use penetration has a positive impact on financial access, indicating that higher internet user activities can increase bank’s outreach to the unbanked population so they are able

to open bank accounts without visiting the physical branch of the bank. However, the internet user penetration shows a negative effect on financial usage. Using financial deposits-to-GDP ratio as a measurement for usage, it is reasonable that higher internet user penetration will lead to higher internet activities and financial transactions from existing bank customers which, subsequently, can result in higher aggregate economic output. Sabater and Garrity (2011) have illustrated in the Global Information Technology Report that as more citizens in emerging economies go online and connectivity levels become closer to the advanced economies' standard, the global share of the internet activities and transactions will gradually shift towards emerging and developing economies.

Furthermore, the number of ATM in a bank network indicate positive effect on a country's financial access. This implies that a well-functioning ATM network has the ability to increase financial inclusion by encouraging unbanked population to open up a bank account and obtain access of the bank's financial products and services through the ATMs located near home or workplaces. On the other hand, the number of physical branches of the bank has failed to affect the financial inclusion in the banking industry. The result indicates that the presence of bank branches may no longer be the main channel for customers to do their transactions in the digitalization era.

In terms of population size, the result of the study shows a positive impact on financial access, in which higher population density in the emerging and developing countries corresponds to higher bank account ownership. From macroeconomic front, the country's aggregate output indicates positive effect on financial access, implying that higher GDP corresponds to higher number of bank accounts. This result confirms the IMF study that a 1 percent increase in Findex can increase the country's GDP per capita by 0.14% (Loukoianova et al., 2018). In addition, Demirguc-Kunt et al. (2015) illustrate some factors that can influence consumer's choice to own savings account, which depend on individual and country characteristics across 123 countries. They conclude that higher level of income and education is positively associated with greater financial inclusion.

Finally, HDI as a measure for the country's welfare and development shows a strong positive impact on financial access as well as financial usage. The higher the HDI level, the greater the opportunity to increase financial inclusion and, therefore, the better access to educational and health opportunities that can make people aware for availing the benefits of financial extension facilities (Datta and Singh, 2019).

6. Conclusions

This study examines the impact of ICT on financial inclusion in the banking industry across emerging and developing countries. Although the direct linkage between banking technology and financial inclusion is somewhat hard to determine, this study is able to identify significant associations between technological and socio-economic variables with financial access and financial usage. The findings highlight some conclusions for emerging and developing countries to accelerate financial inclusion through the use of ICT in the banking industry.

First, we conclude that it is imperative for emerging and developing countries to build an economy-wide ecosystem that can accelerate technology adoption, particularly in mobile technologies, in order to enhance financial inclusion. Mobile phone penetration in particular can increase both financial access and financial usage in the banking industry. This result implies the need for a more progressive banking policy to facilitate banking products and services to be delivered through mobile app channel. As higher proportion of the population use mobile devices and improvement in digital connectivity continues, the ICT development in the banking industry will provide an enormous opportunity for emerging and developing countries to accelerate their financial inclusion.

Furthermore, access to banking should be extended to the unbanked population in rural areas. A more suitable products and services can be designed to allow better fit to the lower segment of the population. Banks can accelerate their outreach by expanding their digital channels as well as the banking ATM network to facilitate their marketing of the products and services. For instance, the presence of ATMs in rural areas will instill trust and confidence among the unbanked people to start using the bank's products and services. Although internet penetration may not contribute to the increase of financial deposits significantly, the digital connectivity will play an important role for emerging and developing countries in facilitating branchless banking in their rural areas.

From socioeconomic front, better quality of life can improve financial inclusion in emerging and developing countries. Hence, the government in emerging and developing countries should formulate public policies that can improve social welfare, health, and education to achieve higher standards of living and, consequently, better inclusivity of the financial system.

Improvement in the society's awareness about banking ICT is also equally an important task for the financial sector in the emerging and developing countries. In order to use technology as an enabler, emerging and developing countries need to implement policies that can enhance the ICT infrastructure. Banks must be able to provide secure and sustainable technology for their existing as well as new customers. Hence, deeper collaboration between financial institutions, telecommunication providers, and the government is needed to improve digital banking services.

Lastly, since this study only focuses on the supply side of financial inclusion, additional analysis is needed to cover the demand side, i.e., the quality of financial products and services, to measure whether they match existing as well as potential customers' needs. Further exploration can be conducted to explore the demand side associated with the customers' use of technology, such as the consumers' readiness, products fitness, and pricing, particularly for the unbanked population.

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Appendix

Table 1. Emerging Countries

No.	Country	Financial Inclusion Index*	Emerging markets**	Emerging market and developing economies***
1.	Argentina	49 %	O	V
2.	Bangladesh	50 %	-	V
3.	Brazil	70 %	V X O	V
4.	Brunei Darussalam	-	-	V
5.	Czech Rep.	-	X O	-
6.	Chile	74 %	V X O	V
7.	China	80 %	V X O	V
8.	Colombia	46 %	V X O	V
9.	Egypt	33 %	V X O	V
10.	Greece	85%	X O	-
11.	Haiti	33%	-	V
12.	Hungary	75 %	V X	V
13.	India	80 %	V X O	V
14.	Indonesia	49 %	V X O	V
15.	Kenya	82 %	-	V
16.	Malaysia	85 %	V X	V
17.	Mexico	37 %	V X O	V
18.	Morocco	29%	O	V
19.	Mozambique	42%	-	V
20.	Myanmar	26 %	-	V
21.	Nigeria	40 %	O	V
22.	Pakistan	21 %	V X	-
23.	Peru	43 %	V X O	V
24.	Philippines	34 %	V X O	V
25.	Poland	87%	X O	V
26.	Qatar	-	X O	V
27.	Rwanda	50 %	-	V
28.	Saudi Arabia	72%	-	V
29.	South Africa	69 %	V X O	V
30.	Thailand	82 %	V X O	V
31.	Turkey	69%	X O	V
32.	Uganda	59%	-	V
33.	Ukraine	63 %	-	V
34.	United Arab Emirates	88%	X O	V
35.	Vietnam	31 %	-	V

Note:

*Based on World Bank Survey, 2017.

**V: based on Global S&P Dow Jones Index; S&P Emerging BMI Equity; Fact sheet as of October 30, 2020.

X: based on Morgan Stanley Capital International Emerging Market Index.

O: based on Emerging Market Economies Economic Outlook 2019, Focus-Economics.com.

*Based on World Economic Outlook: Global Manufacturing, Downturn, Rising Trade Barriers, Table A.4. Emerging Market and Developing Economies: Real GDP, IMF, October 2019.

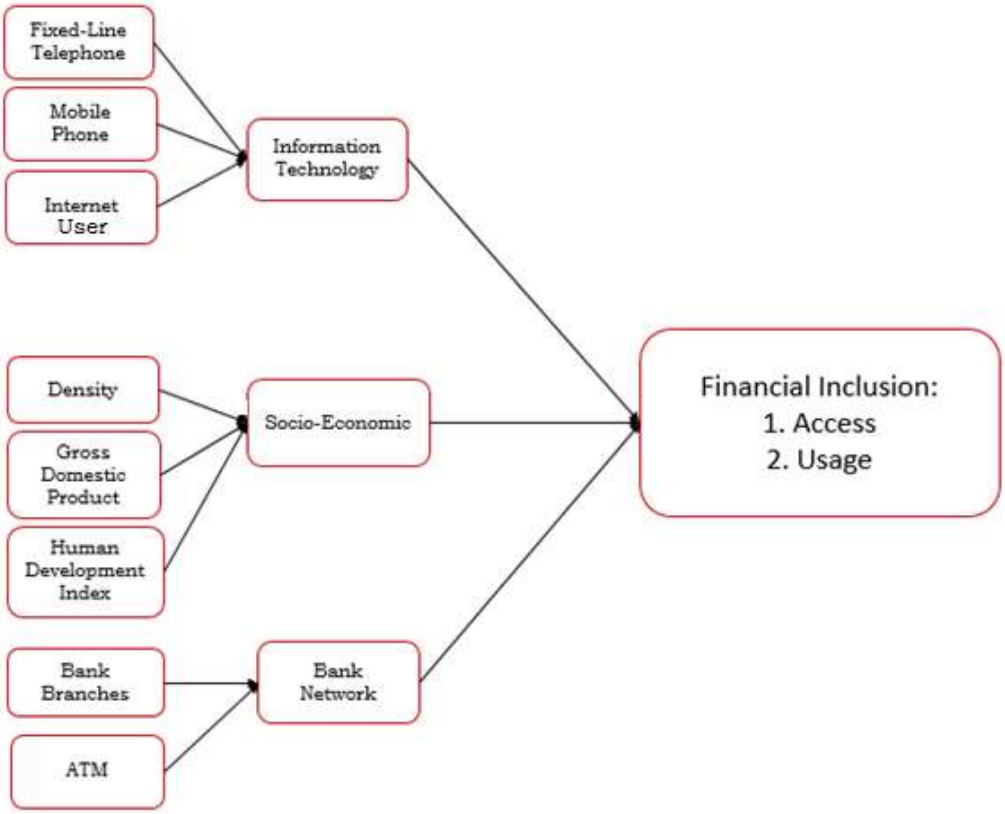


Figure 1. Variables Linkage

Table 2. Variable Definition

Variable	Notation	Definition	Source
Bank Account	LnBankACC	Number of deposit accounts with commercial banks per 1.000 adults in natural logarithmic	International Monetary Fund
Financial system deposits to GDP	DEPtoGDP	Demand, time, and saving deposits in banks and other deposit taking financial institutions as a share of gross domestic product	World Bank
Fixed-line Subscription	TELE	Fixed-telephone lines per 100 people	International Monetary Fund
Mobile Subscription	MOB	Mobile cellular subscription per 100 people	International Monetary Fund
Internet	INT	Individuals using the internet in percentage of population	World Bank
Density	DENS	Population density, number of people per square kilometer of land area	World Bank
ATM	ATM	Automated teller machines (ATM) per 100.000 adults	World Bank
Bank Branches	BBRANCHES	Commercial bank branches per 100.000 adults	World Bank
Gross domestic product	LnGDP	Gross domestic product in natural logarithmic	World Bank
Human Development Index	HDI	An index that summarizes the measure of average achievement in key dimensions of human development	UNDP

Table 3. Descriptive Statistics

Variable	Observation	Mean	Std. Dev.	Min	Max
LnBankACC	341	6.728569	1.028106	2.773205	9.17871
DEPtoGDP	315	49.17168	27.52856	7.260910	128.8390
TELE	347	12.59289	11.00197	0 .0525094	54.75146
MOB	349	105.1718	37.52420	0.9990076	212.6390
INT	346	43.13296	25.23514	0.22000	99.65285
DENS	350	167.0859	208.5757	12.38797	1239.579
ATM	342	43.27658	31.57890	0.0906179	122.7815
BBRANCHES	347	11.93158	7.893641	0.4337687	42.28505
LnGDP	350	26.09403	1.529104	22.4627	30.26254
HDI	350	0 .6961257	0.1384493	0.1384493	0.89100

4. Correlation Matrix for Model 1 – Access

Variables	LnBankACC	TELE	MOB	INT	DENS	ATM	LnGDP	HDI
LnBankACC	1.0000							
TELE	0.4622	1.0000						
MOB	0.5237	0.4881	1.0000					
INT	0.4518	0.6261	0.7350	1.0000				
DENS	-0.1770	-0.3847	-0.2983	-0.3594	1.0000			
ATM	0.5117	0.5913	0.6318	0.5995	-0.4053	1.0000		
LnGDP	0.0580	0.2846	0.3265	0.2344	-0.1114	0.3708	1.0000	
HDI	0.5383	0.7676	0.7459	0.8251	-0.3323	0.7035	0.3775	1.0000

5. Correlation Matrix for Model 2 – Usage

Variables	DEPtoGDP	TELE	MOB	INT	DENS	ATM	BBRANCHES	LnGDP	HDI
DEPtoGDP	1.0000								
TELE	0.2644	1.0000							
MOB	0.4171	0.5213	1.0000						
INT	0.3467	0.6324	0.7420	1.0000					
DENS	-0.0865	-0.3836	-0.3190	-0.3719	1.0000				
ATM	0.3925	0.6027	0.6274	0.5971	-0.415	1.0000			
BBRANCHES	0.4220	0.6394	0.3601	0.5133	-0.2047	0.4506	1.0000		
LnGDP	0.2067	0.2833	0.3611	0.2589	-0.1217	0.4057	0.2795	1.0000	
HDI	0.3914	0.7682	0.7572	0.8239	-0.3356	0.6887	0.5997	0.3810	1.0000

Table 6. Estimation Results from the Two-Step System GMM.

Variable	LnBankACC	DEPtoGDP
TELE	-0.0009838	-0.47439***
	(-0.000598)	(0.062195)
MOB	0.0004527***	0.142197***
	(-0.0001447)	(0.00931)
INT	0.0059014***	-0.18655***
	(-0.0002175)	(0.023558)
DENS	0.0003001**	-0.02077
	(-0.0001579)	(0.015093)
ATM	0.0045079***	-0.01942
	(-0.0006204)	(0.033619)
BBRANCHES		-0.09565
		(0.083353)
LnGDP	0.0385637***	-0.55738
	(-0.0092388)	(0.619085)
HDI	3.105002***	42.99833***
	(-0.2418799)	(10.15268)
Constant	2.9564***	-5.850205
	(-0.1929112)	(11.18829)
Prob(F-statistic)	0.000000	0.000000

Note: (***), (**), and (*) represent significance at 1%, 5% and 10%, respectively.

Table 7. Summary of the Estimation Results.

Variable	LnBankACC	DEPtoGDP
TELE	Not Significant	(-)
MOB	(+)	(+)
INT	(+)	(-)
DENS	(+)	Not Significant
ATM	(+)	Not Significant
BBRANCHES		Not Significant
LnGDP	(+)	Not Significant
HDI	(+)	(+)