ICT DEVELOPMENT, DIGITAL PAYMENT and GLOBAL FINANCIAL INCLUSION: A CROSS-COUNTRY ANALYSIS USING PANEL DATA

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ABSTRACT

Digitalization is viewed as a promising solution to address global financial inclusion – a core topic of economic development and poverty reduction. While traditional financial institutions are not fully capable of providing financial services to low-income populations, digital payment can potentially leverage alternative data for credit scoring, reduce the need for physical infrastructure, and provide affordable transaction services. ICT development, represented by access to mobile phone and internet, provides basis for applying digital payment and thus determines the level of financial inclusion. This paper analyzes to what extent individual access to ICT infrastructure impacts the level of financial inclusion. Using panel data of 189 countries and 12 years from 2005 to 2017, this paper applies fixed-effects regression to test the role of mobile subscription and internet access in predicting 1) deposit accounts, 2) loan accounts, 3) outstanding deposits and 4) outstanding loans at commercial banks, along with control factors of bank overhead cost, income, education, urban population, remittance, inflation, government effectiveness, political stability and the rule of law. As a result, the paper found strong positive effects of ICT development on financial inclusion: higher levels of mobile penetration and internet coverage are associated with higher number of bank accounts, as well as more deposits and loans taken from commercial banks. A close focus on developing countries also yield similar results, despite a higher weight on inflation control and regulation to stimulate the use of financial services. The finding supports that countries should prioritize ICT infrastructure for financial inclusion, in order to improve economic wellbeing of ordinary people. The paper also emphasizes the importance of stabling and government regulatory quality along with investments to extend financial services.

The research and writing of this thesis
is dedicated to everyone who helped along the way.

Many thanks,
Chenming Ran Student

TABLE OF CONTENTS

1. INTRODUCTION

Financial inclusion is usually defined as the access to proper transaction account services that allow people to save for living and borrow for business activities. However, financial services have long been inadequate for millions of people in underdeveloped areas. The World Bank reports that 1.7 billion adults worldwide have no bank accounts (Demirguc-Kunt et al. 2018). In 2019, the International Finance Corporation (2019) estimated this figure at 2.5 billion and claimed that 200 million businesses in developing countries were unable to access bank credit services. Governments and international organizations have recognized the need to integrate the unbanked population into the formal financial system, which helps to create capital investment and employment opportunities, reduce income inequality and stimulate economic growth (Kpodar and Andrianaivo. 2011; Leora Klapper. 2016; Global Partnership for Financial Inclusion. 2016; Bisht, Singh and Mishra. 2016).

Extending traditional financial services in developing countries confronts three major constraints: 1) insufficient physical financial infrastructure in remote and underdeveloped areas; 2) high transaction cost of money transfers; 3) lack of credit history to assess the creditworthiness of underserved population; (Kpodar and Andrianaivo. 2011; Jack and Suri, 2011; Economides and Jeziorski. 2014; Soumare et al. 2016; Bisht and Mishra. 2016; Bozkurt, Karakus and Yildiz. 2018). While governments and mainstream financial institutions are not fully capable of providing financial services to low-income populations, digital payment is viewed as a prospective approach that can potentially remove such barriers (The World Bank. 2018; The World Bank 2019). In order to enable mobile payment as a pathway for financial inclusion, the individual access to ICT infrastructure, mainly including mobile phone and internet network, provides the basis for a digital financial ecosystem. In this case, the ICT

development tends to have positive effects on financial inclusion, which ultimately leads to a country's greater economic prosperity.

Hence, this paper investigates the impact of individual access to ICT infrastructure on the access to financial services at the country level, with a goal of providing better policy insights to improve global financial inclusion and economic well-beings. Assuming that ICT development has a positive impact on the level of financial inclusion, this paper uses empirical data from 189 countries and 12 years from 2005 to 2017 to test their relationship. Specifically, this paper defines the financial inclusion as the access to saving and borrowing, and the use of such services, and it emphasizes mobile penetration and internet access as ICT development indicators to represent the country's capability of leveraging digital payments. Other control factors concerning cost of service, economic status and the strength of governance are also taken into consideration for predicting financial inclusion.

Using fixed-effects regression models, the empirical analysis tests different combinations of the rate of mobile subscriptions, the proportion of internet users and controlling factors in predicting 1) deposit accounts, 2) loan accounts, 3) outstanding deposits and 4) outstanding loans at commercial banks. he analysis also uses the GMM model as a robustness check to further examine the results, and then restrict the analysis to low- and middle- and low-income countries. These results withstand a battery of robustness. Applying a system GMM approach, the results remain stable and consistent with earlier model specifications.

Consequently, the paper finds strong positive effects of ICT development on financial inclusion: higher levels of mobile penetration and internet coverage overall result in a higher number of bank accounts, as well as more deposits and loans at commercial banks. The price level, government effectiveness and the strength of law are also significant factors determining

the level of financial inclusion. Focusing on low-income and low-middle income countries, the access to mobile phone and internet is also found to exert significant and positive effects on bank account ownership, although the number of deposits and loans are likely to depend on inflation rate and the government regulatory qualities. Those findings support that countries should prioritize ICT infrastructure and digital payment for financial inclusion, in order to improve their economic well-beings. The paper also highlights the need of price stabilization, as better regulatory qualities along with ICT investment to extend financial services.

2. LITERATURE REVIEW AND HYPOTHESIS

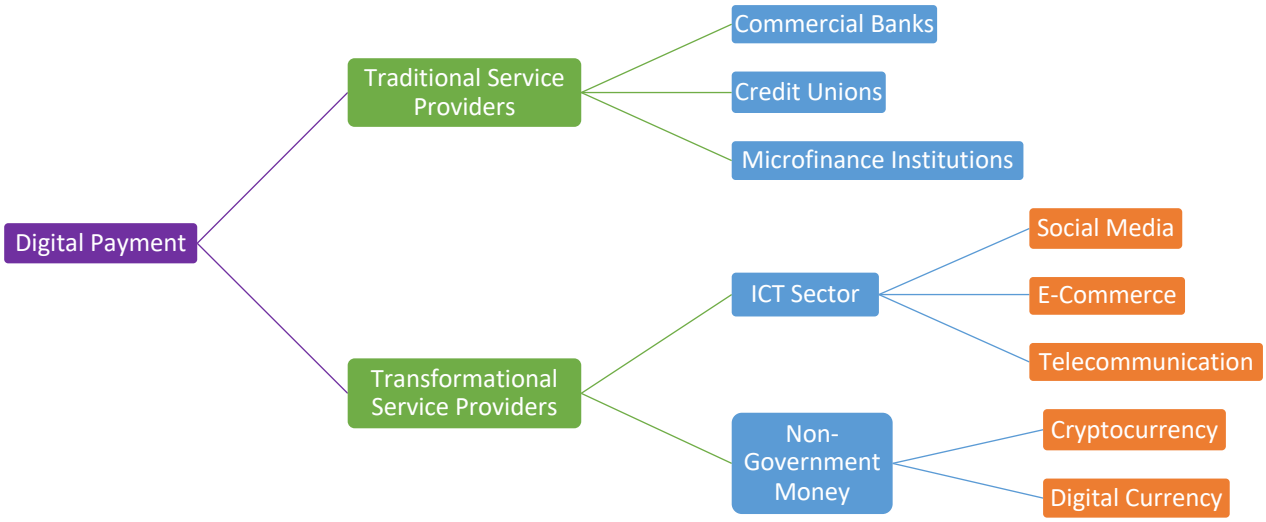
In early 1980, Hardy published a pioneer study, identifying telecommunication media as a determinant for economic growth. He pointed out that the connectivity between geographically dispersed populations is positively related to their participation in economic activities (Hardy, 1980). More connected populations can communicate more effectively, thereby enhancing information sharing and the economic productivity of social corporations (Hardy, 1980). This was later classified by the IMF as indirect economic effects of ICT development (Kpodar and Andrianaivo. 2011), which is evident in empirical studies of many developing countries (Waverman, Meschi and Fuss. 2005; Seki. 2008; Ngozi and Chiamaka. 2019).

The economic growth driven by ICT development can be explained in part by financial inclusion (Kpodar and Andrianaivo, 2011). The mobile phone and internet network allow the expansion of digital financial services to the underserved population in developing countries, since the telecommunication network can increase the access to financial services through digital platforms like mobile phone apps, favors developing economies where establishing traditional bank branches is expensive and subject to geographic constraints (Kpodar and Andrianaivo. 2011; Bisht and Mishra. 2016; Bozkurt, Karakus and Yildiz. 2018). Hence, the increasing trend

of mobile penetration and Internet coverage allows more people to enjoy the savings and lending services provided by financial institutions.

At first, the digital transaction yielded a long pending period and high transactional fees that were not usually affordable for most people, but the emergence of fintech increased the convenience for ordinary people to use mobile phone for savings, payments, and insurance products. (Jack and Suri, 2011; Economides and Jeziorski. 2014; Soumare, Tchana and Kengne. 2016; Demirguc-Kunt et al. 2017). The Graph 1 illustrates the service providers of such mobile payments that can be categorized as either traditional, or transformational (Malaguti. 2015). The former category represents traditional financial institutions, such as commercial banks, which provide mobile payment services themselves. However, the latter one has been a more popular trend that ICT sector players are primary service providers, which include social media and e-commerce platforms, as well as telecommunication providers. In addition, the blockchain-based cryptocurrency has opened a dialogue surrounding super platforms (Plassaras. 2013). Such platforms can not only extend digital financial service but also potentially alter the monetary system by competing with the legal tender **(**Moid and Jain. 2019**)**.

Graph 1. Framework of Digital Payment Providers



Source: Center for Global Development; International Monetary Fund[1]

Nevertheless, all types of service providers can enable customers to save, to borrow and to transfer funds in a real-time and low-cost fashion (Piscini et al. 2015). Second, with the development of big data and artificial intelligence, many digital platforms allowed banks to leverage alternative data for credit scoring, removing barriers of gathering traditional financial data among people who don't have access to physical banking services (Bauguess, 2017). This has certainly increased the incentive for banks to adopt digital payments through cooperations with ICT service providers (Brainard. 2017).

Governments and international organizations also have interests in utilizing digital payment as a pathway for financial inclusion. According to the IMF (2018), governments of more than 80 countries have adopted digital payment systems to extend financial services to millions of

[1] The framework is based on the working paper "Payment System Regulation for Improving Financial Inclusion" published by Center for Global Development (Malaguti. 2015). This paper includes non-government money, which was not included in the original framework, and the non-government money category derives from "The Rise of Digital Money" published by the IMF (Tobias & Tommaso, 2019).

financially excluded the poor population in 2019. The G20 committed to implement the G20 High-Level Principles for Digital Financial Inclusion (Global Partnership for Financial Inclusion. 2016). The World Bank (2018) later launched the Universal Financial Access 2020 Goal. Together with the International Telecommunication Union (ITU) and the Gates Foundation. The Bank (2019) has also started Financial Inclusion Global Initiative (FIGI), which aims to promote country-level financial inclusion through digital transformation.

Since mobile payments certainly rely on the individual access to mobile phone and internet network, ICT infrastructure, mainly including mobile telephone and internet network, plays a key role in integrating the digital ecosystem for economic and social activities. By enabling the digital payment to for financial inclusion, better access to ICT infrastructure has positive effects on local business and economic wellbeing (Bozkurt, Karakus and Yildiz. 2018; Magnusson and Hermelin. 2019). Therefore, strengthening ICT development is seen as a crucial developmental strategy for stimulating economic growth, reducing inequality, and strengthening poverty reduction (Economides and Jeziorski. 2014; Klapper. 2016; Suri and Jack. 2016; Oyelami, Saibu and Adekunle. 2017; Bozkurt, Karakus and Yildiz. 2018)

According to existing studies, the increasing access to ICT infrastructure is likely to favor digital transformation of financial services, thereby enhancing financial inclusion (Kpodar and Andrianaivo. 2011, Bozkurt, Karakus and Yildiz. 2018; Magnusson and Hermelin. 2019), so this paper formulates the following hypothesis prior to the empirical analysis:

Hypothesis 1: Access to ICT infrastructure enables more people to adopt digital payment, which has a positive impact on financial inclusion.

However, improving access to ICT infrastructure is subject to other restrictions, which will affect its degree of impact on financial inclusion. First, whether banking services are mature and

affordable affects people's choices between digital and traditional financial services (Kpodar and Andrianaivo. 2011; Allen et al. 2016) Second Second, increasing personal use of digital services requires a certain level of income, education, and literacy (Kumar. 2013; Soumare, Tchana and Kengne. 2016; Zins and Weill. 2016; Bozkurt, Karakus and Yildiz. 2018; Lotto. 2018). Third, people in places near banks and the ICT sector, such as urban areas, are also more likely to adopt digital payments for financial inclusion (Bhattacharyay. 2016; Soumare, Tchana and Kengne. 2016). Fourth, the price level and the source of production growth also affects the use of financial services. Specifically, a more stable inflation rate can lead to higher level of financial inclusion (Yetman, 2017), and the financial inclusion tend to be more critical for families whose' primary source of income is remittance (Dodgson et al. 2015). Accordingly, the paper proposes the second hypothesis based on the existing research:

Hypothesis 2: higher income, education, and proportion of urban population can increase the level of financial inclusion, whereas higher cost of traditional banking and higher price level decrease the level of financial inclusion.

Finally, regulation is a key constraint for digitalized financial services. In particular, there are concerns directly related to financial stability indicated that digital payments are disruptive to traditional banking services (Gibson and Buckley. 2015; Plassaras. 2013; Malaguti. 2017), arguing more stronger regulations on payment systems. For example, Plassaras (2013) specifically discussed the issue of cryptocurrency, and he pointed out the need of regulation to tackle unstable effects of emerging digital currencies on the foreign currency exchange market. Gibson and Buckley (2015) analyzed the regulatory liability issue of digital financial inclusion, and they suggested a mandatory compliance mechanism of rewards and penalties to regulate the digital financial agents (Gibson and Buckeley. 2015).

Another important concern of digital payments is the issue of data security. Whether service providers should use alternative data for credit scoring is always a controversial issue, and countries with higher interests in privacy control are generally less active in practice. In the United States, consumer data privacy and fair lending action have raised doubts on digital payments (Abraham et al. 2019). European Union also launched the General Data Protection Regulation (GDPR) to impose strict limits on ICT service providers in using customer data (Oojien and Vrabec. 2019), allowing more personal controls over data.

Independent of these concerns, scholars advocate stricter regulation of digital payments, which can either positively or negatively change the impact of ICT development on financial inclusion. While stronger institutional capacity and political stability make a nation more capable of extending individual access to ICT infrastructure, stringent standards of law and regulation may discourage innovations like digital payments for the sake of financial integrity. Consequently, this paper formulates the third hypothesis based on the literature:

Hypothesis 3: A more effective government and higher political stability will have a positive impact on financial inclusion, but strict regulations and laws will have a negative impact on financial inclusion.

3. EMPIRICAL ANALYSIS

To test those hypotheses, this paper analyzes empirical data for 189 countries from 2005 to 2017, which is detailed in the next section. With the change of financial inclusion as the right-hand side variable, the present study mainly investigates the impacts of mobile penetration and internet coverage. Controlling factors mentioned, including the cost of banking services, income, education, proportion of urban population, inflation, and remittance are also included in empirical analysis. In this section, the present study first explains the construction of dependent

and independent variables, and then it establishes the baseline statistical model. Second, the baseline model is extended to include indicators of socio-economic status and government regulation. Finally, present study demonstrates a series of robustness tests to strengthen that the financial Inclusion is driven by mobile penetration and internet coverage. All results of robustness checks are included in Appendix 6 and are discussed in the Section 4.2.

3.1 Variable Selection

Detailed description of all variables is shown in Appendix 1. Data for the dependent variables come from the IMF Financial Access Survey (FAS) that covers 189 countries and spans from 2005 to 2017. The dependent variables are selected based on the Global Partnership for Financial Inclusion (GPFI) is a featuring initiative of G20 countries working on financial inclusion (GPFI, 2012). In general, the GPFI (2012) provides three categories of financial inclusion indicators: 1) individual access and 2) small-enterprise (SME) access to deposits and loan accounts, as well as 3) point of service indicated by bank branches. Each category has been linked to specific indicators in the IMF FAS, which is useful for empirical analysis.

However, owing to data limitations, the empirical analysis does not include each single indicator under all G20 categories. This study recognizes 1) data on SME financial access are missing in many countries and across time-series, so it is unsuitable for data analysis; 2) presence of bank branches hardly indicates the financial inclusion by digital payments; 3) the IMF FAS do not have complete indicators for microfinance institutions and credit unions other than commercial banks, given the dominance of bank as the major financial institution (Kpodar and Andrianaivo. 2011). [2]As a result, the present study considers only individual financial access to

[2] Not including microfinance institutions and credit unions does not significantly decrease the efficiency of empirical results. According to Kpodar and Andrianaivo (2011), commercial bank service is the most used formal system in both developed and developing countries. Although the presence of bank branches and ATMs is much less

indicate financial inclusion, using the following four variables from IMF FAS: 1) deposit accounts at commercial banks; 2) loan accounts at commercial banks; 3) outstanding loans at commercial banks; 4) outstanding loans at commercial banks.

In terms of independent variables, the present study combines several different data sets. The rationale provided by the existing research is that mobile financial services (mainly a form of cooperation between banks and ICT service providers) can be seen as an ideal method of serving people without bank accounts (Kpodar and Andrianaivo. 2011; Bisht and Mishra. 2016; Bozkurt, Karakus and Yildiz. 2018). Given that all types of digital payments rely on ICT infrastructure that is mainly mobile penetration and internet coverage (Waverman, Meschi and Fuss. 2005; Seki. 2008; Kpodar and Andrianaivo. 2011; Ngozi and Chiamaka. 2019), the key independent variables are the mobile subscription rate and percentage of internet users collected from International Telecommunication Union (ITU).

This study also adopts the indicators of the cost of banking, income, education, and urban population, inflation rate and remittance are most frequently tested variables to represent economic status, digital readiness and geographic convenience (Kpodar and Andrianaivo. 2011; Kumar. 2013; Oyelami, Saibu & Adekunle. 2016; Zins and Weill. 2016; Bozkurt, Karakus and Yildiz. 2018). Hence, the bank overhead cost, GNI per capita, years of schooling, urban population, inflation rate are used as control variables. Current research also includes the use of remittances as a share of GDP as an additional control measure. Dodgson et al. (2015) pointed out that low-cost digital financial services tend to be more attractive in countries where remittance is a primary source of income, indicating that the income source plays an important role in determining the level of financial inclusion.

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common in developing countries compared to advanced economies, commercial banks still dominate the financial system in most developing countries.

Moreover, given the concerns about financial stability and data security issues associated with financial inclusion (Hanning and Stefan, 2011; Gibson and Buckley. 2015; Plassaras. 2013; Malaguti. 2017; Oojien and Vrabec. 2019), this paper use indexes of Worldwide Governance Indicators to indicate country-level regulatory force. Three indicators have been frequently used in financial inclusion literature. First, following Bozkurt, Karakus and Yildiz (2018) who found significant impacts of government effectiveness and political stability on financial inclusion, the present study test government effectiveness index and political stability index as controls. Second, the rule of law index, tested in a study by Asian Development Bank (Park and Mercado. 2015) is also included. Summary statistics are shown below in Table 2.

Table 1. Descriptive Statistics

Variables	**Obs.**	**Mean**	**Std. Dev**	**Min.**	**Max.**
Outstanding Deposits (% of GDP)	2,320	52.83	45.74	1.21	477.35
Outstanding Loans (% of GDP)	2,318	45.84	37.71	0.20	347.46
No. of deposit accounts (per 1,000 adults)	1,415	1156.38	1154.45	1.66	7827.30
No. of loan accounts (per 1,000 adults)	1,139	309.59	348.19	0.51	2909.29
Mobile Subscription (per 100 habitants)	2,332	88.97	45.54	0.26	328.79
Internet Access (% of population)	2,314	36.18	28.79	0.07	100.00
Bank Overhead Cost to Total Asset (%)	2,218	3.73	3.35	0.001	81.90
GNI Per Capita (US$)	2,340	12672.29	17649.50	140	104560
Urban Population (% of population)	2,368	56.70	23.13	9.38	100
Education (years)	2,310	8.08	3.17	1.30	14.10
Inflation Rate (%)	2,277	5.51	10.99	-10.07	379.85
Remittance (% of GDP)	2,194	4.64	6.68	0.0002	49.290
Government Effectiveness Index	2,277	0.002	0.97	-2.08	2.44
Rule of Law Index	2,289	-0.03	0.98	-2.03	2.10
Political Stability Index	2,292	-0.05	0.96	-2.83	1.62

The patterns of these indicators show some important characteristics of ICT development and financial inclusion. First, the average number of deposit accounts is more than two third of that of loan accounts, which indicates that people's access to credit and loan services in the world is insufficient compared to saving. According to Graph 2, from 2005 to 2017, the average deposit account ownership increased by 40 percent, and the average loan account ownership increased

greater by 75 percent. [3]Despite those increases of bank accounts, there is still a severe gap between access to loan services and access to saving.

Second, the outstanding deposits from commercial banks are on average 46% of GDP, and the outstanding loans is on average 53% of GDP, which indicates the outstanding position of commercial banks as the primary financial service provider. According to Graph 3, from 2005 to 2017, the average outstanding deposits from commercial banks increased by 43 percent, and the average outstanding loans also increased greater by 43 percent. [4] Therefore, for the use of bank services, there is also a gap between saving and borrowing, but it is much smaller compared to the gap of access.

In terms of ICT development, the mobile subscriber rate shows a high mobile phone coverage rate because an average of 86 people out of 100 people have subscribed to mobile phones. The average percentage of Internet users is 36%, which is also less than half of the surveyed population. Moreover, there has been a long-term upward trend in the availability of the mobile and internet services 2005 and 2017: the average of mobile phone subscriptions increased by 145 percent, and the average number of Internet users has increased by 178%. [5] Other telecommunication services such as mobile broadband and fixed broadband are also growing in the same period (Ogawa, 2019).

According to the results reported in Appendix 2, although the magnitude of the change seems to be different at different points in time, the level of financial inclusion and the accessibility of

[3] According to the IMF FAs data on bank accounts, the average numbers of deposit accounts per 1000 habitants were 985 in the year 2005 and 1378 in the year 2017. The average numbers of loan accounts per 1000 adults were 214 in the year 2005 and 375 in the year 2017.
[4] According to the IMF FAs data on bank statement, the average proportions of outstanding deposits over GDP were 44 in the year 2005 and 63 in the year 2017. the average proportions of outstanding loans over GDP were 36 in the year 2005 and 52 in the year 2017.
[5] According to the ITU data on mobile subscription and internet users, the average mobile-cellular telephone subscriptions per 100 habitants were 46 in the year 2005 and 112 in the year 2017. The average percentage of individuals using internet were 21 in the year 2005 and 56 in the year 2017.

ICT infrastructure have shown an upward trend over time. There are also significant heterogeneities across countries in terms of bank account ownership. To control for such time and country differences, the present study uses either fixed effects or random effects for empirical estimations In addition, since the standard deviation of financial inclusion variables is large, all of them are logged for model estimation. Similarly, independent variables including mobile subscription, internet access, bank overhead cost, GNI per capita are also logged. Hence, the distribution of key variables becomes approximately normal and more skewed. The frequency distributions are shown the Appendix 3.

3.2 Empirical Model

The present study follows the existing studies to tests each change of financial inclusion as a function of mobile subscription rate (x_1), percentage of internet users (x_2) and other controls users (x_n) (Waverman, Meschi and Fuss. 2005; Seki. 2008; Kpodar and Andrianaivo. 2011; Kumar. 2013; Oyelami, Saibu & Adekunle. 2016; Zins and Weill. 2016; Bozkurt, Karakus and Yildiz. 2018; Ngozi and Chiamaka. 2019). The equation for regression analysis is constructed that:

$$Y_{n,\,it} = \beta_0 + \beta_1 (x_{1,\,it}) + \beta_2 (x_{2,\,it}) + \beta_3 x_{n,it} + t_t + \alpha_I + \varepsilon_{it,}$$

whereby I is for countries and t is for years. $Y_{n,it}$ is the level of financial inclusion for country I at time t. As mentioned in the previous section, the number of deposit accounts at commercial banks ($Y_{1,\,it}$), number of loan accounts at commercial banks ($Y_{2,\,it}$), number of outstanding deposits at commercial banks ($Y_{3,\,it}$) and number of outstanding loans ($Y_{4,\,it}$) at commercial banks as dependent variables to measure financial inclusion.

β_1 and β_2 represent the coefficients on key independent variables representing access to ICT infrastructure, including mobile subscription and internet access. B_3 represents the coefficient on

additional control variables $x_{n,it..}$ The model also incorporates time fixed effects that we denote t_t to control for time specific on changes in global financial inclusion. Additionally, we include country fixed effects (α_i) to eliminate unobserved country specific characteristics that might affect the relation between mobile subscription and financial inclusion and that between internet coverage and financial inclusion.[6]

Moreover, this paper notices that the change of each financial inclusion indicator is persistent over time that a lagged dependent variable $Y_{n,\ it-1}$ may improve the empirical model (Roodman. 2009). However, a fixed effects regression with the lagged dependent variable can introduce a dynamic panel bias. For robustness check, therefore the present study also uses Generalized Method of Moments (GMM) techniques in the in the context of estimating small time horizons and large number of countries. The equation of GMM is constructed that:

$$Y_{n,\ it+1} = \beta_0 + \beta_1 (Y_{n,\ it}) + \beta_2 (x_{1,\ it}) + \beta_3 (x_{2,\ it}) + \beta_4 x_{n,it} + t_t + \alpha_I + \varepsilon_{it+1}$$

whereby $Y_{n,\ it+1}$ is the first lag of the dependent variable to control for potential persistence changes of each financial inclusion indicator. $Y_{n,it}$ is the level of financial inclusion for country I at time t. β_2 and β_3 represent the coefficients on key independent variables representing access to ICT infrastructure, including mobile subscription and internet access. B_3 represents the coefficient on additional control variables $x_{n,it.}$ Similarly, t_t denotes time specific effects on changes in global financial inclusion, and α_I represent the country fixed effects. Given that the mobile subscription and internet coverage do not vary substantially over time outcomes, the maximum lag of instruments is only restricted to one lag.

[6] Based on Hausman test, the data analysis reports the output of the preferred choice between fixed effects and random effects. Then series of robustness tests, including serial correlation, heterogeneity and LM test, on both the baseline models and optimal models are used to further verify the significance of empirical results.

To address the different characteristics of the developing world, GMM models are also used to test the impact of ICT development on the financial inclusion specifically low-income and low-middle-income countries. Therefore, the sample is restricted to 76 countries whose GNI per capita is below 3955 dollars in the year 2017, and the same model is applied to the data. The estimated results and interpretations are shown in the next section.

4. RESULTS

4.1 Empirical Results

The empirical results of digital impacts on financial inclusion are reported in Table 2 – 5. Each table shows estimated results of two dependent variables. Table 2 and 3 report the results on bank accounts. Table 4 and 5 report the results on deposits and loans of the bank statement. Model 1 and 4 of table is the baseline model that accounts for the impacts of mobile subscription or internet access, whereas model 2, 3, 5 and 6 test different combinations of key independent variables and controls and show how each set is affecting financial inclusion.

Table 2. Estimated Results – Mobile Subscription on Deposit and Loan Accounts

	No. of Deposit Accounts			*No. of Loan Accounts*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Mobile Subscription	0.272***	0.276***	0.257**	0.384***	0.303***	0.344***
	(0.097)	(0.100)	(0.089)	(0.104)	(0.072)	(0.080)
Bank Overhead Cost		-0.080*	-0.082***		-0.009	
		(0.043)	(0.039)		(0.144)	
GNI per capita		0.285***	0.376***		0.034	
		(0.090)	(0.069)		(0.144)	
Urban Population		0.003			0.019	
		(0.006)			(0.017)	
Education		0.089***	0.112***		0.136**	0.226***
		(0.030)	(0.030)		(0.061)	(0.059)
Remittance		0.017***	0.017***		0.0006	
		(0.006)	(0.006)		(0.008)	
Inflation Rate		0.002			0.002	
		(0.002)			(0.003)	
Government Effectiveness		0.172			0.017	
		(0.130)			(0.132)	
Rule of Law		0.198			0.708***	0.545***
		(0.149)			(0.220)	(0.153)
Political Stability		-0.004			0.040	
		(0.084)			(0.112)	

Constant	5.135*** (0.350)	2.098*** (0.578)	1.362** (0.442)	3.190*** (0.370)	1.389 (1.157)	1.790*** (0.413)
N	1,386	1,141	1,204	1,117	907	1,096
Year FE	Yes	Yes	Yes	No	Yes	No
# Countries	128	111	117	112	96	109
R-Squared	0.281	0.632	0.623	0.416	0.656	0.660

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) Both fixed effects and random effects regressions are tested, and Hausman test determines the preferred model at the significance level of 0.05. According to the chi-squared values of Hausman test, Model 1, 4, 5 and 6 report results of fixed effects, and Model 2 and 3 report results of random effects.
4) Year fixed effects are included if test for joint significance on year dummies show that year effects are significant at the significance level of 0.05.

The estimated number of bank accounts proves the strong support of the first hypothesis and the second hypothesis. In general, the mobile subscription is positively associated with the both deposit and loan accounts at commercial banks, and their relations are significant across country and over time. On average, a 1% increase in mobile subscription per 100 people alone tends to increase the number of deposit accounts by 0.28 % and the number of loan accounts by 0.377%. For the baseline models, 28 % of the variation on deposit account ownership and 41.3% on loan account ownership can be explained by the mobile phone subscriptions. This result shows fairly strong associations between access to ICT infrastructure and access to bank accounts.

Including control variables successfully reduces the serial correlations of the baseline models [7]and improves the quality of prediction. For the baseline model, the predicted ownership of deposit accounts explains 53 % of the actual ownership, and that of loan accounts explains 64.5 % of actual ownership. Comparing model 3 with the baseline model of predicting deposit accounts, the results show that the accuracy of prediction increases by 26.5 percentage points.

[7] Serial correlations are diagnosed using Wooldridge test for autocorrelation. Intuitively, models including control variables mostly lead to decreased test statistics.

Compared with Model 6 and the baseline model, the accuracy of predicting loan accounts is also improved by 16.8%.[8]

The model 3 is optimal for to determine the positive impact of mobile penetration on deposit accounts. Significant coefficients on bank overhead cost, GNI per capita, years of schooling and remittance to the model supports that economic status, education and the cost of banking impact the number of bank accounts. According to the Model 3, a 1% increase in mobile subscription per 100 people tends to increase the number of deposit accounts by 0.257 %. Since the coefficients and standard errors of mobile subscription become smaller, and the robustness of fit increases significantly, including controls of bank cost, income, and education well addressed the issue omitted variable bias of the baseline model.

As for estimating the number of loan accounts, years of schooling and rule of law are statistically significant control variables. After including education and rule of law, it is observed that a 1% increase in mobile subscription per 100 people tends to increase the number of loan accounts by 0.344 %. More years of schooling and higher rule of law index also leads to more loan accounts at commercial banks, and together reduce the coefficient of mobile subscription by 0.04 percentage points. While the coefficients of other control factors are not significant, their presence still leads to better estimates of the mobile subscription and overall fitness of the model. Nonetheless, given the higher number of observations and higher r-squared, Model 6 is preferable to Model 5, and it is optimal in explaining the effect of mobile subscriptions.

Table 3. Estimated Results – Mobile Subscription on Outstanding Deposits and Loans

	Outstanding Deposits			*Outstanding Loans*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Mobile Subscription	0.136***	0.122***	0.118**	0.193***	0.197***	0.192***
	(0.039)	(0.043)	(0.041)	(0.039)	(0.046)	(0.039)

[8] For Model 3 and 6, the correlation between predicted ownership and actual ownership of deposit account is 78.9%, and that between predicted ownership and actual ownership of deposit account is 81.3%.

Bank Overhead Cost		-0.082***	-0.082***		-0.109***	-0.073***
		(0.021)	(0.020)		(0.029)	(0.030)
GNI per capita		-0.033			0.055	
		(0.052)			(0.074)	
Urban Population		-0.014**	0.013**		-0.0002	
		(0.007)	(0.007)		(0.004)	
Education		0.019			0.045*	0.051
		(0.026)			(0.025)	(0.039)
Remittance		0.007*	0.007**		-0.004	
		(0.004)	(0.004)		(0.007)	
Inflation Rate		-0.004*	-0.004**		-0.003	
		(0.002)	(0.002)		(0.002)	
Government Effectiveness		0.140***	0.142***		0.057	
		(0.045)	(0.042)		(0.065)	
Rule of Law		0.195***	0.188***		0.196**	0.150**
		(0.057)	(0.054)		(0.076)	(0.077)
Political Stability		0.029			0.096*	0.040
		(0.035)			(0.057)	(0.076)
Constant	3.008***	4.044***	3.900***	2.567***	2.002***	2.300
	(0.134)	(0.567)	(0.319)	(0.135)	(0.402)	(0.339)
N	2,271	1,865	1,880	2,269	1,859	2,067
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# Countries	183	161	163	183	161	172
R-Squared	0.192	0.203	0.215	0.275	0.557	0.554

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) Both fixed effects and random effects regressions are tested, and Hausman test determines the preferred model at the significance level of 0.05. According to the chi-squared values of Hausman test, Model 1-5 report results of fixed effects, and Model 6report results of random effects.
4) Year fixed effects are included if test for joint significance on year dummies show that year effects are significant at the significance level of 0.05.

The estimated results on outstanding deposits and loans from commercial bank also demonstrate support for the first hypothesis. The mobile subscription is positively associated with both the outstanding deposits and outstanding loans, and their relations are significant across country and over time. On average, a 1% increase in mobile subscription per 100 people alone tends to increase the proportion of outstanding deposits on GDP by 0.136 % and the proportion of outstanding loans on GDP by 0.193%. However, for the baseline models, 19.2 % of the variation on deposit account ownership and 27.5% on loan account ownership can be

explained by the mobile phone subscriptions. This shows less robustness of fit compared to the association between mobile subscriptions and bank account ownerships.

Taking into account the economic situation and regulation, the predicting quality of outstanding deposits barely improved, but the predicting quality of outstanding loans can be significantly improved. The robustness of fit of Model 3, represented by the R-squared, is merely 2.3 percentage points higher than the baseline model for outstanding deposits, whereas the R-squared of Model 6 is 27.9 percentage points higher than that of the baseline model for outstanding loans. Moreover, for model 1, the predicted proportion of outstanding deposits explains 43.8 % of the actual values, and that of outstanding loans explains 52.4 % of the actual values. Comparing model 3 with the baseline model of predicting outstanding deposits, the results show that the accuracy of prediction increases by 2.5 percentage points. For predicting outstanding loans, the accuracy increases by 22 % comparing model 6 with the base line model.[9]

The mobile subscription is positively associated with both the outstanding deposits and outstanding loans, and their relations are significant across country and over time. On average, a 1% increase in mobile subscription per 100 people alone tends to increase the proportion of outstanding deposits on GDP by 0.136 % and the proportion of outstanding loans on GDP by 0.193%. However, for the baseline models, 19.2 % of the variation on deposit account ownership and 27.5% on loan account ownership can be explained by the mobile phone subscriptions. This shows less robustness of fit compared to the association between mobile subscription and bank account ownerships.

Considering economic status and regulation increases the quality of prediction slightly on outstanding deposits but significantly on outstanding loans. The robustness of fit of Model 3,

[9] For Model 3 and 6, the correlation between predicted ownership and actual proportions of outstanding deposits is 46.3%, and that between predicted ownership and actual proportions of outstanding loans is 77.1%.

represented by the R-squared, is merely 2.3 percentage points higher than the baseline model for outstanding deposits, Whereas the R-squared of Model 6 is 27.9 percentage points higher than that of the baseline model for outstanding loans. Moreover, for model 1, the predicted outstanding deposits explains 43.8 % of the actual values, and that of outstanding loans explains 52.4 % of the actual values. Comparing model 3 with the baseline model of predicting outstanding deposits, the results show that the accuracy of prediction increases by 2.5 percentage points. For predicting outstanding loans, comparing model 6 with the base line model, the accuracy increases by 22 %.[10]

In terms of outstanding deposits, factors other than gross national income per capita, education and political stability have resulted in smaller estimates of coefficient on the mobile subscription. The coefficient of mobile subscription decreased by 1.8 percentage points, but the standard error has also slightly increased by 0.2 percentage points. At the same time, for predicting outstanding loans, the control variables are almost unimportant except for bank overhead and the rule of law, and they have no significant effect on the coefficient and standard error of the mobile subscription. Comparing the robustness of the fit and accuracy, however, Model 3 and Model 6 are still preferable to the baseline model and are therefore the optimal results of the estimation.

Table 4. Estimated Results – Internet Access on Deposit and Loan Accounts

	No. of Deposit Accounts			*No. of Loan Accounts*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet Access	0.369***	0.246***	0.259**	0.398***	0.221***	0.199***
	(0.047)	(0.062)	(0.055)	(0.055)	(0.054)	(0.054)
Bank Overhead Cost		-0.055			0.028	
		(0.042)			(0.047)	
GNI per capita		0.330***	0.408***		0.321***	0.381***
		(0.073)	(0.086)		(0.119)	(0.135)

[10] For Model 3 and 6, the correlation between predicted ownership and actual proportions of outstanding deposits is 46.3%, and that between predicted ownership and actual proportions of outstanding loans is 77.1%.

Urban Population		0.002			0.012*	0.019
		(0.006)			(0.006)	(0.015)
Education		0.028			0.060	
		(0.035)			(0.041)	
Remittance		0.018***	0.018***		0.013*	0.012*
		(0.007)	(0.007)		(0.008)	(0.007)
Inflation Rate		0.002			0.002	
		(0.002)			(0.003)	
Government Effectiveness		0.155			-0.041	
		(0.109)			(0.131)	
Rule of Law		0.145			0.584***	0.572**
		(0.128)			(0.177)	(0.185)
Political Stability		0.006			0.001	
		(0.091)			(0.104)	
Constant	5.353***	2.650***	2.236***	3.711***	0.528	0.221
	(0.142)	(0.516)	(0.651)	(0.163)	(0.805)	(1.091)
N	1,367	1,135	1,259	1,101	901	991
Year FE	No	No	No	No	No	No
# Countries	127	111	119	111	96	101
R-Squared	0.594	0.639	0.624	0.618	0.677	0.665

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) Both fixed effects and random effects regressions are tested, and Hausman test determines the preferred model at the significance level of 0.05. According to the chi-squared values of Hausman test, Model 1, 3, 4 and 6 report results of fixed effects, and Model 2 and 5 report results of random effects.
4) Year fixed effects are included if test for joint significance on year dummies show that year effects are significant at the significance level of 0.05.

According to Table 4, internet access is positively associated with the number of deposit and loan accounts at commercial banks, and their relationships are significant across country. On average, a 1% increase in proportion of internet users alone tends to increase the number of deposit accounts by 0.369 % and the number of loan accounts by 0.398%. The variation on internet access explains 59.4% of variations on the ownership of deposit accounts and 61.8% of variations on the ownership of loan accounts. Despite the similar magnitude of prediction, the

internet access is a relatively stronger predictor of bank account ownership compared to the mobile penetration.[11]

However, compared with the baseline model, adding control variables does not seem to significantly improve the estimation results. For Model 1 and 4, the predicted ownership of deposit account explains 77.1 % of the actual ownership, and that of loan account explains 78.6 % of actual ownership. The result of Model 2 shows that the accuracy of predictions only increases by 2.9 percentage points According to Model 6, the accuracy of predicting loan accounts is improved by 14.4%.[12] Although income, education, remittances, and the rule of law are important determinants, they have not significantly changed the prediction of bank account ownership by the internet access.

Under Model 2 and 3, adding controls of economic status and regulation results in smaller estimates of coefficients on internet access but higher standard errors, which may be due to reduced observations. In this case, it is uncertain whether those factors improve the baseline model. However, GNI per capita and remittance are statistically significant. Given the sufficient observations of the model, including GNI per capita certainly addressed the issue omitted variable bias. The coefficient on rule of law index also shows that awareness of strengthening legal rights has a significant impact on the ownership of loan accounts.

Table 5. Estimated Results – Internet Access on Outstanding Deposits and Loans

	Outstanding Deposits			*Outstanding Loans*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet Access	0.154***	0.127***	0.120***	0.214***	0.215***	0.221***
	(0.030)	(0.031)	(0.032)	(0.036)	(0.042)	(0.036)
Bank Overhead Cost		-0.074***	-0.083***		-0.084***	-0.051*
		(0.023)	(0.024)		(0.004)	(0.029)

[11] In reality, the first generation of electronic banking was on website, and later the development mobile phone led to evolvement of electronic banking that most of those services became available on mobile apps. This explains relatively higher importance of internet access compared to the mobile subscription in the past few years.
[12] For Model 2 and 6, the correlation between predicted ownership and actual ownership of deposit account is 80 %, and that between predicted ownership and actual ownership of deposit account is 81.3%.

GNI per capita		-0.037			0.044	
		(0.052)			(0.085)	
Urban Population		-0.016**	-0.003		-0.003	
		(0.007)	(0.003)		(0.009)	
Education		0.011			0.044	
		(0.026)			(0.041)	
Remittance		0.007**	0.007**		-0.006	
		(0.003)	(0.003)		(0.008)	
Inflation Rate		-0.004*	-0.004*		-0.002	
		(0.002)	(0.002)		(0.002)	
Government Effectiveness		0.114***	0.136***		-0.011	
		(0.044)	(0.037)		(0.066)	
Rule of Law		0.170***	0.169***		0.154*	0.113
		(0.057)	(0.046)		(0.091)	(0.080)
Political Stability		0.035			0.118**	0.061
		(0.036)			(0.062)	(0.077)
Constant	3.133***	4.400***	3.518***	2.758***	2.445***	2.836***
	(0.067)	(0.507)	(0.141)	(0.084)	(0.808)	(0.095)
N	2,255	1,847	1,874	2,253	1,850	2,088
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# Countries	182	161	163	182	161	175
R-Squared	0.360	0.166	0.437	0.487	0.560	0.588

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) Both fixed effects and random effects regressions are tested, and Hausman test determines the preferred model at the significance level of 0.05. According to the chi-squared values of Hausman test, Model 1-5 report results of fixed effects, and Model 6report results of random effects.
4) Year fixed effects are included if test for joint significance on year dummies show that year effects are significant at the significance level of 0.05.

The internet access is also positively associated with the outstanding deposits and outstanding loans, and their relationships are significant across country and over time. On average, a 1% increase in the proportion of internet users alone tends to increase the proportion of outstanding deposits on GDP by 0.154 % and the proportion of outstanding loans on GDP by 0.214%. Similar to Table 4, are not very different from coefficients on mobile subscription. Nevertheless, the variation on internet access explains 36 % of variations on the proportion of outstanding deposits and 48.7% of variations on the ownership of loan accounts, so the internet access still appears to be a relatively stronger predictive indicator compared to the mobile penetration.

Adding control variables does not improve the estimated results compared to the baseline model. For Model 1 and 4, the predicted proportion of outstanding deposits explains 60 % of the actual values, and that of outstanding loans explains 69.8 % of actual ownership. The results of Model 3 show that the accuracy of the prediction has only increased by 6.6 percentage points. For predicting loan accounts, the accuracy of Model 6 remains the same.[13] Although the bank overhead cost, remittance, government effectiveness and rule of law tested to be important determinants, it is uncertain whether they improve the prediction of internet access on bank account ownership, since the standard error of internet access becomes larger with fewer observations. Therefore, the results of the baseline model are optimal because of the robustness and accuracy of the fit when predicting outstanding deposits and loans.

To sum up, all estimated results show strong and positive effects of the access to ICT infrastructure on both the ownership of bank accounts and the use of financial services, which strongly support the major hypothesis. At the same time, the generally negative relationship between bank overhead and financial inclusion means that digital payments have advantages over the physical banking systems in providing affordable savings and lending services. This provides a rationale for governments to invest in ICT infrastructure and promote digital payments, which are beneficial to the individual financial access and financial well-beings

The overall results also endorse the second hypothesis, which asserts different degrees of impact on financial inclusion according to different socio-economic status. Meanwhile, higher levels of financial inclusion rely on higher level of income, education attainment and urbanization, and higher GDP share of remittance places higher weights on the access to bank accounts and saving. The fact that higher inflation rate leads to lower outstanding loans at the

[13] For Model 2 and 6, the correlation between predicted and actual outstanding deposits is 66.6 %, and that between predicted and actual outstanding loans is 69.8%.

commercial banks indicates a need of macroeconomic measures to stabilize price level, in order to encourage the use of saving services, although it does not affect the access to bank accounts.

The empirical results also found that government effectiveness and the rule of law are significant determinants of financial inclusion, although political stability seems not to have such great impacts This finding provides some support for the third hypothesis that emphasizes the importance of effective government, as a higher level of government effectiveness represents greater institutional capacity for nationwide financial inclusion initiatives. However, more rigorous law and regulations appear to have positive impacts on financial inclusion, which is different from the third hypothesis. This implies that higher level of financial integrity does not create barriers for individual financial access and is indeed beneficial.

4.2 Robustness Check

According to the time-series pattern shown in the Appendix 2, it can be recognized that the change of each financial inclusion indicator is quite persistent over time that a lagged dependent variable $Y_{n,\ it-1}$ is required to improve the empirical model. However, a fixed effects regression with the lagged dependent variable can introduce a dynamic panel bias. For robustness check, therefore, the present study uses Generalized Method of Moments (GMM) estimation techniques in the context of estimating small time horizons and a large number of countries (Roodman. 2009). which requires improvement of the empirical model. Observed from tables in Appendix 6, the number of mobile subscriptions per 100 inhabitants and the proportion of internet users still show overall positive associations with most financial inclusion indicators, though the magnitude of coefficients on ICT development indicators decreases significantly.

Including the lag dependent variable greatly improves the accuracy of the regression and reduce the bias of overestimation. [14]According to Table 1 and 2 in Appendix 6, a 1% increase in the number of mobile subscriptions per 100 habitants tends to 1) increase the number of deposit accounts at commercial banks by 0.110% standard deviations of its historic trend, 2) increase the number of proportion of outstanding deposits on GDP by 0.043% standard deviations of its historic trend, and 3) increase the number of proportion of outstanding loans on GDP by 0.082% standard deviations of its historic trend. As for internet access in Table 3 and 4, a 1% increase in the proportion of internet users tends to 1) increase the number of deposit accounts at commercial banks by 0.094% standard deviations of its historic trend, 2) increase the number of loan accounts at commercial banks by 0.136% standard deviations of its historic trend and 3) increase the number of proportion of outstanding loans on GDP by 0.138% standard deviations of its historic trend.

Although most GMM results are consistent with the fixed effects estimation, they show less support for the main hypothesis. The coefficient on mobile subscription is not statistically significant when estimating the number of loan accounts at commercial banks, and the coefficient on internet access is not statistically significant when estimating the number of outstanding deposits from commercial banks. Instead, the ownership of loan accounts is positively determined by the proportion of urban population and the rule of law, and the outstanding deposits are determined by inflation and regulatory factors. Furthermore, in GMM models, the significance of social and economic factors is reduced, to an extent that bank overhead cost, education and share of remittance are not significant at all. This shows only marginal support to the second hypothesis.

[14] Correlations between the predicted and the actual values across all models are over 90 %.

Nonetheless, the GMM results prove the importance of regulation, but its magnitude and direction are different from the fixed effect results. Specifically, government effectiveness, political stability and rule of law all seem to impact financial inclusion. With the presence of internet access, stronger rule of law appears to restrict people from having loan accounts at commercial banks, but with the presence of mobile phone subscription it is likely increase both the access and use of loans. Hence, similar to fixed effects, the GMM estimates do not support the third hypothesis.

The GMM result is not a big disruption to empirical models of the previous section, since the mobile subscription and internet coverage foster the overall access to bank accounts, which are fundamental for individual financial well-beings. The number of deposits and loans are more likely to depend on the price level and regulation. Given the effects of ICT development on the amount of deposits and loans have become less important compared to inflation and government effectiveness, the finding suggests that countries need greater institutional capacities to carry out effective macroeconomic measures and to maintain financial integrity.

4.3 Developing Countries

To address the different characteristics of the developing world, the present study also uses GMM models to test ICT development on the financial inclusion of low-income and low-middle-income countries. After restricting the sample to countries whose GNI per capita is below 3955 dollars in the year 2017, the present study found fairly consistent results as testing all 189 countries: the number of mobile subscriptions per 100 habitants, and the proportion of internet users have overall positive associations with the number of deposits accounts, but the impacts differ on loan accounts and outstanding deposits. In addition, ICT development does not seem to have a major impact on commercial bank loans.

According to Table 1 and 2 in Appendix 7, a 1% increase in the number of mobile subscriptions per 100 habitants tends to 1) increase the number of deposit accounts at commercial banks by 0.063% standard deviations of its historic trend, 2) increase the number of loan accounts at commercial banks by 0.145% standard deviations of its historic trend, 3) increase the number of proportion of outstanding deposits on GDP by 0.047% standard deviations of its historic trend. As for internet access in Table 3 and 4, a 1% increase in the proportion of internet users tends to 1) increase the number of deposit accounts at commercial banks by 0.085 % standard deviations of its historic trend, 2) decrease the number of proportion of outstanding deposits on GDP by -0.025% standard deviations of its historic trend.

The coefficient on mobile subscription is not statistically significant when estimating outstanding loans at commercial banks, and the coefficient on internet access is not statistically significant when estimating loan accounts and outstanding loans from commercial banks. In terms of the impact on credit services, only consistent and important factors are inflation rates and regulatory factors, which correspond to some GMM results of all countries. Thus, the GMM estimation on developing countries barely support the second hypothesis. This finding, compared with fixed effect models, implies that macroeconomic measures are more important than the ICT development in determining the access and use of borrowing.

Social and economic factors only have marginal effects on the financial inclusion, to an extent that GNI per capita, bank overhead cost, and share of remittance are not significant in most models. Education and proportion of urban population also appear not to be significant. The only control factor that has a sustained and significant impact is the inflation rate, which corresponds to the previous GMM results of all countries. Higher inflation rate tends to increase

the number of deposit accounts but is likely to decrease the number of outstanding deposits and loans. This implies the significance of macroeconomic measures towards financial inclusion.

Moreover, the results on the regulatory forces show some distinctive features of developing countries, but they still correspond to the general country-level results. In particular, with the presence of mobile phone, the rule of law does not seem to affect bank accounts and outstanding deposits but is likely to reduce the number of outstanding loans. With the presence of internet access, government effectiveness and political stability only matter for loan account and outstanding loans at commercial banks, while the rule of law seems to reduce the number of outstanding loans. In view of the fact that the regulation greatly affects the access and use of borrowing, the GMM estimates for developing countries support Hypothesis 3 to some extent.

After all, with a close-up focus on developing countries, the GMM results strengthened the previous finding that ICT development has significant and positive effects on the access to saving, and the mobile penetration itself also tends to increase the number of loan accounts. As for the actual usage of banking services, represented by outstanding deposits and loans, ICT development is relatively less important than inflation and regulation, which also reinforced the finding from previous models testing all countries. Although ICT development provides the access to financial services, there would be an emphasis on institutional capacity to maintain price level and to ensure financial integrity for the long-term individual financial well-beings.

5. CONCLUSIONS

This paper studies the impact of ICT development on financial inclusion, considering a sample of 189 countries from 2005–2017. Emphasizing the development of mobile and the Internet, empirical analysis found that the popularization of ICT infrastructure has had an overall positive impact on global financial inclusion. In this case, the paper argues that digital payment

is one of the most important channels for economic development, through which mobile penetration and internet coverage contributes to financial inclusion.

Using standard fixed-effect models, the estimation results show that ICT development brought by mobile subscribers and Internet access can improve financial inclusion. Specifically, financial inclusion is measured by four indicators including the number of deposit accounts, the number of loan accounts, outstanding deposits, and outstanding loans at commercial banks. Both mobile subscription and internet access have significantly positive effects on each of the financial inclusion indicators in the empirical models. The negative correlation between bank overhead costs and financial inclusion means that, compared to the physical banking system, digital payments have advantages in providing affordable savings and borrowing services. Higher level of income, education attainment and urbanization, and higher GDP share of remittance tends to reinforce individual access to saving and borrowing services.

The robustness check shows that the internet has a relatively insignificant impact on outstanding loans and deposits, and the impact of ICT development on the number of loan accounts is also minimal. Instead, the loan account is more likely to be decided by the regulatory strength. Focusing on developing countries, better ICT development increases the access to saving, and increased mobile penetration further raises the number of loan accounts. Those findings, however, do not significantly decrease the confidence of the conclusion that mobile phone and internet can enable digital payment for financial inclusion purposes. If people have bank accounts, saving and borrowing services are available to them, whereas the use of financial services, meaning the amount of deposits and loans they actually take, is more likely to depend on price level and government regulatory forces.

Hence, this paper suggests that countries should encourage different sources of investment in ICT infrastructure and digital payments to provide individual financial access, including public institutions, the private sector, and public-private partnerships. Apart from building infrastructure itself, the government should also be responsible for implementing efficient macroeconomic policies to maintain price level. Inflation stabilization has long-term effects on financial inclusion, since it strongly determines the amount of bank deposits and is also likely to affect loans. Although lower costs of banking and better access to mobile phones and Internet access allow people to use financial services, it must be noted that actual use depends more on the overall economic prosperity.

The exception for predicting loan accounts is reasonable, since more barriers exist for people to borrow than to save at commercial banks, and most mobile payments today function to enable saving, paying bills, and transferring money (Kpodar and Andrianaivo. 2011). In this case, mobile penetration and internet coverage cannot explain much of the individual access to bank credit services. Strengthening the rule of law seems to reduce the number of loan accounts and outstanding loans of commercial banks, which also corresponds to more obstacles to accessing bank credit services. Neither fact, however, provides good reasons for loosening regulations and reducing barriers to financial access, since those two measures would impose high risks on financial stability that developing countries cannot afford in the long term. In this case, this paper still follows the existing studies by suggesting proper and stronger institutional capacity and stronger regulations along with ICT development.

To be specific, governments might want to strengthen the mechanism of monitoring ICT development and bank services, and the government should also establish solid legal framework to ensure that financial service providers, both from ICT sector and financial institutions comply

with laws related to financial and data security. Strengthening regulatory power is positively related to financial access, since a country is able to provide a safeguard for people to save and borrow from financial institutions. The rationale is that government effectiveness and regulatory efficiency can increase public trust in the financial system, so more people believe in government initiatives in promoting digital financial services (Das. Quintyn and Chenard. 2004; Kim. 2010; OECD. 2013; Ahamed and Mallick. 2017).

In conclusion, the finding of this paper underscores the importance of access to ICT infrastructure, including mobile coverage and internet, as a basis for digital transformation and their ultimate potential of improving financial inclusion. In turn, higher level of financial inclusion is expected to benefit economic growth and poverty reduction. Thus, this paper recommends policies to encourage investment in ICT infrastructure and to support the development of digital payment. Maintaining price stability and strengthening regulatory quality are also needed to reinforce the effects of ICT development.

6. REFERENCE

Abraham, Facundo, Schmukler, Sergio L., Tessada, and Jose. "Using Big Data to Expand Financial Services." *Open Knowledge Repository*. The World Bank, Washington, DC, November 1, 2019. https://openknowledge.worldbank.org/handle/10986/32655.

Adeleye, Ngozi, and Chiamaka Eboagu. "Evaluation of ICT Development and Economic Growth in Africa." *NETNOMICS: Economic Research and Electronic Networking* 20, no. 1 (2019): 31–53. https://doi.org/10.1007/s11066-019-09131-6.

Allen, Franklin, Asli Demirguc-Kunt, Leora Klapper, and Maria Martinez Peria. "The Foundations of Financial Inclusion: Understanding Ownership and Use of Formal Accounts." Journal of Financial Intermediation 27 (July 1, 2016): 1–30. http://search.proquest.com/docview/1835022524/.

Ahamed, M. Mostak, and Sushanta Mallick. "Does Regulatory Forbearance Matter for Bank Stability? Evidence from Creditors' Perspective." Journal of Financial Stability 28 (2017): 163–80. https://doi.org/10.1016/j.jfs.2017.01.001.

Bauguess, Scott. The Role of Big Data, Machine Learning, and AI in Assessing Risks: a Regulatory Perspective. *United States and Exchange Commission*. 2017. https://www.sec.gov/news/speech/bauguess-big-data-ai.

Bhattacharyay, Biswa Nath. *Determinants of Financial Inclusion of Urban Poor in India: An Empirical Analysis*. Vol. 6096. CESifo Group Munich, 2016.

Bisht, Shailendra Singh, and Vishal Mishra. "ICT-Driven Financial Inclusion Initiatives for Urban Poor in a Developing Economy: Implications for Public Policy." *Behaviour & Information Technology* 35, no. 10 (2016): 817–32. https://doi.org/10.1080/0144929X.2016.1183711.

Bozkurt, Ibrahim, Karakuş, Rıfat, and Yildiz, Melek. "Spatial Determinants of Financial Inclusion over Time. *Journal of International Development* 30, no.1 (September 2018): 1474–1504. https://doi.org/10.1002/jid.3376.

Brainard, Lael. "Where Do Banks Fit in the Fintech Stack?" *Board of Governors of the Federal Reserve System*, 2017. https://www.federalreserve.gov/newsevents/speech/brainard20170428a.htm.

Das, Udaibir S., Marc Quintyn, and Kina Chenard. "Does Regulatory Governance Matter for Financial System Stability? An Empirical Analysis." *IMF Working Papers* 04, no. 89 (2004): 1. https://doi.org/10.5089/9781451851311.001.

Demirguc-Kunt, Asli, Klapper, Leora, Singer, Dorothe, Ansar, Saniya, and Hess, Jake. "Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution."

Washington, DC: *The World Bank,* (2018). https://doi.org/10.1596/978-1-4648-1259-0.

Dodgson, Mark, David Gann, Irving Wladawsky Berger, Naveed Sultan, and Gerard George. "Managing Digital Money." *Academy of Management Journal* 58 (February 23, 2015). https://journals.aom.org/doi/pdf/10.5465/amj.2015.4002.

Economides, Nicholas, and Przemyslaw Jeziorski. "Mobile Money in Tanzania." *Marketing Science* 36, no. 6 (2014): 815–37. https://doi.org/10.1287/mksc.2017.1027.

"Expanding Financial Inclusion." IFC Insights. International Finance Corporation. Accessed April 9, 2020. https://www.ifc.org/wps/wcm/connect/REGION__EXT_Content/IFC_External_Corporate_Site/Sub-Saharan+Africa/Priorities/Financial+Inclusion/

"Financial Inclusion Global Initiative (FIGI)." The World Bank, July 18, 2019. https://www.worldbank.org/en/topic/financialinclusion/brief/figi.

Gibson, Evan, and Ross P. Buckley. "Regulating Digital Financial Services Agents in Developing Countries to Promote Financial Inclusion." *SSRN Electronic Journal*, 2015. https://doi.org/10.2139/ssrn.2973806.

Hannig, Alfred, and Stefan Jansen. "Financial Inclusion and Financial Stability: Current Policy Issues." *IDEAS Working Paper Series from RePEc*, January 1, 2011. http://search.proquest.com/docview/1698261271/.

Hardy, Andrew P, Stanford University, and United States. "The Role of the Telephone in Economic Development*." Institute for Communication Research, Stanford University*, Available from National Technical Information Service, U.S. Dept. of Commerce, 1980. http://hdl.handle.net/2027/inu.30000001691090.

"Interbank Electronic Payment System (SPEI)." *Bank of Mexico*, 2016. https://www.banxico.org.mx/payment-systems/d/{90965A55-8F44-7DD2-45CF-2BF1D7C0B75B}.pdf.

Kim, Pan Suk. "Building Trust by Improving Governance: Searching for a Feasible Way for Developing Countries." Public Administration Quarterly 34, no. 3 (2010): 271–99. https://www.jstor.org/stable/41288350.

Klapper, Leora. "Financial Inclusion Has a Big Role to Play in Reaching the SDGs." *World Bank Blogs*, September 15, 2016. http://blogs.worldbank.org/developmenttalk/financial-inclusion-has-big-role-play-reaching-sdgs.

Kpodar, Kangni, and Mihasonirina Andrianaivo. "ICT, Financial Inclusion, and Growth Evidence from African Countries." *IMF Working Papers* 11, no. 73 (2011): 1. https://doi.org/10.5089/9781455227068.001.

Kumar, Nitin. "Financial Inclusion and Its Determinants: Evidence from India." *Journal of*

Financial Economic Policy 5, no. 1 (April 5, 2013): 4–19. https://doi.org/10.1108/17576381311317754.

Lotto, Josephat. "Examination of the Status of Financial Inclusion and Its Determinants in Tanzania." *Sustanability* 10, no. 8 (2018): 2873. https://doi.org/10.3390/su10082873.

Magnusson, Dick, and Brita Hermelin. "ICT Development from the Perspective of Connectivity and Inclusion: The Operation of a Local Digital Agenda in Sweden." *Norsk Geografisk Tidsskrift* 73, no. 2 (2019): 81–95. https://doi.org/10.1080/00291951.2019.1596153.

Moid, Sana, and Shreyansh Jain. "The Economics of Digital Currency: World of Crypto Currency." *Journal of Management and Technology* 15, no. 1 (2019): 25–35. https://jaipuria.edu.in/jim/wp-content/uploads/2019/11/JIMQUEST-Sep-2019.pdf#page=29

Malaguti, Maria C. "Payment System Regulation for Improving Financial Inclusion." CGD Policy Paper 070. Washington, DC: *Center for Global Development*, (2015). http://www.cgdev.org/content/publications/payment-system-regulation-improving-financial-inclusion

Moid, Sana, and Shreyansh Jain. "The Economics of Digital Currency: World of Crypto Currency." *Journal of Management and Technology* 15, no. 1 (2019): 25–35. https://jaipuria.edu.in/jim/wp-content/uploads/2019/11/JIMQUEST-Sep-2019.pdf#page=29

Ogawa, Márcia. "Insights about Digital Transformation and ICT Opportunities for Brazil." *Deloitte*, 2019. Accessed March 18, 2020. https://www2.deloitte.com/br/en/pages/technology-media-and-telecommunications/articles/insights-sobre-o-setor-de-tic---deloitte-brasil.html.

Ooijen, I., and Helena Vrabec. "Does the GDPR Enhance Consumers' Control over Personal Data? An Analysis from a Behavioural Perspective." *Journal of Consumer Policy* 42, no. 1 (March 15, 2019): 91–107. https://doi.org/10.1007/s10603-018-9399-7.

Oyelami, Lukman. O, Saibu, Olufemi M, and Adekunle, Babatunde. S. "Determinants of Financial Inclusion in Sub-Sahara African Countries." *Covenant Journal of Business & Social Sciences (CJBSS)* 8, no.2, (December 2017): http://journals.covenantuniversity.edu.ng/index.php/cjbss/article/view/700

Park, Cyn-Young, and Rogelio Mercado. "Financial Inclusion, Poverty, and Income Inequality." The Singapore Economic Review 63, no. 1 (March 1, 2018): 185–206. https://doi.org/10.1142/S0217590818410059.

Piscini, Eric, Ulrike Guigui, Sanjib Banerjee, and Denise Rotatori. "Real-Time Payments Are Changing the Reality of Payments." *Deloitte,* 2015. Accessed March 18, 2020. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/strategy/us-cons-real-time-payments.pdf.

Plassaras, Nicholas A. “Regulating Digital Currencies: Bringing Bitcoin within the Reach of the IMF.” *Chicago Journal of International Law* 14, no.1 (2018): 377–407. doi: http://chicagounbound.uchicago.edu.proxy.library.georgetown.edu/cjil/.

Roodman, David. “How to Do Xtabond2: An Introduction to Difference and System GMM in Stata.” The Stata Journal: Promoting Communications on Statistics and Stata 9, no. 1 (2009): 86–136. https://doi.org/10.1177/1536867x0900900106.

Seki, Ismail. "The Importance of ICT for the Knowledge Economy: A Total Factor Productivity Analysis for Selected OECD Countries," *Izmir University of Economics* (2008): pp 72-90. https://ideas.repec.org/h/izm/prcdng/200804.html

Soumaré, Issouf, Fulbert Tchana Tchana, and Thierry Martial Kengne. “Analysis of the Determinants of Financial Inclusion in Central and West Africa.” *Transnational Corporations Review* 8, no. 4 (2016): 231–49. https://doi.org/10.1080/19186444.2016.1265763.

Suri, Tavneet, William Jack, and Tavneet Suri. “The Long-Run Poverty and Gender Impacts of Mobile Money.” *Science (New York, N.Y.)* 354, no. 6317 (December 9, 2016): 1288–92. https://doi.org/10.1126/science.aah5309.

“The G20 Basic Set of Financial Inclusion Indicators,” *Global Partnership for Financial Inclusion*, 2012. http://databank.worldbank.org/data/download/g20fidata/GPFIsummarynote.pdf.

Tobias, A., & Tommaso, M. “The Rise of Digital Money.” Washington, D.C.*: International Monetary Fund*, (2019). https://www.imf.org/en/Publications/fintech-notes/Issues/2019/07/12/The-Rise-of-Digital-Money-47097

“Trust in Government, Policy Effectiveness and the Governance Agenda.” Chapter 2. In *Government at a Glance 2013*, 19–37. Paris, France: OECD Publications Centre, 2013.

“UFA2020 Overview: Universal Financial Access by 2020.” The World Bank, October 1, 2018. https://www.worldbank.org/en/topic/financialinclusion/brief/achieving-universal-financial-access-by-2020.

Waverman, Leonard, Meloria Meschi, and Melvyn Fuss. “The Impact of Telecoms on Economic Growth in Developing Countries, *The Vodafone Policy Paper Series* 2 (2005): 10–23. https://pdfs.semanticscholar.org/aadc/e446bb919b40d6f743b216c939da0cfa1d18.pdf

Yetman, James. “Adapting Monetary Policy to Increasing Financial Inclusion.” *Bank for International Settlements*, 2017. Accessed April 01, 2020. https://www.bis.org/ifc/publ/ifcb47m_rh.pdf

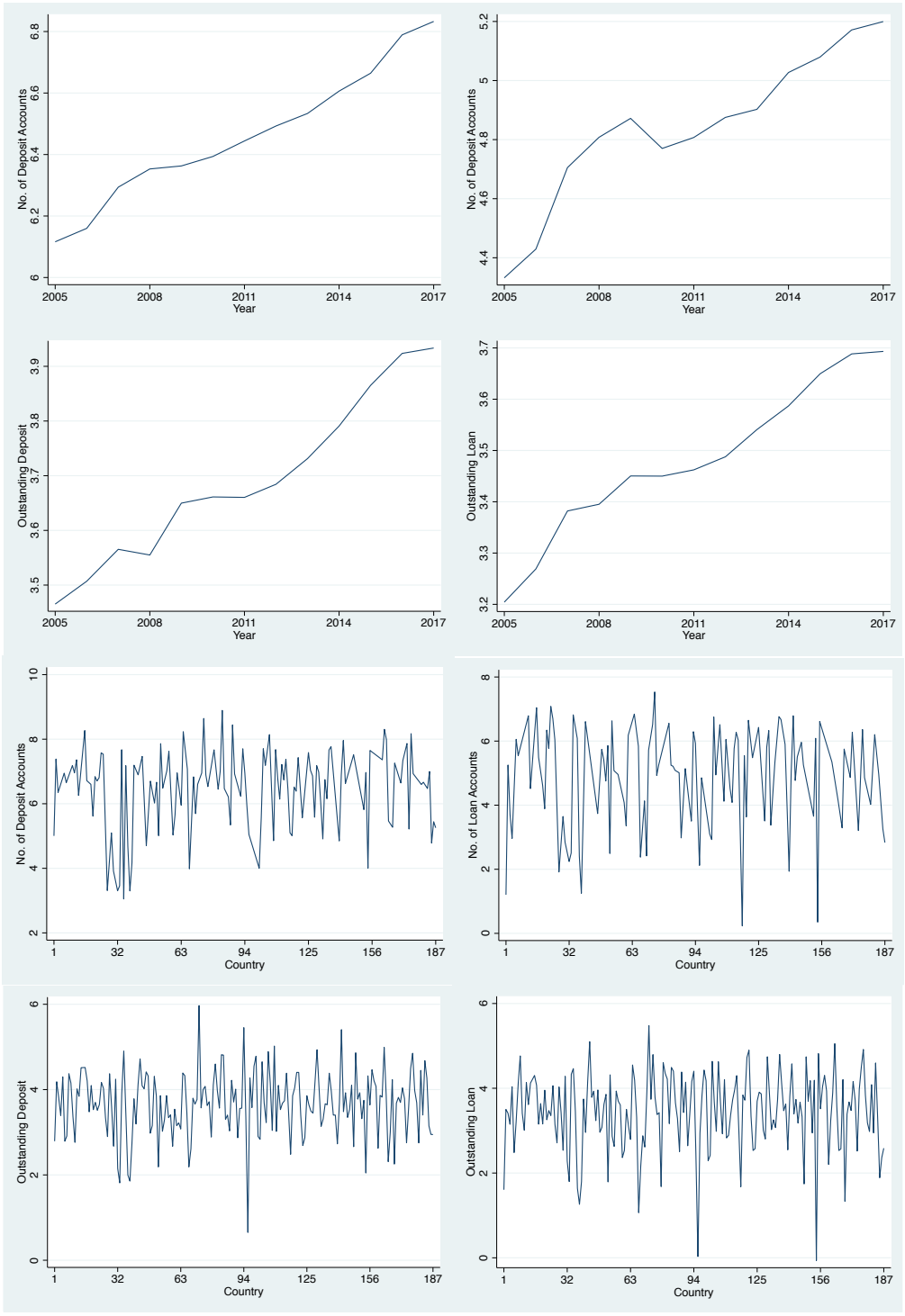
Zins, Alexandra, and Weill, Laurent. “The Determinants of Financial Inclusion in Africa.” *Review of Development Finance* 6, no. 1 (2016): 46–57. https://doi.org/10.1016/j.rdf.2016.05.001.

7. APPENDICES

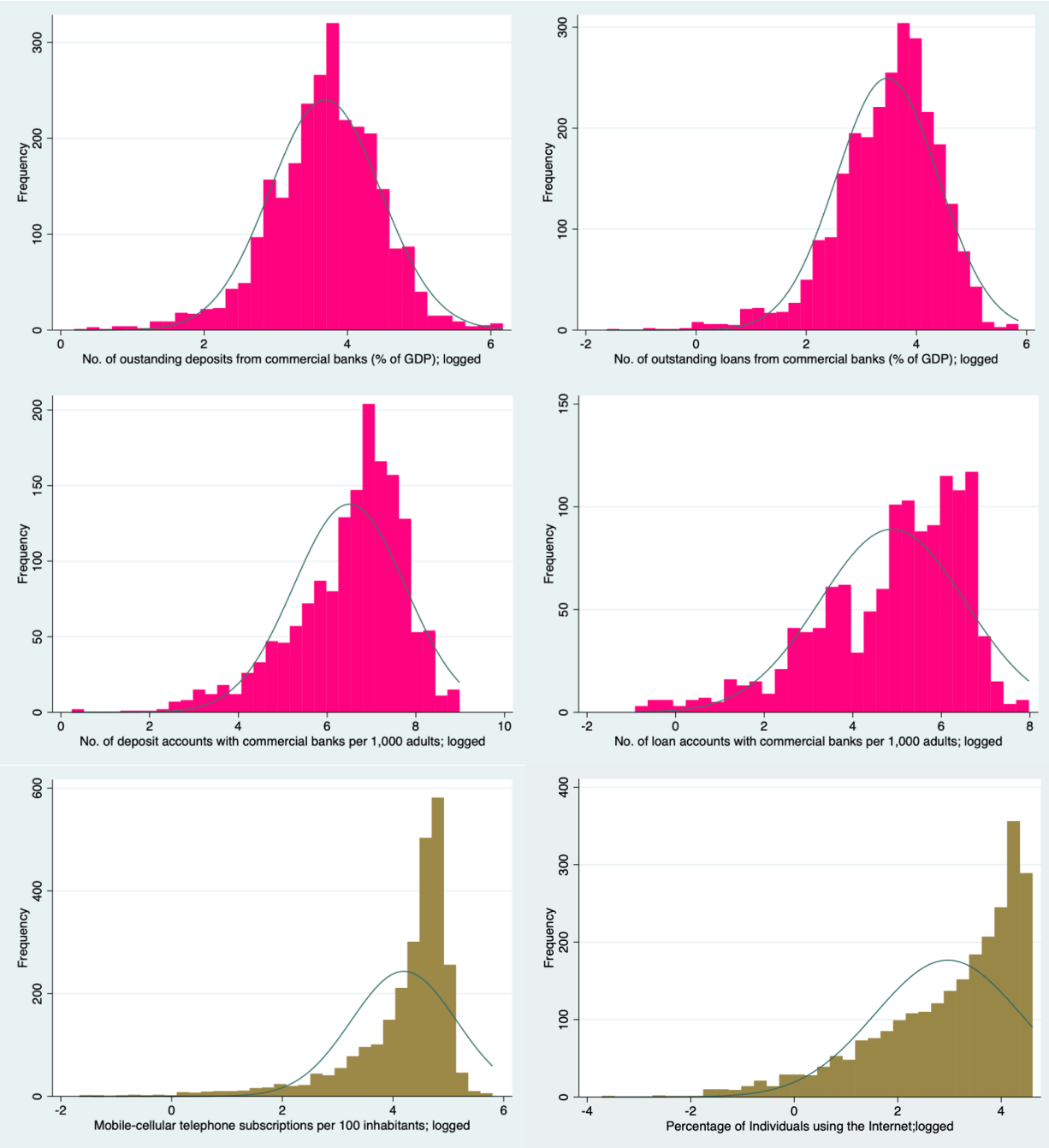
Appendix 1. Variable Description

Variable	Role	Source	Description
Outstanding Deposits from Commercial Banks	Dependent	IMF Financial Access Survey	Number of outstanding deposits from commercial banks (% of GDP)
Outstanding Loans from Commercial Banks	Dependent	IMF Financial Access Survey	Number of outstanding loans from commercial banks (% of GDP)
Deposit Accounts with Commercial Banks	Dependent	IMF Financial Access Survey	Number of deposit accounts with commercial banks per 1,000 adults
Loan Accounts with Commercial Banks	Dependent	IMF Financial Access Survey	Number of loan accounts with commercial banks per 1,000 adults
Mobile Subscription	Key Independent	International Telecommunication Union	Mobile-cellular telephone subscriptions per 100 individuals
Internet Access Rate	Key Independent	International Telecommunication Union	Percentage of Individuals using the Internet
Bank Overhead Cost	Control	Global Financial Development Data (The World Bank Database)	Bank Overhead Costs To Total Assets (%)
GNI Per Capita	Control	World Bank National Accounts Data and OECD National Accounts Data	Gross National Income per capita in 2019 U.S. dollars
Urban Population	Control	United Nations Population Division: 2018 World Urbanization Prospects (The World Bank Database)	Share of Urban Population calculated as % of Total Population
Education	Control	United Nations Development Program: Human Development Data	Mean Years of Schooling among Total Population
Remittance		IMF Balance of Payments, World Bank and OECD (The World Bank Database)	Share of Personal Remittances Received which is calculated as % of GDP
Inflation Rate	Control	World Development Indicators (The World Bank Database)	Inflation, Consumer Prices (Annual %)
Government Effectiveness Index	Control	Worldwide Governance Indicators (The World Bank Database)	The quality of public services, civil service, policy formulation, policy implementation and credibility of the government's commitment to raise these qualities or keeping them high.
Rule of Law Index	Control	Worldwide Governance Indicators (The World Bank Database)	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.
Political Stability Index	Control	Worldwide Governance Indicators (The World Bank Database)	The likelihood of political instability and/or politically motivated violence, including terrorism.

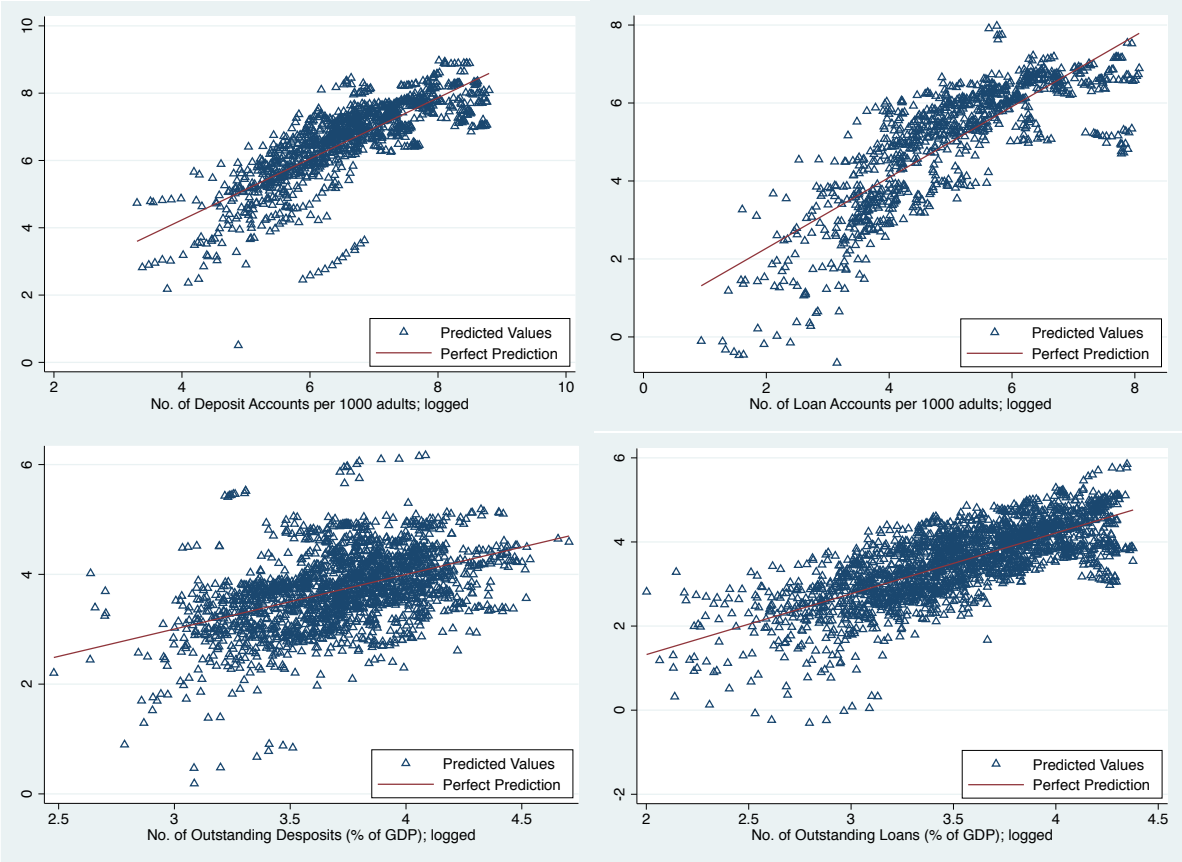
Appendix 2. Heterogeneity of Financial Inclusion Across Time and Country



Appendix 3. Frequency Distribution of Key Indicators

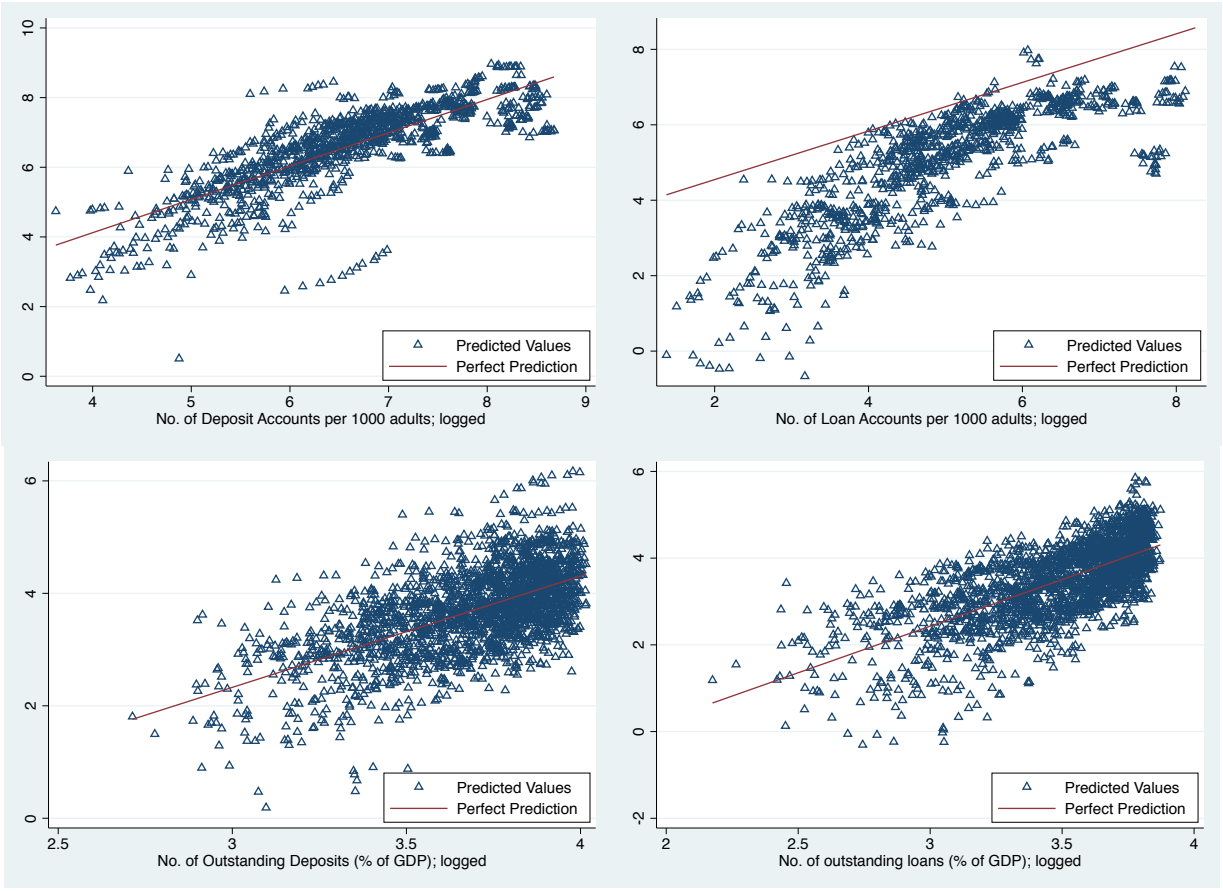


Appendix 4. Quality of Prediction – Mobile Subscription[15]



[15] The quality of prediction is tested on the optimal model identified in the Table 2 and 3 of the Section 4.1, which contains estimated results on the relationship between mobile penetration and financial inclusion.

Appendix 5. Quality of Prediction – Internet Access[16]



[16] The quality of prediction is tested on the optimal model identified in the Table 4 and 5 of the Section 4.1, which contains estimated results on the relationship between internet coverage and financial inclusion.

Appendix 6. Robustness Check – All Countries

Table 1. GMM Results – Mobile Subscription on Deposit and Loan Accounts

	No. of Deposit Accounts			*No. of Loan Accounts*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Mobile Subscription	0.110**	0.040	0.058*	0.111	0.086**	0.058
	(0.055)	(0.26)	(0.031)	(0.076)	(0.038)	(0.038)
Bank Overhead Cost		-0.022			0.025	
		(0.024)			(0.023)	
GNI per capita		0.026			0.043	
		(0.041)			(0.038)	
Urban Population		0.0006			0.002*	0.226***
		(0.001)			(0.001)	(0.059)
Education		0.022**	0.022		0.013	
		(0.011)	(0.018)		(0.013)	
Remittance		0.004			-0.0001	
		(0.003)			(0.003)	
Inflation Rate		0.003*	0.002*		-0.0003	
		(0.002)	(0.001)		(0.002)	
Government Effectiveness		0.092			0.135**	
		(0.074)			(0.066)	
Rule of Law		-0.110			-0.189**	0.545***
		(0.069)			(0.075)	(0.153)
Political Stability		-0.041*	0.043		0.052	
		(0.024)	(0.031)		(0.043)	
Dependent	0.891***	0.846***	0.543***	0.889***	0.854***	0.832***
	(0.037)	(0.054)	(0.199)	(0.032)	(0.038)	(0.041)
Constant	0.414***	0.561**	0.543***	0.272***	-0.071	0.458***
	(0.113)	(0.294)	(0.199)	(0.081)	(0.208)	(0.152)
N	1,258	1,036	1,173	951	817	987
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# Countries	128	110	121	106	95	109
Sargan χ^2	108.96	481.99	214.36	154.78	342.72	185.54
Pr > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.000	0.000	0.000	0.001	0.000	0.000
AR (2)	0.128	0.814	0.323	0.937	0.211	0.731

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) The dependent variable is the lead of each variable listed at the top of each column. GMM instruments are restricted to one lag. AR (1) and AR (2) are the p-values of the test statistics for first and second order serial correlation in first differenced residuals.
4) Year fixed effects show "Yes" if significant at the significance level of 0.05 and "No" otherwise.

Table 2. GMM Results – Mobile Subscription on Outstanding Deposits and Loans

	Outstanding Deposits			*Outstanding Loans*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Mobile Subscription	0.043***	-0.021**	0.006	0.082***	0.0001	0.035*
	(0.015)	(0.010)	(0.014)	(0.024)	(0.014)	(0.020)
Bank Overhead Cost		0.016			0.013	
		(0.010)			(0.012)	
GNI per capita		0.057***	0.033**		0.042*	
		(0.020)	(0.014)		(0.023)	
Urban Population		-0.0006			0.0003	0.226***
		(0.0006)			(0.0006)	(0.059)
Education		-0.005			-0.003	
		(0.004)			(0.005)	
Remittance		-0.0005			-0.0001	
		(0.001)			(0.001)	
Inflation Rate		-0.002**	-0.003**		-0.007***	-0.007***
		(0.001)	(0.001)		(0.001)	(0.001)
Government Effectiveness		0.017			0.016	
		(0.031)			(0.034)	
Rule of Law		-0.056**	-0.055***		-0.067**	0.131***
		(0.027)	(0.018)		(0.029)	(0.025)
Political Stability		-0.014			-0.005	
		(0.013)			(0.019)	
Dependent	0.906***	0.945***	0.935***	0.868***	0.955***	0.974***
	(0.027)	(0.015)	(0.028)	(0.027)	(0.015)	(0.022)
Constant	0.233***	-0.077	-0.005	0.230***	-0.084	-0.216***
	(0.061)	(0.118)	(0.101)	(0.055)	(0.148)	(0.117)
N	2,089	1,703	1,946	2,086	1,705	1,943
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# Countries	183	160	173	183	160	173
Sargan χ^2	136.83	430.41	236.02	252.22	588.61	341.31
Pr > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.000	0.000	0.000	0.000	0.000	0.000
AR (2)	0.724	0.609	0.490	0.643	0.345	0.729

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) The dependent variable is the lead of each variable listed at the top of each column. GMM instruments are restricted to one lag. AR (1) and AR (2) are the p-values of the test statistics for first and second order serial correlation in first differenced residuals.
4) Year fixed effects show "Yes" if significant at the significance level of 0.05 and "No" otherwise.

Table 3. GMM Results – Internet Access on Deposit and Loan Accounts

	No. of Deposit Accounts			*No. of Loan Accounts*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet Access	0.094**	0.061*	0.089**	0.136**	0.051	0.068
	(0.044)	(0.32)	(0.038)	(0.068)	(0.044)	(0.049)
Bank Overhead Cost		-0.018			0.034	
		(0.029)			(0.030)	
GNI per capita		0.029			0.025	
		(0.052)			(0.039)	
Urban Population		-0.0005			0.003**	0.006**
		(0.002)			(0.002)	(0.003)
Education		0.019			0.011	
		(0.012)			(0.014)	
Remittance		0.004			0.0005	
		(0.003)			(0.003)	
Inflation Rate		0.003**	-0.001****		0.0007	
		(0.002)	(0.0002)		(0.002)	
Government Effectiveness		0.054			0.181***	0.222***
		(0.071)			(0.070)	(0.084)
Rule of Law		-0.080			-0.239***	-0.134*
		(0.071)			(0.088)	(0.080)
Political Stability		0.037			0.065	
		(0.025)			(0.045)	
Dependent	0.851***	0.823***	0.859***	0.852***	0.857***	0.811***
	(0.050)	(0.061)	(0.045)	(0.047)	(0.044)	(0.049)
Constant	0.828***	0.709*	0.796***	0.532***	0.162	0.539***
	(0.241)	(0.426)	(0.220)	(0.136)	(0.227)	(0.198)
N	1,240	1,031	1,183	990	812	977
Year FE	Yes	No	Yes	No	No	No
# Countries	127	110	123	110	95	108
Sargan χ^2	102.22	518.04	144.65	125.66	365.93	153.47
Pr > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.001	0.005	0.001	0.001	0.000	0.001
AR (2)	0.060	0.350	0.068	0.954	0.258	0.849

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) The dependent variable is the lead of each variable listed at the top of each column. GMM instruments are restricted to one lag. AR (1) and AR (2) are the p-values of the test statistics for first and second order serial correlation in first differenced residuals.
4) Year fixed effects show "Yes" if significant at the significance level of 0.05 and "No" otherwise.

Table 4. GMM Results – Internet Access on Outstanding Deposits and Loans

	Outstanding Deposits			*Outstanding Loans*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet Access	0.004	-0.018	-0.005	0.138***	-0.021	-0.004
	(0.013)	(0.011)	(0.010)	(0.042)	(0.015)	(0.017)
Bank Overhead Cost		0.008			0.016	
		(0.010)			(0.012)	
GNI per capita		0.043**	0.025**		0.050**	0.051***
		(0.020)	(0.010)		(0.025)	(0.016)
Urban Population		-0.0005			0.0007	
		(0.0005)			(0.0007)	
Education		-0.0006			0.0005	
		(0.005)			(0.005)	
Remittance		-0.0005			0.001	
		(0.001)			(0.001)	
Inflation Rate		-0.002*	-0.003**		-0.007***	-0.007***
		(0.001)	(0.001)		(0.001)	(0.001)
Government Effectiveness		0.009			-0.021	
		(0.033)			(0.035)	
Rule of Law		-0.040*	-0.040*		-0.061**	-0.133***
		(0.024)	(0.021)		(0.028)	(0.026)
Political Stability		-0.010			-0.007	
		(0.014)			(0.019)	
Dependent	0.932***	0.949***	0.944***	0.949***	0.965***	0.991***
	(0.036)	(0.018)	(0.028)	(0.092)	(0.016)	(0.023)
Constant	0.277***	-0.045	0.062	-0.289	-0.199	-0.269*
	(0.098)	(0.149)	(0.132)	(0.259)	(0.188)	(0.140)
N	2,073	1,695	1,928	2,068	1,687	1,925
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# Countries	182	160	172	182	160	172
Sargan χ^2	170.11	467.96	238.39	963.45	665.45	426.75
Pr > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.000	0.000	0.000	0.000	0.000	0.000
AR (2)	0.751	0.822	0.886	0.317	0.542	0.697

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) The dependent variable is the lead of each variable listed at the top of each column. GMM instruments are restricted to one lag. AR (1) and AR (2) are the p-values of the test statistics for first and second order serial correlation in first differenced residuals.
4) Year fixed effects show "Yes" if significant at the significance level of 0.05 and "No" otherwise.

Appendix 6. Robustness Check – Developing Countries

Table 1. GMM Results – Mobile Subscription on Deposit and Loan Accounts

	No. of Deposit Accounts			*No. of Loan Accounts*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Mobile Subscription	0.161**	0.063*	0.069	0.168	0.145***	0.187***
	(0.081)	(0.034)	(0.044)	(0.116)	(0.048)	(0.072)
Bank Overhead Cost		-0.067*	-0.055		0.0008	
		(0.036)	(0.039)		(0.024)	
GNI per capita		0.057			0.049	
		(0.062)			(0.049)	
Urban Population		-0.0007			-0.001	
		(0.002)			(0.001)	
Education		0.021			0.021**	0.053**
		(0.013)			(0.008)	(0.022)
Remittance		0.004			0.0001	
		(0.003)			(0.002)	
Inflation Rate		0.005***	0.003		0.002	
		(0.002)	(0.002)		(0.003)	
Government Effectiveness		0.157**	0.102***		0.159***	0.161*
		(0.077)	(0.038)		(0.058)	(0.085)
Rule of Law		-0.061			-0.120	
		(0.060)			(0.073)	
Political Stability		0.047*	0.048		0.067**	0.077*
		(0.027)	(0.030)		(0.073)	(0.045)
Dependent	0.837***	0.797***	0.857***	0.806***	0.845***	0.832***
	(0.063)	(0.064)	(0.049)	(0.058)	(0.048)	(0.041)
Constant	0.632**	0.730*	0.878***	0.452***	0.095	0.504**
	(0.278)	(0.388)	(0.273)	(0.123)	(0.237)	(0.214)
N	533	437	468	423	354	423
Year FE	No	Yes	No	No	No	No
# Countries	55	48	51	50	44	50
Sargan χ^2	82.25	350.35	260.03	89.57	240.73	143.62
Pr > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.004	0.012	0.007	0.008	0.022	0.008
AR (2)	0.124	0.896	0.519	0.826	0.412	0.671

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) The dependent variable is the lead of each variable listed at the top of each column. GMM instruments are restricted to one lag. AR (1) and AR (2) are the p-values of the test statistics for first and second order serial correlation in first differenced residuals.
4) Year fixed effects show "Yes" if significant at the significance level of 0.05 and "No" otherwise.

Table 2. GMM Results – Mobile Subscription on Outstanding Deposits and Loans

	Outstanding Deposits			*Outstanding Loans*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Mobile Subscription	0.047***	-0.015	-0.006	0.075*	0.018	0.043*
	(0.016)	(0.011)	(0.013)	(0.045)	(0.019)	(0.024)
Bank Overhead Cost		0.017*	0.004		0.003	
		(0.010)	(0.014)		(0.016)	
GNI per capita		0.045*	0.024		0.027	
		(0.024)	(0.016)		(0.033)	
Urban Population		-0.0009			-0.002	
		(0.0007)			(0.001)	
Education		-0.0005			0.004	
		(0.004)			(0.006)	
Remittance		-0.0004			-0.002	
		(0.001)			(0.002)	
Inflation Rate		-0.005***	-0.005***		-0.007***	-0.006***
		(0.001)	(0.001)		(0.001)	(0.002)
Government Effectiveness		-0.025			0.035	
		(0.030)			(0.045)	
Rule of Law		-0.024			-0.104**	-0.147***
		(0.033)			(0.038)	(0.050)
Political Stability		0.002			0.041	0.078***
		(0.015)			(0.017)	(0.027)
Dependent	0.916***	0.941***	0.927***	0.826***	0.926***	0.894***
	(0.044)	(0.017)	(0.017)	(0.066)	(0.017)	(0.031)
Constant	0.212	-0.005	0.167*	0.369***	0.147	0.267***
	(0.133)	(0.136)	(0.090)	(0.136)	(0.196)	(0.101)
N	819	674	714	811	671	768
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# Countries	73	65	68	73	65	70
Sargan χ^2	77.44	269.57	119.44	130.16	370.79	167.68
Pr > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.000	0.000	0.000	0.000	0.000	0.000
AR (2)	0.132	0.108	0.127	0.358	0.525	0.229

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) The dependent variable is the lead of each variable listed at the top of each column. GMM instruments are restricted to one lag. AR (1) and AR (2) are the p-values of the test statistics for first and second order serial correlation in first differenced residuals.
4) Year fixed effects show "Yes" if significant at the significance level of 0.05 and "No" otherwise.

Table 3. GMM Results – Internet Access on Deposit and Loan Accounts

	No. of Deposit Accounts			*No. of Loan Accounts*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet Access	0.119**	0.085**	0.138***	0.531	-0.023	0.047
	(0.054)	(0.33)	(0.052)	(0.387)	(0.039)	(0.063)
Bank Overhead Cost		-0.074**	-0.089*		0.054**	0.033
		(0.037)	(0.048)		(0.027)	(0.052)
GNI per capita		-0.019			0.088	
		(0.065)			(0.055)	
Urban Population		0.0006			0.002	
		(0.001)			(0.001)	
Education		0.020			0.017*	0.014
		(0.065)			(0.010)	(0.017)
Remittance		0.003			0.003	
		(0.003)			(0.003)	
Inflation Rate		0.004***	0.004**		-0.0003	
		(0.002)	(0.002)		(0.003)	
Government Effectiveness		0.141**	0.075		0.201***	0.281**
		(0.068)	(0.053)		(0.063)	(0.140)
Rule of Law		-0.050			-0.042	
		(0.063)			(0.075)	
Political Stability		0.034			0.028	
		(0.025)			(0.028)	
Dependent	0.808***	0.800***	0.787***	0.623***	0.859***	0.795***
	(0.068)	(0.066)	(0.059)	(0.229)	(0.044)	(0.064)
Constant	1.050***	1.253**	1.269***	-0.390	-0.034	0.837***
	(0.355)	(0.530)	(0.341)	(1.067)	(0.239)	(0.320)
N	528	432	463	416	349	391
Year FE	No	Yes	Yes	Yes	No	No
# Countries	55	48	51	49	44	48
Sargan χ^2	77.23	376.08	206.06	374.65	272.51	136.41
Pr > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.007	0.024	0.013	0.178	0.024	0.017
AR (2)	0.053	0.291	0.201	0.837	0.349	0.351

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) The dependent variable is the lead of each variable listed at the top of each column. GMM instruments are restricted to one lag. AR (1) and AR (2) are the p-values of the test statistics for first and second order serial correlation in first differenced residuals.
4) Year fixed effects show "Yes" if significant at the significance level of 0.05 and "No" otherwise.

Table 4. GMM Results – Internet Access on Outstanding Deposits and Loans

	Outstanding Deposits			*Outstanding Loans*		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Internet Access	-0.038**	-0.025**	-0.015	0.077	-0.009	0.014
	(0.019)	(0.013)	(0.016)	(0.083)	(0.020)	(0.015)
Bank Overhead Cost		0.012			0.012	0.004
		(0.010)			(0.014)	(0.021)
GNI per capita		0.046**	0.023		0.036	
		(0.021)	(0.019)		(0.032)	
Urban Population		-0.001			-0.001	
		(0.0007)			(0.001)	
Education		0.003			0.007	
		(0.004)			(0.005)	
Remittance		0.0001			-0.002	
		(0.001)			(0.002)	
Inflation Rate		-0.005***	-0.004***		-0.006***	-0.006***
		(0.001)	(0.002)		(0.001)	(0.002)
Government Effectiveness		-0.032			0.018	
		(0.032)			(0.042)	
Rule of Law		-0.011			-0.103***	-0.081**
		(0.036)			(0.034)	(0.039)
Political Stability		-0.005			0.045**	0.076***
		(0.015)			(0.019)	(0.022)
Dependent	0.972***	0.946***	0.939***	0.831***	0.938***	0.902***
	(0.030)	(0.016)	(0.018)	(0.152)	(0.017)	(0.029)
Constant	0.156**	-0.051	0.124	0.104	0.041	0.371*
	(0.080)	(0.139)	(0.136)	(0.430)	(0.224)	(0.105)
N	813	666	766	808	663	712
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
# Countries	73	65	71	73	65	68
Sargan χ^2	62.14	284.11	160.60	586.78	392.95	260.00
Pr > χ^2	0.000	0.000	0.000	0.000	0.000	0.000
AR (1)	0.000	0.000	0.000	0.102	0.000	0.000
AR (2)	0.202	0.205	0.211	0.477	0.996	0.962

Note: 1) ***, **, * indicate statistical significance for each variable at 0.01, 0.05 and 0.10 levels, respectively.
2) The dependent variable is listed at the top of each column. All dependent variables are logged. Mobile Subscription, GNI per capita and bank overhead cost are also logged.
3) The dependent variable is the lead of each variable listed at the top of each column. GMM instruments are restricted to one lag. AR (1) and AR (2) are the p-values of the test statistics for first and second order serial correlation in first differenced residuals.
4) Year fixed effects show "Yes" if significant at the significance level of 0.05 and "No" otherwise.