DEVELOPMENT IN THE DIGITAL AGE:

Understanding technology adoption, welfare effect and institutional implication

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RONG CHEN

ST ANTONY'S COLLEGE

OXFORD DEPARTMENT OF INTERNATIONAL DEVELOPMENT

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Contents

Abstract

This thesis consists of three self-contained but connected papers, around the topic of digital development, from aspects of technology adoption, welfare effect and institutional implication. Utilizing household surveys that collect information about internet access and usage at household and individual levels in more than 20 countries, chapter 1 identifies a positive relationship between mobile internet adoption and social network in developing countries, offering insights on potential endeavors to reduce digital divide. Leveraging the same survey, chapter 2 examines the relationship between gig economy participation and women economic empowerment. It is found that as a newly emerged digital economic activity, gig work is equally accessible to both men and women. Engaging in gig work is associated with women economic empowerment, as reflected in higher disposable income and more contribution to household expenditure. Chapter 3 analyzes whether and what types of mobile banking regulation promote financial inclusion. A regulatory index that measures the regulatory environment for mobile banking activities in more than 80 countries, as well as individual level financial inclusion data from the World Bank Findex survey are used. Findings show that individuals are more likely to have an active financial transaction account in countries that adhere to a higher number of mobile banking regulatory practices. Certain regulatory provisions such as allowing agents to conduct a wide range of financial services, and non-exclusivity of contracts between agents and financial institutions are the driving factors. The papers contribute to the literature by providing new empirical evidence about opportunities for developing countries to reap dividends from digitalization, testing different theories such as social network vs. status structure view, public choice vs. public interest theory in the context of digital economic

activities, and in the meantime bringing forth policy discussions on how governments in developing countries can leverage digital technology advances to achieve development.

Introduction

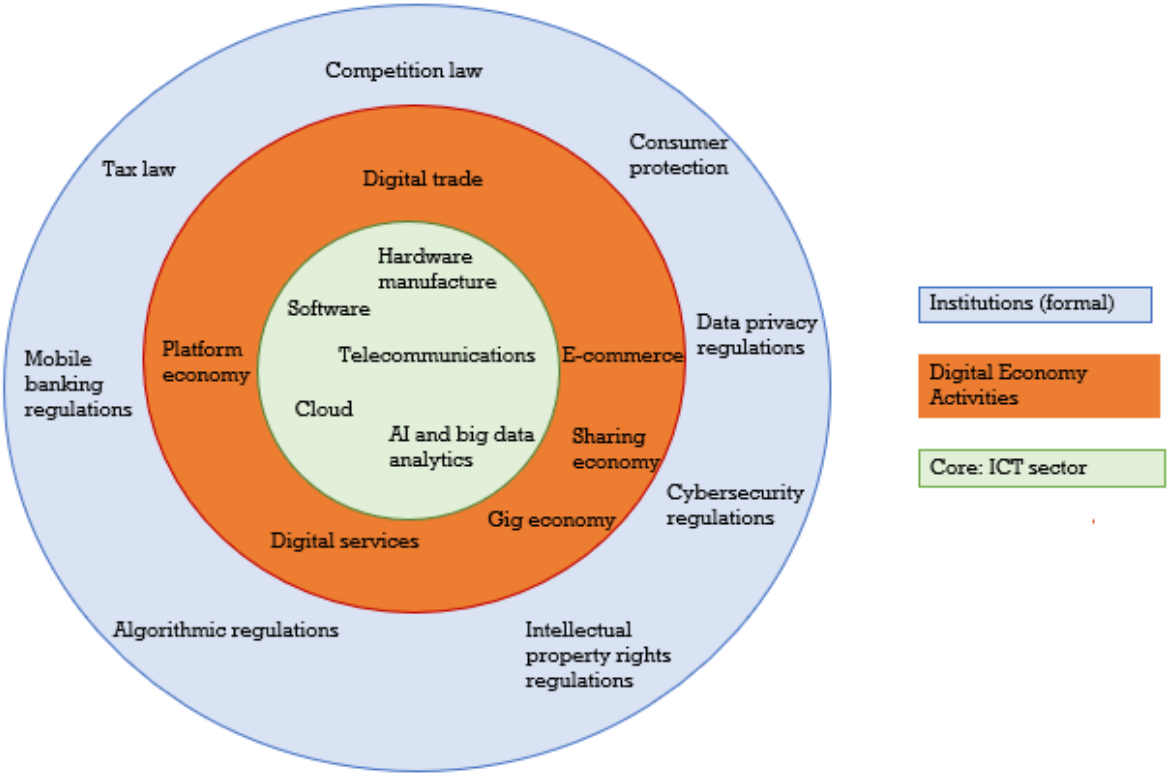
Since Don Tapscott coined the term "digital economy" in his best seller "The Digital Economy: Promise and Peril in the Age of Networked Intelligence" in 1996, there have been rising interests in academia and the development world in the potential economic impacts and policy implications of the new wave of digital technologies. Evolving with the changing landscape of market activities, the digital economy is now recognized as "the part of economic output derived solely or primarily from digital technologies with a business model based on digital goods or services" (Bukht and Heeks, 2017).

The booming digital economy has transformed the ways people interact, business conduct commercial transactions and governments deliver public services. International internet bandwidth nearly tripled between 2015 and 2019, to 466 terabytes per second.[1] The share of the global population using the internet increased from 8.0 percent in 2001 to 66.0 percent in 2022.[2] Internet users on average spend about two and half hours on social media every day globally.[3] A variety of new business models and applications are emerging such as e-commerce, mobile payment, ride hailing, online gig work etc. E-government becomes prevalent across the globe, with 177 countries enabling citizens to register a business online.[4] Digital technologies also play an indispensable role in sustaining social and economic activities during the COVID-19 crisis. Digital platforms for remote learning and remote healthcare allow continuity of undertakings that are often done offline. Governments like Korea, Singapore and China use digital technology enabled contact tracing to identify people who have contagion risks to control outbreaks.

[1] ITU statistics.
[2] World Development Indicators.
[3] Statista.
[4] Statista. United Nations 2022 survey.

Smooth and sustainable functioning of the digital economy relies on a few factors, including development, adoption and usage of digital technologies and the associated innovation ecosystem for continuous technology advances, prevalence of digital applications across social and economic life, as well as enabling regulatory environment that takes into account of unique market failures associated with digital economy (figure 0.1).

Figure 0.1. Factors contributing to a smooth digital economy



Source: adapted from Bukht and Heeks, 2017.
Note: The list of digital technologies, activities, and institutions is not exhaustive. These are shown as examples.

First, the engine of digital economy development lies in the ICT (information and communications technology) sector, which refers to "a combination of manufacturing and services industries that capture, transmit and display data and information electronically" (OECD, 2002). Internet has been argued as a general-purpose technology (GPT) (Carlsson,

2004), like steam engine and electrification, that is expected to be pervasive across the society and have far reaching impacts on economic growth in the long term. Globally more than 95 percent of population are now covered by 3G network (ITU, 2020). A new generation of digital technologies including artificial intelligence— technical systems and their application that can think and act like human mind with capabilities such as problem solving and decision making (Russell and Norvig, 2010), cloud computing—on-demand access to digital infrastructure, applications and services (Mell and Grance, 2011), and big data analytics—techniques of processing large amounts of data to uncover hidden pattern and insights, are also propelling the development of digital economy.

Access and usage of digital technologies is the first step for people to reap the benefits of digital economy. However, there exists significant gap, between different demographic population subgroups, rural and urban areas, and developed and developing countries regarding access and usage of digital technologies. About half of the world's population is still offline. Only 0.48 out of 100 people in low-income countries have fixed broadband subscriptions, compared to the level of 36.9 out of 100 in high income countries. Women are 19 percent less likely than men to use mobile internet (GSMA, 2023a). Development of frontier digital technology like artificial intelligence is dominated by a few countries such as China and United States. Until 2021, China has filed 389,571 artificial intelligence technology related patents, accounting for almost three quarters of global total patents in the field of artificial intelligence (WIPO, 2021).

Second, digital economy is more than expansion and adoption of digital infrastructure and technologies, but emphasizes placing digital technologies at the center of the social and economic activities, driving innovation of business models and applications. There has

been a booming of digital economic activities with the emergence of new terms such as platform economy, sharing economy, gig economy etc. Unlike the traditional market economy whose business activities tend to be linear with inputs on one end and output delivered on the other end after going through a series of value addition steps (Alstyne et al., 2016), platform economy is known as two-sided or multi-sided markets, with emergence of platforms that match producers and consumers. Based on the type of value that's exchanged in a platform's core transaction, platform models can mainly be grouped into categories of service platform, asset sharing platform, product platform, social and media content platform, and payment platform (Parker et al., 2016). Telemedicine platforms such as VulaMobile, a South African service platform, provides remote diagnosing and teleconsulting services for individuals in rural areas. Hello Tractor, an asset and service sharing platform emerged in Nigeria, establishes a network of tractor owners, offering the equipment as well as services if needed to those who can't afford to buy one for farming activities. E-commerce platforms, such as Shoppe in Southeast Asia, Taobao.com in China, Flipkart in India as well as Jumia in Nigeria, well represent the product platform. User-generated content prevails social and media content platforms, from world known Facebook or Youtube, to other niche ones such as Afrigator, an Africa focused platform for photos or videos sharing, as well as the SkilledAfricans, Africa's version of LinkedIn. Mobile payment platforms, such as M-Pesa originated from Kenya allows those that do not have an account with commercial banks to send and receive money.

Digital economic activities show great potential in welfare promotion by providing job opportunities. Take "Taobao Village" in China as an example. Since 2009, many villagers start to sell consumer goods, agricultural products and handicraft works on Taobao.com—

one of the largest e-commerce platforms in China, and with high number of households getting engaged in e-commerce and high volume of e-commerce transaction, those villages are referred to as "Taobao Village".[5] Numerous Taobao Villages have created more than 20 million jobs over the past years, drawing more rural youth who migrated to cities for better opportunities back to hometowns to start up online microenterprises (AliResearch, 2019). Meanwhile, it becomes prevalent to adopt advanced technologies to improve business operation efficiency in Taobao Villages. Automatic sorting in warehouse, artificial intelligence in customer service as well as mining big data to develop marketing strategy are highlights of many such initiatives. In addition, more and more people especially youth are getting job opportunities through online gig platforms, such as Freelancer, Upwork and Fiverr. It is expected that online gig work now accounts for 4.4 to 12.5 percent of the global force, and more than half of the online gig workers are under the age of 30 (Datta et al., 2023).

Digital economic activities exhibit features that are distinct from those of traditional economic activities. Tremendous amount of data are accumulated through digital economic activities, which can either be utilized to improve business efficiency or develop other related businesses, playing a self-reinforcing role (Chen, 2019). For instance, BigHaat, one of India's largest agricultural inputs marketplace platforms, offers personalized advisory services to farmers based on their transaction data. Jinri Toutiao, whose name means "today's headlines" in Chinese, provides customized news content to clients based on

[5] The cluster of rural e-tailers is referred as a "Taobao Village" where 1) those e-tailers operate businesses within an administrative village; 2) annual village e-commerce transaction volume exceeds 10 million yuan (around $US1.6million); and 3) at least 10% of village households actively engage in e-commerce or there are 100 or more active online-shops, primarily with the use of Taobao.com Marketplace.

clients' historic web-browsing behavior or other social media data reflecting their reading preferences. More and more e-commerce platforms are providing microcredit services utilizing customers' transaction data on the e-commerce platforms to assess customers' creditworthiness. JD Baitiao, a customer loan product offered by JD.com, one of the biggest Chinese e-commerce platforms, is a case in point on how new business product can be developed by leveraging existing data such as e-commerce transaction data. Digital marketplace also tends to show high market concentration in a short period of time, due to low entry barrier comparing with traditional production activities that require high costs of physical investment upfront, as well as positive network effects—value of a platform established by a business increases with growing number of participants from either side, be it a consumer or a producer/supplier (Parker and Van Alstyne, 2005; Rochet and Tirole, 2003; Weyl, 2010). For instance, Grab, a ride-hailing company established in Singapore in 2012, became the market leader in Southeast Asia in less than five years, and had about 2.8 million active drivers in 2019. Pinduoduo, now the third largest e-commerce platform in China, reached an annual GMV (gross merchandise volume) of RMB100 billion ($14.7 billion) within two years since its establishment in 2015. Moreover, digital economic activities require a high level of trust and associated consumer protection given the lack of physical interactions among counterparts (Paliszkiewicz and Chen, 2021; Ryan, 2019). There are new mechanisms that try to build two-side trust (e.g., brand certification and third-party validations) to remove informational asymmetries (Sundararajan, 2016). In Honduras, VoaComer develops a platform for users to search for restaurants based on public and/or friend recommendations, and rate their own experiences. which improves the culinary experience of visitors and locals.

Third, new characteristics of digital economic activities bring new challenges and call for adaptive policies and regulations to create an enabling environment for sustainable development of the digital economy. Given the essential role of data in digital economic activities, governments are adopting laws and regulations on personal data protection to achieve a balance on enabling data use and reuse for better economic outcomes while at the same time protecting rights of individuals to avoid abusive usage of data. European Union is one of the pioneers, by adopting the General Data Protection Regulation (GDPR) in 2018. Across the globe, 137 countries have put in place legislations on data privacy and protection.[6] Advances of big data enabled artificial intelligence technologies also impose challenges on how policy makers can prevent discrimination embedded in algorithm or data (Stankovich et al., 2023). Competition law to address the mentioned "winner-takes-all" monopoly among digital platform businesses is also critical. More digital businesses tend to go beyond monopolistic power within a sector but manifest wild ambition by penetrating across various sectors in economic life. Amazon is not only an online retailer, but also publishes books, manufactures hardware, and even enters grocery-store business after purchasing Whole Foods Market—a supermarket chain. Starting from Taobao.com marketplace, Alibaba group in China now dominates the mobile payment market with the product Alipay, and takes a significant stake in online entertainment sector through acquiring Youku.com. Whether these behemoths would impose threat on public interest or suppress innovation are urgent issues for governments to tackle. In addition, labor law shall be updated to address the new working arrangement such as gig work emerged in digital economy. Blurring lines between formal and casual employment, characterized by

[6] UNCTAD database.

independent or temporary work arrangements such as on call workers, contract workers or freelancers, may be a trojan horse with hidden danger. Income fluctuation associated with those new types of work accompanies job instability. It also becomes difficult for those who are engaged in the new types of work to have access to regular benefits that are available to traditional employees, like pension plans, health insurance, and paid vacation. Moreover, tax law faces challenges from digital business activities, as the long-standing taxation principles of permanent establishment and physical presence—a government's current taxing rights on corporate income are based on the physical presence of a firm in its jurisdiction, become inapplicable in the digital economy. Google ducked a tax bill of $1.27 billion from the French taxation authority for the years 2005 to 2010, as it didn't have a physical presence in France though it had been selling its online advertisement posting services to French clients. For similar reasons, social media companies like Facebook are not paying tax in many developing countries which already face severe difficulties on fiscal revenue, while customers in those countries account for large customer base and contribute to dynamism of those platforms. There are many other market frictions associated with digital economy, such as lawsuits against search engine on placing misleading advertisements, or complaints about counterfeited products on various e-commerce marketplaces, as well as obscure property rights protection on digital assets. In the 2022 Review of Notorious Markets for Counterfeiting and Piracy (the Notorious Markets List) released by the Office of the United States Trade Representative, 39 online markets across the globe were identified with substantial issues on trademark counterfeiting or copyright piracy, including WeChat e-commerce ecosystem and Pinduoduo in China, as well as Tokopedia, one of the largest e-commerce platforms in

Indonesia (Office of the United States Trade Representative, 2022).

Academic research on the digital economy has primarily concentrated on a few aspects. First, some studies focus on the macroeconomic perspectives, including proposing new methodologies to measure the size of the digital economy and understanding the relationship between advances of digital technologies and productivity growth (Ahmad and Schreyer, 2016; Aruoba et al., 2016; Benzell and Brynjolfsson, 2019; Brynjolfsson et al., 2019; Brynjolfsson and Collis, 2019; Bukht and Heeks, 2017; David and Foray, 2016; Moulton, 2000). GDP-B is proposed as an alternative GDP measurement metric that takes into account of consumer surplus generated by free digital goods and other nonmarket goods through conducting surveys to collect information on how much individuals are willing to be paid to give up a given good for a certain period of time (Brynjolfsson and Collis, 2019). Moulton (2000) puts forward a few methodological changes to better reflect digital economy in the GDP, including separating quality change from price change, measuring output of services, and using new electronic sources of data. Size of digital economy also depends on the specific definitions of digital economy, with an estimated range of 4.5 percent to 15.5 percent of the global GDP according to Asia-Pacific Economic Cooperation (Asia-Pacific Economic Cooperation, 2023). Rapid development of digital technologies, in contrast with stagnant and even declining productivity growth as shown in statistics, engendering the so called “productivity paradox”. Brynjolfsson et al. (2019) explained that this is mainly due to time lag between the advent of the technology, prevalence of the technology to social and economic activities, and reflection in measurement. Benzell and Brynjolfsson (2019) proposed a third factor “genius”, representing superstar individuals and intangible assets, and contended that those genius

factors are increasingly scarce, thus resulting in slow growth. Second, digital divide drives research to examine determinants of the gap about ICT access and usage between individuals, households, businesses and geographic areas (Armey and Hosman, 2015; Birba and Diagne, 2012; Goldfarb and Prince, 2007; Penard et al., 2015; Srinuan and Bohlin, 2011; van Dijk, 2006). Socio-economic factors such as income level, education background, gender, age, locality, and household size are found to have significant impacts for internet adoption and usage. Infrastructure factors such as increasing electricity distribution and enhancing competition among network providers also help promote the adoption of internet services (Armey and Hosman, 2015; Rodriguez-Castelan et al., 2019). A third stream of research is about market structure of the digital economy as well as challenges and opportunities for businesses, in aspects such as price levels, price elasticity, brand loyalty and market concentration (Acemoglu and Autor, 2011; Brynjolfsson and Smith, 2000; Cramer and Krueger, 2016; Farronato and Fradkin, 2018; Yang and Peterson, 2004). Brynjolfsson and Smith (2000) found that prices and menu costs are lower in internet markets, and there exists substantial price dispersion online. Internet marketing and digital media make it easier for companies to directly engage with customers thus increasing loyalty (Alam Kazmi et al., 2018; Nuseir, 2016). Non-rivalry nature of digital data, positive network effects of digital platforms, the "scale without mass" feature of digital business activities, have raised concerns on market concentration (Cohen, 2017; Cornière and Taylor, 2020; Katz, 2019; Khan, 2016; Nuccio and Guerzoni, 2019). Nuccio and Guerzoni (2019) argued that though big data could trigger market concentration, it could also help limit the possibility of abuse of market dominance. Khan (2016) proposed two potential approaches for addressing Amazon's power: 1) reforming competition law to

take into account of anticompetitive practices of digital platforms through updating provisions on predatory pricing and vertical integration, and 2) regulating digital platforms as public utility companies like water and electricity with requirements such as price limit. A fourth research avenue is about the impact of digital economy on the labor market with discussions on displacement effects of automation on labor demand, skill-biased technological changes, emergence of new types of work arrangement and etc. (Acemoglu and Restrepo, 2019; Anwar and Graham, 2020; Frey and Osborne, 2017; Hall and Krueger, 2016; Kässi and Lehdonvirta, 2018; Wood et al., 2019). Acemoglu and Restrepo (2019) argue that the impact of ICT technologies on employment depends on the interplay between the growth of labor demand due to innovation of ICT technologies and the loss of jobs from ICT-enabled automation replacement effects. An increasingly polarized labor market, characterized with increasing employment in high-income cognitive jobs and low-income manual occupations, in accompany with the disappearing middle income routine jobs, has raised concerns (Frey and Osborne, 2017). The observed rapid rise in the relative wage of skilled workers in conjunction with an upward trend in their relative supply indicates the recent technological change being skill-biased (Acemoglu, 2002). Technological progress benefits only a sub-group of workers, placing technical change also at the centerstage of the income distribution debate. In the meantime, there emerges an explosion of "Uberized" labor marketplaces, often referred as gig work platforms that can make certain types of work accessible to every individual and on a more flexible basis, relying on digital devices and digital technologies. These online gig work platforms help match service providers and clients, showing great potential in reducing frictions in labor market and creating job opportunities but also raise other issues on work condition and social protection as gig

workers often fall outside the purview of labor laws (Graham et al., 2017; Kuek et al., 2015; Woodcock and Graham, 2020). Fifth, as digital technologies penetrate to all round of social and economic life, more and more researchers try to examine the welfare impacts of digital economy. Empirical evidences show that e-commerce participation is associated with higher household income and higher consumption growth (Luo et al., 2019; Luo and Niu, 2019). Digital applications such as mobile payment is found to be associated with increased risk sharing within and among households, enhanced household consumption and saving, and reduced poverty rates in the long term (Jack and Suri, 2014, 2011). Across Africa, 3G coverage is linked to a 14 percent increase in total consumption, and 10 percent reduction in extreme poverty in Senegal (Masaki et al., 2020). Similarly, evidence from Nigeria shows that mobile broadband coverage reduces the proportion of households in extreme poverty by 4.3%, thanks to its positive effects on labor force participation and employment (Bahia et al., 2020). Globally, a 10 percentage-point expansion of 3G and 4G connections per capita has been found to reduce the Gini coefficient by 1.35 points (Calderon and Cantu, 2021). Lastly, as climate change becomes an imperative global issue, there's a new trend of understanding the relationship between digital economy and sustainable development. Production and expansion of digital infrastructure create carbon footprints. For instance, installing network infrastructure affects biodiversity and land use (Baldé et al., 2017). Manufacturing digital devices and establishing required infrastructure is associated with generation of e-waste, natural resource degradation, and high use of energy, water and material resources (Kumar et al., 2017; Mello and Ter-Minassian, 2020; Velden, 2018). Studies estimate that the ICT sector's share of global emissions is about 1.8-2.8% in 2020 (Andrae and Edler, 2015; Belkhir and Elmeligi, 2018; Malmodin and Lundén,

2018). Besides the direct effect of digitalization on environment and sustainability, digital development may indirectly affect efforts to mitigate, adapt to and monitor climate change across other sectors. For instance, digital technologies play an important role in smooth integration of decentralized renewable energy resources into existing electric grids and increase energy efficiency through improving predictive maintenance and allowing for effective supply-and-demand matching (Hassani et al., 2019; International Renewable Energy Agency, 2020; Rolnick et al., 2022). Digital technologies also underpin the concept of "mobility-as-a-service" which refers to respective digital platforms that establish one unified routing and payment platform to provide a multimodal mobility package in comparison with personally-owned modes of transportation. Such shift of transportation modes would potentially have an impact on aggregated carbon footprints of vehicles (Giesecke et al., 2016; Kamargianni et al., 2016; Tirachini, 2020).

This DPhil thesis aims to contribute to the digital economy research field by: 1) analyzing the relationship between social network and adoption of mobile internet—an essential internet access channel in developing countries; 2) conducting a quantitative exercise to examine the impacts of participation in the gig economy on individual welfare, in particular on women economic empowerment; and 3) assessing whether and what mobile banking regulatory frameworks are conducive to financial inclusion. Each of the three aspects—technology adoption, new types of economic activity, and institutional environment, corresponds to one key component of a functioning digital economy as mentioned in figure 0.1. Access and usage of the digital technology is the first prerequisite to exploit the potential benefits in the digital era. A better understanding of the welfare effects of new digital economic activities would help uncover the beneficiaries or those

who got excluded. Corresponding policies can then be devised to enable more vulnerable groups to benefit from the digital advances. Lastly, to respond to the new market players and business models, governments also need to know how to craft clear, coherent rules to facilitate digital economic activities.

Each of the chapter also tries to fill in research gaps in the above-mentioned respective dimension. For instance, existing research on the digital divide focuses on fixed-line internet access and usage or mobile phone ownership (Aker and Mbiti, 2010; Bjorkegren and Grissen, 2018; Forenbacher et al., 2019; van Biljon and Kotzé, 2007). Individuals' decisions on adopting mobile internet—an essential internet access channel in developing countries, remain to be further examined (Srinuan et al., 2012a). Besides conventional socioeconomic factors such as gender, age or income that existing studies primarily focus on, it is worth exploring whether social network plays a role especially considering the different ways of social interactions (e.g., social media) in the digital age. Also, quantitative exercises to analyze the impacts of participation in certain new types of digital economic activities on individual welfare are limited. There only exist anecdotal stories on how gig economy brings more job opportunities to people at the economic peripheries. Moreover, there is limited research to examine the digital economy through the lens of new institutional economics (Liu and Weingast, 2018; Zhu and Thatcher, 2010). Understanding the impacts of institutions on digital economic activities would be particularly important for developing countries that are eager to devise enabling institutional environments to reap the digital dividends.

Chapter 1 is about mobile internet adoption in the global south from a social network perspective. By using nationally representative household-level data from more than 20

countries in Africa, Asia and Latin America, the analysis utilizes a logit model to explore adoption of mobile internet by individuals in developing countries focusing on social network factors. Findings show a positive relationship between social network and mobile internet adoption. Those who have more close friends using an online social network are more likely to adopt mobile internet. Such relationship is found to be particularly strong in Africa. It's also worth noting that social network tends to matter more in individuals' decision on mobile internet usage than other conventional demographic characteristics such as gender, marital status, location of residence and age. This provides additional empirical evidence to the debate on whether social structure or social network plays a more important role in individuals' behavior. From a policy perspective, findings indicate that interventions to reduce digital divide from the demand side are very much needed while most of endeavors focused on the supply side in the past decade by deploying and expanding mobile network infrastructure. In particular, partnering with social media companies to leverage the social network effect is a potential route to promote individuals' mobile internet usage.

Chapter 2 is about gig economy participation and women economic empowerment. Anchoring from the angle of digital and gender, the analysis tries to answer questions on gender equality in accessing gig work opportunities, and the relationship between participating in gig economy and income growth for female in developing countries. It contributes to the literature by showing whether digital business models help change entrenched gender inequality issues in labor markets, and is one of the first studies that try to quantify the welfare impacts of gig economy at the individual level. It presents evidence on characteristics, motivations and backgrounds of participants in the gig economy in

developing countries, complementing existing studies which mainly rely on transaction data from large gig platforms with information on geography location of gig workers and types of gig work. It offers policy insights on how to better leverage digital economic activities to promote equality in the digital age. Using a household survey conducted in 2017/2018 by Research ICT Africa, an ICT policy think tank, and utilizing a propensity score matching method, the analysis shows that women and female are on a level playing field in accessing gig work opportunities, and gig economy participation is associated with enhanced women welfare, with the disposable income of the female gig economy participants almost double that of females who are not participating in the gig economy.

Chapter 3 is about regulatory environment for digital economic activities, zooming into mobile banking regulation and financial inclusion. Mobile banking, a new of way delivering financial services enabled by digital technologies brings about opportunities such as reduction of transaction cost and increase of risk sharing, but also challenges for regulators for instance on consumer protection. Governments have been adopting different regulatory approaches to regulate mobile banking, aiming to balance the goal of achieving financial inclusion while at the same time standardizing behaviors of both service providers and consumers to engender trust to the new economic activity. This chapter provides an assessment of mobile banking regulatory attributes in 80 countries, and probes what regulatory practices are conducive to financial inclusion. By employing a World Bank index measuring the regulatory quality for mobile banking activities in more than 80 countries in year 2017, as well as individual level financial inclusion data from the World Bank Findex survey, this chapter assesses whether and what mobile banking regulations affect individual's behaviors of having a financial transaction account and depositing into

a financial transaction account. This paper not only provides empirical evidences to understand the role of regulatory environment in affecting the impact of digital economic activities which is rare in existing studies, but also contributes to the literature from the institutional economics perspective, by testing whether the public choice theory or the public interest theory is applicable to digital economic activities and showing what regulatory attributes are the driving factors in promoting financial inclusion.

Digital technologies have shown a great potential beyond improving convenience or efficiency, playing an indispensable role in social and economic activities. Developing communities are in urgent need to better harness the benefits of digital technologies and address the potential risks associated with digital economic activities. It's worth highlighting that due to data limitation, the major goal of the thesis is not to prove causal relations but providing more empirical evidence to better understand core dimensions of digital economy—technology adoption, welfare impact and institutional implication in developing countries, thus promoting more policy discussions in those areas.

Chapter 1: Mobile Internet Adoption in the Global South: A Social Network Perspective

1.1 Introduction

Mobile internet has been the main and often sole channel of connecting to the internet in developing countries. Penetration of fixed broadband internet is far from satisfactory in low-income countries, where, in 2021, fixed broadband subscriptions averaged 0.48 per 100 people.[7] On the contrary, in low- and middle-income countries, mobile cellular subscriptions reached a relatively high level of 104 per 100 people in 2021.[8] In the meantime, it is estimated that 95% of global population are covered by 3G network by 2020 (ITU, 2020). The increasing rate of mobile phone ownership in combination with expanding 3G network coverage show promises to promote access to and usage of mobile internet.

Research findings have provided evidence on the development impacts of mobile internet access and usage. Katz and Callorda (2018) estimate that a 10 percent increase in mobile broadband penetration is associated with a 1.8 percent increase in gross domestic product (GDP) in middle-income countries, and a 2 percent increase in GDP in low-income countries. Mobile broadband coverage is also shown to have large and positive impacts on household consumption levels (Bahia et al. 2020). Mobile internet access and usage are also found to have a positive impact on people's happiness and well-being (GSMA and Gallup 2018) and women's empowerment (Bailur and Masiero 2017). It is argued that access to and usage of ICT reduce poverty, by fostering access to and exchange of information, and improving the transparency and accessibility of public services—all

[7] World Development Indicators.
[8] World Development Indicators.

benefits that would also apply to mobile internet (Cecchini and Scott, 2003; Roller and Waverman, 2001; Waverman et al., 2005).

Despite the potential of mobile internet to help achieve development goals, there is a significant digital divide among and within countries. According to the Organisation for Economic Co-operation and Development (OECD), the digital divide refers to the "gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access ICTs and to their use of the Internet for a wide variety of activities". According to the Global System for Mobile Communications, those who are not connected through mobile internet are disproportionately rural, women, or illiterate. For instance, in developing countries, women still remain 7 percent less likely than men to own a mobile phone, and 19 percent less likely than men to use mobile internet services. Similarly, rural populations are 29 percent less likely to use mobile internet than urban populations (GSMA, 2023b).

Some studies consider the factors affecting fixed-internet access and usage and other aspects of the digital divide. For instance, income, installation fees, and age are shown to be significant factors predicting fixed-internet usage (Birba and Diagne 2012; Cerno and Amaral 2006; Katz and Rice 2003). Other socioeconomic variables such as education, gender, locality and household size are also found to be drivers for internet adoption and usage in general. For instance, Goldfarb and Prince (2008) find that low income, less-educated people spend more time online. Similarly, Penard et al. (2012) and Penard et al (2015) find that education and computer literacy increase internet usage. Gilwald et al. (2018) provide evidence on lower internet adoption rate among women and those who live in rural areas. Other infrastructure factors such as increasing the distribution of electricity

and improving competition in digital infrastructure are found to help promote the adoption of internet services (Armey and Hosman 2016; Rodriguez-Castelan et al. 2019).

However, with regards to mobile internet, existing studies have a few limitations. First, previous research has mainly focused on understanding the determinants of mobile phone ownership in developing countries. Education, employment status, and type of electricity are found to be important factors (Aker and Mbiti 2010; Björkegren 2019; Forenbacher et al. 2019; van Biljon and Kotzé 2007). Second, studies on mobile internet adoption tend to focus on the supply side, emphasizing technological aspects such as the efficient compression of images or data delivery (Kim and Kim 2002). Funk (2005) presents how certain technological products such as the push mail service and micropayment systems promote mobile internet adoption. Third, only specific country or regional data are used in the few studies analyzing the demand-side factors affecting mobile internet adoption. For instance, Srinuan, Srinuan, and Bohlin (2012) use data from Thailand to find that price, the availability of fixed telephony, and individuals' age and location are strong determinants of mobile internet adoption. Consumers' perspectives on service applications are also found to affect mobile internet adoption in Taiwan (Hsu, Lu, and Hsu 2007). Hasbi and Dubus (2020) provide evidence of the positive impact of being part of an online social community on mobile broadband use in Sub-Saharan Africa. Moreover, many of those studies tend to focus on conventional socioeconomic factors such as gender, age or income, with little emphasis on the impact of social network. Even when touching upon social interactions, few studies tried to examine the magnitude of impacts between social network effects and other conventional socioeconomic factors, or differentiate the impacts of different types of social network.

This paper aims to (1) examine how socioeconomic variables and perception factors are related with mobile internet adoption, with a focus on social network; (2) compare the relationship between social network and mobile internet adoption across different regions and demographic groups; 3) understand whether different types of social network matter differently for mobile internet adoption. The paper adds to the literature in the following ways: (1) it is one of the first studies to explore relationship between social network and mobile internet adoption in developing countries; (2) it uses nationally representative household-level data that follow a consistent methodology across countries allowing for cross-country comparisons, which is a rarity in the literature, and (3) it establishes a significant relationship between social network effects and mobile internet adoption, which presents significant policy implications.

The study finds a positive relationship between social network and mobile internet adoption. Those who have more close friends using an online social network are more likely to adopt mobile internet. Individuals whose five closest friends are using an online social network (e.g., Facebook, Twitter) are 66.1 percent more likely to adopt it than those without any close friends using such online social network sites/apps. Such relationship holds across all regions but is particularly salient in Africa. Social network is found to play a more important role than other demographic variables, such as gender, marital status, location of residence, age etc., showing that social network matters more than social structure in adopting mobile internet. Different types of social network also exhibit different levels of association with the mobile internet adoption.

The paper is organized as follows: section 1.2 outlines the study's conceptual framework. Section 1.3 describes the data used. Section 1.4 lays out the study's empirical

strategy. Section 1.5 presents the results of several modeling exercises and section 1.6 conducts robustness check. Section 1.7 concludes and discusses policy implications.

1.2 Conceptual Framework

Myriad of studies have tried to examine drivers of technology adoption in general. Among them, Diffusion of Innovations Theory (Rogers, 1995) emphasized that "innovation is communicated through certain channels over time among the members of a social system, and adoption of technology goes through five stages of understanding, persuasion, decision, implementation, and confirmation. Theory of Reasoned Action (TRA) model specified three factors that affect human behavior, including attitudes, social norms or social influence, intention (Fishbein and Ajzen, 1975). Unified Theory of Acceptance and Use of Technology (UTAUT) identified performance expectancy, effort expectancy, social influence and facilitating conditions as four predictors of users' behavior (Venkatesh et al., 2003).

One common element of the above-mentioned models is the recognition of the social influence. Social network theory becomes applicable in the context. Network is based on the interconnection between nodes, and social network refers to relationship between actors—can be individuals or organizations, within a society (Tabassum et al., 2018). In face with new technologies, individuals tend to revert to social network for opinions on the usefulness of the technology. Depending on how much an individual trusts the counterparts in a social network, he or she will form his or her own opinion about the technology and make corresponding decisions. In the meantime, as more and more members within a social network form similar opinion, the social network would also indirectly shape an individual's perception on a new technology or product, through some members

proactively sharing opinions and experience about the technology or product to other members. In this way, social network serves as a knowledge transfer mechanism, in which individuals are nodes that absorb, process and express the knowledge, and ties among the nodes are communication channels for the inflow and outflow of knowledge (Wang et al., 2010). How the inflow and outflow of information happens, through different ways such as human communication, courses, operation, and how individuals mentally process the information will not be dealt with in this paper.

With regards to internet technology, much attention was devoted to the importance of physical infrastructure access following the technological determinism of the early 2000s (Jerome Lim 2002; Lentz and Oden 2001; Moss 2002). However, as the digital divide widened, despite expanding service coverage, many researchers explored other underlying socioeconomic factors affecting demand, such as literacy, education, income, and geography (Bagchi 2005; Gauld, Goldfinch, and Horsburgh 2010; Salajan, Schönwetter, and Cleghorn 2010). At a later stage, other social science disciplines came into play as the research on the digital divide evolved. One strand of the literature argues that psychological attitudes toward ICTs affect their adoption (Srinuan and Bohlin 2011; van Dijk 2006), while a second strand emphasizes the role of social networks in shaping perceptions and driving adoption, such as membership in occupational, religious, or cultural communities (Al-Jaghoub and Westrup 2009; Andrés et al. 2010). The abovementioned studies primarily focus on assessing the determinants of fixed-internet access and usage, many in developed countries. Nevertheless, the fixed internet and mobile internet are different in a variety of aspects such as the price of access devices, convenience of access, coverage and reliability of signal, connection speed, and so on.

Following the strand of research on the role of social networks in affecting internet adoption, this paper tests a few hypotheses regarding the relationship between social network and mobile internet adoption.

Hypothesis 1: An individual is more likely to use mobile internet if his or her close friends are also using mobile internet; and social network could play a more important role than other demographic and socioeconomic factors such as gender, age, income etc.

There have been long standing debates between status structure view and network structure view, in discussions predicting human behaviors. According to status structure view, individual attributes such as age, gender and economic status play an important role in deciding the resources an individual holds, while network structure view argues that social network decides whether and how much resources an individual can have access to and possess.

This paper tests the hypothesis that social network plays a more important role than status or individual attributes in accessing and using mobile internet. Unlike other goods, internet tends to be non-rivalry, meaning that one individual's usage often does not affect another individual's usage (except with minor effect on internet speed) as long as the physical infrastructure is available. Under such condition, social network, whether an individual's friends and family accesses or uses mobile internet, and how many of them are using it, matters when an individual decides whether it is worthy to access and possess such resources or product. It is argued that when more members within an individual's social network are using mobile internet, an individual is more likely to do the same. Such effects would be more obvious than other socioeconomic factors.

Taking into account of different social and cultural contexts across the globe, the paper

is also going to examine whether and how the relationship between social network and mobile internet adoption varies across the globe. Moreover, subgroups of population tend to be affected by social network differently, given that their level of dependence on social network may be different. For instance, young people may be more reliant on social network; those who live in rural areas may have stronger bonding with members within their social network. Therefore, the paper will also test whether the impact of social network effects differs among different subgroups of population.

Hypothesis 2: Different types of social network exhibit different levels of association with the mobile internet adoption, and influence from close friends could be stronger than that from family members.

A strand of research within social network theory is the strong tie and weak tie theory (Brass et al., 1998; Brown and Reingen, 1987). Family, friends, colleagues and other members with whom the interaction is frequent are considered as strong ties, and other casual relationships are weak ties. Strong ties can be further categorized as family, friend and business ties (Brass et al., 1998; Krackhardt, 2003). Not only impacts between strong ties and weak ties are different, there may exist differentiated impacts within different categories of strong ties. It is argued that the effect is strongest when members of a particular social network share goals and have exposure to similar social and economic activities (Brown and Abrams, 1986). Though family members have the biological bonding, individuals may have strong emotional attachment with close friends with whom they often exchange views and ideas. Such emotional attachment, exchanges of ideas and often sharing similar experiences could have strong influence on individuals' perception and behavior.

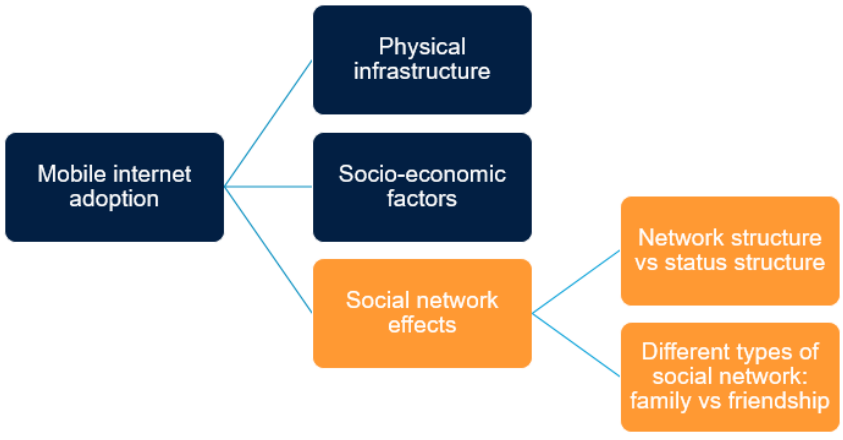
With regards to a new technology product like mobile internet, especially with functions associated with social media, individuals may be more likely to refer to close friends to inquire user experience, and explore different functions (e.g. mobile applications) together. On the contrary, within a household, older people tend to have inertia to adopt new technologies; and men often are in a more privileged position than women to access new resources. Therefore, the paper tests the hypothesis that different types of social network exhibit different levels of association with mobile internet adoption, and the effects on using mobile internet would be stronger from close friends than those from family members.

Besides social network, other factors will also be included in understanding individual's decision on mobile internet adoption, following the existing studies. As shown by Srinuan and Bohlin (2011) and Helbig, Gil-Garcia, and Ferro (2005), the determinants of digital divide can be grouped into three categories: (1) physical infrastructure on the supply side; (2) socioeconomic factors on the demand side, such as income and education level; and (3) perspective factors on the demand side shaped by the institutional environment, culture, language, and network effects. This is also consistent with the framework proposed by van Dijk (2006), who argues that there is a cumulative and recursive model of digital technology adoption, starting with motivation, followed by physical/material access, subsequently requiring digital skills and complementary services (such as electricity) to achieve usage, leading to strengthened motivation and increased usage over time. A higher level of skills and more customized products could strengthen the initial motivation.

This paper will include in the analysis the above mentioned three main groups of factors

behind the adoption of general ICTs and examine whether they apply to mobile internet as well (figure 1.1). First, the physical infrastructure needed to access mobile internet at the level of 3G or above differs from the telephone or fixed-line broadband connections needed for fixed internet. Household access to electricity is essential for laptop usage with fixed connections, but people can charge mobile phones at other places outside the home, such as offices, community hotspots, or with neighbors. Second, socioeconomic factors such as income and education level might affect access to and usage of mobile internet differently than the way they affect other types of ICTs. For instance, the cost of a mobile phone device is often less than that of a desktop computer. Many mobile network operators and technology firms (e.g., social media platforms) offer a variety of data promotion packages to attract potential customers, and mobile systems can be more intuitive and easier to learn. Third, in terms of perspective factors, with the recent booming of social media, it is argued that social network effects such as the desire to follow friends or family on social media mobile apps are of particular relevance to the access and usage of mobile internet.

Figure 1.1. Proposed factors affecting mobile internet adoption



1.3 Data

In 2017–18, ICT policy think tanks in the global South, including RIA (Research ICT Africa), LIRNEasia (Learning Initiative for Network Economies in Asia), and DIRSI (el Diálogo Regional sobre la Sociedad de la Información / Regional Dialogue on the Information Society), coordinated a global initiative, conducting household surveys to collect information about ICT access and usage at household and individual levels. The random sampling for households and individuals is based on Census sample frames. Households were sampled using simple random sample for each selected Enumerator Area, and an individual within a household was randomly selected (see Annex 1.1 for more survey methodology details). Ten African countries (Ghana, Kenya, Lesotho, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Tanzania, and Uganda), six Asian[9] countries (India, Sri Lanka, Pakistan, Bangladesh, Nepal, and Cambodia), and six Latin American countries (Argentina, Colombia, Ecuador, Guatemala, Paraguay, and Peru) were covered.

Going beyond other microlevel data sets such as the Living Standards Measurement Study and the Global Findex database, this data set collects rich, in-depth information on ICT access and usage from the demand side. It provides valuable information on mobile phone ownership and usage, internet access and usage, social media activities, digital finance, participation in the gig/sharing economy, as well as the reasons for engaging in those ICT-enabled activities. The surveys are nationally representative, and the data can be disaggregated on the basis of gender, age, location (urban or rural), and income level.

Unfortunately, there is no direct question on mobile internet adoption in the surveys.

[9] The majority of the Asian countries covered in the sample are in South Asia.

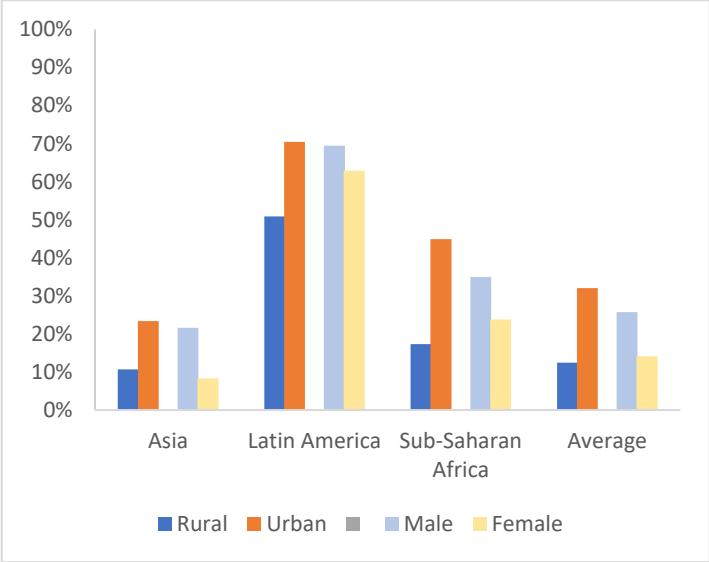
However, such information can be captured through combining data gained through multiple survey questions regarding whether respondents: (1) have used the internet or not, (2) own a mobile phone, and (3) whether the type of mobile phone they own allows internet access.[10] An individual is counted as using mobile internet if he or she has used the internet and also owns an internet-enabled phone.[11] Results show that Latin American countries have the highest rate of mobile internet adoption: 65.6 percent of the total population. The rural and urban divide is significant across all regions (figure 1.2), especially in Africa, where the adoption rate among urban residents is more than twice that among rural residents. Asian countries in the sample have the widest gender gap: only 8.4 percent of females used mobile internet in 2017. Those who are at the bottom 40 percent of the national income distribution have a lower adoption rate across regions, while the gap is minimal in Latin America.

[10] See Annex 1.3 for country level statistics on phone ownership, Annex 1.4 for country level statistics on smartphone phone ownership, and Annex 1.5 for country level statistics on internet usage.

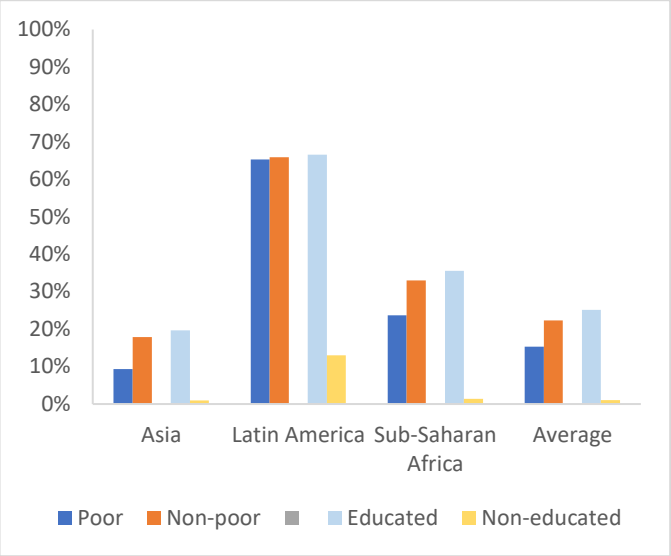
[11] Internet-enabled phones include smartphones and feature phones. Admittedly, this constructed variable cannot completely rule out cases of individuals owning an internet-enabled phone who in fact accessed the internet through Wi-Fi–enabled fixed broadband. However, data from Telegeography show that household fixed-broadband penetration is low (at 13.5 percent) across countries in the sample; thus, such cases should be minimal. The estimated rate is as low as 3.6 percent among African countries, and 7.7 percent among the Asian countries covered.

Figure 1.2. Mobile internet adoption, by subgroup, across regions (% of population)

a. Rural vs. urban and male vs. female



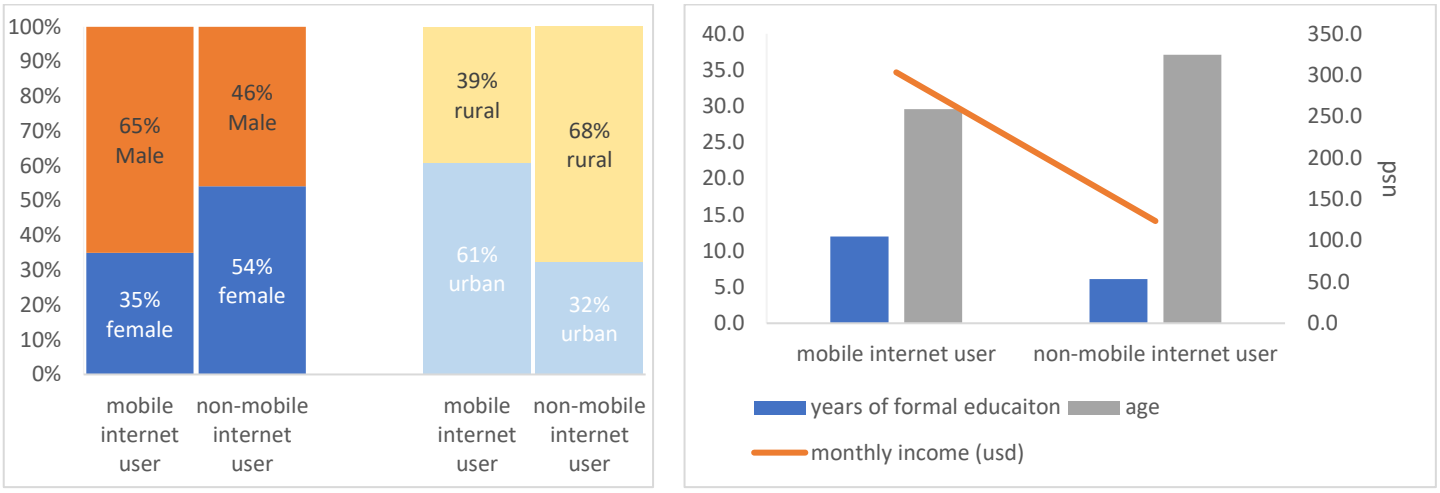
b. Poor vs. non-poor and educated vs. non-educated



Note: Individuals who have completed at least primary education are grouped as "educated"; individuals who are in the bottom 40 percent of the national income distribution are classified as "poor." Individual weights are applied in the calculation.

The demographic profiles of mobile internet users and nonusers are notably different (figure 1.3). Across the countries covered in the sample, 54 percent of the nonusers are female, and 68 percent of them are living in rural areas, while the majority of mobile internet users are male and urban residents. The average age of mobile internet users is 29.6 while that of the nonusers is 37.1, indicating that the elderly lag behind in adopting new technologies. Mobile internet users tend to be more educated and wealthier than nonusers. The average number of years of formal education (12.0 years) of mobile internet users is almost twice that of the nonusers (6.1 years). Furthermore, 92 percent of mobile internet users have at least completed primary school, while more than half of the nonusers have either no formal education or have not completed their primary education. The monthly income of mobile internet users is $303.4, more than double that of nonusers at $123.6.

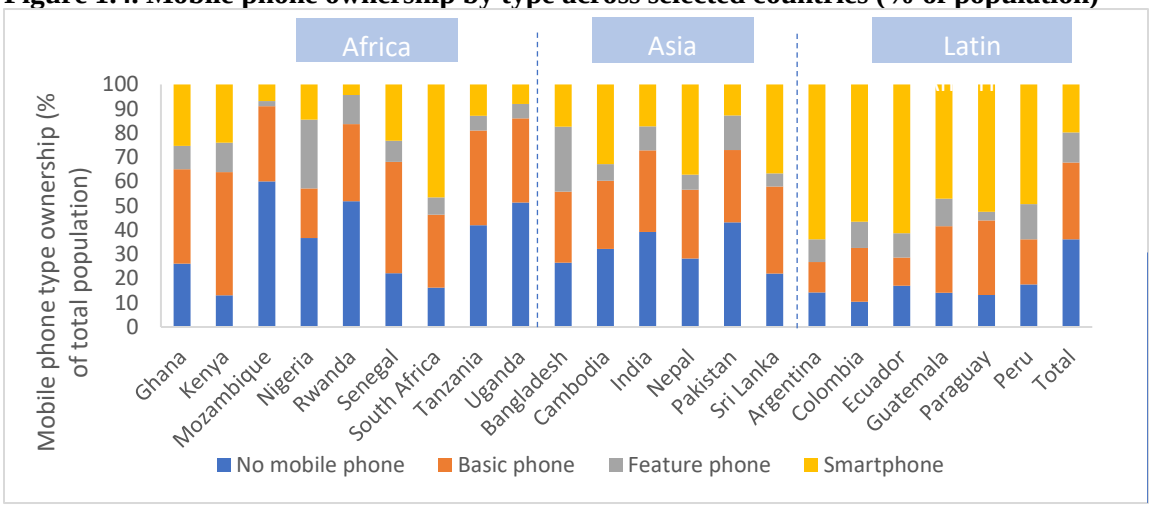
Figure 1.3. Demographic profiles of mobile internet users and nonusers



Note: Individual weights are applied in the calculation.

The analysis examines decision factors from two perspectives: owning an internet-enabled phone and using internet through the internet-enabled phone. Having an access device, or internet-enabled phone, is the first prerequisite to using mobile internet. More than half of the total population own a mobile phone in almost all the countries covered except for Mozambique, Rwanda, and Uganda (figure 1.4). There remains a significant divide between men (77.8 percent) versus women (50.4 percent), and urban (73.6 percent) versus rural residents (58.1 percent).

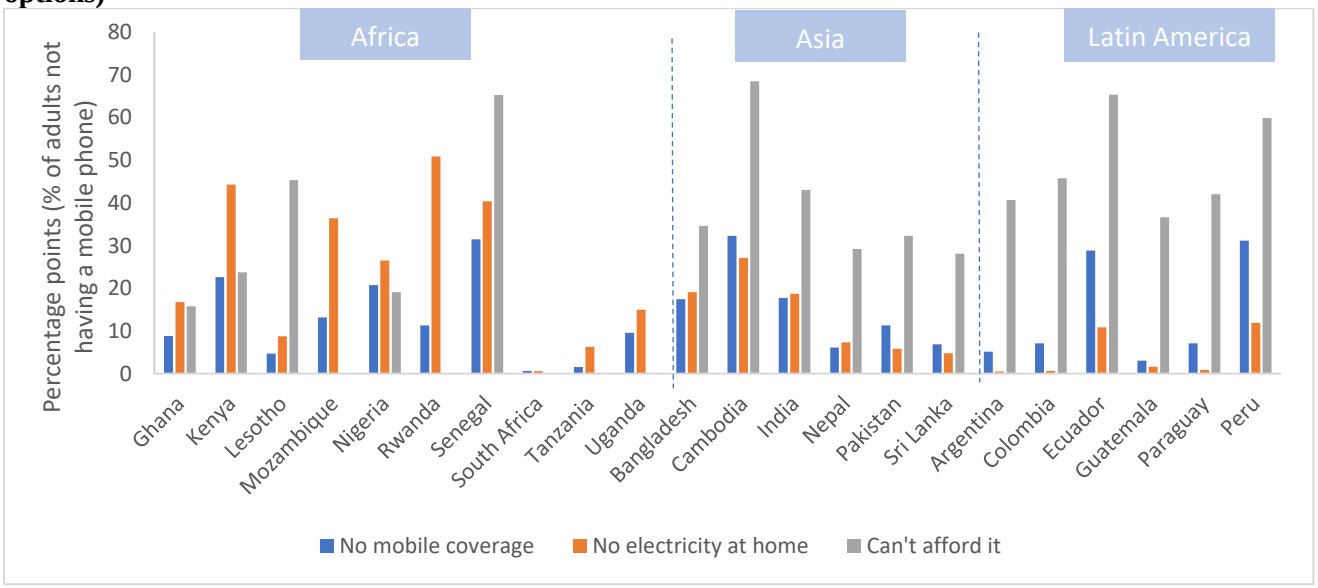
Figure 1.4. Mobile phone ownership by type across selected countries (% of population)



Note: Individual weights are applied in the calculation.

With regard to obstacles to owning a mobile phone, different reasons are cited such as affordability (39.3 percent), no mobile coverage (16.3 percent), and no electricity at home (17.7 percent). For those who do not have a mobile phone, affordability is a bottleneck across countries: 68.5 percent of those without a mobile phone in Cambodia cite affordability as such. The obstacle of electricity access is particularly severe in Africa (figure 1.5), especially in Rwanda (50.9 percent) and Senegal (40.4 percent). A lack of mobile coverage is challenging in Cambodia (32.3 percent), Peru (31.2 percent), and Senegal (31.5 percent).

Figure 1.5. Reasons cited for not having a mobile phone (respondents can select multiple options)



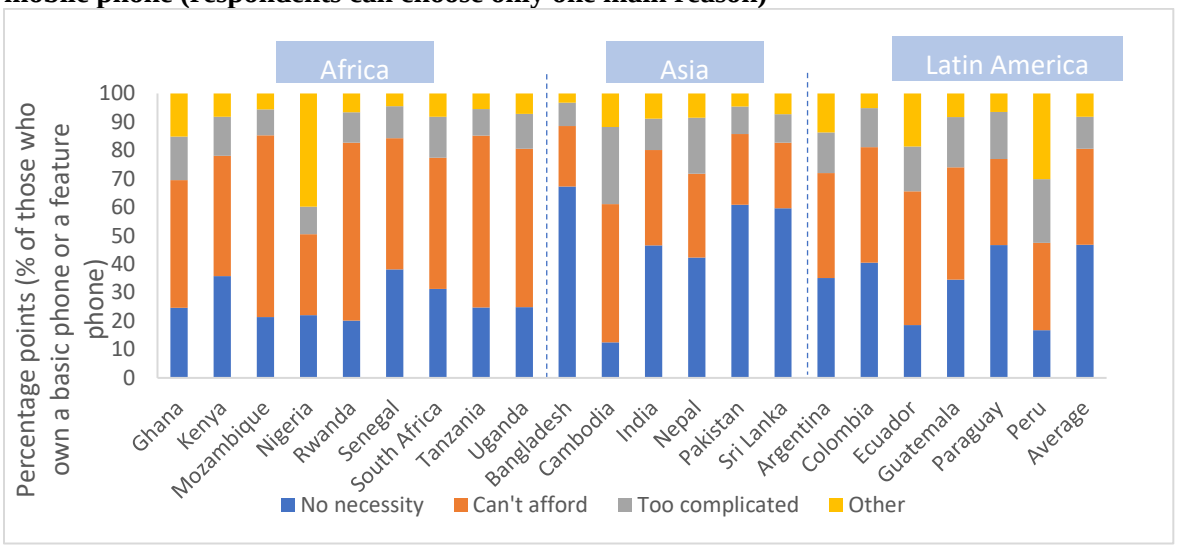
Note: Individual weights are applied in the calculation.

Around 70 percent of those who own a mobile phone only have a basic or feature phone.[12] Overall, smartphone penetration is higher in Latin American and Asian countries than in African countries. For instance, among those who own a mobile phone, the percentage with a smartphone is above half in all Latin American countries in the sample,

[12] Detailed country-level information on smartphone ownership and smartphone uptake rates are included in the Annex.

and close to half in Asian countries (48.5 percent in Cambodia, 51.8 percent in Nepal, and 47 percent in Sri Lanka). That a smartphone is not necessary and not affordable are the two most cited reasons for not having one (figure 1.6). The affordability obstacle is especially severe in Mozambique, Rwanda, and Tanzania.

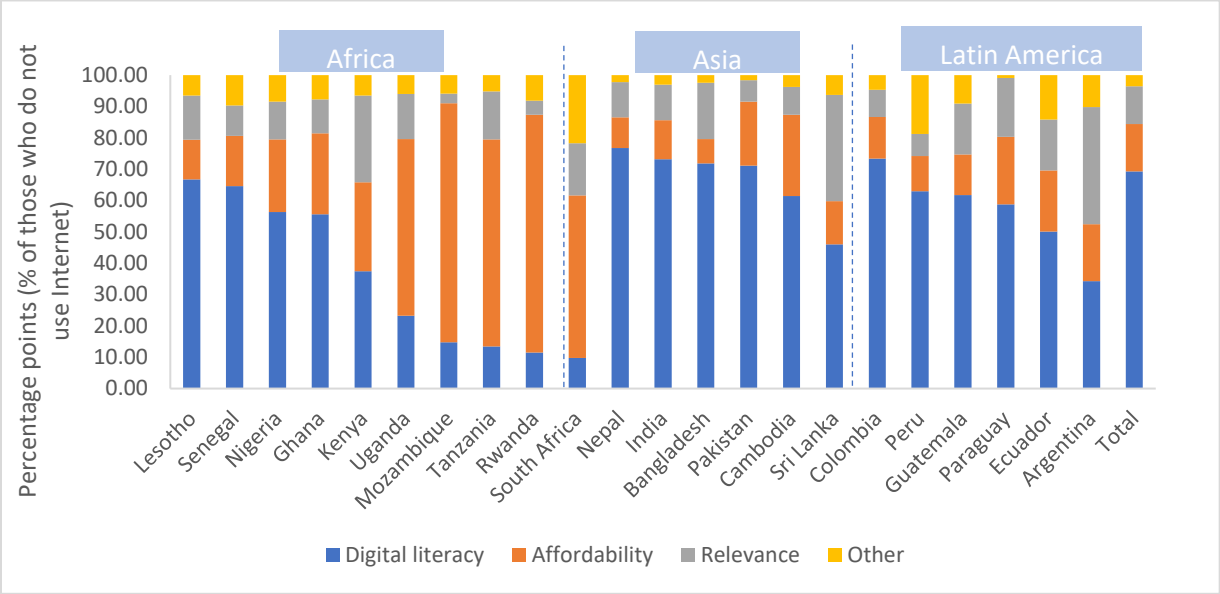
Figure 1.6. Main reason cited for not choosing a smartphone among owners of a basic mobile phone (respondents can choose only one main reason)



Note: Individual weights are applied in the calculation.

Besides owning an internet-enabled phone, individuals face challenges in accessing and using the internet. For those who do not use the internet at all, the most cited reasons relate to digital literacy, including "do not know what internet is" and "do not know how to use the internet" (figure 1.7). No access to a device (computer or mobile phone) is another internet usage constraint. Other factors such as lack of content in the local language or data privacy concerns do not appear to be key obstacles. Among those who do actually use the internet, the extent of their usage is constrained primarily by lack of time, high data costs, and internet speed.

Figure 1.7. Main reason for not using the internet across the population as a whole (in percentage points)



Note: The digital literacy category includes "do not know what internet is" and "do not know how to use internet"; affordability includes "no access device" and "too expensive"; the relevance category includes "no interest/not useful" and "no relevant content in local language." Individual weights are applied in the calculation.

People also engage in various mobile internet activities. Survey results show that social networking apps are the most often used app type among people who have an internet-enabled phone. More than a quarter of internet-enabled phone owners use social networking apps daily. Average monthly expenditure on mobile phone data, as a percentage of total income, is 0.9 percent in all the countries covered. In a few countries, such as Sri Lanka, South Africa, and Ghana, monthly mobile data expenditure is more than 2 percent of monthly income—an affordability threshold set by the United Nations.[13] Meanwhile, male, urban residents and young people tend to spend more, which may be associated with their income and level of digital awareness.

Those who use the internet adopt different methods to save data charges, such as

[13] The United Nation's "1 for 2" threshold of internet affordability is defined as 1 gigabyte (GB) for no more than 2 percent of average monthly income. https://a4ai.org/affordable-internet-is-1-for-2

accessing the internet in a free Wi-Fi area (37.2 percent) or at home or at work (41.9 percent) and taking advantage of special data promotions (49.6 percent). Using special data promotions is the most popular method to save on data charges across countries. This may be related to not only the various promotion packages offered by mobile network operators, but also zero-rating plans offered by content providers such as Facebook.

1.4 Empirical Strategy

To further unravel the factors affecting mobile internet adoption, following the approach of Forenbacher et al. (2019) and Hasbi and Dubus (2020), this analysis tries to estimate the probability of using mobile internet through the following model:

$$\text{Mobile Internet}_i = \alpha + \beta_k x_{ik} + \ldots + \beta_k x_{ik} \qquad (1)$$
$$k = 1,\ldots,m;\ i = 1,\ldots,n$$

where *Mobile Internet*$_i$ is a binary variable that equals 1 if individual *i* uses mobile internet, and 0 if not. Given that the dependent variable is a binary variable, a logit model is adopted for the estimation to predict the probability of an individual adopting mobile internet. By logarithmically transforming the outcome variable, it allows the examination of a nonlinear association in a linear way. The coefficient β_k measures, ceteris paribus, the effect of a one-unit change in x_{ik} on the dependent variable.

Variable of interest is the social network effect, referring to the number (up to 5) of the respondents' closest friends who use an online social network like Facebook or Twitter (0 refers to no close friend and 5 refers to all five closest friends). Following the existing studies which categorize factors affecting the digital divide into three groups, other variables in the model include: (1) infrastructure factors (3G network coverage and household access to electricity); and (2) socioeconomic factors such as gender, income level, education level, and rural/urban location (table 1.1). Those factors also reflect what

the descriptive statistics show to be the main obstacles to owning an internet-enabled phone or using internet, as outlined in the data section above.

Infrastructure factors include whether an individual's location is covered by a 3G mobile network signal, and whether the individual's household has access to electricity. Whether an address is covered by a 3G mobile signal is identified by mapping the household survey data (which feature GPS location data at the individual level) with the global mobile network coverage data from the Collins Bartholomew data set.[14]Socioeconomic factors include gender, age, education level, income level, marital status, and urban/rural location. Demographic information at the individual level is taken directly from the household survey.

Though three waves of data were collected in years 2008, 2012, and 2017, the survey samples were different in each wave, so no panel is available. Given the rapid pace of change in the ICT sector, analysis is confined to the most recently available data for the year 2017, based on cross-sectional estimation.

Table 1.1 Data description

Variable	Definition, Year	Source
Dependent variable		
Mobile internet	Accessing the internet through a smartphone or feature phone	After Access data, 2017
Infrastructure variable		
3G network coverage	The individual's household is covered by a 3G mobile network signal	After Access data, 2017; Collins Bartholomew data, 2017

[14] Not all countries have geolocation data at the individual/household level in the ICT household survey. For countries that do not have geolocation data at the individual/household level, a household is considered as not having a 3G mobile network coverage if anyone from the same survey enumerator area identified a lack of mobile coverage as an obstacle to accessing the internet.

Electricity access	The individual's household has access to electricity	After Access data, 2017
Socioeconomic variables		
Female	Respondent is female, 2017	After Access data, 2017
Age group (1-3)	Respondent's age group, 2017 (1 stands for young people, 15-30 years old; 2 stands for middle-age people, 30-60 years old; 3 stands for elderly people, >60 years old)	
Education (1–5)	Respondent's education level, 2017 (1 stands for no formal education; 2 stands for less than 6 years of formal education; 3 stands for more than 6 but less than 12 years of formal education; 4 stands for more than 12 but less than 16 years of formal education; 5 stands for more than 16 years of formal education)	
Log value of monthly income	Log value of the individual's monthly income in USD	
Married	Individual is married	
Urban	Individual resides in an urban area	
Social network effect		
Close friend (0–5)	The number (up to 5) of the respondents' closest friends who use an online social network like Facebook or Twitter (0 refers to no close friend and 5 refers to all five closest friends)	After Access Data, 2017

Table 1.2. Data summary

	Mean	SD	Min	Max
Mobile internet	0.338	0.473	0	1
Household 3G network coverage	0.909	0.288	0	1
Household having access to electricity	0.843	0.364	0	1
Female	0.563	0.496	0	1
Age group (1-3)	1.695	0.632	1	3
Log value of monthly income	4.709	1.411	-6.274	11.353
Married	0.558	0.497	0	1
Urban residence	0.541	0.510	0	2
Education level (1-5)	2.740	1.035	1	5

Number of closest friends using online social networks like Facebook or Twitter (0–5)	2.072	2.211	0	5

1.5 Results

The results section first presents the results from the basic model (1) specification applied to the entire sample, as well as the disaggregation of the sample by geographic region. Several alternative modeling strategies are then explored, including taking consideration of different types of social network such as close friends and family members, as well as alternative ways of modeling the influence of income on uptake decisions.

1.5.1 Mobile internet adoption in the global South

Estimations show that individuals whose five closest friends are using an online social network (e.g., Facebook, Twitter) are 66.1 percent more likely to use the mobile internet than those who do not have any close friends using such online social network sites/apps. Other factors affecting the adoption of mobile internet are largely consistent with those that affect general digital divides (table 1.3). Among infrastructure factors, having access to electricity at the household level is found to significantly associated with the increased likelihood of mobile internet adoption. Socioeconomic factors such as gender, age, income, and education level all have a significant impact on the usage of mobile internet. Females, the elderly, those who live in rural areas, and those who have lower levels of income or education are less likely to adopt mobile internet. Social network effects in general have a more significant positive impact on the usage of mobile internet, comparing with other socioeconomic factors. The adjusted R2 decreases from 0.448 to 0.346 if the social network effect variable “how many close friends are using an online social network” is removed from the model.

Table 1.3. Logit regression results on mobile internet adoption

Model	Logit Mobile internet adoption	
	Coefficient	Marginal effects
Infrastructure factors		
Household 3G network coverage	0.188**	0.041**
	(0.085)	(0.018)
Household having access to electricity	0.759***	0.164***
	(0.110)	(0.024)
Social-economic factors		
Female	-0.142***	-0.031***
	(0.044)	(0.010)
Age group (middle age, 30-60)	-0.695***	-0.151***
	(0.048)	(0.011)
Age group (old people, >60)	-1.985***	-0.430***
	(0.109)	(0.024)
Log value of monthly income	0.195***	0.042***
	(0.018)	(0.004)
Married	-0.138***	-0.030***
	(0.049)	(0.011)
Urban	0.378***	0.082***
	(0.046)	(0.010)
Years of formal education (less than 6)	0.676***	0.146***
	(0.124)	(0.026)
Years of formal education (6-12)	1.603***	0.347***
	(0.118)	(0.025)
Years of formal education (12-16)	2.388***	0.518***
	(0.125)	(0.026)
Years of formal education (>16)	2.551***	0.553***
	(0.139)	(0.029)
Social network effects		
1 close friend uses an online social network	1.461***	0.317***
	(0.087)	(0.018)
2 close friends use an online social network	1.335***	0.289***
	(0.076)	(0.016)
3 close friends use an online social network	1.791***	0.388***
	(0.076)	(0.016)
4 close friends use an online social network	2.115***	0.458***
	(0.096)	(0.020)
5 close friends use an online social network	3.049***	0.661***

	(0.064)	(0.014)
_cons	-4.287***	
	(0.225)	
Country fixed effects	Yes	Yes
Number of observations	19,979	19,979
R2		
Adjusted R2	0.448	0.448

Note: *** p<0.01, ** p<0.05, * p<0.1. Marginal effects at mean are presented.

1.5.2 Differences in mobile internet adoption across regions

Results are slightly different if model (1) is estimated for each region separately (table 1.4). The estimated marginal effect is particularly high in Africa, implying close bonding among social members in the society. Among the infrastructure factors, 3G network coverage's impact is significant in Asia, and household access to electricity matters a lot in Africa and Asia. In terms of socioeconomic factors, gender significantly affects the adoption of mobile internet in Asian countries, implying potential gender inequality in digital access and usage in the regions. In Asia, married people tend not to use mobile internet as much as others. Residence in a rural or urban location as well as income level have a significant impact across all regions.

Table 1.4. Logit regression results for mobile internet adoption by region

Model	Logit Marginal effects			
	All region	Africa	Latin America	Asia
Infrastructure factors				
Household 3G network coverage	0.041**	0.012	0.051	0.039*
	(0.018)	(0.021)	(0.043)	(0.022)
Household having access to electricity	0.164***	0.122***	0.200	0.083**
	(0.024)	(0.021)	(0.123)	(0.041)
Social-economic factors				
Female	-0.031***	-0.020*	-0.002	-0.043***
	(0.010)	(0.012)	(0.016)	(0.012)
Age group (middle age, 30-60)	-0.151***	-0.113***	-0.177***	-0.095***
	(0.011)	(0.014)	(0.019)	(0.013)

Age group (old people, >60)	-0.430***	-0.213***	-0.494***	-0.248***
	(0.024)	(0.034)	(0.030)	(0.042)
Log value of monthly income	0.042***	0.037***	0.015***	0.048***
	(0.004)	(0.005)	(0.006)	(0.006)
Married	-0.030***	0.000	-0.033*	-0.058***
	(0.011)	(0.013)	(0.018)	(0.015)
Urban	0.082***	0.071***	0.082***	0.049***
	(0.010)	(0.014)	(0.018)	(0.011)
Years of formal education (less than 6)	0.146***	0.085***	0.130*	0.125***
	(0.026)	(0.031)	(0.068)	(0.030)
Years of formal education (6-12)	0.347***	0.258***	0.336***	0.243***
	(0.025)	(0.027)	(0.068)	(0.028)
Years of formal education (12-16)	0.518***	0.398***	0.483***	0.355***
	(0.026)	(0.028)	(0.070)	(0.031)
Years of formal education (>16)	0.553***	0.460***	0.541***	0.315***
	(0.029)	(0.034)	(0.076)	(0.032)
Network effects				
1 close friend uses an online social network	0.317***	0.301***	0.196***	0.189***
	(0.018)	(0.021)	(0.047)	(0.021)
2 close friends use an online social network	0.289***	0.238***	0.211***	0.201***
	(0.016)	(0.019)	(0.040)	(0.018)
3 close friends use an online social network	0.388***	0.329***	0.269***	0.267***
	(0.016)	(0.020)	(0.038)	(0.019)
4 close friends use an online social network	0.458***	0.376***	0.340***	0.322***
	(0.020)	(0.027)	(0.044)	(0.024)
5 close friends use an online social network	0.661***	0.579***	0.537***	0.406***
	(0.014)	(0.020)	(0.027)	(0.020)
Number of observations	19,979	8,068	5,469	6,442
R2				
Adjusted R2	0.448	0.454	0.366	0.394

Note: *** p<0.01, ** p<0.05, * p<0.1.

1.5.3 Alternative way of modeling the social network effect

The social network variable included in model (1) is about the number (up to 5) of the

respondents' closest friends who use an online social network like Facebook or Twitter (0 refers to no close friend and 5 refers to all five closest friends). Besides friendship, there are other types of social networks, such as family, colleagues, religious members etc. Different types of social network may have different levels of association with mobile internet adoption, according to the social network literature regarding strong ties and weak ties. To examine different types of social network, the analysis tries an alternative specification by including proxies for both friendship and family relationships. By combining the variable "Does the household have a working internet connection (exclusive for the household and is accessible to all household members" and the variable specifying the connection mode, a new variable is created to measure if household members have access to mobile internet. If the household has a working internet connection to all household members, and the internet is connected through mobile phone, it is considered as the individual's family members having access to mobile internet. Only Asian countries have data on these variables, therefore only Asian countries are included in the sample.

Results show that both friendship and family relationships matter in individual's decision regarding mobile internet adoption. If an individual has family members using mobile internet, he or she is 25.6% more likely to adopt mobile internet. The sign and level of significance of other variables in model (1) remain largely similar (see tables 1.5 and 1.3). When comparing the magnitude of impact between friendship and family relationship, it is interesting to see that the impact from family members is at a higher level when 3 or fewer close friends are exerting the influence; however when more than 3 close friends use an online social network, the impact from friendship is more significant. This also indicates that size of social network matters in mobile internet adoption.

Table 1.5. Logit regression results considering different types of social network

Model	Logit	
	Mobile internet adoption	
	Coefficient	Marginal effects
Infrastructure factors		
Household 3G network coverage	0.295**	0.041**
	(0.150)	(0.021)
Household having access to electricity	0.414	0.057
	(0.319)	(0.044)
Social-economic factors		
Female	-0.381***	-0.053***
	(0.088)	(0.012)
Age group (middle age, 30-60)	-0.720***	-0.100***
	(0.089)	(0.013)
Age group (old people, >60)	-1.833***	-0.253***
	(0.323)	(0.044)
Log value of monthly income	0.313***	0.043***
	(0.040)	(0.006)
Married	-0.412***	-0.057***
	(0.103)	(0.014)
Urban	0.275***	0.038***
	(0.080)	(0.011)
Years of formal education (less than 6)	0.793***	0.110***
	(0.213)	(0.029)
Years of formal education (6-12)	1.541***	0.213***
	(0.207)	(0.027)
Years of formal education (12-16)	2.261***	0.313***
	(0.229)	(0.030)
Years of formal education (>16)	1.988***	0.275***
	(0.243)	(0.031)
Network effects		
1 close friend uses an online social network	1.109***	0.153***
	(0.150)	(0.020)
2 close friends use an online social network	1.237***	0.171***
	(0.131)	(0.018)
3 close friends use an online social network	1.729***	0.239***

	(0.135)	(0.019)
4 close friends use an online social network	1.951***	0.270***
	(0.178)	(0.025)
5 close friends use an online social network	2.534***	0.350***
	(0.109)	(0.017)
If family members use mobile internet	1.849***	0.256***
	(0.095)	(0.015)
_cons	-5.728***	
	(0.452)	
Number of observations	6,442	6,442
R2		
Adjusted R2	0.447	

Note: *** p<0.01, ** p<0.05, * p<0.1.

1.5.4 Alternative way of modeling the influence of income

Model (1) includes the income variable, which is an important explanatory factor for ICT adoption in general according to the literature. Individuals' income level could affect their decisions to purchase an Internet-enabled phone, and afford mobile data packages to access internet, which jointly have an impact on the decision of mobile internet adoption. To further unpack the impact of income on affordability, the analysis tries an alternative specification with inclusion of a few affordability dummies while other co-variates remain the same. To understand how the prices of mobile data packages affect the adoption of mobile internet, the analysis considers a country's average cost per 1 gigabyte (GB) of mobile data, and constructs a dummy variable that equals 1 if the country's average cost per 1 GB of mobile data is more than 2 percent of the individual's monthly income. Moreover, since the affordability of an access device is often cited as an obstacle to internet usage, the analysis uses data about a country's average cost of an internet-enabled phone from International Data Corporation (IDC) and constructs a dummy variable that equals 1 if the average phone cost is more than the individual's monthly income. Due to collinearity

concerns, the inclusion of these affordability measures precludes the incorporation of the income variable directly.

Results confirm the important role of affordability issues in driving mobile internet adoption. The high cost of mobile data packages and expensive mobile phones negatively affect the adoption of mobile internet. If the country's average cost per 1 GB of mobile data is more than 2 percent of an individual's monthly income, that individual is 5 percent less likely to adopt mobile internet. If the country's average cost of an internet-enabled phone is more than an individual's monthly income, that individual is 4 percent less likely to adopt mobile internet. Meanwhile, the sign and level of significance of other variables in model (1) remain largely similar (see tables 1.6 and 1.3). For instance, individuals whose five closest friends are using an online social network (e.g., Facebook, Twitter) are 65.4 percent more likely to use the mobile internet than those who do not have any close friends using such online social network sites/apps, while the impact level is 66.1 percent in model (1). The overall explanatory power of the regression is slightly lower when income is used (0.45) than when the two affordability dummies are used (0.47).

Table 1.6. Logit regression results with different treatment of the income variable

Model	Logit	
	Mobile internet usage	
	Coefficient	Marginal effects
Infrastructure factors		
Household 3G network coverage	0.180*	0.038*
	(0.108)	(0.023)
Household having access to electricity	0.770***	0.164***
	(0.121)	(0.026)
Social-economic factors		
Female	-0.235***	-0.050***
	(0.049)	(0.010)
Age group (middle age, 30-60)	-0.709***	-0.151***
	(0.054)	(0.012)

Age group (old people, >60)	-1.914***	-0.407***
	(0.118)	(0.025)
Married	-0.130**	-0.028**
	(0.055)	(0.012)
Urban	0.362***	0.077***
	(0.052)	(0.011)
Years of formal education (less than 6)	0.801***	0.171***
	(0.164)	(0.034)
Years of formal education (6-12)	1.743***	0.371***
	(0.154)	(0.031)
Years of formal education (12-16)	2.541***	0.541***
	(0.161)	(0.032)
Years of formal education (>16)	3.016***	0.642***
	(0.182)	(0.037)
High cost of internet-enabled phone	-0.189***	-0.040***
	(0.071)	(0.015)
High cost of mobile data package	-0.226***	-0.048***
	(0.074)	(0.016)
Network effects		
1 close friend uses an online social network	1.577***	0.336***
	(0.097)	(0.020)
2 close friends use an online social network	1.416***	0.301***
	(0.086)	(0.018)
3 close friends use an online social network	1.797***	0.382***
	(0.086)	(0.018)
4 close friends use an online social network	2.205***	0.469***
	(0.110)	(0.023)
5 close friends use an online social network	3.073***	0.654***
	(0.072)	(0.015)
_cons	-3.119***	
	(0.250)	
Number of observations	16,591	16,591
R2		
Adjusted R2	0.466	0.466

Note: *** p<0.01, ** p<0.05, * p<0.1.

1.6 Robustness Check

To evaluate the validity of the model, a Hosmer–Lemeshow goodness-of-fit test is conducted after the estimation. Given the large number of observations, the test is

conducted with 100 groups. A p-value of 0.7387 of the Pearson chi-square from the Hosmer and Lemeshow's goodness-of-fit test indicates that the model fits the data well. To detect if any potential observations have a significant impact on the model, model (1) is retested by excluding observations with Pearson residual value more than 2, deviance residual value more than 2, and leverage value more than 3 times the average leverage. The sign and significance of the coefficient of the social network effect on individual's mobile internet adoption is still retained after excluding those observations.

Considering that different subgroups of population may have different levels of reliance on social network, interaction effects between demographic features (e.g., gender, age, marital status and location of residence) of an individual and individual's social network are included in the analysis (table 1.7). The social network effects remain positively significant after taking into account of the interaction terms. Results show that the coefficients on the interaction terms between female and social network, and marital status and social network are insignificant, implying that dependence of friendship social network between men and women, and married and single people don't differ significantly. Interaction term between urban residence and social network is negative and significant at 10% level, implying that rural residents tend to have a higher level of reliance on close friends. This may be because entrenched social isolation challenges for rural residents, due to limited public transportation and digital access (Rockenbauch and Sakdapolrak, 2017). Therefore, they tend to be more heavily reliant on close friendship compared to urban residents who usually have a larger size of social network. Interaction terms between age groups and social network are negative and significant. Young people in general are more likely to be affected by conformity, showing herd instinct. A dummy variable measuring if

an individual has any close friend using online social network (converted from the categorical variable the number (up to 5) of the respondents' closest friends who use an online social network) is used in the analysis. Results between demographic features and categorical variable of the social network effect are shown in Annex 1.2.

Table 1.7. Logit regression results with interaction terms included

Model	Logit			
	Mobile internet adoption			
	Gender interaction	**Marital status interaction**	**Location of residence interaction**	**Age interaction**
	Coefficient	**Coefficient**	**Coefficient**	**Coefficient**
Infrastructure factors				
Household 3G network coverage	0.237***	0.236***	0.236***	0.236***
	(0.081)	(0.081)	(0.082)	(0.081)
Household having access to electricity	0.882***	0.882***	0.882***	0.880***
	(0.109)	(0.109)	(0.109)	(0.110)
Social-economic factors				
Female	-0.304***	-0.168***	-0.168***	-0.166***
	(0.097)	(0.042)	(0.042)	(0.042)
Age group (middle age, 30-60)	-0.750***	-0.748***	-0.749***	-0.577***
	(0.046)	(0.046)	(0.046)	(0.104)
Age group (old people, >60)	-2.166***	-2.162***	-2.165***	-1.806***
	(0.106)	(0.106)	(0.106)	(0.201)
Log value of monthly income	0.229***	0.229***	0.228***	0.229***
	(0.018)	(0.018)	(0.018)	(0.018)
Married	-0.207***	-0.121	-0.205***	-0.202***
	(0.047)	(0.102)	(0.047)	(0.047)
Urban	0.458***	0.458***	0.616***	0.457***
	(0.044)	(0.044)	(0.099)	(0.044)
Years of formal education (less than 6)	0.615***	0.619***	0.614***	0.619***
	(0.124)	(0.124)	(0.124)	(0.124)
Years of formal education (6-12)	1.635***	1.640***	1.633***	1.640***
	(0.118)	(0.118)	(0.118)	(0.118)
Years of formal education (12-16)	2.579***	2.584***	2.579***	2.583***
	(0.124)	(0.124)	(0.124)	(0.124)

Years of formal education (>16)	2.755***	2.763***	2.760***	2.759***
	(0.137)	(0.137)	(0.137)	(0.137)
Social network effects				
Has close friend using an online social network	2.183***	2.323***	2.378***	2.401***
	(0.076)	(0.085)	(0.086)	(0.087)
Interaction terms				
Female x Social network	0.164			
	(0.106)			
Married x Social network		-0.102		
		(0.109)		
Urban x Social network			-0.195*	
			(0.109)	
Age group (middle age, 30-60) x Social network				-0.208*
				(0.112)
Age group (old people, >60) x Social network				-0.446**
				(0.226)
_cons	-4.244***	-4.365***	-4.391***	-4.422***
	(0.227)	(0.233)	(0.229)	(0.233)
Number of observations	19,979	19,979	19,979	19,979
R2				
Adjusted R2	0.412	0.412	0.412	0.412

Note: *** p<0.01, ** p<0.05, * p<0.1.

However, the model contains potential endogeneity issues. One strategy adopted is accounting for as many factors as possible to limit the issue of omitted variable bias. Relevant variables that affect mobile internet adoption, from different aspects of infrastructure (e.g. 3G coverage and household electricity availability) and socio-economic elements such as gender, age, location, married status etc. are all included. Given the cross-sectional nature of the data, concerns of simultaneity bias between mobile internet adoption and social network factors cannot be fully obviated. Those who have adopted mobile internet may have developed a comprehensive online social network in which contains

their close friends or make friends that are becoming close. The reflection concern surfaces, as individuals within a social network act similarly may reflect the underlying reasons for joining the network such as facing similar environment or sharing similar individual characteristics, rather than the effect of the network itself. However, information such as the composition of an individual's closest friends' circle, how such network is formed and how the friends interact, is not available, therefore it is difficult to fully resolve the reflection issue. Coefficients and marginal effects therefore should be interpreted with caution. Though it is insufficient to draw causal inference from the results, the positive relationship between social network and mobile internet adoption is identified and future of research could consider collecting richer information on the network itself to probe the mechanisms through which the network affects individuals' behaviors.

1.7 Conclusion

As digital technologies penetrate various aspects of social and economic life, having access to affordable and reliable internet becomes essential for individuals to stay connected with their social networks, efficiently engage in online economic activities, and better receive public services. The United Nations Sustainable Development Goals set the target (9.c) to "significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020." A better understanding of key drivers and main constraints for internet access is the first prerequisite for governments to design targeted policy solutions.

Results from the study show that social network effects are positively related to mobile internet adoption. Those who have more close friends using an online social network are

more likely to adopt mobile internet. Individuals whose five closest friends are using an online social network (e.g., Facebook, Twitter) are 66.1 percent more likely to adopt mobile internet than those without any close friends using such online social network sites/apps. Such relationship is present across all regions and is particularly salient in Africa. Collaborating with different firms across social media platforms to leverage these positive social network effects is one route to reduce the digital divide in mobile internet connections. Admittedly due to data limitation to completely address potential endogeneity issues, the results shall be interpreted with caution. Future research can try to collect more information regarding the composition of social network such as attributes of close friends, and how friends interact, in order to further test the causal inference.

The estimated marginal effects of social network are higher than those of other demographic variables, such as gender, marital status, location of residence, age etc., implying that social network may matter more than social structure in adopting mobile internet. Different types of social network exhibit different levels of association with the mobile internet adoption. Both friendship and family relationships matter in individual's decision regarding mobile internet adoption. The impact from family members is at a higher level when an individual only has 3 or less close friends adopting the mobile internet; however when more than 3 close friends use an online social network, the impacts from friendship is more significant. This also indicates that size of social network matters in mobile internet adoption.

Moreover, besides infrastructure investment, which has been the main focus of many developing countries, other demand-side factors are of critical importance with regards to mobile internet adoption. Across the developing world, females, the elderly, those who live

in rural areas, and those who have a relatively low level of income or education are less likely to adopt mobile internet. Therefore, policy measures targeted at reducing gender inequality and the urban/rural divide could support wider adoption of mobile internet. Enhancing education levels to increase people's awareness of the benefits of being digitally connected could also positively affect mobile internet adoption. Among infrastructure factors, having access to electricity at the household level is significantly associated with mobile internet adoption, particularly owning an internet-enabled phone. 3G network coverage remains to be a significant factor, especially in Asia.

Lastly, income is a strong driver of mobile internet adoption in its own right. Moreover, the high cost of smartphones and mobile data packages negatively affects the adoption of mobile internet. It is estimated that if a country's average cost for 1 GB of mobile data is more than 2 percent of an individual's monthly income, that individual is 5 percent less likely to adopt mobile internet. If the country's average cost of an internet-enabled phone is more than the individual's monthly income, that individual is 4 percent less likely to adopt mobile internet. This implies the necessity to create a competitive market with multiple players offering data packages at affordable prices, and to take measures to reduce the retail cost of smart phones.

The results offer insights for policy interventions to reduce digital divide. Instead of only focusing on the supply side of deploying and expanding connectivity infrastructure, governments shall gear towards addressing demand side constraints in order to increase the uptake of mobile internet. About 3.2 billion people, equivalent to 40% of global population live in areas that are covered by mobile broadband network but still are not online due to demand side constraints such as digital literacy, affordability to both digital devices and

data packages, availability of local content, concerns on data privacy and cybersecurity (GSMA, 2022). Social network effects also have great potential in promoting the uptake as people's perspectives tend to be shaped by daily social interactions with friends, family members, colleagues etc., therefore community-based programs often can yield good results. For instance, in Rwanda, through an NGO Digital Opportunity Trust (DOT), 6000 local youth helped enhance digital literacy of more than 41,000 people in their communities. More and more social media companies are also joining the force to enhance connectivity. Some provide free data, often in the way of watching digital advertisement to cover gap between two payments of data package. Facebook's "Free Basics" service provides users with "free access to communication tools, health information, education resources and other low-bandwidth services" in developing countries like Indonesia, the Philippines, and Pakistan. The inclination to stay connected with friends and family members on social media platforms, could potentially incentivize individuals to get onto the internet. In addition, given there have been rising concerns about content on social media as well as potential data privacy risks. Regulatory environment that leverages the positive effects of social media and social network but addresses risks such as data privacy and cybersecurity is needed. Potential future research can further examine the impact of regulatory environment, such as content regulation, personal data protection, cybersecurity and cybercrime on mobile internet adoption in developing countries.

Annexes

Annex 1.1. Survey methodology

Though the three think tanks, including RIA (Research ICT Africa), LIRNEasia (Learning Initiative for Network Economies in Asia), and DIRSI (el Diálogo Regional sobre la Sociedad de la Información / Regional Dialogue on the Information Society), conducted the survey separately in 2017/2018. They adopted the same questionnaire and sampling methodology. The random sampling is based on Census sample. A Census divides a country in Enumerator Areas (EAs) which roughly have a household density of 200. Households were sampled using simple random sample for each selected EA. From all household members 15 years or older or visitor staying the night at the house was randomly selected based on simple random sampling. The desired level of accuracy for the survey was set to a confidence level of 95% and a margin of error of 5%, which yields a minimum sample size per tabulation group of 385. Weights at household level and individual level are calculated based on the inverse selection probabilities and gross up the data to national level when applied.

Annex 1.2. Results with interaction terms included

Model	Logit			
	Mobile internet adoption			
	Gender interaction	**Marital status interaction**	**Location of residence interaction**	**Age interaction**
	(1)	**(2)**	**(3)**	**(4)**
Infrastructure factors				
Household 3G network coverage	0.185**	0.190**	0.181**	0.189**
	(0.085)	(0.085)	(0.086)	(0.085)
Household having access to electricity	0.759***	0.760***	0.756***	0.760***
	(0.110)	(0.110)	(0.111)	(0.111)
Social-economic factors				
Female	-0.272***	-0.142***	-0.141***	-0.139***
	(0.095)	(0.044)	(0.044)	(0.044)
Age group (middle age, 30-60)	-0.696***	-0.695***	-0.695***	-0.507***
	(0.049)	(0.048)	(0.048)	(0.101)
Age group (old people, >60)	-1.981***	-1.985***	-1.984***	-1.574***
	(0.109)	(0.109)	(0.108)	(0.197)

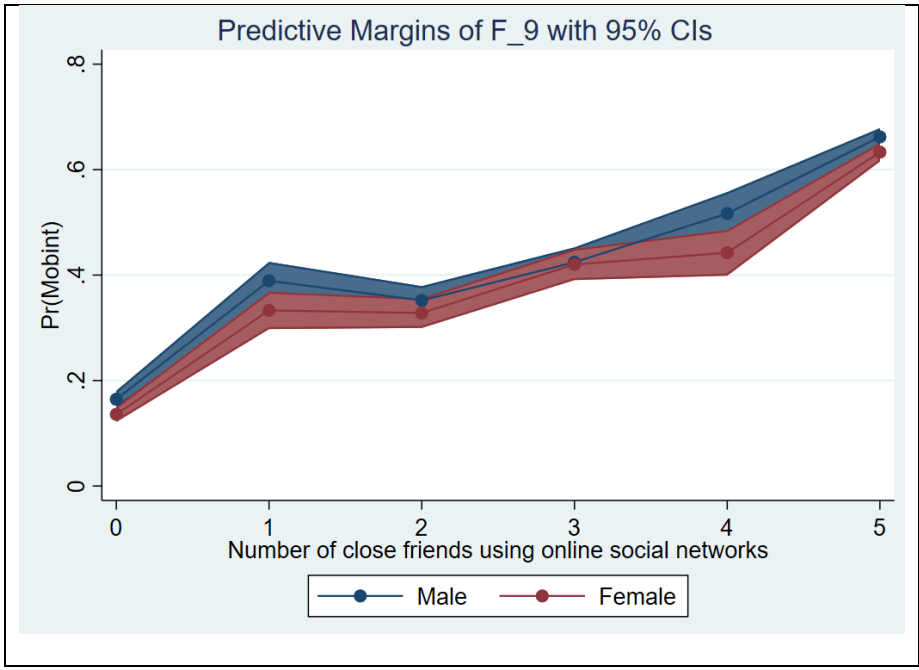
Log value of monthly income	0.196***	0.195***	0.194***	0.196***
	(0.018)	(0.018)	(0.018)	(0.018)
Married	-0.138***	-0.162	-0.135***	-0.129***
	(0.049)	(0.100)	(0.049)	(0.049)
Urban	0.379***	0.378***	0.632***	0.379***
	(0.046)	(0.046)	(0.097)	(0.046)
Years of formal education (less than 6)	0.670***	0.674***	0.672***	0.685***
	(0.124)	(0.124)	(0.124)	(0.124)
Years of formal education (6-12)	1.598***	1.602***	1.597***	1.606***
	(0.117)	(0.118)	(0.118)	(0.118)
Years of formal education (12-16)	2.382***	2.387***	2.383***	2.391***
	(0.125)	(0.125)	(0.125)	(0.125)
Years of formal education (>16)	2.540***	2.551***	2.548***	2.549***
	(0.139)	(0.139)	(0.139)	(0.138)
Social network effects				
1 close friend uses an online social network	1.464***	1.497***	1.461***	1.742***
	(0.120)	(0.132)	(0.145)	(0.129)
2 close friends use an online social network	1.257***	1.266***	1.608***	1.439***
	(0.103)	(0.115)	(0.117)	(0.115)
3 close friends use an online social network	1.655***	1.829***	2.060***	1.883***
	(0.103)	(0.116)	(0.123)	(0.116)
4 close friends use an online social network	2.147***	2.057***	2.351***	2.088***
	(0.130)	(0.138)	(0.156)	(0.140)
5 close friends use an online social network	2.957***	3.026***	3.209***	3.250***
	(0.084)	(0.092)	(0.099)	(0.097)
Interaction terms				
Female x 1 close friend using an online social network	-0.018			
	(0.174)			

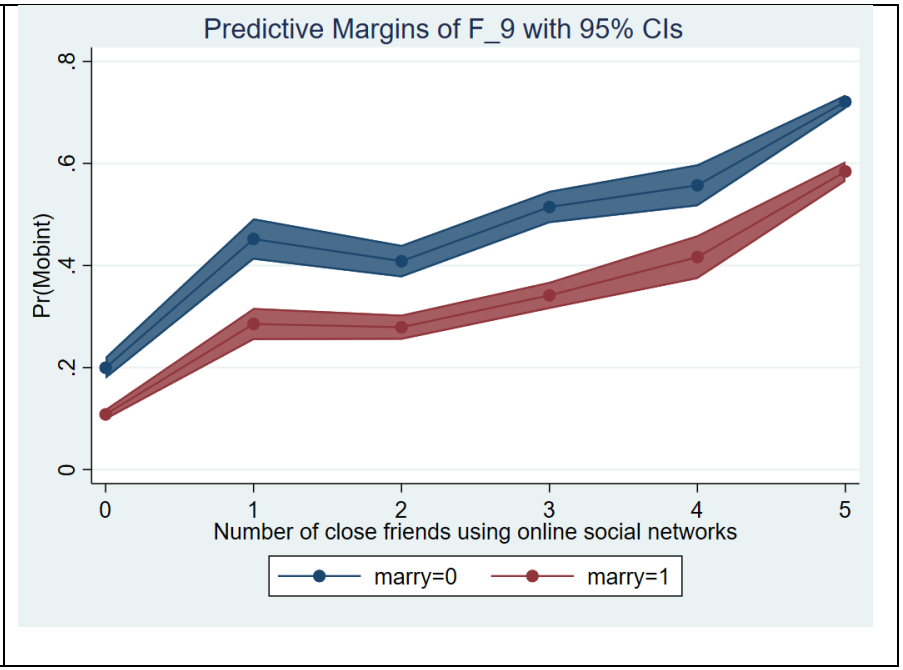
Female x 2 close friends using an online social network	0.161		
	(0.149)		
Female x 3 close friends using an online social network	0.292**		
	(0.148)		
Female x 4 close friends using an online social network	-0.078		
	(0.190)		
Female x 5 close friends using an online social network	0.188		
	(0.116)		
Married x 1 close friend using an online social network		-0.069	
		(0.176)	
Married x 2 close friends using an online social network		0.123	
		(0.151)	
Married x 3 close friends using an online social network		-0.069	
		(0.150)	
Married x 4 close friends using an online social network		0.116	
		(0.189)	
Married x 5 close friends using an online social network		0.040	
		(0.118)	
Urban x 1 close friend using an online social network			-0.024
			(0.182)
Urban x 2 close friends using an online social network			-0.462***
			(0.151)
Urban x 3 close friends using an online social network			-0.450***
			(0.153)

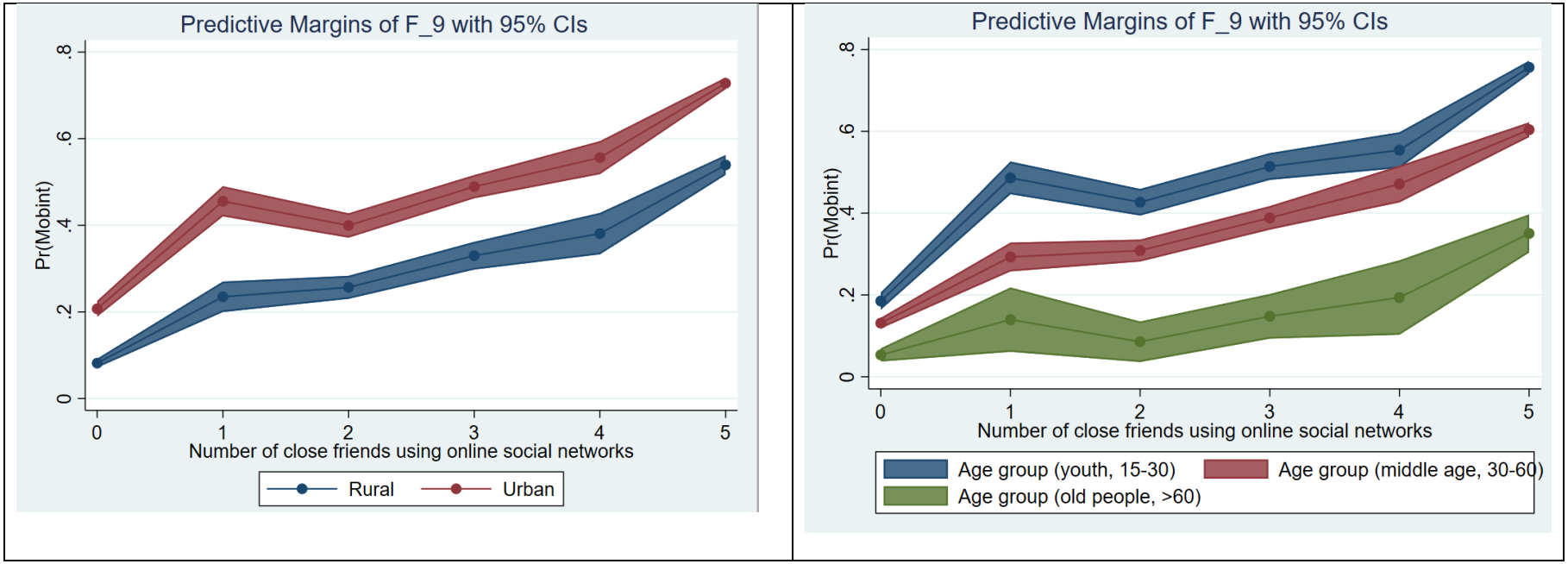
Urban x 4 close friends using an online social network	-0.394**	
	(0.195)	
Urban x 5 close friends using an online social network	-0.274**	
	(0.120)	
Age group (middle age, 30-60) x 1 close friend using an online social network		-0.515***
		(0.180)
Age group (middle age, 30-60) x 2 close friends using an online social network		-0.117
		(0.154)
Age group (middle age, 30-60) x 3 close friends using an online social network		-0.106
		(0.153)
Age group (middle age, 30-60) x 4 close friends using an online social network		0.133
		(0.193)
Age group (middle age, 30-60) x 5 close friends using an online social network		-0.320***
		(0.121)
Age group (old people, >60) x 1 close friend using an online social network		-0.530
		(0.460)
Age group (old people, >60) x 2 close friends using an online social network		-0.875**
		(0.426)
Age group (old people, >60) x 3 close friends using an online social network		-0.591*
		(0.343)
Age group (old people, >60) x 4 close friends using an online social network		-0.391
		(0.438)

Age group (old people, >60) x 5 close friends using an online social network				-0.489**
				(0.246)
_cons	-4.222***	-4.276***	-4.410***	-4.415***
	(0.227)	(0.235)	(0.230)	(0.234)
Number of observations	19,979	19,979	19,979	19,979
R2				
Adjusted R2	0.448	0.448	0.448	0.449

Note: *** p<0.01, ** p<0.05, * p<0.1.







Annex 1.3. Mobile Phone Ownership (%)

Country	Male	Female	Rural	Urban	Elderly	Young	Non-poor	Poor	No formal education	Years of formal education (less than 6)	Years of formal education (6–12)	Years of formal education (12–16)	Total
Argentina	84	87	94	86	81	92	85	86	51	59	85	93	86
Bangladesh	87	58	72	78	71	75	78	64	62	70	80	97	74
Cambodia	78	62	64	81	64	71	76	56	41	63	78	90	68
Colombia	89	90	84	92	90	89	92	87	61	84	90	95	90
Ecuador	84	83	78	86	84	82	82	85	44	73	83	84	83
Ghana	81	67	62	84	72	75	84	58	52	70	80	90	74
Guatemala	90	82	85	87	83	88	89	81	75	80	88	96	86
India	79	43	55	71	59	62	67	47	37	57	67	86	61
Kenya	92	83	85	93	88	86	93	79	58	76	84	98	87

Lesotho	80	78	72	87	74	83	82	74	49	64	82	92	79
Mozambique	50	32	33	55	43	39	57	16	22	33	60	93	40
Nepal	80	65	65	76	64	78	70	82	n.a.	75	85	96	72
Nigeria	70	57	54	78	67	61	74	48	25	56	77	93	63
Pakistan	68	43	56	59	64	53	74	33	39	59	74	87	57
Paraguay	89	85	81	90	84	91	92	80	66	78	91	98	87
Peru	86	80	80	83	81	83	88	76	n.a.	66	80	90	82
Rwanda	60	37	45	61	51	46	63	28	23	47	62	92	48
Senegal	81	74	72	84	76	79	82	71	67	86	82	96	78
South Africa	83	85	80	86	85	83	85	82	62	74	84	97	84
Sri Lanka	86	72	77	84	76	82	85	67	32	57	77	94	78
Tanzania	64	53	51	74	63	55	75	33	26	41	62	93	59
Uganda	58	40	44	64	54	46	66	24	23	41	50	89	49
Total	78	50	58	73	64	64	71	50	39	59	71	89	64

Annex 1.4. Smartphone (%)

Country	Male	Female	Rural	Urban	Elderly	Young	Non-poor	Poor	No formal education	Years of formal education (less than 6)	Years of formal education (6–12)	Years of formal education (12–16)	Total
Argentina_3g	100	100	100	100	100	100	100	100	100	100	100	100	100
Argentina_smartphone ownership	62	66	74	64	52	79	60	70	13	23	62	77	64
Argentina_smartphone uptake	62	66	74	64	52	79	60	70	13	23	62	77	64
Bangladesh_3g	97	96	97	96	97	96	96	98	94	98	97	100	97
Bangladesh_smartphone ownership	22	12	16	21	10	23	19	14	4	10	25	47	17
Bangladesh_smartphone uptake	23	12	16	21	10	23	19	14	5	10	25	47	18
Cambodia_3g	80	82	81	82	78	84	81	81	86	80	81	76	81
Cambodia_smartphone ownership	40	28	28	48	19	46	39	24	9	19	48	73	33
Cambodia_smartphone uptake	42	30	29	49	20	47	40	25	9	20	50	75	34
Colombia_3g	99	100	100	100	100	100	100	100	97	99	100	100	100
Colombia_smartphone ownership	56	57	50	60	42	69	64	48	3	25	60	81	57

Colombia_smartphone uptake	56	57	50	60	43	69	64	48	3	25	60	81	57
Ecuador_3g	94	95	87	99	94	96	95	96	100	93	94	96	95
Ecuador_smartphone ownership	65	59	57	64	47	71	61	62	0	31	62	75	61
Ecuador_smartphone uptake	65	59	55	64	47	71	61	62	0	30	61	74	61
Ghana_3g	73	83	54	98	79	78	85	69	70	81	77	91	78
Ghana_smartphone ownership	29	22	16	33	16	32	32	16	4	9	27	60	25
Ghana_smartphone uptake	33	26	19	34	20	36	35	17	5	7	32	60	29
Guatemala_3g	97	98	96	99	98	97	98	96	99	97	98	97	97
Guatemala_smartphone ownership	56	39	45	49	28	62	47	47	17	30	55	72	47
Guatemala_smartphone uptake	56	39	45	49	28	61	47	47	17	29	55	72	47
India_3g	93	95	95	91	94	94	94	94	95	96	92	94	94
India_smartphone ownership	25	10	11	28	9	24	20	11	1	8	19	53	17
India_smartphone uptake	25	10	11	28	9	24	20	11	1	8	19	54	17
Kenya_3g	76	69	65	92	68	74	77	64	37	69	68	82	72
Kenya_smartphone ownership	29	20	14	51	15	30	33	11	1	3	12	44	24
Kenya_smartphone uptake	33	23	16	50	17	33	35	15	2	4	16	44	28
Lesotho_3g	74	73	77	63	76	71	72	75	74	73	73	72	73
Lesotho_smartphone ownership	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Lesotho_smartphone uptake	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mozambique_3g	93	94	94	93	93	94	94	94	93	94	95	86	94
Mozambique_smartphone ownership	9	5	2	17	4	8	10	2	0	1	16	49	7
Mozambique_smartphone uptake	9	4	2	16	4	8	10	2	0	1	15	50	7
Nepal_3g	98	95	96	97	96	97	96	98	n.a.	95	97	97	97
Nepal_smartphone ownership	44	31	30	41	21	50	37	40	n.a.	23	53	79	37
Nepal_smartphone uptake	45	31	30	42	22	50	37	41	n.a.	24	54	80	38
Nigeria_3g	72	73	58	94	72	72	73	71	46	72	83	84	72
Nigeria_smartphone ownership	18	11	9	23	12	16	16	12	1	1	17	36	15
Nigeria_smartphone uptake	22	14	12	23	14	20	20	14	1	1	19	35	18
Pakistan_3g	93	92	92	94	93	92	94	91	93	97	88	91	93
Pakistan_smartphone ownership	14	11	9	19	15	11	17	7	3	10	21	50	13

Pakistan_smartphone uptake	14	10	8	20	15	11	17	7	3	11	21	53	13
Paraguay_3g	88	88	75	96	87	89	90	85	77	84	90	94	88
Paraguay_smartphone ownership	51	53	37	61	36	77	59	44	11	23	69	87	52
Paraguay_smartphone uptake	54	54	37	62	38	78	60	46	15	24	69	88	54
Peru_3g	99	99	97	100	99	100	99	99	n.a.	98	99	99	99
Peru_smartphone ownership	52	48	30	55	36	61	54	44	n.a.	12	48	61	49
Peru_smartphone uptake	52	48	29	55	36	61	54	44	n.a.	11	48	61	49
Rwanda_3g	100	100	100	100	100	100	100	100	100	100	100	100	100
Rwanda_smartphone ownership	5	3	1	16	3	5	7	1	1	1	4	53	4
Rwanda_smartphone uptake	5	3	1	16	3	5	7	1	1	1	4	53	4
Senegal_3g	80	83	77	87	81	82	85	77	81	81	80	83	82
Senegal_smartphone ownership	29	17	17	30	15	31	27	18	8	18	29	64	23
Senegal_smartphone uptake	31	20	20	32	17	33	29	21	9	21	31	69	26
South Africa_3g	89	89	86	90	89	89	90	87	88	81	89	94	89
South Africa_smartphone ownership	50	44	33	54	38	56	46	47	13	12	48	78	47
South Africa_smartphone uptake	51	46	33	56	39	57	49	47	14	10	50	78	48
Sri Lanka_3g	100	100	100	100	100	100	100	100	100	100	100	100	100
Sri Lanka_smartphone ownership	45	30	35	45	23	57	42	28	3	6	33	62	37
Sri Lanka_smartphone uptake	45	31	34	47	22	58	42	30	4	7	32	62	37
Tanzania_3g	98	97	96	100	97	97	98	96	87	96	99	100	97
Tanzania_smartphone ownership	15	11	5	29	8	16	19	4	0	1	10	71	13
Tanzania_smartphone uptake	16	11	5	29	8	17	19	4	0	2	10	71	13
Uganda_3g	90	94	92	95	94	91	92	92	94	92	92	91	92
Uganda_smartphone ownership	9	7	3	23	5	10	12	2	0	1	6	36	8
Uganda_smartphone uptake	9	7	3	24	4	11	12	2	0	1	6	36	8
Total_3g	91	92	91	93	92	91	92	91	89	94	92	93	92
Total_smartphone ownership	25	15	13	32	13	25	23	14	2	8	23	54	20
Total_smartphone uptake	25	15	13	32	13	25	23	15	2	9	23	55	20

Note: Smartphone ownership reflects the ownership rate of the entire population. The uptake rate refers to the ownership rate for the subpopulation covered by 3G. "_3g" stands for the 3G coverage rate.

Annex 1.5. Internet Usage Ratio

Internet Usage by Country and Subgroup

Country	Total	Male	Female	Rural	Urban	Elderly	Young	No formal education	Years of formal education (less than 6)	Years of formal education (6–12)	Years of formal education (12–16)
Argentina	79	80	78	79	79	66	96	9	29	79	93
Bangladesh	13	18	7	11	19	6	18	2	4	20	47
Cambodia	40	47	34	34	57	21	56	6	21	57	85
Colombia	77	77	78	72	80	58	94	8	38	88	98
Ecuador	80	85	77	76	82	61	93	19	40	84	94
Ghana	26	31	21	15	35	13	36	1	9	29	63
Guatemala	62	70	55	58	66	36	81	17	33	78	92
India	19	26	11	14	27	8	28	1	8	22	56
Kenya	26	31	21	16	53	13	34	1	3	15	46
Lesotho	32	36	31	18	54	13	52	2	3	31	83
Mozambique	23	26	20	9	44	16	26	3	5	33	60
Nepal	45	43	50	34	51	23	60	0	20	51	83
Nigeria	29	37	20	20	41	19	35	0	4	37	69
Pakistan	17	21	12	16	18	10	20	2	24	24	55
Paraguay	57	55	58	40	67	39	84	11	26	77	90
Peru	71	77	68	46	78	50	90	0	17	70	88
Rwanda	39	46	29	28	59	39	39	75	14	43	69
Senegal	30	33	26	21	39	15	43	7	25	41	83
South Africa	71	74	68	61	75	62	77	31	37	69	90
Sri Lanka	37	45	30	35	45	20	62	3	6	31	67
Tanzania	31	32	29	13	55	22	34	2	4	22	81
Uganda	45	44	46	39	54	30	50	0	17	40	64

Annex 1.6. Mobile Internet Adoption and Uptake Rates by Country and Subgroup

Country	Male	Female	Rural	Urban	Elderly	Young	Non-poor	Poor	No formal education	Years of formal education (less than 6)	Years of formal education (6–12)	Years of formal education (12–16)	Total
Argentina_3g	100	100	100	100	100	100	100	100	100	100	100	100	100
Argentina_mobile internet	73	73	78	73	59	92	68	81	9	22	73	88	73
Argentina_mobile internet_uptake	73	73	78	73	59	92	68	81	9	22	73	88	73
Bangladesh_3g	97	96	97	96	97	96	96	98	94	98	97	100	97
Bangladesh_mobile internet	17	7	11	18	6	17	14	9	2	4	19	45	13
Bangladesh_mobile internet_uptake	18	7	11	18	6	18	14	9	2	4	19	45	13
Cambodia_3g	80	82	81	82	78	84	81	81	86	80	81	76	81
Cambodia_mobile internet	39	25	25	46	15	46	36	22	5	16	47	75	31
Cambodia_mobile internet_uptake	41	27	27	47	15	47	37	24	5	17	49	79	32
Colombia_3g	99	100	100	100	100	100	100	100	97	99	100	100	100
Colombia_mobile internet	66	68	61	71	49	86	74	60	8	28	75	92	68
Colombia_mobile internet_uptake	67	68	61	71	49	86	74	60	9	29	75	92	68
Ecuador_3g	94	95	87	99	94	96	95	96	100	93	94	96	95
Ecuador_mobile internet	78	71	69	76	54	89	73	75	0	33	77	91	74
Ecuador_mobile internet_uptake	79	71	69	76	54	89	73	75	0	34	76	91	74
Ghana_3g	73	83	54	98	79	78	85	69	70	81	77	91	78
Ghana_mobile internet	27	19	13	32	12	32	27	17	1	9	25	58	23
Ghana_mobile internet_uptake	32	22	14	32	14	36	30	19	1	8	28	60	27
Guatemala_3g	97	98	96	99	98	97	98	96	99	97	98	97	97
Guatemala_mobile internet	64	47	52	58	30	74	54	56	14	29	70	85	55
Guatemala_mobile internet_uptake	64	47	52	58	31	74	54	56	15	29	70	84	55
India_3g	93	95	95	91	94	94	94	94	95	96	92	94	94
India_mobile internet	22	8	10	24	7	22	18	9	1	5	17	51	15

India_mobile internet_uptake	23	8	10	25	7	22	18	9	1	6	16	53	15
Kenya_3g	76	69	65	92	68	74	77	64	37	69	68	82	72
Kenya_mobile internet	30	19	15	50	12	32	32	13	1	3	13	45	24
Kenya_mobile internet_uptake	35	23	18	50	15	37	36	17	2	5	16	48	29
Lesotho_3g	74	73	77	63	76	71	72	75	74	73	73	72	73
Lesotho_mobile internet	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Lesotho_mobile internet_uptake	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mozambique_3g	93	94	94	93	93	94	94	94	93	94	95	86	94
Mozambique_mobile internet	20	16	6	36	12	19	22	8	2	3	26	55	18
Mozambique_mobile internet_uptake	20	15	6	35	12	19	22	7	2	3	25	57	17
Nepal_3g	98	95	96	97	96	97	96	98		95	97	97	97
Nepal_mobile internet	39	27	25	37	16	45	32	35		14	48	77	32
Nepal_mobile internet_uptake	40	27	25	38	17	46	33	35		15	49	79	33
Nigeria_3g	72	73	58	94	72	72	73	71	46	72	83	84	72
Nigeria_mobile internet	33	16	15	37	16	29	27	20	0	3	31	62	24
Nigeria_mobile internet_uptake	41	20	22	38	21	36	33	26	0	4	33	65	30
Pakistan_3g	93	92	92	94	93	92	94	91	93	97	88	91	93
Pakistan_mobile internet	15	7	10	14	10	13	16	5	1	13	17	52	12
Pakistan_mobile internet_uptake	17	8	11	15	10	14	17	6	1	14	19	57	12
Paraguay_3g	88	88	75	96	87	89	90	85	77	84	90	94	88
Paraguay_mobile internet	53	56	38	64	37	81	62	45	11	24	73	89	55
Paraguay_mobile internet_uptake	55	58	38	65	39	83	63	47	15	25	74	91	57
Peru_3g	99	99	97	100	99	100	99	99		98	99	99	99
Peru_mobile internet	65	60	35	70	42	81	68	53		11	61	77	62
Peru_mobile internet_uptake	66	60	36	70	42	81	69	54		12	61	78	62
Rwanda_3g	100	100	100	100	100	100	100	100	100	100	100	100	100
Rwanda_mobile internet	31	24	16	50	32	26	35	11	18	8	28	65	28

Rwanda_mobile internet_uptake	31	24	16	50	32	26	35	11	18	8	28	65	28
Senegal_3g	80	83	77	87	81	82	85	77	81	81	80	83	82
Senegal_mobile internet	30	24	19	37	14	40	29	25	7	22	35	82	27
Senegal_mobile internet_uptake	32	27	21	38	16	42	31	26	7	26	36	85	29
South Africa_3g	89	89	86	90	89	89	90	87	88	81	89	94	89
South Africa_mobile internet	68	60	51	69	56	69	65	62	20	33	60	84	64
South Africa_mobile internet_uptake	69	61	50	70	57	70	66	62	21	26	61	85	65
Sri Lanka_3g	100	100	100	100	100	100	100	100	100	100	100	100	100
Sri Lanka_mobile internet	41	24	29	39	17	55	36	23	2	4	26	59	31
Sri Lanka_mobile internet_uptake	41	24	29	39	15	56	35	24	4	6	24	60	31
Tanzania_3g	98	97	96	100	97	97	98	96	87	96	99	100	97
Tanzania_mobile internet	29	27	12	50	20	31	37	8	2	4	20	77	28
Tanzania_mobile internet_uptake	29	27	12	50	20	31	37	8	2	4	20	77	28
Uganda_3g	90	94	92	95	94	91	92	92	94	92	92	91	92
Uganda_mobile internet	30	38	22	47	24	37	40	15	0	4	25	56	33
Uganda_mobile internet_uptake	30	39	22	48	22	39	41	16	0	5	27	55	34
Total_3g	91	92	91	93	92	91	92	91	89	94	92	93	92
Total_mobile internet	26	14	12	32	11	26	22	15	1	7	23	57	20
Total_mobile internet_uptake	26	14	13	32	12	27	23	15	1	7	23	59	20

Note: Mobile internet reflects the adoption rate of the entire population. The uptake rate refers to the adoption rate for the subpopulation covered by 3G. "_3g" stands for the 3G coverage rate.

Chapter 2: Can gig economy promote women economic empowerment in developing countries?

2.1 Introduction

Gig economy, a recent buzz term, is a collection of markets that match service providers to consumers on a gig (or job) basis, through internet-based technology platforms or smartphone applications. It is an extension of the long-standing on-demand commerce, enabled by penetration of internet connectivity and smartphone ownership (Abraham et al., 2018; Donovan et al., 2016; Woodcock and Graham, 2020). It consists of work that is transacted through digital platforms but delivered locally such as transport and food delivery, as well as remote work such as data entry (Wood et al., 2018). By efficiently matching service providers and consumers, it has great potential in reducing frictions in labor market, offering more job opportunities and improving welfare of people at the economic peripheries (Graham et al., 2017; Hunt and Samman, 2019; Kuek et al., 2015).

In particular, gig economy appears to address pain points that have historically constrained women's participation in labor market to achieve economic independence, such as social norms to be the unpaid care provider at home, or gender-based discrimination on hiring, compensation and career development (Cook et al., 2020; Hunt and Samman, 2019; Kasliwal, 2020; Liang et al., 2018). Flexibility on working time and location is argued to enable women to fit gig work into an unpredictable housework schedule. Gender-blind algorithm when matching service providers and consumers on a gig platform has potential to reduce the chance of gender-based discrimination as observed in traditional hiring. Moreover, gender-based differential compensation becomes impractical as the online interactions can be anonymized and the pay structure is often only tied to output (e.g.

deliver one item or complete one task online). Nevertheless, the picture is not guaranteed rosy. The cost to take up gigs (e.g. purchasing a smartphone and the associated data consumption) may overweigh the income earned, especially considering that many women in developing countries do not possess valuables such as computer or smartphone and extra efforts and costs are needed to gain access. Algorithmic control such as bidding among workers creates downward pressure on pay rates, which may further exacerbate the situation of income falling short of costs (Wood et al., 2018). Women who are often obedient, may easily fall victims to such algorithmic management unconsciously. Taking into account of both the positive potential of providing job opportunities and overcoming motherhood penalty in career development, and the unpredictability of costs and complexity in engaging in gig economy activities, this paper aims to examine whether gig economy could be an avenue for women economic empowerment by answering the following questions: 1) Is there a gender discrimination in accessing gig economy opportunities? 2) Whether and to what extent participating in gig economy help improve disposable income of female in developing countries?

Existing quantitative studies on gig economy and gender largely rely on administrative data from different gig platforms in developed countries, to understand different motivations of men and women in participating in gig economy, and examine whether and to what extent there is a wage gap in the gig economy. Churchill and Craig (2019) find that though income was the primary driver for both men and women to participate in the gig economy in Australia, flexibility to fit around non-work schedule is another important reason for women. Using ridesharing data from Uber in the United States, Cook et al. (2020) find a 7% gender earnings gap among drivers, due to experience on the platform

and other gender-related difference in preference on driving speed and driving location. Using data from Amazon Mechanical Turk, a leading gig work platform, Liang et al. (2018) show that women only earn 81.4% of the hourly wage of male, which partially can be attributed to gender differences in job application strategy.

However, women's participation in gig economy in developing countries, especially from the angle of women economic empowerment, remains largely unexplored systematically and quantitatively. Using a household survey conducted in 2017/2018 by Research ICT (Information and Communications Technology) Africa, an ICT policy think tank, this paper finds that women are not particularly disadvantaged in accessing gig opportunities in general. However, those who have access to the digital infrastructure are more likely to participate in the gig economy. Given the wide digital divide among men and women in the developing world, ensuring access to digital devices becomes among the first requisites for women to take advantage of new job opportunities in the gig economy. Moreover, using a propensity score matching method, the analysis finds that both male and female are benefiting from participating in the gig economy. The direct effect of gig economy participation on individual's disposable income is 38.408 USD per month in African countries. The positive effects are much more significant for female, as the disposable income of the female gig economy participants almost doubled that of females who are not participating in the gig economy. This shows the great potential of gig economy in increasing women's capacity in securing income. It is worth noting that though gig economy participation is positively associated with increased disposable income for both men and women, it is only positively related to women's contribution to household consumption. This implies further development impact resulting from women economic

empowerment, and is consistent with the long-standing argument that women tend to spend more on household expenses (e.g. health, education etc.) while men have higher tendency on discretionary expenditure (e.g. cigarettes, alcohol, etc.) when income increases (Attanasio and Lechene, 2002; Hoddinott and Haddad, 1995; Thomas, 1990).

Overall, this paper falls under the research avenue of digital and gender. On one hand, it is shown that digital divide could prevent individuals from accessing life-enhancing services such as employment opportunities offered by gig economy. Closing the digital gender divide is therefore important for women to grasp work opportunities to achieve economic empowerment, and to reduce compounded gender inequality in the society. On the other hand, innovative digital business models exemplified by gig platforms show great potential in empowering women by overcoming gender inequality bottlenecks in conventional labor market. Specifically, this paper contributes to the gig economy literature by providing new empirical evidences on its developmental impact through the lens of gender in the context of developing countries, in particular to examine differential effects with regards to disposable income on men and women. This is the first paper according to the author's knowledge that aims to quantify the welfare impacts of gig economy on individuals. As the gig economy is becoming an important component of the future of work (Janine Berg, 2018), understanding its developmental impact on vulnerable groups such as women helps governments better design targeted policy interventions to either reap the benefits or avoid the risks. This paper also contributes to the gender literature by illustrating whether the entrenched gender inequality issues in labor markets such as unequal access to employment opportunities or gendered segregation of work type exist in the digital economy, and if any tailored interventions are needed to promote gender equality in the

digital age.

The remainder of the paper is organized as follows. Section 2.2 lays out the background of women economic empowerment and gig economy. Section 2.3 describes the conceptual framework of the study. Section 2.4 describes the data. Section 2.5 explains the empirical methods. Section 2.6 presents the results of estimations. Section 2.7 concludes and discusses policy implications.

2.2 Background

2.2.1 Women economic empowerment

Over history, women have been deprived of constituents of development, ranging from health and education resources, to economic and political opportunities (Duflo, 2012). The journey to strive for women's equality started almost two centuries ago with the publication of *the Subjugation of Women* by Harriet Taylor Mill and John Stuart Mill. Yet to date, women are still lagging behind men in different fronts. For instance, female labor force participation rate is 52.9% globally in 2019, much less than their male counterparts with a participation rate of 78.5%.[15] Empowering all women and girls is identified as one of the United Nations Sustainable Development Goals.

Women empowerment is multi-dimensional compassing different social, economic, political and even psychological angles (Mandal, 2013). Economic empowerment is at the core of those aspects, as SEWA (Self Employed Women's Association) argues that economic empowerment is the prerequisite to raise social and political status for women[i]. Women's economic empowerment refers to a "process whereby women's and girls' lives are transformed from a situation where they have limited power and access to economic

[15] International Labour Organization (ILO). Data retrieved from World Bank Gender Data Portal.

assets to a situation where they experience economic advancement" (Pereznieto and Taylor, 2014). Such transformation shall focus on mobilizing self-help efforts to maintain access and ownership of economic resources for long-term rather than providing a one-off financial support.

Employment opportunities are crucial to achieve the economic empowerment sustainably. The ability to earn money and contribute to household expenditure provides women a strong sense of independence (Mammen and Paxson, 2000). Research also shows that women having fewer opportunities in the labor market could result in their unequal treatment in the household (Duflo, 2012). Meanwhile, leveraging employment opportunities to realize economic empowerment involves different chains of link. Avoiding gender hiring bias and ensuring equal access to employment opportunities is the first step (Goldin and Rouse, 2000; Kuhn and Shen, 2013). At work, a level competing field to facilitate equal treatment and compensation then helps further strengthen the enabling environment for women to gain economic self-sufficiency. Finally, full discretion on the usage of income earned helps reduce women's financial dependence on other people, potentially improve financially associated inferior status, and sustain incentives for future endeavors to earn money.

Women empowerment is not only a human rights advocacy but also a proposition based on the associated development benefits it brings along (Duflo, 2012; Mehra, 1997). Empirical evidences confirm a positive relationship between women empowerment and economic growth (Saqib, 2016). Research also shows that women are more likely to use the increased income to spend on children's food, cloth or education, while men tend to indulge themselves with expenditure on alcohol or tobacco (Attanasio and Lechene, 2002;

Hoddinott and Haddad, 1995; Thomas, 1990). Such expenditure inclination of women has a positive impact on building human capital of future labor force (Doepke and Tertilt, 2019).

2.2.2 Gig economy

Gig economy has been growing rapidly in recent years. The Online Labor Index[16], a measurement of the supply and demand of online labor marketplace published by the University of Oxford, has grown more than 50% from 2016 to 2020 (Kässi and Lehdonvirta, 2018). From 2004 to 2016, the EU28 freelancers' population grew from 6.2 million to nearly 10 million. The number of freelancers in the United States reached 57.3 million in 2017, a 30% increase from previous year (Freelancing in America, 2017). A significant portion of those freelancers rely on online freelancing platforms to attain tasks. On the supply side, United States-based employers/task requesters contribute to 52% of all projects/tasks posted on freelancing platforms. United Kingdom and Europe follow, accounting for 6% and 16% respectively. According to the 2016 Global Contingent Workforce Study, on average 17 percent of companies' workforces are contingent. Samsung of South Korea sources 65 percent of its data science work, 17 percent of software development work as well as 10 percent of marketing automation work, through freelancing platforms.

Gig economy activities exist in local markets such as Tutorama, an Egyptian online platform connecting students with quality local private tutors. It can also have global footprint like the well-known global freelancing platform Upwork or Freelancer. Gig

[16] The Online Labour Index (OLI) is the first economic indicator that provides an online gig economy equivalent of conventional labour market statistics. It measures the supply and demand of online freelance labour across countries and occupations by tracking the number of projects and tasks across platforms in real time.

economy activities range from driving services (e.g. Didi Chuxing in China, Careem in the Middle East region), to household services (e.g. SweepSouth in South Africa), delivery services (e.g. Deliveroo in the United Kingdom) or medical care (e.g. Ping An Good Doctor in China). Gig economy is not only a developed country phenomenon, but has also started to take roots in emerging markets. Workers from India, Bangladesh, the Philippines account for around 50% of active task providers on Odesk, a global freelancing platform.[17] Grab, a ride-hailing company who offers app-based mobility options is now present in more than 160 cities covering 8 countries of the Southeast Asia region, connecting more than two million driving partners to passengers.

A new type of labor emerges from the gig economy—gig workers. They are different from independent contractors or traditional freelancers such as musician or editor who directly manage customer relationship, rely on word-of-mouth to receive tasks and hold individual compact to a certain level of bargaining power. Gig workers utilize digital platforms such as Upwork, TaskRabbit, Handy to attain tasks without directly accruing their customer base or managing customer relationship. They freely choose when and where to switch on the working mode. Some gig workers in developing countries rely on those platforms or apps to take up gigs as their main economic activity. In developed countries, the flexibility and low entry barrier also attract many who have traditional jobs to join the gig economy as a supplementary income source, usually referred to as "moonlighters".

The rise in gig work generates controversy on its developmental impact. There exist a few qualitative studies or anecdotal stories on how gig economy creates jobs and better

[17] Odesk is now acquired by UpWork.

connects many vulnerable or disadvantaged groups such as women to the market in developing countries (Kalkanci et al., 2018). For instance, interviews with digital workers in Sub-Saharan Africa and Southeast Asia highlight how gig activities offer earning opportunities for those who are not able to secure traditional employment in local labor markets (Graham et al., 2017). Other anecdotal stories show that in Jordan, as many gig economy tasks can be conducted online, it suits the need of refugee women who have limited mobility due to socio-cultural norms. SweepSouth, an on-demand platform, connects 4000 women domestic workers with homeowners in four South African cities. The flexible work arrangement offered by gig work allows people to integrate gigs into existing schedule, thus supplementing income from day jobs easily (Hall and Krueger, 2016). The additional income could help reduce income volatility (Farrell and Greig, 2016).

Nevertheless, many doubt that gig economy would be a silver bullet to reduce poverty or promote inclusive prosperity. One explanation of the rising gig economy is that people have no better alternatives but to supplement their income with gigs. Wages from traditional employment are not enough. Taking up gig usually requires expenses on personal resources (e.g. car/motorcycle, smartphone, internet access and data consumption), and it is not guaranteed that income earned would cover such costs, especially when the demand for services decreases but regular wear and tear of those resources continues (Daniels and Grinstein-Weiss, 2019). In addition, research trying to assess the quality of gig economy shows that algorithmic control applied in gig platforms could result in low pay, social isolation and overwork (Wood et al., 2018). Concerns also arise as income gained through gig work tends to bypass labor market regulations, resulting

in another form of informality.

2.3 Conceptual framework

Based on the literature about women economic empowerment and the unique characteristics of gig economy, it is proposed that gig economy participation can affect women economic empowerment through three key channels of job opportunities, working environment and treatment, as well as income and household expenditure.

Leveraging gig platform to gain access to new work opportunities is the first step. Research shows that digital platforms can create instant business opportunities for entrepreneurs, thereby creating jobs (World Bank and Alibaba Group, 2019). E-commerce activities' impacts on promoting entrepreneurship have been tested by researchers through firm registry datasets (Dai and Zhang, 2015; Huang et al., 2018). Similar to e-commerce activities, gig platforms such as ride sharing apps, freelancing websites could also offer a channel of job creation through efficiently matching employers and laborers, and fostering entrepreneurship such as self-employment.

Equal access to such opportunities as men further incentivizes women to explore and exploit them. It is argued that women and men are on a level competing field when seeking gig work opportunities. A gender-blind algorithm when matching gig workers and employers adopted by many gig platforms limits a gender-based choice by employers. Meanwhile, as authenticity of gig workers' demographic information including gender is difficult to be assessed or verified online, employers may be more inclined to make a selection based on skill profiles (e.g. demo of works) or reviews, thus reducing the potential discrimination based on gender stereotype. Moreover, a few studies hold that gender disparity in labor market, be it participation rate or wage gap, is caused mainly by women's choices. For instance, women may voluntarily quit from the labor market to take up more

children care responsibility, known as the motherhood penalty (Mas and Pallais, 2017). Nevertheless, gig economy, characterized with flexible work arrangement, offers an opportunity to overcome this hurdle to redraw women back to the labor market. The discretion over one's work schedules could allow women to integrate their work with other obligations, such as childcare or household chores (Chen, 2016). This is important for female who are often the primary caregivers within households. Therefore, equal access to gig work opportunities that fit the needs of women could become the first step for women economic empowerment.

Secondly, when competing in a working environment, fair treatment on career progression and no gendered-based discrimination on compensation could help ensure that women's financial reward at work is associated with performance rather than any gender stereotype. Gig economy has potential in achieving that goal, with the characteristics of anonymized online interactions and output-based compensation scheme. As the personal demographic information (e.g. gender, age) of online gig workers is hard to verify, customers on a gig platform tend to focus on the quality of services or outputs, which leaves little room for differentiated compensation or treatment based on gender. Meanwhile, getting a higher rating or review score on a gig platform is similar to getting a promotion in conventional work environment, which is associated with higher rate of compensation or access/matching with better work opportunities. As the gig work relationship is usually one-time off, gig workers have a large pool of customers to provide feedback on their performance, which also reduces the impact of gender discrimination of a particular customer.

Thirdly, work opportunities and fair treatment at work translate to income earned to

realize economic empowerment directly. Related literature on e-commerce shows that e-commerce participation is found to be associated with higher household income in general (Luo and Niu, 2019). In the same vein, hypothesis holds that accessing gig work opportunities offers an avenue to generate income, and is associated with increased income at free disposal by women. For those who do not have stable salaried jobs before, they may be able to use free time to earn income through gig platforms. For those who have other income sources, gig work becomes an additional complement. Meanwhile, it is argued that due to the efficient functioning of markets on gig platforms, income earned would be sufficient to cover costs associated with gig work (e.g. ICT access and usage), thus increasing disposable income. Gig platforms provide efficient pairing with potential employers, thus saving time and cost otherwise spent by laborers to find the employers. The efficiency is particularly valuable for women who may have other household responsibilities throughout the day and the opportunity cost on searching for a job would be high. The lowered search costs during job hunting could translate into more disposable income indirectly. This is consistent with general ICT research findings that internet reduces the product search cost for consumers. According to Lieber and Syverson (2012), although the search cost is not completely free, it is modest compared with the time it would take to travel and search among offline counterparts. Lower transaction costs also increase the level of specialization, implying more variety of gig tasks/working opportunities. Furthermore, through clearly disclosing information from both supply and demand sides, gig platforms improve the transparency of labor market, avoiding potential exploitation on offering lower than market rates based on gender.

This paper focuses on examining the first and third channels on whether there exists

any gender-based disparity on accessing gig work opportunities and whether participating in gig economy is positively associated with women's disposable income. Due to a lack of data on rating/review/compensation received on gig platforms, the second channel on women's career progression and treatment in work environment is not analyzed in this paper.

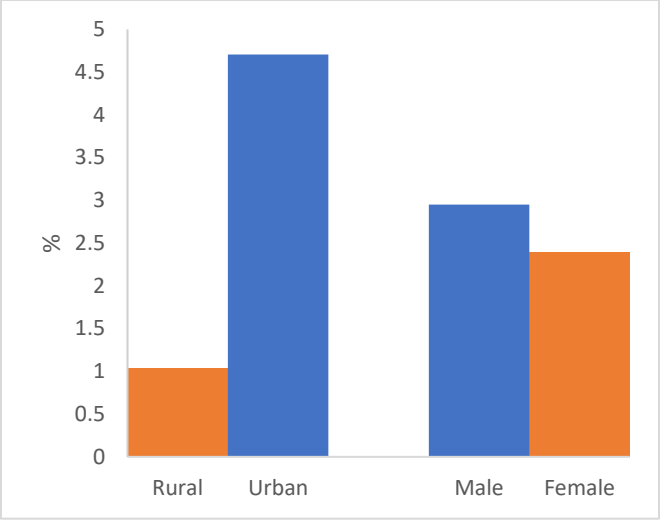
2.4 Data

The analysis draws upon a household survey conducted in nine African countries (Ghana, Kenya, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Uganda) in 2017/2018 by Research ICT Africa, an ICT policy think tank. In addition to demographic information associated with income and expenditure, as well as household attributes, it also collects information on gig economy participation which is very rare in household surveys. The surveys are nationally representative and the data can be disaggregated on the basis of gender, age, location (urban and rural), and income levels. The random sampling is based on a Census sample. A Census divides a country into Enumerator Areas (EAs) which roughly have a household density of 200 each. The desired level of accuracy for the survey was set to a confidence level of 95% and a margin of error of 5%, which yields a minimum sample size per tabulation group of 385. Weights at household level and individual level are calculated based on the inverse selection probabilities.

Descriptive statistics show that around 2.7 percent of adult population are involving in the gig economy in the surveyed African countries (Annex 2.1). This is consistent with other estimations that around 3% of the global labor force are participating in the gig economy (World Bank, 2018). Similarly, active gig workers absorb 3.7 percent of all workers in Germany as of 2018. The comparable statistics with the global average or that of the developed countries imply that gig economy is becoming popular in developing

countries, which calls for a better understanding about its development impact. Survey results show that gig economy participation rate is slightly higher among male (3.0%) than that among female (2.4%). Moreover, there are far more urban residents participating in the gig economy than those living in the rural areas. More than 4.7% of urban residents are involved in the gig economy, while only one percent of rural residents have engaged in digital gig work (figure 2.1).

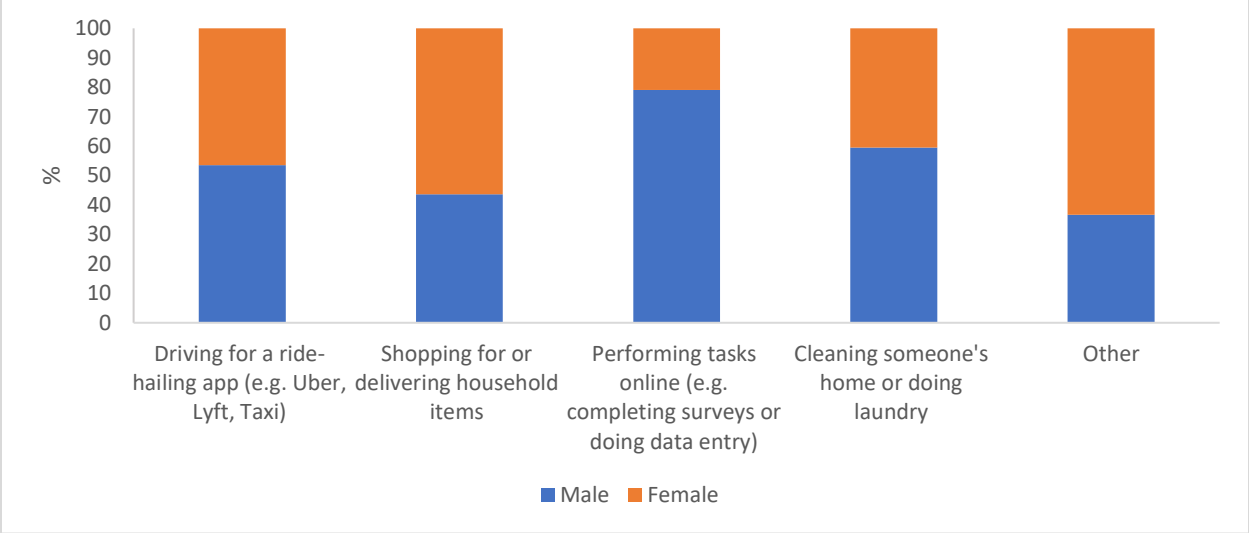
Figure 2.1. Percentage of adult population involving in gig economy activities, by subgroups



Those who are participating in gig economy activities in African countries are mainly involved in activities such as cleaning someone's house/doing laundry, performing tasks online such as completing surveys or doing data entry, and shopping for or delivering household items. Nevertheless, women and men are showing varying inclination in choosing different types of gig activities (figure 2.2). Almost 80 percent of those who have performed tasks online (e.g. completing surveys or doing data entry) are male. Shopping for or delivering household item is the only type in which women participation rate is higher than that of men. The gendered segregation of work type (e.g. men in engineering and women in retail) which is common in traditional labor market (Amin and Islam, 2014;

Tejani and Milberg, 2016) also seem to be present in the gig economy.

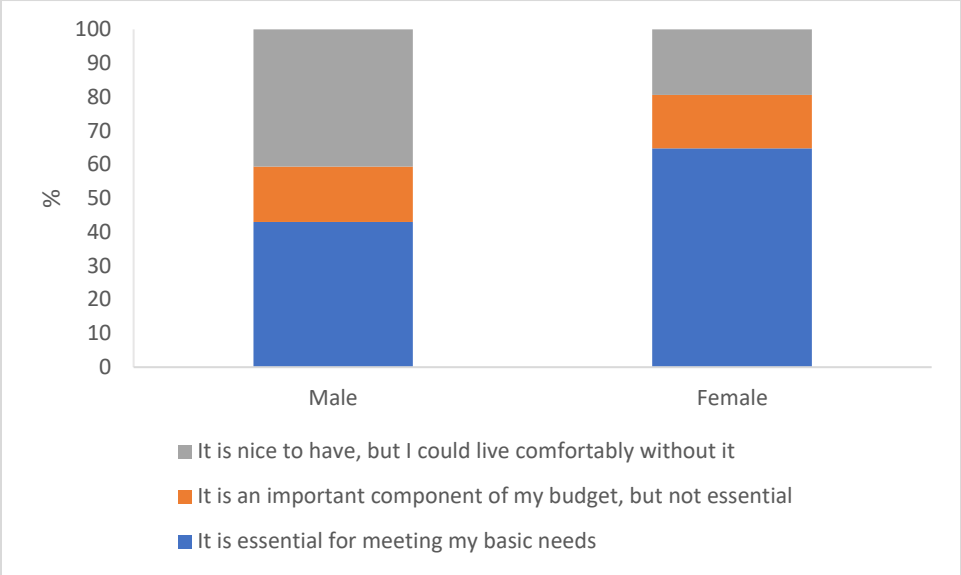
Figure 2.2. Male/female ratio in different types of gig activities



Many have doubted the importance of gig economy activities in contributing to the income basket for individuals if a large proportion of gig workers already have a salaried job. However, survey results show that for those who participated in the gig economy in Africa, more than two thirds of them think that income earned through gig economic activities are either essential or an important component for their budget. The estimations are also consistent with various case studies showing that gig workers in developed countries tend to be "moonlighters" while gig task is the bread earning channel for gig workers in developing countries. Almost two thirds of women participants indicate that income from gig work is essential for meeting basic needs, at a much higher rate than their male counterparts, implying the significant potential of gig economic activities in improving economic welfare for women (figure 2.3). It's worth noting that even for those who are employed but still participate in the gig economy, almost half of them consider income gained through gig work as essential. This may reflect other frictions in the labor marketplace related to career progression or low wage rates, indicating that people have no

better alternatives but to supplement their income with gigs.

Figure 2.3 Importance of income from gig work (percentage of respondents)

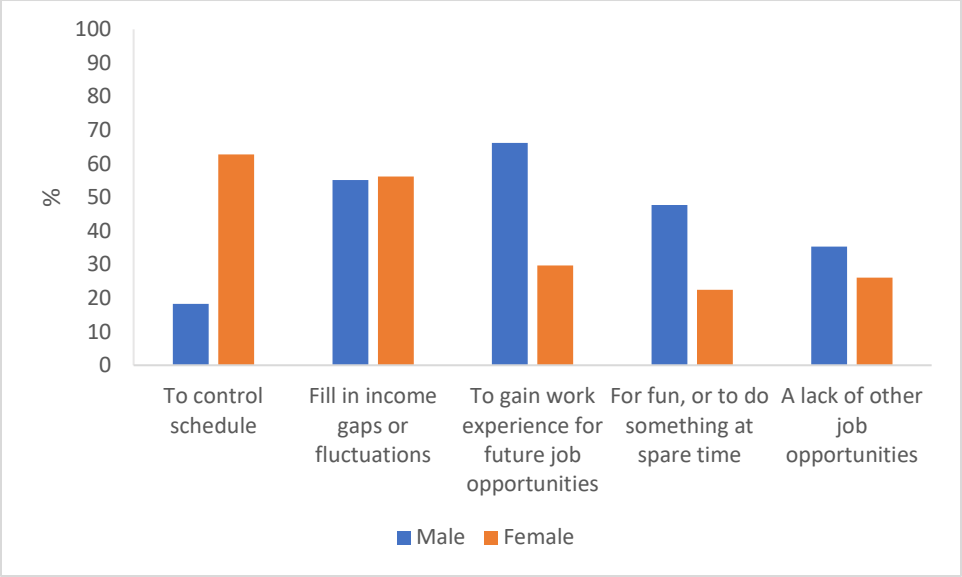


Professional backgrounds of gig workers are quite different between men and women as shown from the survey data (Annex 2.2). The largest group of male participants (41.2%) are those who already have a salaried job, while the largest group of female participants (41.7%) are self-employed without employees. About 6% of female participants are primarily involved in unpaid housework, while almost zero male participants fall into this category. This implies the division of labor within a household as well as the opportunities gig economy could offer to women who used to be only involved in unpaid housework. In addition, around 40% of those gig workers are vulnerable or marginalized groups that used to be at peripheries of the market. For instance, 8.1% of them are unpaid houseworkers, 17.8% are unemployed individuals and 16.2% are students. This suggests the potential of gig economy in connecting other disadvantaged groups to the market.

Individuals in the sample have indicated different reasons of participating in the gig economy, such as to fill in income gaps, gain work experience, control one's own schedule

and a lack of other job opportunities in the area (figure 2.4). To fill in income gaps or fluctuations is recognized as important for both men and women. Controlling one's own schedule is identified as the most common reason of participating in the gig economy for female. This may be due to female's common role and obligation in childcare and other family responsibilities. While for male, to gain work experience for future job opportunities is the most common reason to participate in the gig economy.

Figure 2.4. Reasons of participating in the gig economy (percentage of respondents)



2.5 Empirical strategy

This section presents the empirical strategy to examine whether women are less likely to participate in gig economy activities, and whether and to what extent participating in gig economy help improve disposable income of female in developing countries.

If gig economy participation is random across the population, following (Imbens and Wooldridge, 2009), the causal impact of gig economy participation on individual's disposable income or contribution to household expenditure can be assessed by measuring the average treatment effect on the treated (ATT):

$$ATT=E[Y(1)-Y(0)|T=1]$$

where Y(1) and Y(0) are outcome indicators, representing the disposable income for those who participate in the gig economy, and the disposable income for those who do not participate in the gig economy respectively. T is a treatment indicator.

However, the survey data are collected in an un-experimental setting, where gig economy participation is not random but determined by individual's choice based on observable and unobservable factors. The dependence between the choice of participating in the gig economy and those factors introduces selection bias in the estimate of ATT. The choice of treatment and control groups simply based on gig economy participation in the observed survey data is far from scientifically rigorous. The magnitude of self-selection bias is considered to be $E[Y(0)|T=1-Y(0)|T=0]$ in the equation below:

$$E[Y(1)-Y(0)|T=1]=ATT+E[Y(0)|T=1-Y(0)|T=0]$$

To remediate the un-experimental setting, this paper uses propensity score matching (PSM) method. The method estimates the effect of a treatment or intervention, by matching treated units with untreated units of similar characteristics based on the propensity score. The common practice is to use predicated values from a logit model to estimate the propensity score (Dehejia and Wahba, 1999). The propensity score shows the probability of receiving treatment conditional—participating in gig economy, based on the multiple observed covariates. It helps to reduce the dimensionality of the matching problem (Rosenbaum and Rubin, 1983). Propensity score matching in observation data then creates matched treatment and control groups to the extent possible. There are different matching algorithms, such as nearest neighbor matching or radius matching (Austin, 2014). After matching, PSM does not assume any parametric relationship between the outcome variable

and the participation decision to calculate the treatment effect. In other words, for the matched treatment and control groups, the only difference should be the reflection of treatment or intervention. ATT is then estimated at

$$ATT=E[Y(1)|T=1,p(x)]-E[Y(0)|T=0,p(x)]$$

It is worth noting that identification based on the PSM method requires a few assumptions. Unconfoundedness is a key assumption requiring all variables that influence treatment assignment and potential outcomes simultaneously must be observed. Admittedly, the survey data may not be able to capture all variables that affect the participation of gig economy. In the logit model predicting the participation of gig economy, individual and household level attributes include gender, age, marriage status, years of formal education, years of work experience, urban/rural locality, ownership of personal desktop computer/laptop, ownership of mobile phone, household size, ratio of children at the household, and a constructed household wealth index. Some important unobservable factors include individuals' business acumen, personal drive, willingness to engage in new activities, which are likely associated with higher income regardless of the participation in the gig economy. Therefore, there potentially exists upward bias in the estimation of the magnitude of income increase due to the gig economy participation.

Common support is another important assumption to ensure the robustness of the PSM method. It requires that no attributes should perfectly predict participation. In other words, individuals with the same attributes (e.g. gender) have a positive probability of being both participants and nonparticipants of gig economy. Balance tests are conducted to check the common support assumption, ensuring that all the matching variables (e.g. individual or household attributes) are balanced across the treatment and control groups. T tests on these

variables between the matched treatment and control groups are included in the results section.

PSM has been widely employed in empirical studies of different disciplines. Some researchers argue that designs with PSM produce similar results to randomized control trials (Olmos and Govindasamy, 2015). Jalan and Ravallion (2003) found that piped water helps reduce diarrhea for children in rural India using PSM with cross-sectional data. Through PSM with multiple treatment, Chiputwa et al. (2015) presented evidence showing that certification increases the livelihoods of smallholder coffee farmers in Uganda and reduces poverty. PSM also helps identify the positive impact of e-commerce participation on household income growth in China (Luo and Niu, 2019).

In this paper, following the PSM, firstly, a logit model is adopted to estimate an individual's likelihood to participate in the gig economy.

$$Gigpart_i = a_0 + a_1(Gender_i) + a_2\{Individual\ Controls_i\} + a_3\{Household\ Controls_i\} + Country_j + \epsilon_{ij} \quad (1)$$

where *Gigpart* is a binary variable that equals 1 if individual i is involved in gig economy activities. Individual and household level attributes are included in the logit model. Individual level variables are gender, age, marriage status, years of formal education, years of work experience, urban/rural locality, ownership of personal desktop computer/laptop, and ownership of mobile phone. Household level variables are household size, ratio of children at the household, and a constructed household wealth index. Country fixed effects are included to count for any country specific factors that could impact the likelihood of participating in gig economy. To evaluate the validity of the model, a Hosmer–Lemeshow goodness-of-fit test is conducted after the estimation. A link test is

also performed to check any specification error.

Secondly, using the propensity scores from the logit model (1), individuals who participate in the gig economy and those who do not participate are matched through the radius matching method. Basically, if the difference in propensity score is less than 0.1, individuals are matched together. After matching, ATT of the gig economy participation is calculated. The treatment effect of different subgroups, stratified by individual attributes such as gender, location, education level, marital status and age are further examined.

2.6 Results

2.6.1 Accessing gig work opportunities

Results from the logit model show that gender factor doesn't affect the likelihood of participation in general when controlling other individual and household attributes (table 2.1). Other individual attributes such as age, education level or previous work experience also do not significantly affect the decision of gig economy participation, indicating the lower entry barrier for gig economy activities and its potential benefit of inclusion. However, access to digital infrastructure (e.g. desktop computer, mobile phone) is among the key factors that affect the likelihood of participating in gig economy, which implies the necessity of digital infrastructure investment and narrowing digital divide. Interacting digital infrastructure variables with gender variable doesn't change the significance, indicating that digital infrastructure is essential for both women and men when accessing gig work opportunities. In addition, urban residents have a higher chance of participation. Many types of gig economic activities are happening locally, such as on-demand delivery, ride hailing or housecleaning services. This requires a relatively well-off and dense community to generate relevant demand.

When decomposing gig economy activities into specific types, it is found that women

are less likely to participate in performing tasks online (e.g. completing surveys or doing data entry). Due to data limitation, the results cannot explain why women are less likely to participate in this particular type of gig work. However, there may be a few potential reasons. Tasks on online gig platforms vary from simple data entry to more complex and cognitive tasks such as graphic design. It offers the potential to start from simple tasks and move to more complex tasks through learning by doing. Literature shows that unlike women who usually select self-employment in order to balance housework and market work, men are more interested in seeking more rewards during self-employment (Georgellis and Wall, 2005; Hundley, 2001). Therefore, they may be more inclined to engage in the type of gig work that offers such potential, similar to the career progression in a traditional job. Online gig tasks also include a few opportunities that used to be conducted offline, such as financial advisory; performing similar tasks online may offer an easy transition to similar organizationally employed and salaried jobs offline in the future. This is also consistent with the descriptive statistics which show that to gain work experience for future job opportunities is the most common reason for men to participate in the gig economy.

Table 2.1. Gig economy participation estimation

Model	Logit				
	Participating in the following gig work				
Dependent variable	Gig work in general	Driving for a ride-hailing app (e.g. Uber, Lyft, Taxi)	Shopping for or delivering household items	Performing tasks online (e.g. completing surveys or doing data entry)	Cleaning someone's home or doing laundry
	(1)	(2)	(3)	(4)	(5)
			Coefficients		
Female	0.208	-0.109	1.055*	-1.489***	-0.517
	(0.379)	(0.627)	(0.625)	(0.163)	(0.698)

Respondent Age	-0.004	0.056*	-0.002	-0.013	0.004
	(0.025)	(0.033)	(0.044)	(0.027)	(0.025)
Married	0.116	1.361***	1.184	0.739***	-0.089
	(0.376)	(0.309)	(1.067)	(0.214)	(0.315)
How many years of formal education do you have?	0.048	-0.021	0.074	0.039	-0.112***
	(0.037)	(0.033)	(0.049)	(0.098)	(0.031)
How many years of work experience do you have?	0.029	-0.070***	0.051	-0.072*	-0.010
	(0.056)	(0.025)	(0.058)	(0.037)	(0.032)
Does this household have a working internet connection?	1.298***	1.775***	1.331**	0.585*	0.012
	(0.347)	(0.184)	(0.554)	(0.311)	(0.727)
Do you own a personal desktop computer/laptop?	0.547***	-0.570	1.376***	0.325	0.448
	(0.174)	(0.397)	(0.388)	(0.465)	(1.039)
Do you own a mobile phone?	0.967***	-0.904	0.246		0.143
	(0.098)	(1.147)	(1.400)		(0.595)
Urban residents	0.991***	(dropped)	-0.566	1.605***	1.114***
	(0.315)		(0.600)	(0.110)	(0.284)
How many persons, including yourself, live in this household?	0.098***	-0.247***	-0.459*	-0.105***	0.023
	(0.032)	(0.074)	(0.248)	(0.013)	(0.038)
Ratio of children at the household	-2.680**	1.685	1.497	-3.222**	-3.366
	(1.128)	(1.527)	(1.060)	(1.595)	(2.161)

Household wealth index ==1	-0.907***	-0.529	1.047***	-0.832	-1.017
	(0.231)	(0.767)	(0.104)	(1.287)	(1.063)
Household wealth index ==2	-1.344**	-0.419	1.105	1.017	-0.381
	(0.684)	(0.417)	(1.367)	(1.368)	(0.385)
Household wealth index ==3	-0.243	-0.784***	-0.821	2.746***	-0.830
	(0.158)	(0.082)	(1.209)	(1.013)	(0.789)
Household wealth index ==4	-0.498**		-1.254	2.245*	-0.961
	(0.238)		(1.587)	(1.183)	(0.612)
Household wealth index ==5	-2.169**			2.574***	
	(0.996)			(0.640)	
Household wealth index ==6	(dropped)				
_cons	-5.574***	-3.456	-5.540***	-9.494***	-3.374*
	(0.148)	(2.505)	(0.326)	(1.072)	(1.801)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	4,677	2,263	4,534	3,668	4,277
Adjusted R2	0.204	0.342	0.275	0.295	0.139
note: .01 - ***; .05 - **; .1 - *;					

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Note: household wealth index is an aggregated score to measure if the household owns the following assets of landline telephone, refrigerator, electric/gas stove, radio, TV, satellite decoder, car or truck and motorcycle or 3 wheeler.

To evaluate the validity of the model, a Hosmer–Lemeshow goodness-of-fit test is conducted after the estimation. Given the large number of observations, the test is conducted with 100 groups. A p-value of 0.3688 of the Pearson chi-square from the Hosmer and Lemeshow's goodness-of-fit test indicates that the model fits the data well. The link test is also performed to check any specification error. Results show that the post-estimation predicted value squared is not significant, indicating that the model is correctly

specified.

2.6.2 Impact of participating in gig economy activities

Propensity scores for the individuals participating and not participating in the gig economy, are the predicted probability of participation from the logit model (1), as shown in figure 2.5. For individuals who are participating in the gig economy, the mean score is 0.054 with a standard error of 0.05; for individuals who are not participating in the gig economy, the mean score is 0.026 with a standard error of 0.024. The difference of propensity scores in the two groups is 0.028, which is significant at the 1% level.

Figure 2.5. Histogram of propensity scores

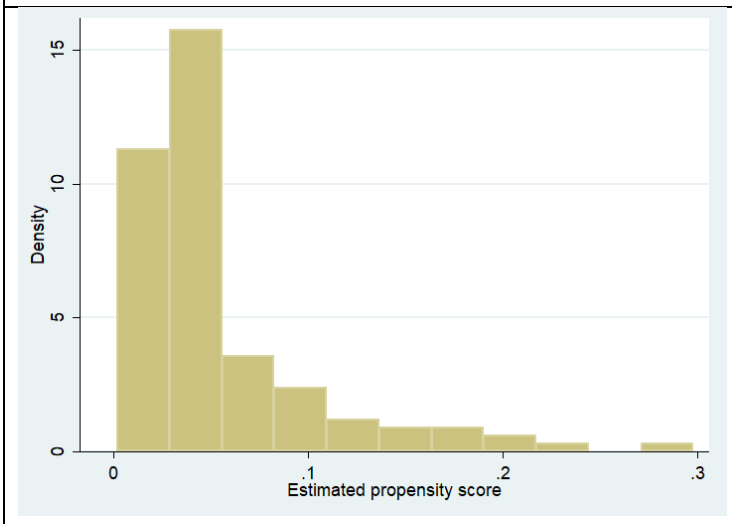
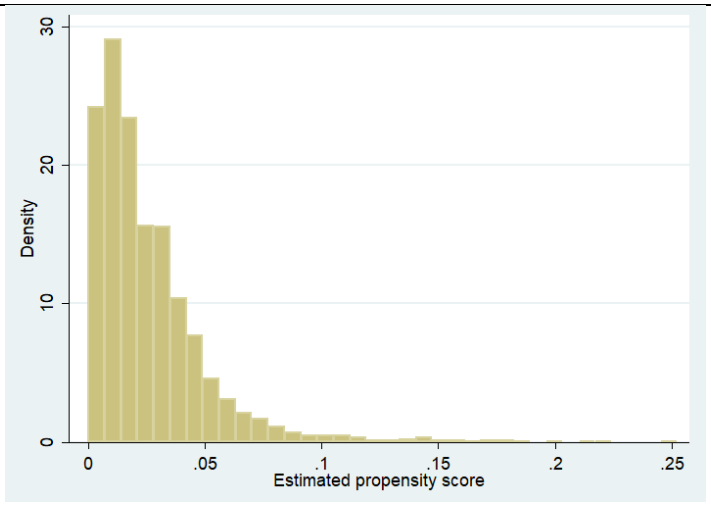
Propensity score for individuals who are participating in the gig economy	Propensity score for individuals who are not participating in the gig economy
	

Table 2.2 presents the matching results in the control group (individuals not participating in the gig economy) and treatment group (individuals participating in the gig economy). The estimated propensity scores are divided into 7 blocks. Though the propensity score adjusts for all covariates using a single covariate, research has shown that stratifying the propensity score into more than five blocks can remove 95% of the biases

associated with one single covariate (Cochran and Chambers, 1965; Imbens, 2004; Li, 2013).

Overall, the probability of participating in the gig economy is low. Only 185 respondents out of the 7449 sample have participated in the gig economy. 125 of those who have participated in the gig economy are matched with 4489 individuals who haven't participated in the gig economy. Radius matching is adopted, which does not require a one-to-one matching. The matching procedure results in 2835 unmatched observations, which are excluded from the analysis. The matching has passed the balancing tests and satisfied the common support assumption (table 2.3). The mean differences are not significantly different among matched treatment and control groups for all the attributes, which indicate that no single variable can perfectly predict participation.

Table 2.2. Matched observations in control and treatment groups

Block ID	Inferior of block of pscore	Respondents not participating in gig economy	Respondents participating in gig economy	Total
1	0.002039	1,455	12	1,467
2	0.0125	719	8	727
3	0.01875	502	16	518
4	0.025	1,310	51	1,361
5	0.05	414	21	435
6	0.1	85	13	98
7	0.2	4	4	8

Table 2.3. Balancing Test

Mean difference between the matched individuals who are participating in the gig economy and those who are not per block							
	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Block 7
age== 1 (<15 years old)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
age== 2 (15-35 years old)	-0.016	-0.098	-0.114	0.074	-0.113	0.169	0.250
age== 3 (35-50 years old)	0.048	-0.016	-0.028	-0.016	0.065	-0.090	-0.250
age== 4 (50-70 years old)	0.005	0.096	0.125	-0.060	0.046	-0.079	0.000
age== 5 (>70 years old)	-0.038	0.018	0.016	0.003	0.002	0.000	0.000
edu== 1 (no formal education)	0.061	0.117	-0.009	0.007	-0.031	0.000	0.000

edu== 2 (0-6 years of education)		-0.009	-0.144	0.090	0.003	0.029	-0.018	0.000
edu== 3 (6-12 years of education)		0.095	0.148	-0.039	-0.094	0.054	0.051	0.000
edu== 4 (12-16 years of education)		-0.179*	-0.030	-0.109	0.098*	-0.024	0.033	0.000
edu== 5 (>16 years of education)		0.033	-0.090	0.068	-0.013	-0.029	-0.066	0.000
Household Wealth Index==	0	-0.098	-0.032	0.089	-0.004	-0.015	0.035	0.250
Household Wealth Index==	1	-0.094	0.098	-0.151	0.053	0.018	-0.018	0.000
Household Wealth Index==	2	0.100	0.005	-0.005	0.033	-0.065	-0.018	0.000
Household Wealth Index==	3	0.088	0.053	0.145	-0.116*	0.121	-0.037	-0.250
Household Wealth Index==	4	0.043	-0.022	-0.035	0.007	-0.089	0.038	0.000
Household Wealth Index==	5	-0.040	-0.101*	-0.043	0.027	0.029	0.000	0.000
Household Wealth Index==	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Respondent is female		-0.170	0.242	0.022	0.068	-0.109	0.010	-0.250
Respondent is married		0.062	0.213	0.236*	-0.004	-0.106	-0.138	-0.500
How many years of work experience do you have?		-4.175	2.720	-0.368	-0.643	1.695	0.187	12.250
Does this household have a working internet connection?		0.005	0.017	0.028	0.005	-0.081	-0.029	0.000
Do you own a personal desktop computer/laptop?		-0.059	-0.192**	-0.035	0.012	0.009	0.001	0.000
Do you own a mobile phone?		-0.178	0.055	-0.025	0.016	-0.012	0.000	0.000
Urban residents		-0.093	-0.130	-0.081	0.046	-0.014	0.000	0.000
How many people live in the household?		1.608*	0.198	0.328	-0.296	0.155	-0.593	-1.250
Ratio of children at the household		0.063	0.034	0.049	-0.005	0.007	-0.033	-0.325
Observations		1467	727	518	1361	435	98	8

Note: *** p<0.01, ** p<0.05, * p<0.1. Household wealth index is an aggregated score to measure if the household owns the following assets of landline telephone, refrigerator, electric/gas stove, radio, TV, satellite decoder, car or truck and motorcycle or 3-wheeler.

After the radius matching and balancing procedure, 4489 of 7449 observations in the control group are matched with all 125 observations in the treatment group. As shown in table 2.4, for the full sample, the estimated average treatment effect on the treated, which is an estimate of gig economy participation direct effect on individual's income at free disposal, is 38.408 USD per month. Compared to the mean income in the control group, which is 48.256 USD per month, this result is equivalent to an income growth of 80% for

the full sample.

For female, the positive effects are particularly significant. The disposable income of the female gig economy participants almost doubled the disposable income of females that are not participating in the gig economy. For male, the positive effect is a growth of 58% on disposable income. This shows gig economy activities' greater potential in improving financial independence for women. Meanwhile, applying the similar PSM method on monthly contribution to household expenditure shows that gig economy participation also is associated with a 52% increase on female's monthly contribution to household expenditure. The positive effects are not significant for male on this respect (Annex 2.3).

Additionally, the positive effect of gig economy participation on disposable income doesn't hold for rural residents or poor individuals. This indicates that participating in the gig economy has not benefited the bottom of pyramid such as rural population or those who are at the bottom 40% of the income distribution. Nevertheless, it is worth noting that the average daily income of those who are not at the bottom 40% of the income distribution in the sample is less than $10 per day due to the low-income level among African countries in general. They are usually considered as "strugglers" just escaped from poverty. Therefore, gig economy participation can still be considered with positive developmental impact to a certain degree, but just not benefiting the poorest.

Moreover, though age or education level doesn't affect the likelihood of participating in the gig economy, they do affect how much individuals can benefit from gig economy activities. Results show that those who have completed primary school education are benefiting the most from participating in the gig economy among all education levels. This may be because that those who do not have any formal education lack the basic digital

literacy such as using mobile apps to access the gig economy, or do not have the needed knowledge to perform some gig tasks such as data entry. On the contrary, highly educated individuals may have other better alternatives of work opportunities, thus the opportunity costs of participating in the gig economy could be high. With regards to age groups, middle-aged group (35-50 years old) enjoys 1.4 times of income increase when participating in the gig economy. The effects of participation are not significant for the young generation or elderly group. This may be related to the nature of the majority of gig tasks which tend to be manual labor (e.g. cleaning, driving, delivery) suitable for the middle-aged group. The above-mentioned demographic characteristics not affecting the likelihood of participating in the gig economy but the magnitude of impacts implies an overall low entry barrier to this market on the one hand but relatively narrow applicability across the population on the other hand.

Table 2.4. Propensity score matching results

	Income at free disposable per month of those not participating in gig economy (mean, USD)	Income gain due to participating in gig economy (USD)	Income gain as % of pre-intervention income	T-stat
All sample	48.256	38.408	80%	3.316
Female	41.815	40.147	96%	2.171
Male	54.827	31.990	58%	2.289
Urban	57.859	39.093	68%	2.638
Rural	33.883	-4.401	-13%	-0.351
Marry	54.352	62.027	114%	2.928
Single	42.464	16.480	39%	1.167
Poor	9.096	1.174	13%	0.618
Non-poor	67.888	39.949	59%	2.835
No formal education	26.759	-27.508	-103%	-1.819
0-6 years of education	40.278	-10.544	-26%	-0.400
6-12 years of education	36.698	38.866	106%	2.318
12-16 years of education	77.863	64.371	83%	1.622
>16 years of education	103.854	-10.294	-10%	-0.182
age group (15-35)	33.930	9.024	27%	0.694

age group (35-50)	61.705	86.303	140%	2.511
age group (50-70)	89.353	-7.472	-8%	0.348

Note: A t-test is used to test the null hypothesis that the gig economy participation effect is zero. Poor refers to those who are at the bottom 40% of the income distribution in his/her country.

2.7 Conclusion

Gig economy is gaining popularity in developing countries. Results from a household survey in nine African countries show that around 2.7 percent of adult population are involving in the gig economy in Africa, which is consistent with the global estimation of 3 percent. Women and men are showing different motivations in participating in this new type of economic activity. Almost two thirds of women participants indicate that income from gig work is essential for meeting basic needs, at a much higher rate than male counterparts, implying the significant potential of gig economic activities in improving economic welfare for women. Controlling one's own schedule is identified as the most common reason for female. While for male, to gain work experience for future job opportunities is the most common reason. The difference on motivation is also reflected in the occupational background of male and female gig economy participants. The largest group of male participants (41.2%) are those who already have a salaried job, while the largest group of female participants (41.7%) are self-employed without employees. About 6% of female participants are primarily involved in unpaid housework, while almost zero male participants fall into this category. This implies the division of labor within a household as well as the opportunities gig economy could offer to women who used to be only involved in unpaid housework.

The analysis shows that gender factor doesn't affect the likelihood of participating in gig economy in general after controlling for other individual or household attributes, indicating a relatively equal access to gig work opportunities. However, women are less

likely to participate in a particular type of gig work—performing tasks online (e.g. completing surveys or doing data entry). Due to data limitations, the author cannot examine the reason behind. A few potential explanations include men's stronger tendency to achieve career progression and realize higher financial rewards through engaging in online tasks which range from simple data entry to complex advisory or design work with higher pay.

Access to digital infrastructure (e.g. desktop computer, mobile phone) is among the key factors that affect the likelihood of participating in gig economy for both men and women, which implies the necessity of digital infrastructure investment in developing countries. In 2021, fixed broadband subscription was 0.48 per 100 people among low-income countries.[18] Unique mobile subscriber penetration rate, as a share of population, was still as low as 45 percent in the Sub-Saharan Africa region in 2018. Digital divide between male and female further highlights the urgency. In developing countries, women still remain 7 percent less likely than men to own a mobile phone, and 19 percent less likely than men to use mobile internet services (GSMA, 2023a).

The rise in gig work is providing new opportunities to improve people's welfare. The analysis adopts the propensity score matching method and provides evidence showing that 1) participating in the gig economy is associated with a higher level of disposable income; it is estimated that the direct effect of gig economy participation on individual's disposable income is 38.408 USD per month in African countries; 2) the positive effects are particularly significant for female; the disposable income of the female gig economy participants almost doubled that of females that are not participating in the gig economy. Moreover, gig economy participation is associated with a 52% increase in monthly

[18] World Development Indicators.

contribution to household expenditures for female, while such positive effects are not observed among male.

These findings have important policy implications amid ongoing discussions about whether gig economy could serve as a mechanism to help those who used to be at the economic peripheries such as women to gain more work opportunities and enhance their welfare. It is shown that gig economy offers equal access to work opportunities for male and female. However, access to the digital devices is among the first prerequisites to engage in gig work. Considering the glaring digital divide among male and female, it is of great importance to improve the access and usage of digital devices for female to ensure their access to new work opportunities to achieve economic empowerment.

The positive effect of participating in gig economy activities on improving disposable income for female in developing countries confirms the potential of gig economy to promote women economic empowerment. The significant benefits suggest that enabling the participation in gig economy could be one policy option to promote women empowerment. The enhanced disposable income could have long-term benefits, as shown in the increase in women's contribution to household expenditure. The enhanced expenditure on education or healthcare of kids could help build human capital of future labor force.

Nevertheless, gig economy shall not be viewed as a panacea. Similar to the traditional labor market, there also exists a slight gendered segregation of work type in gig economy, as evidence shows that men are likely to participate in a particular type of gig work—performing tasks online. Future research shall explore the reasons behind the divergence and whether such divergence is associated with the gender wage gap as found in a few

existing studies. Moreover, the positive effects of participation are not significant for rural residents or individuals who are among the bottom 40% of income distribution; this indicates that there is still room to enable those who are at the bottom of pyramid to also benefit from the digital technology advances and associated economic activities.

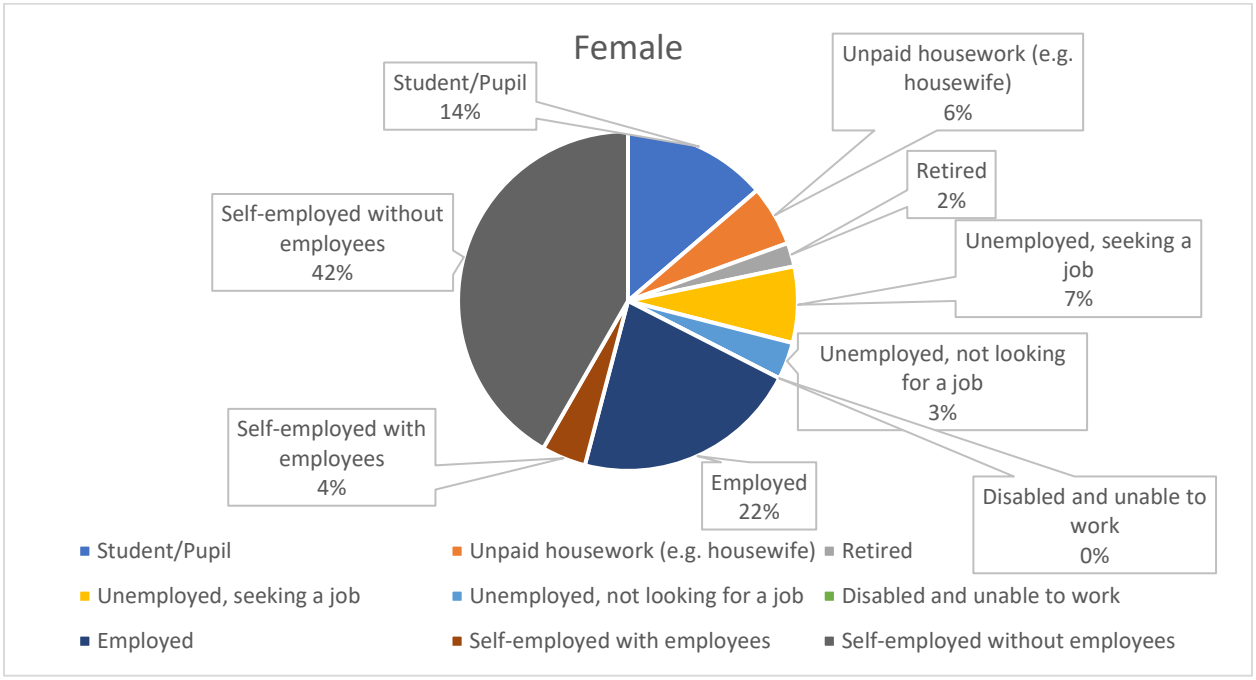
Though gig economic activities present great potential in improving individual welfare, it does bring other regulatory and social protection problems that are not addressed in this paper. Income gained through gig work tends to bypass labor market regulations, resulting in another form of informality. Many gig platforms are not required to withhold income taxes on behalf of service providers, but up to gig workers to declare. Regulatory arbitrage breeds informality or lowers incentives to exist informal sector, which calls for government interventions. For instance, a data sharing agreement with these labor matching platforms can help avoid tax evasion, meanwhile transit those in informal sector to the formal one through building tax records. Moreover, most of the gig workers do not have basic health or unemployment insurance which is often based on a formal employer-employee relationship. Fully reaping the advantage of gig economy requires a rethink of social protection rules. There are proposals calling for the establishment of a third employment category for gig workers and grant gig workers some benefits associated with a more traditional employment relationship (e.g., insurance, tax withholding, rights of organization) but not those that are based on the period of working time, such as overtime or unemployment insurance (Harris and Krueger, 2015). Potential future research areas include the relationship between gig economy and informality, regulatory environment (e.g. tax rules, social protection measures) and the development of gig economy.

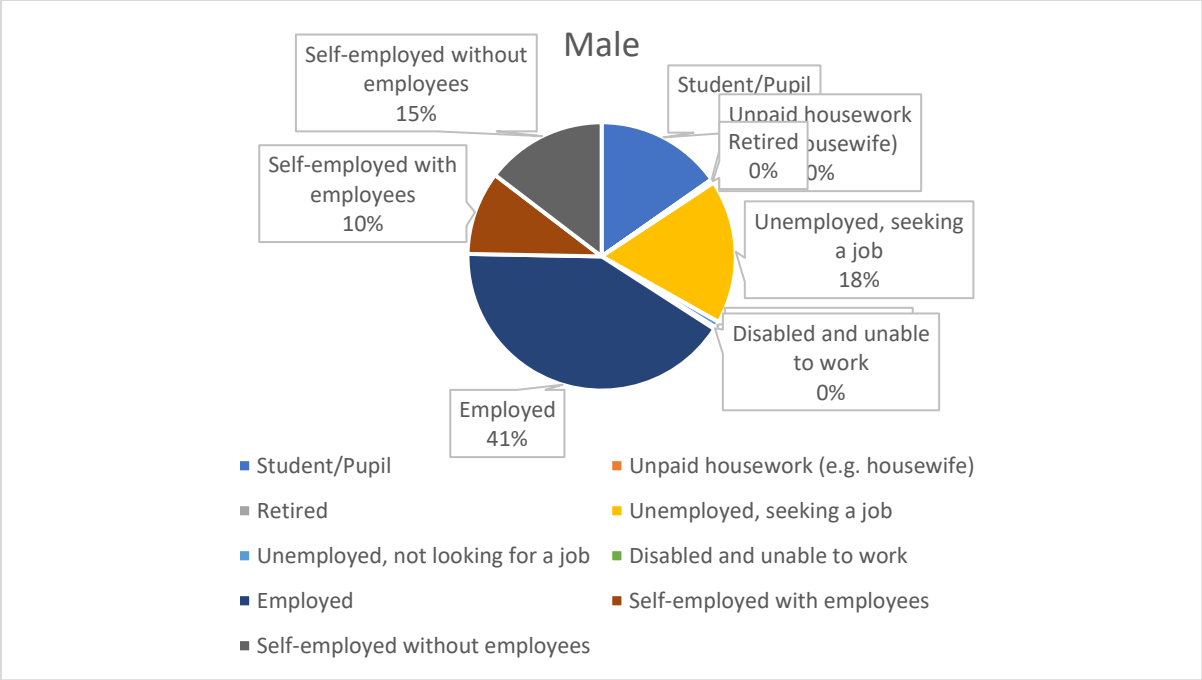
Annexes

Annex 2.1. Gig economy participation rate (%)

	Total	Female	Male
Kenya	0.98	0.84	1.14
Mozambique	7.76	2.97	10.81
Ghana	0.99	0.99	1.00
Nigeria	2.72	2.52	2.91
Rwanda	1.58	0.81	2.13
South Africa	6.49	5.56	7.45
Tanzania	0.56	1.00	0.22
Uganda	3.04	2.74	3.27
Senegal	2.45	2.46	2.44
Total	2.67	2.39	2.95

Annex 2.2. Professional backgrounds of gig workers





Annex 2.3. Propensity score matching results on monthly contribution to household expenditure

	Monthly contribution to household expenditure of those not participating in gig economy (control mean, USD)	Effect on household expenditure contribution due to participating in gig economy (USD)	Change on contribution to household expenditure as % of pre-intervention contribution	T-stat
All sample	90.752	40.755	45%	2.888
Female	74.249	38.679	52%	2.009
Male	107.588	28.907	27%	1.402
Urban	110.755	34.575	31%	2.079
Rural	60.812	-9.050	-15%	-0.536
Marry	114.484	71.084	62%	2.855
Single	68.204	9.843	14%	0.788
Poor	9.003	3.616	40%	1.014
Non-Poor	131.735	30.728	23%	1.799

Chapter 3: Mobile Banking Regulation and Financial Inclusion

3.1 Introduction

Financial inclusion refers to access by individuals and businesses to useful and affordable financial products and services including savings, payments, transfers, credit, insurance, and wealth management (Allen et al., 2016; Lee and Deng, 2018; Sarma, 2008). Mobile banking, a way of delivering financial services not through bank branches but other innovative channels such as mobile phones or point-of-sale agents, has gained popularity in developing countries in the past decade (Klein and Mayer, 2011; Shaikh and Karjaluoto, 2015). By addressing the challenge of high transaction costs to serve clients in remote areas and those with small and infrequent transactions, it offers potential to promote financial inclusion (Alexandre et al., 2010; Siddik, 2014).

In face with the newly emerged mobile banking activities, governments are adopting diverse regulatory approaches. Some promulgated comprehensive legislations to regulate market entry and corresponding mobile banking business operation, while others adopted a laissez-faire or market-centric approach. Whether and what mobile banking regulatory environment is conducive to financial inclusion remains to be further examined. Alexandre et al. (2010) argue that various degrees of adoption of mobile banking activities across countries could be partially attributed to different regulatory environments in general. Gutierrez and Singh (2013) show that rules on e-contracting/e-signature usage, consumer protection, interoperability, and KYC (Know Your Customer) /CDD (Customer Due Diligence) can support mobile banking development. There exist other anecdotal country evidences showing the impacts of particular aspects of mobile banking regulations (Reynolds et al., 2018). For instance, experiences in Indonesia, Bangladesh, Cameroon and

India show that regulations that prohibit or limit non-banks providing mobile banking services can limit the growth of the market and negatively impact financial inclusion (Asian Development Bank, 2017; Evans and Pirchio, 2015; Parvez et al., 2015). A study in Tanzania provides qualitative evidence on how regulations prohibiting financial service providers from signing exclusive contracts with third-party parties to deliver financial services on their behalf incentivized those providers to establish an interoperability agreement which helps promote financial inclusion (Bourreau and Valletti, 2015).

Despite sporadic and qualitative evidence, there lacks quantitative research on the associations between mobile banking regulations and financial inclusion. To provide empirical evidences on such link, this paper aims to: (1) assess the mobile banking regulatory environment across countries from a variety of dimensions corresponding to different types of mobile banking activities, and (2) conduct quantitative analyses to examine how those regulations affect financial inclusion. First, a new regulatory index is constructed to assess mobile banking regulations in 80 countries from different aspects. Second, the paper examines the relationship between the mobile banking regulatory environment and the access and usage of financial services by individuals, using the regulatory index as well as each component under the index separately.

The paper is among the first studies that explores the relationship between mobile banking regulatory environment and the likelihood of individuals having and using a financial transaction account, according to the author's knowledge. Unlike most of the studies which tend to analyze factors affecting financial inclusion at the country level, this study uses nationally representative micro-level data that allow both cross country comparison and individual level controls. The study finds that individuals are more likely

to access and use financial transaction accounts in countries that adhere to a higher number of mobile banking regulatory practices. In particular, results show that legal requirements that specify the type of financial services can be conducted by agents on behalf of financial institutions, as well as legal provision requiring non-exclusivity of contracts between agents and financial institutions are the driving factors of financial inclusion. Legally requiring non-exclusive contracts between agents and financial services providers is associated with a 6% increase in the probability of individual having an active financial transaction account. Moreover, comparing with entry control provisions, consumer protection provisions play an important role in promoting the adoption and usage of financial services. The findings have important policy implications for governments who are in need to craft smart regulations for mobile banking activities.

The remainder of the paper is organized as follows. Section 3.2 lays out the background of mobile banking activities. Section 3.3 describes the theoretical framework of the study. Section 3.4 explains the empirical strategy. Section 3.5 describes components and construction of the mobile banking regulatory index as well as other data used for the estimation. Section 3.6 presents the main estimation results and section 3.7 shows the robustness check results. Section 3.8 concludes and discusses policy implications.

3.2 Background

Financial inclusion is important for improving social inclusion, reducing poverty and promoting economic growth (Bold et al., 2012; Demirguc-Kunt et al., 2017; Kim et al., 2018; Neaime and Gaysset, 2018; Ozili, 2020; Sarma and Pais, 2011). For instance, savings accounts provide a safety net for households to manage emergencies and absorb shocks (Gjertson, 2016). However, the current state of financial inclusion is far from satisfactory

in developing countries. According to the World Bank Findex dataset, more than 30 percent of global adult population do not have a financial transaction account in 2017.[19] Large variance exists across countries. Though almost 95 percent of adult population in high income countries have a financial transaction account, more than half (57%) of the adult population in the Sub-Saharan Africa region are excluded from the financial system. Almost half (45%) of the adult population in Latin America and Caribbean countries are in a similar state of exclusion (Demirguc-Kunt et al., 2018).

High transaction cost on both accessing and delivering the financial services is one of the key challenges associated with the lower level of financial inclusion among poor population living in remote areas. Mobile banking, leveraging the innovative channels such as mobile phone or point-of-sale agents, offers a solution to address such challenges to promote financial inclusion (Alexandre et al., 2010; Klein and Mayer, 2011). On the supply side, it reduces expense for financial institutions as they would not need to establish costly physical branch networks in unbanked areas. For instance, the set-up costs of a retail agent in Brazil can be as little as 0.5% of the cost of setting up a bank branch (Kumar et al., 2006). On the demand side, it incentivizes people to get access and use financial services by providing economical options of access as they do not need to incur out of pocket expense on transportation and opportunity cost in lost work time to reach a bank branch far away.

There are mainly two distinctive mobile banking models: bank-led model and nonbank/mobile network operator (MNO)-led model (Dias and Mckee, 2010; Porteous,

[19] According to the World Bank Findex dataset, account (% age 15+) denotes the percentage of respondents who report having an account (by themselves or together with someone else) at a bank or another type of financial institution or report personally using a mobile money service in the past 12 months.

2006; Weber and Darbellay, 2010). Under the bank-led model, banks can develop its mobile banking app or website. They can also partner with a retail agent (or a correspondent) to extend financial services to locations where bank branches would be uneconomical (Klein and Mayer, 2011). In comparison, the MNO-led model enables users to conduct a range of financial services without owning a bank account. The customer's "money" is stored in a virtual account on the server of the MNO or a non-bank institution, recognized as mobile money. Customers use a mobile device to get access to the mobile money account and conduct financial transactions such as money transfer or bill payment (Suri, 2017).

The booming mobile banking activities have significant impact on livelihood, business performance and economic development. It reduces transaction costs significantly and improves convenience and security for financial transactions (Economides and Jeziorski, 2015). It also increases risk sharing within and among households through easy and low-cost money transfers (Jack and Suri, 2014, 2011; Riley, 2016). Over the long term, better access to mobile banking services helps reduce poverty rates through increasing household consumption and saving (Jack and Suri, 2014). For firms, adoption of mobile banking services increases the use of trade credit which helps improve firm performance (Beck et al., 2015). Islam et al. (2018) find a positive relationship between firm adoption of mobile money and firm investment.

Nevertheless, mobile banking presents not only opportunities but also challenges for market players and regulators. Governments face the challenge of designing a regulatory environment that encourages financial inclusion through innovation while protecting consumers and the integrity of the financial system. This is a fast-evolving area where

countries are adopting diverse regulatory approaches. For instance, in 2015 Ghana adopted the Guidelines for E-money Issuers, allowing both banks and non-bank institutions to issue mobile money. In 2015 Mozambique developed a regulatory framework focusing on bank-led mobile banking activities. Under the framework, banks are allowed to hire third party agents to provide financial services on their behalf. However, until June 2017, Cambodia did not issue regulations on the non-bank led model of mobile banking, but permitted such activities on an ad hoc basis.[20] Whether regulatory framework is needed for the booming of mobile banking activities, and what kind of regulatory approach helps promote financial inclusion are questions to be answered in the study.

3.3 Theoretical Framework

In a world of uncertainty, institutions are of great importance in shaping the incentive for economic agents in conducting productivity-enhancing activities efficiently. Those incentives can drive individual decisions to become educated, or to get financial services, or firm decisions to innovate and adopt new technologies (Robinson and Acemoglu, 2006). Applying institutional economics to the finance industry, the law and finance literature (La Porta et al., 2002, 1998) shows how a country's legal protection of investor rights affects corporate finance in that country. Though there is no tailored framework that specifically assesses how mobile banking regulations shape incentives of economic agents, we can approach the mechanisms from both the supply side (providers of the financial services) and the demand side (recipients of financial services) using existing theories.

Hypothesis 1a: Comprehensive mobile banking regulations promote financial

[20] The National Bank of Cambodia ("National Bank") issued the Prakas on the Management of Payment Service Providers on 14 June 2017. This regulation establishes a legal framework for the provision of payment services through payment transaction accounts.

inclusion: through the lens of financial service providers

Mobile banking regulations are imposed directly on the providers of relevant financial services, which affect the barriers of entry. There are mainly two schools of thoughts on the regulations of entry. According to the public interest theory, governments use regulations to address market failures and protect the public interest, thus achieving social efficiency. Key purpose of regulatory barriers is to screen out low-quality or undesirable entrants (Pigou, 1938). In contrast, public choice theorists argue that government officials adopt regulations that serve the interests of themselves and their cronies, resulting in corruption and market inefficiencies (Peltzman, 1976; Stigler, 1971; Tullock, 1967). They worry about regulatory capture, as Stigler states "regulation is acquired by the industry and is designed and operated primarily for its benefits" (Stigler, 1971).

The barriers of entry could affect the service providers in the mobile banking market, as well as the quality and cost of their products, which would then impact the access and use of those services by customers. Following the lead of public interest theory, governments that regulate comprehensively are expected to screen out providers of low quality services, and promote a thriving market with higher usage of quality financial products. This in turn should lead to better public outcome, such as more previously unbanked population being included into the financial system. However, public choice theory would predict the opposite result. According to that theory, comprehensive regulations would only benefit a subgroup of providers, namely those who possess privileged political and economic positions or connections to influence regulations in a way that excludes competitors and entrenches their current positions. The result would be market distortions, deteriorating quality and lower customer adoption of mobile banking

services. Which of these effects (public interest theory vs. public choice theory) dominates is unclear a priori in the mobile banking regulation field.

This paper tests the hypothesis that public interest theory dominates in the relationship between mobile banking regulation and financial inclusion. Following the public interest theory, the hypothesis holds that governments who adopt comprehensive and enabling mobile banking regulations create a positive impact on financial inclusion. As a new medium to deliver financial services, the mobile banking sector may include service providers with a wide range of qualifications, calling for more stringent regulatory vetting to screen out unqualified and untrustworthy providers.

Hypothesis 1b: Comprehensive mobile banking regulations promote financial inclusion: from the perspective of financial service recipients

From the demand side based on the perspective of financial service recipients, the impact of regulations can be assessed through the lens of the theory of transaction cost. Institutions provide the structure for exchange that determines the cost of transacting (North, 1990). As North argued, the costs of transacting involve information gathering and measurement, policing and enforcing the agreement, as well as an uncertainty discount to compensate transacting parties for imperfect measurement and enforcement process. The cost of measuring the valuable attributes of what is being exchanged comes first. This involves devoting resources to search and gather information about legal and physical attributes of the goods/services. Mobile banking regulations that clearly define the characteristics and scope of mobile banking services lower customer transaction cost by vetting service providers on customers' behalf. Due to the diffuse nature of mobile banking customers and the complexity of financial products, such a vetting function can be more

economically performed by a centralized regulator than by individual customers. Secondly, when a transaction happens, efficient institutions can help police and enforce the agreement. Legislations regulate rights and obligations of parties involved in a transaction, thereby enforcing the transaction agreement with the state's coercive power. In the context of mobile banking activities, customers of mobile banking services are legally protected to receive promised services such as cash in/out, money transfer, or bill payment. This lowers the uncertainty discount in North's account, thereby reducing the transaction cost of entering into mobile banking transactions.

It is worth noting that in a business transaction, the collection of information is unlikely to be exhaustive. Asymmetric information exists between transaction parties. One party can deliberately hide or forge information. Regulatory enforcement can also be inefficient. Therefore, the third channel for institutions to exert influence on the transaction cost is through affecting the uncertainty and confidence of transaction parties (North, 1990, 1986). An enabling institutional environment can serve as a foundation and safety net to engender trust for market participants.

With regards to mobile banking, a new financial product or new medium of business transaction, regulatory environment with features such as licensing requirements on service providers and customer protection provisions may engender certainty and trust to promote the usage by individuals and organizations. AlGhamdi et al. (2017) argue that law and regulation in internet transaction affect consumers' attitude because it changes recipients' perceptions and attitudes towards such technology. Similarly, González (2004) found that eBay consumers are less likely to make a transaction if they do not get protection from the government.

Hypothesis 2: Different regulatory provisions within a mobile banking legal framework have different levels of association with financial inclusion

A legal framework regulating mobile banking activities usually involves multiple dimensions. Some countries establish different types of regulations following two distinct models of mobile banking activities: agent banking regulations for the bank-led model of mobile banking activities, and mobile money/electronic money regulations for the non-bank led model of mobile banking activities. Under each set of regulation, different provisions such as the qualification of financial service providers, scope of the financial services, consumer protection as well as contract requirements among market players are included. How different regulatory provisions affect financial inclusion is to be assessed.

Agent banking regulations provide a legal framework for financial institutions to hire third parties such as airtime merchants as agents to conduct financial services on their behalf. This legally enables financial institutions to develop the bank-led mobile banking model, extend reach to poor branch penetration areas and serve low value accounts in rural areas. Key dimensions measured for agent banking regulations include qualification of agents, scope of activities allowed for agents, and the relationship between agents and financial institutions. These dimensions are chosen based on practical experiences on key regulatory attributes needed for an agent banking regulatory framework.

Eligibility rules and due diligence tests on agents set the entry bar for agent banking activities. Operating in riskier environments, lack of qualified staff, and inadequate internal management processes may expose agents who are providing financial services on behalf of financial institutions with operational, credit, and liquidity risks (Lyman et al., 2006). Tarazi and Breloff (2011) suggest good regulations should allow agents to carry out a wide

range of services, coupled with requirements to ensure the agents' reliability, security and competence. Moreover, by defining what type of contracts agents may enter into with financial institutions, regulations may affect pervasiveness of agent banking activities thus impacting financial inclusion. While exclusive contracts that grant financial service providers a monopoly over agents may provide more incentives for them to invest in agent network establishment and try other innovative collaboration model with agents, nonexclusive contracts allow agents to provide services for multiple financial institutions, increasing access to financial services (Muthiora, 2015).

Mobile money/electronic money legislations provide the legal framework for non-bank led model of mobile banking activities. The assessment of electronic money/mobile money regulations focuses on whether non-bank businesses such as MNOs are able to carry out mobile banking activities. Under the MNO-led mobile banking model, the MNO manages all relationships within the business ecosystem, and is responsible for all regulatory compliances. Dimensions measured for the mobile money legislations include two key aspects of entry requirements and consumer protection. For instance, as mobile banking services continue to expand, some governments include in the licensing requirement the interoperability – the ability to transfer e-money from one mobile banking service account to another. Though interoperable mobile banking systems bring potential benefits such as increasing convenience through allowing smooth transactions across different financial service providers, mandating the interoperability offers room of free riding the existing financial infrastructure for later comers. The risk of being taken advantage of by later comers may disincentivize existing players in investing in or improving operating systems and other financial infrastructure. Weighing the potential benefits such as increasing

convenience due to interoperable mobile banking systems against the risk of stifling innovation and investment becomes important (Hernandez et al., 2011). In terms of consumer protection, nonbanks are rarely subject to prudential regulations that apply to banks to ensure deposit security. It is recommended to require fund safeguarding measures such as applying liquidity ratios and restrictions on use to ensure that funds collected by nonbanks are protected (Tarazi and Breloff, 2011). Without such protections, the security of customer funds held by a non-bank entity could be seen as significantly riskier than funds held by a prudentially regulated bank, disincentivizing individuals from adopting such financial services. Dias and Mckee (2010) and Ivatury and Mas (2008) also emphasize the importance of consumer protection such as consumer awareness safeguards and complaints redress mechanisms.

3.4 Empirical strategy

To understand the association between mobile banking regulations with financial inclusion at the micro level, following the approach of Gutierrez and Singh (2013), this analysis quantifies the effect of mobile banking regulation on the access and usage of financial transaction account by individuals in the following model:

$$ActiveAccount_{ij} = a_0 + a_1(Regulation)_j + a_2\{Individual\ Controls_i\} + a_3\{Country\ Controls_j\} + Region_k + \epsilon_{ij} \quad (1)$$

where $ActiveAccount_{ij}$ is a binary variable that equals 1 if individual i in country j has an active financial transaction account.[21] This variable filters out cases of dormant account whose owners are not really enjoying benefits of financial inclusion. $Regulation_j$ is country

[21] An active financial transaction is defined as having a financial transaction account and have deposited into the account in year 2017.

j's score on the constructed mobile banking regulatory index. In addition to the aggregated score, each component within the regulatory index is also tested separately. Individual level controls include sex, age, income level, education level as well as the ownership of a mobile phone. Country level controls include GDP per capita, population density, mobile subscription rate, and the maturity of the formal financial sector. Region fixed effects are included to count for any regional factors that could impact the financial inclusion.

Individual level and country level controls are selected based on the literature. Researchers have identified three main categories of factors affecting financial inclusion. First, macro social and economic factors matter. Researches show that low population density is associated with low level of financial inclusion as banks usually prefer to establish branches in populous areas to easily achieve minimum viable scale (Allen et al., 2014). Quality of physical infrastructure such as electronic connectivity, road networks and telecom penetration are important contributing factors to financial inclusion (Sarma and Pais, 2011). Financial sector development also plays a role (Heyer and Mas, 2010). According to Sarma and Pais (2011), high proportion of non-performing loans and high level of foreign ownership in the banking sector are negatively associated with financial inclusion.

Second, a few studies indicate that low level of financial literacy is associated with low level of financial inclusion (Atkinson and Messy, 2013; Grohmann et al., 2018; Kapadia, 2019; Ramakrishnan, 2012). Financial literacy has shown a significant impact not only at the individual level but also at the firm level. According to a survey conducted by Banco de Mocambique, lack of knowledge of the product is one significant obstacle for business owners adopting new financial products (Ortigao et al., 2015).

Third, there is a growing number of studies arguing that financial innovation and technology can promote financial inclusion (Chinoda and Kwenda, 2019; Donovan, 2012; Gabor and Brooks, 2017; Kumar, 2013; Ouma et al., 2017; Sumarsono et al., 2020). Kumar (2013) finds that banks can accelerate financial inclusion by providing modern banking facilities such as internet banking, mobile banking, and ATM facilities. Chinoda and Kwenda (2019) show that mobile phone innovation improves financial inclusion in African countries. Ouma et al (2017) provide evidence on how mobile banking activities promote savings at the household level. Sumarsono et al. (2020) observe that increasing number of internet users and fintech companies helps improve financial inclusion in Southeast Asia.

Given that the outcome variable ($ActiveAccount_{ij}$) is a binary variable, a logit model is adopted for the estimation to predict the probability of an individual having an active financial transaction account. By logarithmically transforming the outcome variable, it allows the examination of a nonlinear association in a linear way. The coefficient a_1 measures ceteris paribus the effect of a one-unit change in the mobile banking regulatory index on the dependent variable. In particular, marginal effects will be calculated to assess the impact of one unit change in the mobile banking regulatory index on the likelihood of an individual having an active financial transaction account. When testing the impact of each component within the regulatory index, the marginal effect reflects whether having the corresponding regulatory practice affects financial inclusion. Regressions are estimated with robust standard error clustered by country. Since only one year of data is available for the mobile banking regulatory index, the identification strategy does not include any time dimension and a cross-sectional estimation is performed. To evaluate the validity of the model, a Hosmer–Lemeshow goodness-of-fit test and specification error test are to be

conducted. The analysis will also try to detect if potential observations have a significant impact on the estimation.

Admittedly, there are some limitations to this model. With regards to the measurement, though the mobile banking regulatory index covers multiple essential dimensions of regulatory areas for mobile banking activities, it is not exhaustive. Some regulatory issues such as data privacy and security are not captured in the index. In addition, the estimation faces potential endogeneity issues. Individuals that are more likely to adopt mobile banking services tend to live in areas with high quality regulations. Reverse causality is however limited as the regulation measure is at the country level while the adoption measure is at the individual level. It is unlikely that an individual's adoption of mobile banking services would affect the regulatory quality at the country-level. There may also be omitted variable bias due to unobservable factors being correlated with the mobile banking regulations. A few additional country characteristics such as the rule of law situation, the overall regulatory quality, as well as the level of dependency on natural resources are thus included as controls in the robustness check.

To further address the potential endogeneity in the model, the study is to instrument the mobile banking regulatory index with the legal origin of a country's commercial code or company law. Earlier studies have provided evidence on how such legal origin can be used as a proxy as a government's inclination to intervene in the economy (Djankov et al., 2000; La Porta et al., 1998). Adapting from the legal origin variable used by Djankov et al. (2000), this study categorizes countries into three groups: Common, Civil and Socialist.[22] The legal origin reflects the overall substantive and procedural aspects of a legal

[22] Djankov et al. (2000) categorizes countries into five groups: English common, French civil, German civil, Scandinavian, and Socialist. There is no country with Scandinavian legal origin in the sample of this study.

system, and therefore has a fundamental association with the legal aspects measured under the mobile banking regulatory index. Meanwhile, it is arguable that a country's legal origin, usually established centuries ago, cannot directly impact an individual's financial behavior recently but through the current specific institutional settings such as mobile banking regulations. Validity of the instrument variable will also be further verified.

3.5 Data

Data of the main variable of interest—mobile banking regulatory index, is from the World Bank Global Indicators Group. Together with the World Bank Global Indicators Group, the author collected data on laws and regulations in the domain of mobile banking activities over 80 countries in 2017 (Annex 3.1).[23] Data are collected through standard questionnaires which are completed by three main types of respondents: financial sector supervisory authorities, financial lawyers, and legal officers of financial institutions. Data are further verified through detailed desk research of legal texts, reflecting the regulatory status of each country as of June 1, 2017. Information on two types of legislations are collected following two distinct models of mobile banking activities: agent banking regulations and mobile money/electronic money regulations. With regards to agent banking regulations, regulatory aspects covered include whether allowing agents to provide financial services on behalf of financial institutions, minimum standards to qualify as an agent, scope of services that can be performed by agent, and liability of financial institutions for acts of agents. Under mobile money/electronic money regulations, measured regulatory aspects include legal recognition of mobile money, whether allowing

French civil and German civil are grouped as the same category of Civil in this study. Therefore, countries are categorized into three groups in this study: Common, Civil and Socialist.

[23] The author is a core team member of the World Bank Global Indicators Group and was in charge of the data collection and verification.

non-bank institutions to issue mobile money, license requirement for non-bank mobile money issuer, and customer protection requirements imposed on non-bank mobile money issuer (See details in table 3.1).

Table 3.1. Details of the mobile banking regulatory index

Regulations affecting bank-led model **Agent banking regulations**	**Regulations affecting MNO-led model** **Electronic money/mobile money regulations**
• According to the law, can banks/financial institutions hire a third party as their agent to provide financial services on their behalf? • Are there minimum standards in order to qualify and operate as an agent? • What type of contracts can agents enter into with commercial banks/financial institutions (only non-exclusive, only exclusive, or both)? • What services can be offered to customers by an agent on behalf of a bank (cash deposit and withdrawals, money transfer, bill payment, etc.)? • Are commercial banks/financial institutions liable for the acts of commission and omission of agents providing financial services on their behalf?	• Does the law allow mobile money? • Can non-bank businesses (i.e. businesses that do not hold a banking license such as mobile network operator) issue mobile money? • What are the requirements to obtain a license? ➢ Initial capital requirements ➢ Interoperability ➢ Existence of internal control mechanisms ➢ Consumer protection mechanisms • Does the law require that customers' funds be safeguarded and deposited in a trust account at a fully prudentially regulated financial institution under which funds are held on behalf of clients?

Source: World Bank Global Indicators Group.

Working together with the World Bank Global Indicators Group, the author constructed the regulatory index measuring the adoption of the above-mentioned regulatory practices in each country. A score of 1 is assigned for each of the practice feature in the law. For example, a score of 1 is assigned if the law allows commercial banks to hire agents to provide financial services. For multiple choice questions, a score of 1 is divided based on the number of options. For instance, a score of ¼ is assigned to each of the four requirements to obtain a license to issue mobile money/e-money (detailed scoring methodology in Annex 3.2).

The overall index is then constructed by looking at the number of regulatory practices in place in each country on the two sets of regulations covered by the mobile banking

regulatory index. Agent banking regulation and electronic money/mobile money regulation are treated as two indicators consisting of the overall mobile banking regulatory index. For each of the indicator i, the score for country j is calculated as follows:

$$X_{ij} = 100 * \left[\frac{GP_{ij} - GPmin_i}{GPmax_i - GPmin_i}\right]$$

where GP is the number of the adopted regulatory good practices in country j under indicator i, GPmin, and GPmax are the minimum and maximum number of regulatory practices measured under indicator i. Summary statistics about the components within the mobile banking regulatory index are included in Annex 3.3. The obtained scores are normalized between 0 and 100, with 100 (0) representing the best (worst) regulatory comprehensiveness. Averaging a country's score on both agent banking laws and mobile money/electronic money laws produces its final score on the mobile banking regulatory index.

Countries' performances on the regulatory index vary. Differences among and within regions and income groups are shown in Annex 3.4. Taking a few country examples, Kenya receives a high score of 93.6/100 on the mobile banking regulatory index. It has established a comprehensive regulatory framework for mobile banking services. It allows nonbank institutions such as MNOs to participate in the market. Full amount of funds collected by nonbank institutions are required to be deposited in prudentially regulated financial institutions. Interoperability among mobile banking service providers is mandated. While Lao PDR receives a score of 0 on the index. As of 2017, there is no regulatory framework allowing commercial banks to hire an agent to conduct financial services on their behalf to promote bank-led mobile banking services. Nonbank institutions are not allowed to provide mobile banking services.

Adoption level of each regulatory practice within the index also differs. Around half of the measured countries have established a legal framework regulating agent banking activities. Among those countries, about 62% of them allow agents to enter into both exclusive and non-exclusive contracts with financial institutions. Regulatory framework for e-money activities is more prevalent, with 90% of measured countries having adopted relevant legislations on this regard. Among those countries, about two thirds of them allow non-financial institution businesses such as mobile network operators or payment companies to issue e-money. Consumer protection related regulatory practices haven't been adopted widely. Across all the measured countries, slightly more than half of them require consumer protection measures such as consumer recourse mechanism or consumer awareness programs to be in place, in order for non-bank businesses to receive a license to issue e-money. Similarly, non-bank e-money issuers are required to keep a minimum liquid amount of assets to safeguard customer funds in about half of the measured countries.

With the detailed assessment of mobile banking regulatory environment (including both the aggregated mobile banking regulatory index as well as the adoption of each regulatory practice measured within the index), this analysis further utilizes individual-level data on accessing and using financial transaction account from World Bank's *Findex* project as the dependent variable. Launched in 2011 and with updates every three years, the Global Findex database contains data on how adults save, borrow, make payments, and manage risk. The data are collected through nationally representative surveys of more than 150,000 adults in over 140 economies. The microdata provides information on whether an individual has an account at a financial institution, either at a financial institution or through a mobile money provider, as well as information capturing the usage such as whether an

individual has made any deposits into a financial transaction account. The microdata is probability-weighted to make it representative of the situation at the national level. The dependent variable used in the model is a constructed dummy variable *ActiveAccount* combining the information of whether an individual has a financial transaction account and whether an individual has made any deposits into the financial transaction account.

Other individual controls including gender, age, education level, income level as well as the mobile phone ownership are also obtained from the Findex dataset. Data of other country level controls are from the World Development Indicators and the Financial Development and Structure Dataset (table 3.2). Since the mobile banking regulatory index reflects country's regulatory situation as of year 2017, the analysis also uses the data of year 2017 for other variables to ensure consistency. Summary statistics of the variables are shown in table 3.3. Correlation results of the dependent variables are included in Annex 3.5.

Table 3.2. Data description

Variable	**Definition, year**	**Source**
Dependent variable		
ACTIVE ACCOUNT	Respondent has an active financial transaction account, 2017	Demirguc-Kunt et al. (2018)
Variable of interest		
REGULATION	Mobile Banking Regulatory index obtained from World Bank Global Indicators Group, 2017; Specific mobile banking regulation attributes from the index	Author's calculation with the World Bank Global Indicators Group
Individual controls		
FEMALE	Respondent is female, 2017	Demirguc-Kunt et al. (2018)
AGE	Respondent age, 2017	
EDUCATION	Respondent's education level, 2017 (completed primary school or less; completed secondary school; completed tertiary education or more)	
INCOME	Within-economy household income quintile, 2017	

MOBILE OWNERSHIP	Respondent owns a mobile phone, 2017	
Country controls		
LOGGDPCAP	Log value of GDP per capita in current US$, 2017	World Development Indicators (2017)
LOGPOPDEN	Log value of total population, 2017	
MOBILE SUBSCRIPTION	Mobile cellular subscriptions (per 100 people), 2017	
CONCENTRATION	Assets of three largest banks as a share of assets of all commercial banks, 2017	Financial Development and Structure Dataset Thorsten Beck et al. (2020)

Table 3.3. Summary statistics

	mean	sd	min	max
Having an active financial transaction account	0.249	0.432	0	1
Mobile Banking Regulatory Index	52.943	27.357	0.000	95.446
Individual is female	0.554	0.497	0	1
Respondent age	38.496	16.869	15	99
Respondent education level	1.621	0.646	1	3
Within-economy household income quintile	3.183	1.427	1	5
Owns a mobile phone	0.762	0.426	0	1
GDP per capita (current USD)	3297.010	3148.981	292.998	14591.860
Bank concentration (%)	58.049	18.164	17.164	100.000
Population density (people per sq. km of land area)	132.553	172.771	6.681	1226.631
Mobile cellular subscriptions (per 100 people)	101.052	30.720	34.143	175.597

3.6 Results

3.6.1 Estimation results of the aggregated mobile banking regulatory index

Results show that the mobile banking regulatory index score (0-100) for a country is positively associated with an individual having and using a financial transaction account, indicating that a more comprehensive regulatory framework is associated with a higher level of financial inclusion (table 3.4). Column (2) in table 3.4 suggests that one unit increase of a country's score on the mobile banking regulatory index increases the

likelihood of individuals' having an active financial transaction account by 0.1%. Standard errors are clustered at the country level. The effects are significant but the magnitude doesn't seem to be at a high level. One explanation is that enabling regulatory environment is only one but non-negligible aspect among all the factors that affect financial inclusion. Financial infrastructure, individual's background such as education level or income level all matter. Another potential reason could be that effect from the index as a whole may not be at a high level of magnitude, but a particular regulatory component within the index could have a larger impact. Therefore, section 3.6.2 and section 3.6.3 further examine whether and what components within the regulatory index are having a stronger impact.

The results support the public interest theory that governments use regulations to address market failures and protect the public interest. Governments who adopt comprehensive and enabling mobile banking regulations create a positive impact on financial inclusion. This may be related to the nature of mobile banking activities. As a new medium to deliver financial services, the mobile banking sector may include service providers with a wide range of qualifications, calling for more stringent regulatory vetting to weed out bad players. Comprehensive regulations and standard rules help avoid potential chaos by screening out non-trustworthy players and engender trust for customers. In addition, results show that senior people, high income group, and highly educated people are more likely to have access and use mobile banking services. Females are less likely to access and use mobile banking services. This indicates that the bottom of the pyramid, such as the poorest or the less educated groups are less likely to adopt mobile banking activities and may need extra help.

In addition, it is argued that regulations may have different impacts on financial

behaviors of individuals with different profiles. Therefore, it is important to understand whether only a subset of population is being affected by mobile banking regulations, or whether the regulations impose opposite effects on different groups of people. For instance, it is worth exploring whether individuals at the bottom 40% of the income distribution within a country will benefit from an enabling regulatory environment to the same extent as the richer people. Results show that mobile banking regulations have largely the same magnitude of impacts on different groups of people (Annex 3.6), implying that a supportive mobile banking regulatory environment can have a comprehensive impact benefiting the entire population. Nevertheless, the positive impact is not significant for individuals who have completed tertiary education or those who are above 40 years old. It is possible that highly educated individuals are already fully aware of the benefits and risks of various financial transactions (e.g. saving, payment, transfer), thus the impact of mobile banking regulation would be marginal. Similarly, for the elderly who tend to lag in adopting new technologies, an enabling regulatory environment may not be sufficient, and other endeavors or incentives are needed to include them in the formal financial system.

Table 3.4. Regression results at aggregated mobile banking regulatory index

Model	Logit	
Dependent variable	**Active account ownership (Having a transaction account and deposited in a transaction account)**	
	Coefficient	**Marginal effects**
	(1)	(2)
Mobile Banking Regulatory Index	0.005***	0.001***
	(0.002)	(0.000)
Individual is female	-0.342***	-0.050***
	(0.072)	(0.011)
Respondent age	0.016***	0.002***
	(0.003)	(0.000)
Completed secondary education	0.760***	0.110***
	(0.065)	(0.009)

Completed tertiary education or more	1.630***	0.236***
	(0.097)	(0.016)
Income quintile_second 20 %	0.250***	0.036***
	(0.053)	(0.008)
Income quintile_middle 20%	0.513***	0.074***
	(0.049)	(0.008)
Income quintile_fourth 20%	0.755***	0.109***
	(0.051)	(0.009)
Income quintile_richest 20%	1.126***	0.163***
	(0.057)	(0.012)
Owns a mobile phone	0.961***	0.139***
	(0.086)	(0.012)
Log of GDP per capita (current USD)	0.721***	0.105***
	(0.122)	(0.018)
Log of population density (people per sq. km of land area)	0.123*	0.018*
	(0.072)	(0.010)
Bank concentration (%)	-0.006	-0.001
	(0.004)	(0.001)
Mobile cellular subscriptions (per 100 people)	-0.003	-0.000
	(0.004)	(0.001)
_cons	-9.429***	
	(1.056)	
Region fixed effects	Yes	Yes
Number of observations	70,824	70,824
R2		
Adjusted R2	0.175	0.175

Note: *** p<0.01, ** p<0.05, * p<0.1.

3.6.2 Estimation results of specific regulatory aspect on service provision and agent contract

In order to further examine which regulatory attributes are driving the impacts on financial inclusion, the analysis tests model (1) using each of the regulatory component within the index separately. Results show that almost all the regulatory components are positively associated with an individual within this country having an active financial transaction account (Annex 3.7). This justifies the validity of the construction of the index, as well as the usage of the index as a proxy to assess the regulatory environment for mobile

banking activities across countries.

Importantly, regulatory provisions about the scope of financial services can be performed by agents as well as the prohibition of exclusive agent contracts have a particularly positive impact, statistically significant at the 5% level (table 3.5 and 3.6). The positive impact of the regulatory provision about the scope of financial services supports the transaction cost theory. Under that theory, enabling institutions help reduce transaction cost and incentivize potential customers to engage in transactions. Standard legal provisions provide quality control on the services provided so that individual customers do not have to verify the attributes of services through other channels like friends or family. Legal requirements on services bind providers to deliver services as promised and offers legal protection for complaints in case of failure to deliver services. From the perspective of potential customers facing a new type of financial services or new medium of delivering financial services like mobile banking, legal provisions regulating the services could engender trust on the type and quality of services they are getting, thus incentivizing them to access and use the services.

Table 3.5. Regression results on legal requirement about service provision of agents

Model	Logit	
Dependent variable	**Active account ownership (Having a transaction account and deposited in the transaction account)**	
	Coefficient	**Marginal effects**
Legal requirement on service provision by agents	0.340**	0.049**
	(0.133)	(0.020)
Individual is female	-0.343***	-0.050***
	(0.072)	(0.010)
Respondent age	0.016***	0.002***
	(0.003)	(0.000)
Completed secondary education	0.770***	0.111***

	(0.064)	(0.009)
Completed tertiary education or more	1.644***	0.238***
	(0.100)	(0.016)
Income quintile_second 20 %	0.250***	0.036***
	(0.053)	(0.008)
Income quintile_middle 20%	0.511***	0.074***
	(0.049)	(0.008)
Income quintile_fourth 20%	0.753***	0.109***
	(0.051)	(0.009)
Income quintile_richest 20%	1.121***	0.162***
	(0.057)	(0.011)
Owns a mobile phone	0.975***	0.141***
	(0.086)	(0.011)
log of GDP per capita (current USD)	0.732***	0.106***
	(0.118)	(0.018)
log of population density (people per sq. km of land area)	0.130*	0.019*
	(0.076)	(0.011)
Bank concentration (%)	-0.006	-0.001
	(0.004)	(0.001)
Mobile cellular subscriptions (per 100 people)	-0.004	-0.001
	(0.004)	(0.001)
_cons	-9.380***	
	(1.097)	
Region fixed effects	Yes	Yes
Number of observations	70,824	70,824
R2		
Adjusted R2	0.175	0.175

Note: *** p<0.01, ** p<0.05, * p<0.1.
Legal requirement on service provision by agents is a binary variable that equals 1 if a country has regulatory requirements on any type of the financial services allowed by agents (cash deposits, cash withdrawals, transfer of funds to other customers' accounts, bill payments, balance inquiry, opening a deposit account, collection of loan application documents), and equals 0 if there is no regulatory requirements on any of the service.

In terms of the regulatory requirement on the contract between agents and financial institutions, there exists controversy in how to regulate the types of contracts signed between financial institutions and agents who are providing mobile banking services on their behalf. Those who support exclusive contracts argue that exclusivity promotes innovation, especially in the early stages of agent banking by encouraging financial service

providers to invest in agent network. However, many believe that nonexclusive contracts are important for financial inclusion. Non-exclusive contracts allow agents to provide services for multiple financial institutions, which could reduce transaction costs for potential customers and promote the access and usage of mobile banking services (Muthiora, 2015). Agents can become a one-stop shop for customers who may have to deal with multiple financial relationships through different financial service providers. For instance, the financial service provider that an individual chooses to receive remittances from overseas family members may be different from that required by local vendors to make payments. If an agent located in the remote rural area is able to conduct services on behalf of different financial services providers, he or she could reduce time and cost otherwise spent by customers on traveling to different branches of those financial providers to get the transactions done. The increased convenience and significant reduction on transaction cost enabled by non-exclusivity contracts could increase the adoption and use of mobile banking services. Moreover, from a competition perspective, non-exclusivity could stimulate competition among different service providers to offer high-quality and affordable products and services to attract customers.

The result supports the latter argument that only allowing non-exclusive contracts has a positive impact on individual's access and usage of mobile banking activities (table 3.6). The relationship is significant even after controlling for legal requirements on services as well as the overall mobile banking regulatory index. Legally requiring non-exclusive contracts between agents and financial services providers is associated with a 6% increase in the probability of individual having an active financial transaction account. The result is also consistent with qualitative findings in regulatory practice. It was found that regulations

prohibiting agent exclusivity in Tanzania incentivized three leading MNOs to establish an interoperability agreement in June 2014 (Bourreau and Valletti, 2015). This agreement allows customers to send and receive mobile money through any of the MNOs involved in the agreement.

Table 3.6. Regression results on legal requirement about non-exclusive contracts between agents and financial institutions

Model	Logit	
Dependent variable	**Active account ownership (Having a transaction account and deposited in a transaction account)**	
	Coefficient	**Marginal effects**
Legal requirement on service provision by agents	-0.162	-0.023
	(0.341)	(0.049)
Non-exclusive contract	0.413**	0.060**
	(0.192)	(0.028)
Mobile Banking Regulatory Index	0.002	0.000
	(0.004)	(0.001)
Individual is female	-0.343***	-0.050***
	(0.072)	(0.010)
Respondent age	0.016***	0.002***
	(0.003)	(0.000)
Completed secondary education	0.770***	0.111***
	(0.064)	(0.009)
Completed tertiary education or more	1.645***	0.238***
	(0.099)	(0.016)
Income quintile_second 20 %	0.250***	0.036***
	(0.053)	(0.008)
Income quintile_middle 20%	0.512***	0.074***
	(0.049)	(0.008)
Income quintile_fourth 20%	0.753***	0.109***
	(0.051)	(0.009)
Income quintile_richest 20%	1.122***	0.162***
	(0.057)	(0.011)
Owns a mobile phone	0.971***	0.140***
	(0.085)	(0.011)
log of GDP per capita (current USD)	0.712***	0.103***
	(0.123)	(0.019)

log of population density (people per sq. km of land area)	0.125*	0.018*
	(0.074)	(0.011)
Bank concentration (%)	-0.006	-0.001
	(0.004)	(0.001)
Mobile cellular subscriptions (per 100 people)	-0.003	-0.001
	(0.004)	(0.001)
Region fixed effects	Yes	Yes
Number of observations	70,824	70,824
R2		
Adjusted R2	0.176	0.176
note: *** p<0.01, ** p<0.05, * p<0.1		

Note: Legal requirement on service provision by agents is a binary variable that equals 1 if a country has regulatory requirements on any type of the services allowed by agents (cash deposits, cash withdrawals, transfer of funds to other customers' accounts, bill payments, balance inquiry, opening a deposit account, collection of loan application documents), and equals 0 if there is no regulatory requirements on any of the service. Non-exclusive contract is a binary variable that equals 1 if the law allows non-exclusive contract, and equals 0 if the law does not prohibit exclusive contract.

3.6.3 Estimation results of a subset of regulatory provisions on entry control and consumer protection

The mobile banking regulatory index constructed together with the World Bank Global Indicators Group was based on two key sub-indices: agent banking regulations as well as mobile money/e-money regulations. This division reflects different models of mobile banking activities. However, there are functional commonalities among the two types of regulations. Both have provisions serving similar purposes such as entry control and consumer protection. For instance, measurements of agent banking regulations include components in minimum standards to qualify and operate as an agent, and similarly licensing requirements of e-money issuer are also measured. In addition, some e-money regulations would require e-money issuers to fully ringfence or keep a minimum liquid amount of assets to safeguard customer funds, while agent-banking regulations would hold financial institutions liable for conducts of agents in consumer interactions. Both aim to protect consumers. The analysis here tries to reconstruct those regulatory attributes from the angle of purposes and tests their impacts on financial inclusion.

Results show that both entry control provisions and consumer protection provisions are positively associated with individuals' access and usage of mobile banking activities, though the significance level is low for entry control provisions (table 3.7). The association is statistically significant for consumer protection provisions, at a level of 1%. This may provide reform indications for governments that entry control of mobile banking service providers does not have to be too stringent. More players in the market could entail competition and innovation. Instead, consumer protection provisions play an important role in promoting the adoption and usage. Explicit requirements such as holding financial institutions liable for the acts of agents, and requiring e-money issuers to safeguard customer funds, could potentially provide confidence for individuals to engage with agents or non-business e-money issuers and try new financial services, thus promoting financial inclusion.

Table 3.7. Regression results on newly constructed mobile banking regulatory sub-indices of entry control and consumer protection

Model: Logit Dependent variable: having an active financial transaction account	
	Coefficient
Legal provisions on entry control	0.028
	(0.031)
Individual is female	-0.342***
	(0.072)
Respondent age	0.016***
	(0.003)
Completed secondary education	0.753***
	(0.066)
Completed tertiary education or more	1.623***
	(0.097)
Income quintile_second 20 %	0.250***
	(0.053)

Model: Logit Dependent variable: having an active financial transaction account	
	Coefficient
Legal provisions on consumer protection	0.247***
	(0.089)
Individual is female	-0.342***
	(0.072)
Respondent age	0.016***
	(0.003)
Completed secondary education	0.758***
	(0.065)
Completed tertiary education or more	1.631***
	(0.098)
Income quintile_second 20 %	0.250***
	(0.053)

Income quintile_middle 20%	0.512***	Income quintile_middle 20%	0.513***
	(0.049)		(0.049)
Income quintile_fourth 20%	0.753***	Income quintile_fourth 20%	0.754***
	(0.052)		(0.051)
Income quintile_richest 20%	1.124***	Income quintile_richest 20%	1.125***
	(0.058)		(0.057)
Owns a mobile phone	0.959***	Owns a mobile phone	0.966***
	(0.086)		(0.087)
log of GDP per capita (current USD)	0.717***	log of GDP per capita (current USD)	0.739***
	(0.118)		(0.122)
log of population density (people per sq. km of land area)	0.142**	log of population density (people per sq. km of land area)	0.122*
	(0.068)		(0.071)
Bank concentration (%)	-0.006	Bank concentration (%)	-0.005
	(0.004)		(0.004)
Mobile cellular subscriptions (per 100 people)	-0.002	Mobile cellular subscriptions (per 100 people)	-0.003
	(0.004)		(0.004)
_cons	-9.431***	_cons	-9.641***
	(0.985)		(1.071)
Region fixed effects	Yes	Region fixed effects	Yes
Number of observations	70,824	Number of observations	70,824
R2		R2	
Adjusted R2	0.173	Adjusted R2	0.175

Note: *** p<0.01, ** p<0.05, * p<0.1

Legal provision on entry control is an aggregated score (0-8) about the entry control for mobile banking service providers in the following aspects: 1) has to be an operating/established business to qualify as an agent; 2) has to have positive financial records to qualify as an agent; 3) has to have real-time connectivity to a financial institution to qualify as an agent; 4) allow non-bank institutions to provide mobile money services; 5) specify initial capital requirements for e-money issuer; 6) impose interoperability as a licensing requirement for e-money issuer; 7) impose as a licensing requirement for e-money issuer the existence of internal control mechanisms to comply with Anti-Money Laundering and Combatting Financing of Terrorism (AML/CFT) laws, standards and measure; and 8) impose as a licensing requirement for e-money issuer the existence of consumer protection measures such as consumer recourse mechanisms, consumer awareness programs, etc.

Legal provision on consumer protection is an aggregated score (0-2) about the consumer protection for mobile banking service providers in the following aspects: 1) Whether banks are liable for the acts of commission and omission of agents providing financial services on their behalf; 2) Whether e-money issuers are required to keep a minimum liquid amount of assets to safeguard customer funds.

3.7 Robustness check

To evaluate the validity of the model, a Hosmer–Lemeshow goodness-of-fit test is conducted after the estimation. Given the large number of observations, the test is conducted with 500 groups. A p-value of 0.1387 of the Pearson chi-square from the Hosmer and Lemeshow's goodness-of-fit test indicates that the model fits the data well. The link test is also performed to check any specification error. Results show that the post-estimation predicted value squared is not significant, indicating that the model is correctly specified. Furthermore, to detect if any potential observations have a significant impact on the model, model (1) is retested by excluding observations with Pearson residual value more than 2, deviance residual value more than 2, and leverage value more than 3 times the average leverage. The sign and significance of the coefficient of the mobile banking regulatory index on individual's having an active financial transaction account is still retained after excluding those observations (Annex 3.8).

One concern of the finding is that the estimated mobile banking regulation's impact on the individual accessing and using financial services may be capturing the effect of other country characteristics especially the overall regulatory environment. For instance, countries with better regulatory quality or rule of law situation may be more likely to establish comprehensive and enabling mobile banking regulations. The better overall regulatory environment may also have a positive impact on individual's adoption of financial products. Moreover, countries whose financial sector is heavily controlled by the state-owned banks may be inclined to craft financial regulations including mobile banking regulations in favor of existing incumbents, thus affecting the quality or comprehensiveness of mobile banking regulations. State-owned banks' dominant position in the financial sector may also affect the adoption of financial services. Additionally, it is

possible that resource dependent countries are in less urgency of developing mobile banking regulations or improving financial inclusion to facilitate daily small transactions. Therefore, a few additional country characteristics variables including the rule of law, regulatory quality, total natural resources rents (% of GDP), and share of banking assets in state-owned banks are included in the model. Columns (1) to (5) in table 3.8 shows that mobile banking regulation's positive impact on individuals accessing and using financial services still hold after adding those controls.

Table 3.8. **Adding other country level characteristic variables as controls**

Model	Logit				
Dependent variable	Active account ownership (Having a transaction account and deposited in a transaction account)				
	Rule of law	Regulatory quality	Total natural resources rents	Share of banking assets in state-owned banks	all
	(1)	(2)	(3)	(4)	(5)
Mobile Banking Regulatory Index	0.004**	0.005**	0.006***	0.005**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Individual is female	-0.344***	-0.342***	-0.344***	-0.379***	-0.380***
	(0.073)	(0.072)	(0.072)	(0.085)	(0.085)
Respondent age	0.015***	0.016***	0.015***	0.015***	0.015***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Completed secondary education	0.748***	0.758***	0.771***	0.787***	0.790***
	(0.067)	(0.066)	(0.067)	(0.075)	(0.074)
Completed tertiary education or more	1.617***	1.623***	1.644***	1.658***	1.664***
	(0.099)	(0.097)	(0.100)	(0.118)	(0.114)
Income quintile_second 20 %	0.250***	0.249***	0.250***	0.277***	0.277***
	(0.053)	(0.053)	(0.053)	(0.059)	(0.059)
Income quintile_middle 20%	0.515***	0.513***	0.513***	0.526***	0.527***
	(0.049)	(0.049)	(0.049)	(0.056)	(0.056)
Income quintile_fourth 20%	0.759***	0.755***	0.757***	0.778***	0.779***
	(0.051)	(0.051)	(0.052)	(0.059)	(0.059)
Income quintile_richest 20%	1.133***	1.126***	1.128***	1.166***	1.168***

	(0.057)	(0.057)	(0.057)	(0.061)	(0.061)
Owns a mobile phone	0.991***	0.969***	0.965***	1.061***	1.064***
	(0.086)	(0.086)	(0.085)	(0.106)	(0.106)
Log of GDP per capita (current USD)	0.575***	0.679***	0.725***	0.823***	0.763***
	(0.134)	(0.145)	(0.110)	(0.105)	(0.113)
Log of population density (people per sq. km of land area)	0.022	0.099	0.039	0.177*	0.120
	(0.078)	(0.073)	(0.082)	(0.106)	(0.108)
Bank concentration (%)	-0.005	-0.006	-0.004	0.000	0.001
	(0.004)	(0.004)	(0.003)	(0.005)	(0.004)
Mobile cellular subscriptions (per 100 people)	-0.005	-0.004	-0.005	-0.006	-0.006
	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Rule of law estimate	0.537***				0.574
	(0.193)				(0.375)
Regulatory quality estimate		0.150			-0.337
		(0.175)			(0.354)
Total natural resources rents (% of GDP)			-0.034**		-0.004
			(0.015)		(0.023)
Share of banking assets in state-owned banks				0.007	0.005
				(0.005)	(0.006)
_cons	-7.415***	-8.839***	-8.852***	-10.643***	-9.841***
	(1.336)	(1.388)	(1.067)	(1.338)	(1.440)
Region fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	70,824	70,824	70,824	55,742	55,742
R2					
Adjusted R2	0.179	0.175	0.178	0.181	0.182

Note: *** p<0.01, ** p<0.05, * p<0.1.

Rule of Law estimate and Regulatory Quality estimate are from the Worldwide Governance Indicators project. Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5. Information on the total natural resources rents (% of GDP), and share of banking assets in state-owned banks are from the World Development Indicators.

To further address the concern that the variable of interest mobile banking regulatory index may be endogenous, the author re-estimates the model using an instrumental variable

approach. The legal origin is used as the instrument variable. It categorizes countries into three groups: Common, Civil and Socialist. Results show that the effect of a more comprehensive and supportive mobile banking regulatory framework on financial inclusion remains positive and significant under the instrumental variable method (table 3.9). First-stage regression results in column (1) of table 3.9 show that countries with a socialist legal origin tend to have a lower score on the mobile banking regulatory index, than the common law countries. The Hansen J statistic overidentification test shown in column (2) of table 3.9 does not reject the null hypothesis that the instruments are valid. However, the instruments are weak given the F statistic is 3.350 for the first-stage regression. Therefore, it is insufficient to draw causal inference from the instrument variable approach, but it adds to the robustness of the relationship between the mobile banking regulatory index and individuals' accessing and using financial services.

Table 3.9. Instrumental Variable test results

	First-stage regression: Mobile banking regulatory index (1)	**Second-stage regression: Active account ownership (2)**		**First-stage regression: Mobile banking regulatory index (3)**	**Second-stage regression: Active account ownership (4)**
Mobile Banking Regulatory Index		0.005**	Mobile Banking Regulatory Index		0.006**
		(0.002)			(0.003)
Legal origin= civil	-11.161				
	(10.441)				
Legal origin= socialist	-32.459**		Legal origin=Socialist	-22.366**	
	(13.359)			(10.444)	
Individual is female	0.073	-0.049***	Individual is female	0.143	-0.049***
	(0.217)	(0.010)		(0.242)	(0.010)
Respondent age	-0.000	0.002***	Respondent age	0.004	0.002***

	(0.020)	(0.000)
Completed secondary education	-1.970	0.114***
	(1.759)	(0.013)
Completed tertiary education or more	0.375	0.311***
	(2.271)	(0.021)
Income quintile_second 20 %	0.109	0.025***
	(0.117)	(0.007)
Income quintile_middle 20%	0.175	0.059***
	(0.230)	(0.007)
Income quintile_fourth 20%	0.195	0.097***
	(0.366)	(0.009)
Income quintile_richest 20%	0.148	0.170***
	(0.594)	(0.012)
Owns a mobile phone	0.449	0.094***
	(1.441)	(0.010)
log of GDP per capita (current USD)	-3.034	0.104***
	(6.885)	(0.038)
log of population density (people per sq. km of land area)	3.629	-0.014
	(3.692)	(0.022)
Bank concentration (%)	0.082	-0.001
	(0.180)	(0.001)
Mobile cellular subscriptions (per 100 people)	0.140	-0.001*

	(0.020)	(0.000)
Completed secondary education	-1.085	0.115***
	(2.111)	(0.015)
Completed tertiary education or more	1.153	0.310***
	(2.541)	(0.023)
Income quintile_second 20 %	0.065	0.025***
	(0.136)	(0.007)
Income quintile_middle 20%	0.102	0.059***
	(0.258)	(0.007)
Income quintile_fourth 20%	0.063	0.097***
	(0.421)	(0.009)
Income quintile_richest 20%	-0.066	0.170***
	(0.683)	(0.012)
Owns a mobile phone	0.332	0.094***
	(1.384)	(0.012)
log of GDP per capita (current USD)	-1.345	0.102**
	(6.524)	(0.044)
log of population density (people per sq. km of land area)	4.636	-0.021
	(3.522)	(0.028)
Bank concentration (%)	0.087	-0.001
	(0.179)	(0.001)
Mobile cellular subscriptions (per 100 people)	0.160	-0.001

	(0.124)	(0.001)
_cons	56.521	-0.846***
	(62.150)	(0.308)
Region fixed effects	Yes	Yes
Number of observations	70,824	70,824
R2	0.245	0.114
Adjusted R2	0.244	0.114
Hansen J statistic (overidentification test of all instruments) p value		0.531
Underidentificaiton test p value		0.113
F stat	3.350	

	(0.123)	(0.001)
_cons	27.663	-0.828**
	(53.017)	(0.357)
Region fixed effects	Yes	Yes
Number of observations	70,824	70,824
R2	0.230	0.073
Adjusted R2	0.230	0.073
Underidentificaiton test p value		0.056
F stat	4.586	

Note: *** p<0.01, ** p<0.05, * p<0.1
Panel on the left side uses a legal origin categorical variable (1-3) as the instrument variable. 1 stands for a country having a legal origin of common law, 2 for civil law origin and 3 for socialist law origin; panel on the right side uses a dummy variable that equals 1 if the country has a legal origin of socialist law and 0 if the legal origin is non-socialist, as the instrument variable.

3.8 Conclusion

To conclude, comprehensive enabling mobile banking regulatory frameworks play an important role in promoting the access and usage of financial services at an individual level. Focusing on regulatory areas that are critical to both bank-led and MNO-led mobile banking models, this paper finds that individuals are more likely to have an active financial transaction account in countries that adhere to a higher number of mobile banking regulatory practices. This finding supports the public interest theory that governments could use regulations to address market failures and protect the public, thus achieving social efficiency. It also implies that enabling mobile banking regulations could play a role in reducing transaction cost and engendering trust for individuals to adopt financial services. Under the research avenue of identifying factors that affect the financial inclusion,

the finding contributes to the literature by quantitively showing the impact of regulation. It is an important finding given that regulation is often not included in most studies examining the financial inclusion gap in developing countries.

In particular, results show that legal requirements that specify the scope of financial services allowed by agents who are providing financial services on behalf of financial institutions, as well as legal provision requiring non-exclusivity of contracts between agents and financial institutions are the most important drivers of financial inclusion within the mobile banking regulatory index. This is consistent with the foundational theory of transaction cost, which states that institutions could shape transaction costs related to information gathering and measurement, contract enforcement, and uncertainty premiums, thus affecting the incentives of market participants. Explicit legal provision on the type of services that agents are allowed to conduct helps reduce the time and cost customers would otherwise spend on verifying the services they expect to receive. Requirement on non-exclusivity contract enables agents to become a one-stop shop for customers who may need to deal with multiple financial service providers. By reducing transaction costs, these regulatory attributes in mobile banking laws are found to promote the adoption and use of financial services. Legally requiring non-exclusive contracts between agents and financial services providers is associated with a 6% increase in the probability of individual having an active financial transaction account. This finding is consistent with existing qualitative studies and anecdotal evidences that prohibiting exclusive contracts could promote collaboration among financial service providers to develop interoperable systems for a better customer user experience, thus increasing the likelihood of financial service adoption.

Finally, across different types of mobile banking regulations imposed on various providers ranging from banks, agents to non-bank institutions, requirements related to entry barrier such as the licensing requirements on non-bank e-money issuers, do not have a significant impact on the access and usage of mobile banking activities. However, consumer protection provisions in mobile banking regulations are positively associated with higher adoption of financial products and services.

The findings suggest several aspects that governments can take into account when devising regulations and policies to promote financial inclusion. First, standard and transparent mobile banking regulations can play a positive role in facilitating financial inclusion. The mobile banking regulatory index can serve as a benchmarking tool for governments to compare its mobile banking regulatory environment with that of other countries, thus advancing towards the global frontier to establish an enabling regulatory framework. In particular, legal requirement on non-exclusivity between agents and financial institutions helps promote financial inclusion. For countries that are promoting agent banking, it is suggested to prohibit exclusive contracts in order to promote competition and innovation among financial institutions, thus achieving better outreach and higher quality of financial products and services. Moreover, instead of keeping a tight door to screen out potential unqualified service providers of mobile banking services, government should prioritize consumer protection to engender trust in the mobile banking sector and promote financial inclusion. Examples of good regulatory practices promoting consumer protection include requiring mobile banking service providers to keep a minimum liquid amount of assets to safeguard customer funds when issuing electronic money, as well as holding commercial banks liable for the acts of agents providing

financial services on their behalf.

Lastly, it is worthwhile noting that devising and promulgation of mobile banking regulations is often influenced by constituencies such as emerging financial technology firms or powerful existing conventional commercial banks. Rising financial technology firms may be able to impose pressure on governments to lower entry barriers to the financial sector, while incumbents such as conventional banks may push back regulations granting financial licenses for non-traditional players. One potential future research area could be to examine the determinants of adopting various levels of mobile banking regulations. Moreover, it is admitted that an important regulatory aspect—data privacy and security is not included in the aggregated mobile banking regulatory index. Individuals leave digital footprints when engaging in mobile banking activities either through mobile phone or at the agents' points of sale. There rise concerns on the data protection and security with mounting cases of data breaches and potential violation of individual rights. How and whether regulatory provision on data protection and security affect the adoption of financial services can be further assessed.

Annexes

Annex 3.1. Countries covered in the Mobile Banking Regulatory Index

High income	Upper middle income	Lower middle income	Low income
Australia	Argentina	Angola *	Afghanistan
Chile	Armenia	Bangladesh	Burundi *
Denmark	Bosnia and Herzegovina	Bolivia	Benin
Spain	Brazil	Côte d'Ivoire	Burkina Faso
Greece	Colombia	Cameroon	Ethiopia
Italy	Dominican Republic	Egypt, Arab Rep.	Guinea
Korea, Rep.	Georgia	Ghana	Haiti
Netherlands	Guatemala	Honduras	Liberia
Poland	Iraq	India	Madagascar
Uruguay	Jordan	Kenya	Mali
United States	Kazakhstan	Kyrgyz Republic	Mozambique
	Sri Lanka	Cambodia	Malawi
	Mexico	Lao PDR	Niger
	Malaysia	Morocco	Nepal
	Peru	Myanmar	Rwanda
	Romania	Nigeria	Sierra Leone
	Russian Federation	Nicaragua	Togo
	Serbia	Pakistan	Tajikistan
	Thailand	Philippines	Tanzania
	Turkey	Sudan *	Uganda
	South Africa	Senegal	Congo, Dem.
		Tunisia	Rep.*
		Ukraine	
		Uzbekistan	
		Vietnam	
		Zambia	
		Zimbabwe	

Note: Countries marked with asterisk are not covered in the World Bank Findex dataset. Only non-high income countries are included in the analyses of this paper.

Annex 3.2. Scoring methodology of the mobile banking regulatory index from the World Bank Global Indicators Group

Agent banking regulations-affecting bank-led mobile banking activities

1. Whether commercial banks can hire a third party as their agent to provide financial services on their behalf. A score of 1 is assigned if the law allows commercial banks to hire agents to provide financial services. A Score of 0 is assigned if there is no law explicitly allowing agent banking and the Central Bank or Banking supervisory authority is not providing approvals to financial services providers to use agents.
2. Whether there are minimum standards in order to qualify and operate as an agent in the following areas: 1) has to be an operating/established business; 2) has to have positive financial records; 3) has to have real-time connectivity to a commercial bank. Each

standard is weighted equally and worth 1/3 of a point. For example: if the law states all three of the minimum standards as requirements to qualify and operate as an agent, the score is 1. If the law states only two out of three of the minimum standards, the score is 2/3.

3. Whether agents can enter into exclusive contracts with only one commercial bank. A score of 1 is assigned if agents are allowed to enter into both exclusive and non-exclusive contracts. A score of ½ is assigned if only non-exclusive contracts are allowed; and a score of 0 is assigned if only exclusive contracts are allowed.
4. The types of services agents can offer on behalf of a bank. This datapoint looks at 7 services: cash deposits, cash withdrawals, transfer of funds to other customers' accounts, bill payments, balance inquiry, opening a deposit account, collection of loan application documents. Each of the above services is equally weighted and worth 1/7 of a point.
5. Whether commercial banks are liable for the acts of commission and omission of agents providing financial services on their behalf. The score is 1 if the legislation states that commercial banks are liable and 0 if they are not liable.

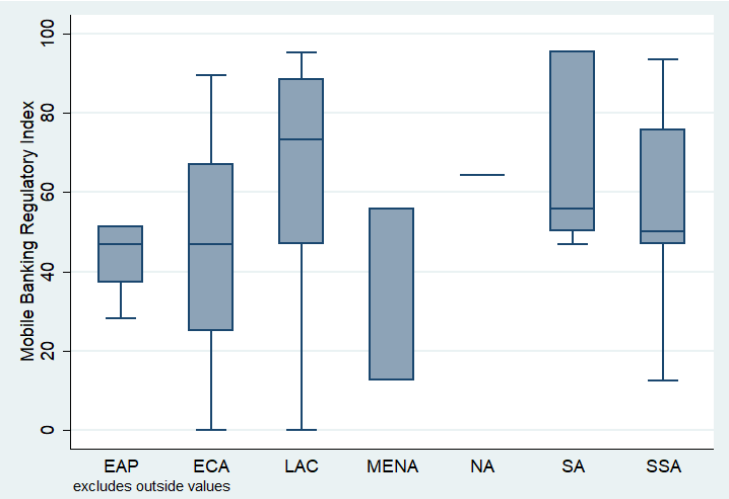
E-money regulations-affecting MNO-led mobile banking activities

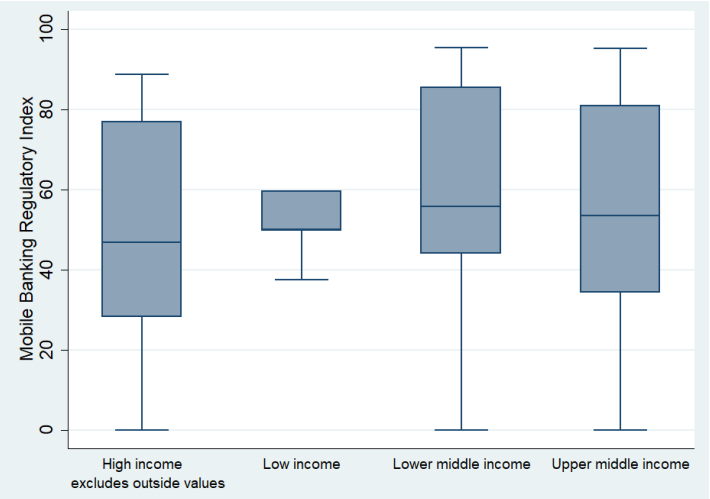
1. A score of 1 is assigned for the following features of the laws:
    - E-money/mobile money is allowed
    - Non-bank businesses such as MNOs are allowed to issue e-money/mobile money
    - Non-bank e-money/mobile money issuers are required to keep a minimum liquid amount of assets to safeguard customer funds
2. The last feature measures the requirements for non-bank businesses to receive a license to issue e-money/mobile money. The four requirements are: an initial capital requirements; interoperability with other existing electronic money payment/transfer systems; existence of internal control mechanisms to comply with Anti-Money Laundering and Combatting Financing of Terrorism (AML/CFT) laws, standards and measures; and Consumer protection measures such as consumer recourse mechanisms, consumer awareness programs, etc. Each of the above services is equally weighted with a score of ¼.

Annex 3.3. Summary statistics about the component within the Mobile Banking Regulatory Index

	mean	sd	min	max
Is there a legal framework regulating agent banking activities in your country?	0.521	0.500	0	1
Minimum standard to become an agent: established business	0.296	0.457	0	1
Minimum standard to become an agent: financial soundness	0.318	0.466	0	1
Minimum standard to become an agent: real time connectivity	0.346	0.476	0	1
Type of contracts between agents and financial institutions	0.438	0.460	0	1
Service provided by agent: cash deposit	0.493	0.500	0	1
Service provided by agent: cash withdrawal	0.493	0.500	0	1
Service provided by agent: transfer	0.507	0.500	0	1
Service provided by agent: bill payment	0.500	0.500	0	1
Service provided by agent: balance inquiry	0.348	0.476	0	1
Service provided by agent: open account	0.224	0.417	0	1
Service provided by agent: collect loan document	0.327	0.469	0	1
Liability of agents	0.507	0.500	0	1
Is there a legal framework regulating e-money activities in your country?	0.895	0.306	0	1
Can non-financial institution businesses issue e-money?	0.602	0.490	0	1
E-money issuer requirement: initial capital	0.491	0.500	0	1
E-money issuer requirement: interoperability	0.270	0.444	0	1
E-money issuer requirement: AML/CFT mechanisms	0.547	0.498	0	1
E-money issuer requirement: consumer protection mechanisms	0.533	0.499	0	1
safeguarding customers' funds	0.519	0.500	0	1

Annex 3.4. Mobile Banking Regulation Index by region and income group





Source: Authors' calculations based on data from the World Bank Global Indicators Group.

Note: EAP stands for East Asia and Pacific; ECA stands for Europe and Central Asia; LAC stands for Latin America and Caribbean; MENA stands for Middle East and North Africa; SA stands for South Asia; SSA stands for Sub-Saharan Africa; NA stands for North America. The upper hinge of the box represents the 75^{th} percentile; the lower hinge of the box represents the 25^{th} percentile; the line within the box represents the median; the upper adjacent line shows the value of the largest observation that is less than or equal to the upper inner fence which is the third quartile + 1.5* interquartile range; and the lower adjacent line shows the value of the smallest observation that is greater than or equal to the lower inner fence which is the first quartile - 1.5* interquartile range. The box charts exclude outside values. Only one country is covered in the North America, thus showing a line in the box chart. In MENA region, five countries are covered and the value of the median, upper hinge of the box, and the upper adjacent line are the same. For low income countries, the line within the box and the lower hinge of the box are very close as the median is 50 and the first quartile is 49.6.

Annex 3.5. Correlation results of dependent variables in the model

	Mobile Banking Regulatory Index	Individual is female	Respondent age	Respondent education level	Within-economy household income quintile	Owns a mobile phone	GDP per capita (current USD)	Bank concentration (%)	Population density (people per sq. km of land area)	Mobile cellular subscriptions (per 100 people)
Mobile Banking Regulatory Index	1.000	0.006	-0.034	-0.084	-0.014	-0.040	-0.025	-0.096	0.226	-0.023
Individual is female	0.006	1.000	0.013	-0.072	-0.086	-0.104	0.029	0.019	-0.013	0.031
Respondent age	-0.034	0.013	1.000	-0.125	-0.013	-0.074	0.164	-0.032	-0.035	0.172
Respondent education level	-0.084	-0.072	-0.125	1.000	0.238	0.279	0.248	-0.060	-0.081	0.223
Within-economy household income quintile	-0.014	-0.086	-0.013	0.238	1.000	0.156	-0.007	0.002	-0.015	-0.020
Owns a mobile phone	-0.040	-0.104	-0.074	0.279	0.156	1.000	0.157	-0.052	-0.059	0.196
GDP per capita (current USD)	-0.025	0.029	0.164	0.248	-0.007	0.157	1.000	-0.143	-0.203	0.539
Bank concentration (%)	-0.096	0.019	-0.032	-0.060	0.002	-0.052	-0.143	1.000	-0.331	-0.194
Population density (people per sq. km of land area)	0.226	-0.013	-0.035	-0.081	-0.015	-0.059	-0.203	-0.331	1.000	-0.138
Mobile cellular subscriptions (per 100 people)	-0.023	0.031	0.172	0.223	-0.020	0.196	0.539	-0.194	-0.138	1.000

Annex 3.6. Impacts of mobile banking regulations on different demographic profiles

	woman	**man**	**poor (bottom 40%)**	**nonpoor**	**primary school or less**	**secondary education**	**tertiary education or more**	**young (15-40)**	**elderly (>40)**
	Marginal effects	Marginal effects	Marginal effects	Marginal effects	Marginal effects	Marginal effects	Marginal effects	Marginal effects	Marginal effects
Mobile Banking Regulatory Index	0.000*	0.001***	0.001***	0.001**	0.001**	0.001***	0.000	0.001***	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Respondent age	0.001***	0.003***	0.001***	0.003***	0.001***	0.003***	0.002**		
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)		
Completed secondary education	0.088***	0.133***	0.056***	0.164***				0.097***	0.109***
	(0.011)	(0.010)	(0.008)	(0.012)				(0.010)	(0.014)
Completed tertiary education or more	0.195***	0.277***	0.130***	0.341***				0.224***	0.239***
	(0.016)	(0.020)	(0.014)	(0.020)				(0.015)	(0.020)
Income quintile_second 20 %	0.027***	0.046***			0.021***	0.044***	0.136***	0.023**	0.057***
	(0.010)	(0.010)			(0.007)	(0.013)	(0.027)	(0.010)	(0.013)
Income quintile_middle 20%	0.050***	0.102***			0.043***	0.104***	0.175***	0.066***	0.091***
	(0.009)	(0.013)			(0.008)	(0.014)	(0.031)	(0.010)	(0.013)
Income quintile_fourth 20%	0.086***	0.137***			0.057***	0.165***	0.233***	0.094***	0.137***
	(0.010)	(0.012)			(0.008)	(0.015)	(0.033)	(0.010)	(0.013)

Income quintile_richest 20%	0.130***	0.202***			0.075***	0.241***	0.367***	0.152***	0.184***
	(0.013)	(0.015)			(0.010)	(0.018)	(0.031)	(0.013)	(0.015)
Owns a mobile phone	0.112***	0.169***	0.085***	0.192***	0.072***	0.225***	0.276***	0.155***	0.114***
	(0.009)	(0.016)	(0.009)	(0.015)	(0.008)	(0.019)	(0.043)	(0.015)	(0.013)
log of GDP per capita(current USD)	0.084***	0.127***	0.075***	0.123***	0.050***	0.158***	0.142***	0.097***	0.123***
	(0.015)	(0.024)	(0.011)	(0.024)	(0.017)	(0.023)	(0.041)	(0.017)	(0.024)
log of population density (people per sq. km of land area)	0.012	0.024**	0.006	0.027**	0.017**	0.020	0.024	0.014	0.023
	(0.010)	(0.012)	(0.007)	(0.014)	(0.008)	(0.016)	(0.027)	(0.010)	(0.015)
Bank concentration (%)	-0.001	-0.001	-0.001	-0.001	-0.000	-0.001	-0.003***	-0.001	-0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Mobile cellular subscriptions(per 100 people)	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	0.000	-0.000	-0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
Individual is female			-0.027***	-0.071***	-0.037***	-0.061***	-0.062**	-0.033***	-0.079***
			(0.007)	(0.015)	(0.011)	(0.009)	(0.027)	(0.008)	(0.017)
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	39,161	31,663	24,815	46,009	33,082	31,192	6,550	41,282	29,542
R2									
Adjusted R2	0.177	0.166	0.133	0.155	0.095	0.116	0.088	0.182	0.159

Annex 3.7. Decomposing the mobile banking regulatory index: effects of each regulatory component on having an active financial transaction account

Model	Logit										
Dependent variable	**Active account ownership (Having a transaction account and deposited in a transaction account)**										
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
Is there a legal framework regulating agent banking activities in your country?	0.340**										
	(0.133)										
Minimum standard to become an agent: established business		0.161									
		(0.192)									
Minimum standard to become an agent: financial soundness			0.177								
			(0.175)								
Minimum standard to become an agent: real time connectivity				0.326**							
				(0.153)							
Type of contracts between agents and financial institutions					0.346**						
					(0.145)						
Service provided by agent: cash deposit						0.306**					

						(0.135)					
Service provided by agent: cash withdrawal							0.306**				
							(0.135)				
Service provided by agent: transfer								0.329**			
								(0.133)			
Service provided by agent: bill payment									0.317**		
									(0.137)		
Service provided by agent: balance inquiry										0.095	
										(0.171)	
Service provided by agent: open account											0.143
											(0.219)
Individual is female	-0.343***	-0.343***	-0.341***	-0.343***	-0.343***	-0.341***	-0.341***	-0.343***	-0.341***	-0.342***	-0.341***
	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)
Respondent age	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Completed secondary education	0.770***	0.745***	0.748***	0.754***	0.768***	0.776***	0.776***	0.773***	0.774***	0.760***	0.757***
	(0.064)	(0.068)	(0.067)	(0.066)	(0.067)	(0.064)	(0.064)	(0.063)	(0.065)	(0.070)	(0.067)
Completed tertiary education or more	1.644***	1.620***	1.620***	1.622***	1.650***	1.649***	1.649***	1.645***	1.649***	1.632***	1.630***
	(0.100)	(0.099)	(0.098)	(0.101)	(0.100)	(0.100)	(0.100)	(0.099)	(0.100)	(0.100)	(0.101)
Income quintile_second 20 %	0.250***	0.250***	0.250***	0.251***	0.249***	0.249***	0.249***	0.249***	0.249***	0.249***	0.249***

	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
Income quintile_middle 20%	0.511***	0.512***	0.512***	0.513***	0.511***	0.511***	0.511***	0.511***	0.511***	0.511***	0.511***
	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)
Income quintile_fourth 20%	0.753***	0.753***	0.753***	0.755***	0.753***	0.752***	0.752***	0.752***	0.752***	0.751***	0.751***
	(0.051)	(0.052)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)	(0.052)	(0.052)
Income quintile_richest 20%	1.121***	1.123***	1.123***	1.125***	1.120***	1.119***	1.119***	1.120***	1.119***	1.120***	1.119***
	(0.057)	(0.058)	(0.057)	(0.057)	(0.057)	(0.056)	(0.056)	(0.057)	(0.056)	(0.057)	(0.058)
Owns a mobile phone	0.975***	0.967***	0.974***	0.971***	0.973***	0.971***	0.971***	0.972***	0.974***	0.968***	0.974***
	(0.086)	(0.086)	(0.085)	(0.086)	(0.086)	(0.086)	(0.086)	(0.086)	(0.086)	(0.087)	(0.081)
log of GDP per capita(current USD)	0.732***	0.719***	0.705***	0.734***	0.724***	0.735***	0.735***	0.754***	0.709***	0.731***	0.720***
	(0.118)	(0.120)	(0.123)	(0.126)	(0.116)	(0.121)	(0.121)	(0.120)	(0.121)	(0.114)	(0.119)
log of population density (people per sq. km of land area)	0.130*	0.134*	0.127*	0.118	0.146*	0.143*	0.143*	0.136*	0.141*	0.149**	0.156**
	(0.076)	(0.079)	(0.076)	(0.077)	(0.076)	(0.076)	(0.076)	(0.076)	(0.076)	(0.074)	(0.073)
Bank concentration (%)	-0.006	-0.006	-0.006	-0.005	-0.007*	-0.005	-0.005	-0.005	-0.006*	-0.005	-0.006
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Mobile cellular subscriptions(per 100 people)	-0.004	-0.002	-0.002	-0.002	-0.004	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
_cons	-9.380***	-9.317***	-9.225***	-9.467***	-9.354***	-9.590***	-9.590***	-9.693***	-9.280***	-9.551***	-9.417***
	(1.097)	(1.050)	(1.067)	(1.116)	(1.108)	(1.103)	(1.103)	(1.106)	(1.109)	(0.967)	(1.031)

Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	70,824	70,824	70,824	70,824	70,824	70,824	70,824	70,824	70,824	70,824	70,824
R2											
Adjusted R2	0.175	0.172	0.173	0.175	0.175	0.175	0.175	0.175	0.175	0.172	0.172

(Continued)

Model	Logit								
Dependent variable	**Active account ownership (Having a transaction account and deposited in a transaction account)**								
	(12)	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**	**(19)**	**(20)**
Service provided by agent: collect loan document	0.250								
	(0.169)								
Liability of agents		0.331**							
		(0.135)							
Is there a legal framework regulating e-money activities in your country?			0.358*						
			(0.206)						
Can non-financial institution businesses issue e-money?				-0.010					
				(0.169)					
E-money issuer requirement: initial capital					0.119				
					(0.162)				

E-money issuer requirement: interoperability						0.007			
						(0.248)			
E-money issuer requirement: AML/CFT mechanisms							0.011		
							(0.174)		
E-money issuer requirement: consumer protection mechanisms								0.036	
								(0.165)	
safeguarding customers' funds									0.104
									(0.165)
Individual is female	-0.342***	-0.343***	-0.343***	-0.342***	-0.341***	-0.342***	-0.342***	-0.342***	-0.342***
	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)
Respondent age	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Completed secondary education	0.760***	0.770***	0.747***	0.754***	0.755***	0.754***	0.753***	0.754***	0.751***
	(0.069)	(0.064)	(0.066)	(0.067)	(0.068)	(0.068)	(0.067)	(0.067)	(0.066)
Completed tertiary education or more	1.638***	1.644***	1.617***	1.629***	1.629***	1.629***	1.628***	1.628***	1.625***
	(0.100)	(0.100)	(0.096)	(0.099)	(0.098)	(0.099)	(0.098)	(0.098)	(0.098)
Income quintile_second 20 %	0.249***	0.250***	0.251***	0.249***	0.250***	0.249***	0.249***	0.249***	0.249***

	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
Income quintile_middle 20%	0.510***	0.511***	0.514***	0.511***	0.512***	0.511***	0.511***	0.511***	0.512***
	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)	(0.049)
Income quintile_fourth 20%	0.751***	0.753***	0.756***	0.752***	0.753***	0.752***	0.752***	0.752***	0.753***
	(0.052)	(0.051)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)	(0.052)
Income quintile_richest 20%	1.120***	1.121***	1.128***	1.121***	1.123***	1.121***	1.121***	1.121***	1.123***
	(0.057)	(0.057)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)	(0.058)
Owns a mobile phone	0.966***	0.974***	0.958***	0.966***	0.958***	0.965***	0.965***	0.963***	0.963***
	(0.086)	(0.086)	(0.085)	(0.085)	(0.084)	(0.084)	(0.085)	(0.085)	(0.086)
log of GDP per capita(current USD)	0.718***	0.729***	0.750***	0.732***	0.730***	0.731***	0.731***	0.725***	0.735***
	(0.119)	(0.118)	(0.114)	(0.115)	(0.118)	(0.115)	(0.117)	(0.115)	(0.120)
log of population density (people per sq. km of land area)	0.137*	0.133*	0.131*	0.157**	0.141**	0.157**	0.157**	0.157**	0.150**
	(0.074)	(0.076)	(0.071)	(0.070)	(0.068)	(0.072)	(0.074)	(0.071)	(0.069)
Bank concentration (%)	-0.006	-0.006	-0.006*	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Mobile cellular subscriptions (per 100 people)	-0.003	-0.004	-0.004	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
_cons	-9.257***	-9.372***	-9.612***	-9.527***	-9.534***	-9.525***	-9.527***	-9.496***	-9.620***

	(1.068)	(1.095)	(0.928)	(0.954)	(0.985)	(1.040)	(1.020)	(0.942)	(1.040)
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	70,824	70,824	70,824	70,824	70,824	70,824	70,824	70,824	70,824
R2									
Adjusted R2	0.173	0.175	0.173	0.172	0.172	0.172	0.172	0.172	0.172

Note: *** p<0.01, ** p<0.05, * p<0.1

Annex 3.8. **Results after excluding influential observations**[24]

Model	Logit
Dependent variable	Active account ownership (Having a transaction account and deposited in a transaction account)
	coefficient
Mobile Banking Regulatory Index	0.006***
	(0.002)
Individual is female	-0.350***
	(0.043)
Respondent age	0.015***
	(0.003)
Completed secondary education	0.907***
	(0.064)
Completed tertiary education or more	1.855***
	(0.093)
Income quintile_second 20 %	0.285***
	(0.058)
Income quintile_middle 20%	0.548***

[24] Observations with Pearson residual value more than 2, deviance residual value more than 2, and leverage value more than 3 times the average leverage from model (1) estimation are excluded in this logit regression.

	(0.063)
Income quintile_fourth 20%	0.888***
	(0.067)
Income quintile_richest 20%	1.321***
	(0.071)
Owns a mobile phone	1.235***
	(0.096)
log of GDP per capita(current USD)	0.927***
	(0.106)
log of population density (people per sq. km of land area)	0.137*
	(0.070)
Bank concentration (%)	-0.008**
	(0.003)
Mobile cellular subscriptions(per 100 people)	-0.006**
	(0.003)
_cons	-11.319***
	(0.929)
Regional fixed effects	Yes
Number of observations	64,251
R2	
Adjusted R2	0.224

Note: *** p<0.01, ** p<0.05, * p<0.1

Conclusion

While drafting the DPhil thesis, digital technologies are still advancing at an exponential rate. For instance, generative AI, a new artificial intelligence technology that not only analyzes and identifies patterns of certain data but also generates new content based on the data, has come into the spotlight with the popular tool ChatGPT. Some countries like China and Korea are forging ahead with the roll-out of next generation networks, with more than 800,000 5G base stations installed as of February 2021 in China. At the same time, advances in the collection, storage, analysis, and transmission of information have fueled a data explosion. In one second, there are about some 3.5 million emails sent and received, and 65,692 gigabytes of internet traffic carried. There rise a squad of data enabled digital platform firms such as Google's Alphabet, Amazon, Facebook, Tencent, and Alibaba now dominating the list of world's top ten most valuable firms with capitalization levels larger than the GDP of many countries. The thesis could not do justice to cover and examine all the new types of digital technologies and digital economy activities. Nevertheless, the conceptual framework (as specified in figure 0.1 in the Introduction) of understanding digital economy from three core components of technology development and adoption, business models and applications, as well as policy and regulatory environment would still be applicable with technology advances.

One thing about digital development is that it is not only a developed country phenomenon but has great potential in eradicating extreme poverty and offering leapfrog opportunities for developing countries, making it an important research topic in the development field. Internet users spend on average six and half hours per day on the

internet in 2023,[25] getting access to a range of health, education, business, financial and entertainment content. This is especially important for those who live in remote areas that have limited ways of accessing to information. Improving access to ICT and providing universal and affordable access to internet is one of the Sustainable Development Goals (SDGs). In the meantime, new work opportunities emerge from innovative digitally enabled business models, providing new sources of income not only for high skilled professionals but those who are at the bottom of pyramid. When fast internet becomes available, the probability that an individual is employed increases by up to 13.2 percent, and total employment per firm increases by up to 22 percent (Hjort and Poulsen, 2019). It is found that income of households engaging in e-commerce is 80% higher than their peer groups in China (Luo and Niu, 2019). More than forty percent of rural online merchants on Taobao.com, an e-commerce platform in China are women, many of whom have not had jobs before. It is estimated that Jumia, one of the largest e-commerce platforms in Africa could create about three million new jobs in Africa by 2025 (Dupoux et al., 2021). The bourgeoning "user-generated-content" sector, exemplified by Youtuber ("up zhu" or uploaders referred in Chinese), as well as large number of active labor force on ride-hailing and food delivery platforms in developing countries, are other cases in point about new job opportunities generated from innovative digital business models. Firms are also adopting digital technologies to enhance efficiency, overcome financing obstacles, and improve productivity. Search, replication, transportation, tracking, and verification costs have all been reduced since the advent of the internet (Goldfarb and Tucker, 2019). In the case of hardware, cloud computing has slashed capital expenditure requirements. Infrastructure as

[25] Statista.com.

a service becomes a new trend for small and medium sized enterprises (SMEs). Besides different market players, governments are also equipped with new digital tools to better design policies and implement poverty alleviation programs. Digital IDs are widely used in social protection programs, making sure that the public resources reach the intended recipients. Governments in Thailand and Philippines are using mobile phone data and earth observation data to predict poverty levels at greater granularity and higher frequency (Asian Development Bank, 2020; Puttanapong et al., 2022). In China, Guizhou province has developed a big data platform connecting 17 government agencies, aim to provide poor households with real time information on health, education and job opportunities (Xinhua, 2021). Admittedly, there are various risks associated with digital economic activities. Engaging in digital transactions inevitably leave footprints associated with personal information, such as disclosing demographic information on social media, submitting credit card information through online payment portal etc. The prevalence of digital activities and usage of data at an unprecedented scale raise concerns on personal data protection and cybersecurity. Between January and August in 2020, internet users in Kenya, Nigeria and South Africa faced millions of malware attacks (Makoni, 2020). In August 2020, Experian, a global consumer credit reporting company, had a data breach, leaking personal data about 24 million South Africans (Cimpanu, 2020). Low income customers also are willing to pay premium to ensure their data privacy (Vidal and Medine, 2020). Therefore, from a development perspective, understanding how to reap benefits of digital economy and avoid risks associated with it, would be beneficial for academia, industry players and policy makers to work together to achieve social and economic development.

This thesis tries to provide insights on development in the digital age, from aspects of digital technology adoption in the global south, welfare effect of digital economic activities for disadvantaged groups and implications of regulatory initiatives tailored to digital economic activities. These aspects correspond to the three key components for the functioning of digital economy as specified in the conceptual framework (figure 0.1). The thesis zooms into mobile internet adoption, gig economy and women economic empowerment as well as mobile banking regulations' impact on financial inclusion, on each of the above-mentioned aspects. It tries to contribute to the literature on digital divide, digital and gender, as well as institutional economics in the digital era, by providing new empirical evidences, testing relevance and applicability of theories in newly emerged digital economic activities, and extending policy discussions. Existing studies about digital divide tend to concentrate on fixed-line internet access and usage, instead of mobile internet which is the main channel of accessing to internet for individuals in developing countries. The thesis tries to understand adoption of mobile internet by individuals in developing countries, in particular from a social network perspective which has been rarely studied but worths great attention given the booming of social network apps in the digital age. Moreover, quantitative exercises to assess the welfare effects of newly emerged digital economic activities such as gig work are limited. The thesis provides new empirical evidence to show the impact of participating in gig economy for women economic empowerment in developing countries. Lastly, understanding the impacts of regulatory environment on digital economic activities is among the first steps for governments to adopt an enabling environment to exploit benefits of the digital economy. The thesis tries to explore the relationship between mobile banking regulations and financial inclusion, and

probe what specific regulatory provision is more likely to be associated with a higher level of financial inclusion.

The first chapter finds that social network plays an important role in individuals' decision to adopt mobile internet. Individuals whose five closest friends are using an online social network (e.g., Facebook, Twitter) are 66.1 percent more likely to adopt it than those without any close friends using such online social network sites/apps. The magnitude of such effects is at a higher level than that of other conventional demographic factors such as gender, marital status, location of residence, age etc. The results imply that instead of only focusing on the supply side of deploying connectivity infrastructure, demand side endeavors are of great important to promote internet access and usage in developing countries. Some social media firms are already taking initiative. For instance, Facebook helps unconnected people use internet data free through its "Free Basics" service, by partnering with mobile carriers in countries like Indonesia, the Philippines and Pakistan. Public private partnership with social media companies to deepen or expand internet connectivity leveraging social network effects is one potential route to address the digital divide.

The second chapter shows that with regards to gig economic activities, women are not particularly disadvantaged in accessing gig work opportunities, and disposable income of female gig economy participants is almost twice of the disposable income for females that are not participating in the gig economy. Also participating in gig economy is found to be associated with an increase of females' monthly contribution to household expenditure. The results show potential of digital business models in addressing or alleviating gender discrimination issues in traditional labor markets. Moreover, new digital economic

activities, characterized with relatively low entry barrier that requires little physical investment, flexibility on work location and schedule, provide work opportunities for those who used to be at market peripheries due to various constraints on mobility, location, other household responsibilities etc. By providing work opportunities, it helps women economic empowerment through enhancement of disposable income and contribution to household expenditure. Contributing more to household expenditure may also be conducive to improving women's family status. The results imply that governments may try to leverage gig work to enhance welfare for vulnerable groups like women. Reducing digital divide and ensuring equal access to digital infrastructure and devices are of great importance to promote the development of gig economy.

The third chapter examines mobile banking regulatory framework and finds a significant positive relationship between mobile banking regulations and financial inclusion. Individuals are more likely to have an active financial transaction account in countries that adhere to a higher number of mobile banking regulatory practices. Regulatory provisions on allowing agents to conduct a wide range of financial services on behalf of financial institutions, and requiring non-exclusivity of contracts between agents and financial institutions are particularly having a high level of impact on financial inclusion. The findings not only contribute to the literature on understanding factors affecting financial inclusion, but also provides empirical evidence justifying that in digital economy, public interest theory is more applicable that regulations could help address market failures and achieve social efficiency. From a policy implication perspective, the analysis also highlights a few aspects and principles when devising policy and regulations for mobile banking activities, such as standard and transparent rules, non-exclusivity and

consumer protection.

This research journey was inspired by observing how the waves of digital technology are bringing new development opportunities to people at the bottom of the pyramid, ranging from rural villagers selling agricultural products and handicrafts on e-commerce platforms, and unemployed youth gaining income and learning skills on gig work platforms, to migrant workers using cost effective mobile payment for remittances and women getting access to the internet to obtain education and healthcare resources. I'm grateful for the opportunity to further probe the observations and try to unlock mechanisms behind for future policy decision making in the global south. Digital technologies are still evolving and I hope the analyses conducted in the thesis provide insights to better understand digital economy and shed lights for future research with upcoming new exciting digital social and economic activities. Some of the potential future research areas include adoption of new disruptive digital technologies such as AI and 5G beyond conventional internet access and usage in the developing world, evolving of various types of new digital business models and their impacts on firm productivity and even industrial structure, the importance of data in digital economy and data governance etc.

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