Financial Inclusion and Digital Financial Services: Empirical evidence from Ghana

Agyekum, Francis and Locke, Stuart and Hewa-Wellalage, Nirosha

School of Business, Valley View University. Accra, Ghana, School of Accounting, Finance and Economics, Waikato Management School The University of Waikato. Hamilton, New Zealand, School of Accounting, Finance and Economics, Waikato Management School The University of Waikato. Hamilton, New Zealand

30 November 2016

Financial Inclusion and Digital Financial Services: Empirical evidence from Ghana

ABSTRACT

The paper examines the relationship between increasing accessibility to digital financial services (DFS) and financial inclusion in lower income countries (LICs). Banks and non-bank organisations use DFS and the analysis indicates non-bank-based DFS emerges as the most efficient means of delivering cost effective financial services to the previously unbanked. Mobile cellular penetration and internet usage are mutually inclusive means through which digital financial services foster financial inclusion. Analysis of data for Ghana, as a case study, uses ordinary least squares and logistic regression models. The results in Difference-In-Difference method confirms the positive significant trend of mobile money usage and negative trend of bank-based DFS facilities over the period 2011-2014 in Ghana. Unambiguous policy ramifications are emphasised, paying attention to technological deepening stimulate positive outcomes of a broader and inclusive financial system.

Highlights

- Technological deepening plays in advancing financial inclusion in Ghana.
- Increase in mobile subscription rate of 1 percent leads to 1.19 percent increase in credit to private sector.
- Increase in internet penetration of 1 percent leads to 17.2 percent increase in financial inclusion in household.
- Delivering digital financial services extends financial inclusion to previously ‘unbanked’.
- Increased availability of financial services for the marginalised increases growth.

JEL classification: O30; O50; G20

Key words: Digital financial services (DFS), financial inclusion, Logistic regression, Difference-in-Difference, LICs, Ghana.

INTRODUCTION

This paper examines the effect on participation in the financial sector in lower income countries (LICs) of increasing accessibility to digital financial services (DFS). Analysis of data from Ghana, as a case study, looks especially at the impact on financial inclusion (FI) of the mobile phone rollout and internet usage. Our motivation stems from a concern for those who are unbanked and financially excluded who may miss opportunities to improve their wellbeing. Technological amenities may drive inclusion through delivery of digital financial services (DFS) and an equitable participation in the gains has important policy implications. The relative impacts may differ between financial (banks) and non-financial (non-bank) entities offering DFS to their clients.

Financial inclusion captures the extent to which financial resources are available, accessible and affordable to a population. The rapid growth in availability and adoption of ICT in many parts of Africa (Adam and Wood 1999; Andrianaivo and Kpodar 2012; Kpodar and Andrianaivo 2011a) proffers an opportunity for expanding financial inclusion. World Bank (WDI) Report, (2014) by Mundial (2014) reveals mobile tele-density (telephone per 100 persons) in Ghana, rose from 1.3 percent in 2001 to 101 percent by 2012 and current ITU/ICT database estimate is 115 percent. The internet penetration rate is relatively slower, averaging 50 percent per annum according to ITU estimates. The potential to enhance financial inclusion leveraging new technology is present (Gelos and Roldós 2004; Kpodar and Andrianaivo 2011a; 2011b; Triki and Faye 2013) but the extent to which financial service delivery to the poor is improving needs investigation.

Financial inclusion lacks precision in prior research, and may simply refer to the provision of appropriate, affordable and widely accessible quality financial services to the marginalised groups in society, when viewed from the supply side (Triki and Faye 2013). A demand side perspective sees financial inclusion as needing to ensure access to financial services, which include an opportunity to save, make payments, transfer and access insurance services (Hannig and Jansen 2010).

Our empirical analysis, using data on Ghana, provides new insights flowing from a more robust treatment than found in earlier research. For an outcome, variable account ownership and usage are suitable proxy indicators of financial inclusion (Allen *et al.* 2016). Ownership of a bank account increases savings, empowers females, and tends to incentivise consumption and productive investment of entrepreneurs (Aportela 1999; Ashraf *et al.* 2010; Dupas and Robinson 2013), promoting financial inclusivity for account holders.

Estimation of a binary model (logit) with a Difference-In-Difference approach as a robustness check provides for more insightful dichotomous multiple-regression modelling. Further, focusing on a single country brings out certain country-specific details and characteristics not emphasised in cross-country studies (Allen, Demirgüç-Kunt, Klapper, and Martinez Peria, 2012). Inclusion of structural rigidities suggests significant policy outcomes. Clear signals for donor agencies with respect to critical matters requiring attention for the attainment of inclusive growth, poverty reduction and a much broader impact from financial inclusion flow from this form of analysis.

LITERATURE REVIEW

Theoretical Underpinnings

Transaction cost, Information Asymmetry and Financial inclusion

Until the recent telecommunication revolution, information cost to many developing countries was significantly high (Norton 1992) due to high cost of information gathering and dissemination (Waverman *et al.* 2005). This high transaction cost means that productivity would be low. For the financial service providers who rely on reliable information to ascertain the credit worthiness of clients, this would suggest that many economic agents would be financially excluded in such countries.

Theoretical framework that are often used in accessing the marginal effect of ICT, is what is known as the network externality effect (Andrianaivo and Kpodar 2012; Waverman *et al.* 2005). As an instance, Waverman *et al.* (2005) argue, “telecommunication networks are part of social overhead capital”, in which case socio-economic returns that accrue from it could potentially outweigh the private returns to society. In this, the indirect effect of ICT amenities such as mobile phones and internet on growth for instance, has attracted research attention (see e.g., Kpodar and Andrianaivo, 2011). The positive externality of telecommunication network is its ability to allow costless flow of information to market participants (Andrianaivo and Kpodar 2012; Norton 1992; Waverman *et al.* 2005). This indeed helps overcome the problems of information asymmetry and transaction cost (Norton 1992), especially in rendering financial services to the previously underserved. Kpodar, argues that this helps promote both credit accessibility and deposit mobilisation, hence financial inclusion. Innovation that accompanies ICT development means that cost of service will reduce translating into increased consumer surplus.

Seen as indirect effects, the Kpodar and Andrianaivo (2011a) regard ICT as a key factor that can potentially deepen financial inclusion. The emergence of branchless banking services in serving the previously excluded, can be attributed to ICT usage, with the ultimate positive impact towards financial inclusion (Kpodar and Andrianaivo 2011a). Both time and distance costs of accessing formal banking services, could prove to be costly for the poor and the marginalised. Consequently, technological deepening that ensures effective communication network replaces the transportation cost to a physical facility. In his study, Norton (1992) as also finds reduction in transaction cost associated with advancement in ICT in a cross-country study involving 47 economies.

ICT, allows credit suppliers to remotely ascertain the credit worthiness of both existing and potential clients. Consequently, Kpodar and Andrianaivo (2011a) argue that financial inclusion is incentivised by ICT amenities such as mobile phones and internet because of their usefulness in ensuring efficient credit allocation.

Growth, according to Hannig and Jansen (2010), emerges when financial intermediaries are in a position to reduce information asymmetries. Transaction costs reduce with the emergence of both financial instruments and institutions, as evidenced by a deepening of the long-run relationship between borrowers and lenders (Levine (2005).

Theories of information asymmetry and transaction cost contribute to explaining the financial constraints and exclusion borrowers encounter. Information opacity that characterises operations of most LICs shows borrowers as less attractive, making them more prone to the risk of not gaining financial inclusion (Dong and Men 2014; Stiglitz and Weiss 1981). Credit rationing based on poor information promotes financial exclusion.

Prior research linking financial inclusion with economic growth and social development raises issues of breadth and depth. Breadth relates to coverage, percentage of the population covered, while depth encompasses how much service is available, variously interpreted as size of credit or the number of instruments and services available. Not surprisingly, there is a range of different variables and metrics, which lack cohesion. Transaction and information technologies (Gelos and Roldós 2004) may offer a means to overcome difficulties in providing sound credit administration to the poor (Kpodar and Andrianaivo 2011b).

Ang (2011) advances evidence suggesting that financial liberalisation reallocates talent from the innovative sector to the financial system, thus retarding technological deepening. An alternative view espoused by (Diniz *et al.* 2012) suggests ICT bridges a financial infrastructural gap for service providers to incorporate new clients who were previously excluded from a financial substructure. ICT, by enhancing access to credit and deposit facilities, assists the allocation and transfer of financial credit thereby boosting financial inclusion. Mobile technology, according to Rasmussen (2010), is bridging the gap in such African countries as Kenya and South Africa.

Triki and Faye (2013) assert that financial inclusion is a key building block for inclusive growth. Using generalised method of moment (GMM), Kpodar and Andrianaivo (2011b) establish that mobile phone rollout significantly spurs economic growth in Africa, as it fosters financial inclusion. Digital financial services evolving in most parts of Africa promote growth at both the firm and national levels, promoting a premise that sustained growth is realisable through greater financial inclusion. Opportunities offered by DFS, such as branchless banking, allow those with limited or no access to the formal financial sector to engage in financial transactions at relatively little cost. Research, to date, suggests technological deepening further deepens the financial process and ultimately leads to inclusiveness.

DATA

World Bank sources predominantly provide our secondary data inputs. International Telecommunication Union's ICT statistics supplement World Bank reports on mobile subscriber and internet users, which are part of the world development indicators (WDI) series. Data cover 1996–2014. The Heritage Foundation/Wall Street[1]produces the Index of Economic Freedom. Global Findex[2] dataset provides the microdata covering account ownership and usage of financial services, demographic characteristics of respondents including gender, age, income, and education.

Table 1 presents the descriptive statistics for the variables. The decomposition of the account ownership into financial institutions-based and MNOs-based helps with the analysis. Approximately 37 percent of respondents own accounts with formal intermediaries compared with 10 percent who own mobile-based accounts (mobile money/wallet). Internet penetration, with the mean value of 4.62, is low compared with mobile penetration rate of 115 percent[3].

[1] (in World Bank domain sources)

[2] *In World Bank domain sources*

[3] That this rate exceeds 100% is expected, as it is common to find people using more than one handset with different network providers, due to network coverage issues.

<<<<<<INSERT TABLE 1>>>>>>>>

Demographic characteristics such as age, income and educational attainments of respondents serve as control variables in the micro-econometric model. Mean age of 34 suggests respondents are mostly young, finding the use of smart phones with internet functionality useful. The income variable indicates 18.7 percent fall within the poorest quintile, 20.1 percent in the second-lower quintile, 18.0 percent in the median quintile, 20.1 percent in the mid-upper quintile, and 23.1 percent within the richest quintile.

Educational levels, although uneven, do fairly reflect the educational attainment levels of the adult population in Ghana. This has implications for financial inclusion if inclusion is predominantly limited to those at top of the educational-ladder.

METHOD

An ordinary least square (OLS) model for the macro-dataset, (following Kendall *et al.* (2010)) and a logistic regression model for the micro-dataset provide the empirical estimations.

OLS deals with relationship between $\mathbf{y_i}$ and $\mathbf{x_i}$ such that the conditional mean function is specified as: $E(y_i/x_i) = x_i'\beta$ …….(a); and the resultant estimator $(\hat{\beta})$, which must satisfy the basic assumption underlying the classical regression model is given below:

$$\hat{\beta} = \underbrace{\min}_{\beta\in R} \sum_{i=1}^{n}(E(y_i/x_i) - x_i'\beta)^2 \qquad 1$$

where $\hat{\beta}$ is the estimator that minimises the conditional mean function in equation 1. The estimator, which is the sum of the error squared (Cameron and Trivedi 2005), is assumed to be BLUE in Gauss–Markov sense (Drygas 1983; Harville 1976; Zyskind and Martin 1969). Accordingly, it is assumed that the model is not only linear in parameters but also with an error term, which is, both serially uncorrelated and homoscedastic.

Logistic regression is employed for the estimation of equation 5, using household-level data with a dichotomous outcome variable (Angrist and Pischke 2008). Given that the error follows a binomial distribution (Gujarati and Porter 1999), logistic serves as the appropriate link function. As a link function, logit transforms the original $F(\pi; 1,0)$ in a way that the estimates $\hat{\pi}$ behave as continuous, using a maximum likelihood estimation (MLE) process. This way, the logit function spreads the outcome variable over the entire range of numbers.

Logit function is expressed as:

$F(\pi) = \log [\pi / (1- \pi)]$

where π is the probability of 'success' or 'that an event occurs'; and [π / (1- π)] is the odds of an event occurring. The monotonic transformation from probability into odds suggests that the odds increase with the probability, and vice versa.

Generally, the logistic model expressed as a probability can be specified as:

$$\Pr(\pi)\,\mathrm{ob}(y = 1|x) = \left(\frac{e^{(\beta X)}}{1+e^{(\beta X)}}\right) \qquad 2$$

where π is that probability of event occurring (agents getting included financially, in our specific case). The *y*, which represents likelihood of financial inclusion, is a dummy variable taking on binary values defined as:

$$y = \begin{cases} 1, \text{ if individaul is includeed (owns an accounts)} \\ \qquad\qquad 0, \text{ if otherwise} \end{cases}$$

The Xs are the explanatory variables and the β_s are the coefficient estimates. The β_s are the logarithmic transformed odd ratios of the logit model.

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \cdots . + \beta_p X_{ip}$$

The Logistic regression model uses household-level data with a dichotomous outcome variable (Angrist and Pischke 2008).

EMPIRICAL MODEL SPECIFICATION

$$\text{FI=f(ICT, MEI, EFI)} \qquad 3$$

Variables

Dependent Variable (DV): The *FI,* in equation 3, denotes financial inclusion.

Independent Variables (IVs): The main IVs are *ICT* indicators viz. mobile phone and internet usage per population. National level indices such as macroeconomic indicators (MEI) and Economic Freedom indicators (EFI) serve as useful control variables in the macro-model.

Specific econometric estimated model 1 (using the Macro-level data)

$$FI_t = \beta_0 + \beta_1 TI_t + \beta_2 X_t + \varepsilon_t \qquad 4$$

The macro-level investigation, equation 4, relies on domestic private credit to GDP as an indicator because it is found to be significantly associated with, and a key part of, financial inclusion (Demirgüç-Kunt and Klapper 2012).

Specific econometric estimated model 2 (using the household/micro-level data)

$$FI_i = \beta_0 + \beta_1 TI_i + \beta_2 X_i + \varepsilon_i \qquad 5$$

The DV in the household model, in equation 5, uses account ownership as a proxy of financial inclusion, which has been used in many prior studies (Brown and Taylor 2011; Demirgüç-Kunt *et al.* 2013; Friedline 2012; Friedline *et al.* 2014; Greeson *et al.* 2010; Kim *et al.* 2011; Mandell 2005). FI_i measures likelihood of inclusion, the TI_i, capturing Technological Infrastructure and X_i, control variables. The β_is are parameter estimates and ε_i is the non-stochastic error term. Maximum-likelihood estimation approach with Logit model provides the link function. Appendix 2 contains details of diagnostic test results.

FINDINGS

The hypothesis that ICT reduces information asymmetry and transaction cost necessary for broader financial inclusion is tested. Technological infrastructure and mobile phone penetration rates are positively correlated with financial inclusion as reported in Table 3, supporting prior studies (see, e.g., (Kendall *et al.* 2010)). ICT influences services provision through the supply of credit information. The resultant impact is a reduction of problems relating to information asymmetry and the transaction cost of rendering financial services. This results in more inclusion in the financial system. As this helps overcome issues relating to information asymmetry and transaction cost of rendering financial services, the outcomes will be a greater inclusion in the financial system.

<<<<<<INSERT TABLE 2>>>>>>>>

The macro-level analysis reported (see Table 2), shows a yearly increase in mobile subscription rate of 1 percent leads to an approximate 1.19 percent increase in credit to the private sector, after controlling for variables such as GDP per capita growth rate *(GDP_pcg)* and unemployment (u-rate). The 'Mobile Subscription' indicator *(MOBsub_Rate)* has a significant positive impact on financial inclusion, suggesting the widespread adoption of mobile network services will impact favourably on the financial sub-sector.

Results from the household-level data (see Table 3) indicate a significant contribution by ICT's towards financial inclusion in Ghana. The use of a mobile phone in financial transactions increases the likelihood of being financially included as mobile technology allows the previously unbanked to perform financial transactions via mobile phones. With such a unique platform as a mobile money facility, payments for utility bills, fees, fund transfers (domestic and cross-border) and other financial services, can be carried out (Donovan 2012; Jack and Suri 2011; Kpodar and Andrianaivo 2011b).

Kpodar and Andrianaivo (2011b) also find a positive correlation between financial inclusion and mobile penetration. They observe that mobile phone penetration enhances credit allocation process, leading to broader inclusion in the financial system. ICT and mobile network services ensure a better flow of information. This helps reduce both information asymmetry and transaction costs of providing financial services to the poor (Donovan 2012; Kpodar and Andrianaivo 2011b). This reduction in information asymmetry between lenders and creditors is made possible as it ensures timely availability of information (Demirgüç-Kunt *et al.* 2008). Jensen (2007) notes that the information flow helps reduce price volatility, adding to the positive economic effects of mobile telephony. Financial inclusion is attainable because ICT amenities bridge the infrastructural gap in delivering financial services to the marginalised (Diniz *et al.* 2012).

Again, prior studies have empirically established that countries with wider platforms for information sharing tend to experience significant levels of financial inclusion as higher bank credits result (Djankov *et al.* 2007; Jappelli and Pagano 2002). LICs provide a better case for policy consideration. Better information accessibility and transparent contract enforcement deepen the financial system (Demirgüç-Kunt *et al.* 2008; Detragiache *et al.* 2005; Djankov et al. 2007), thereby increasing participation in the credit industry.

The internet usage *(INTSub_Rate)* captures the number of people with access to the worldwide web. The macro-level analysis suggests an inverse relationship between financial inclusion proxy and internet penetration rate. The household-level analysis (Table 3, column 5), however, shows a robust positive marginal impact [ME(dy/dx)=0.172] at 5 percent significance levels. The mixed outcome emanates from the nature of the dataset involved, suggesting several explanations as to why the macro and micro results differ.

The macro-level analysis uses internet penetration rate over time (trend), incorporating no direct reference to usage in financial transactions. The household data, however, obtains specific information relating to the use of internet in financial transactions for the past year. Characteristically of most LICs, home-based internet facilities in Ghana are a preserve of the few affluent. There is also concern over internet security[4], which has thwarted the efforts of some intermediaries to introduce an internet-banking facility in Ghana. Figure 1 shows the widespread usage of mobile phone unmatched by the internet accessibility trend in Ghana.

[4] (known in Ghana as computer 'Sakawa')

<<<<<<<<<<<<Figure 1 >>>>>>>>>>>

Figure 1 shows the trends and relationship between mobile phone penetration rate, internet usage and domestic credit to the private sector. It reveals that both internet and mobile telephony were at the low rate of usage prior to the year 2003. However, the exponential rise in the trend of the mobile penetration rate relative to internet over the same period supports the econometric coefficient estimates. The proliferation of smart phones with internet facility as an added feature in recent times probably plays a role in this rise.

Logistic Regression Results: Bank-based and Non-bank-based DFS

An important research question is whether wider financial inclusion emerges from the traditional banking system or non-bank entities such as the MNOs. Both banks and non-bank organisations offer digital financial services to their clients. The micro-level analysis using Global Findex data, (see Table 3) controls for variables such as age, gender and income of the respondents. The highly educated, the aged and rich (higher income group) individuals have a high likelihood of financial inclusion. Gender does not appear to be a significant determinant of financial inclusion, consistent with Annim *et al.* (2014).

Coefficients with odds ratios (ORs) less than 1 suggest a negative relationship and those greater than 1 a positive relationship. Stronger positive relationships give higher coefficient estimates for income for the baseline model (column 2) revealing that the ORs increase consistently (1.10, 2.42, 3.68 & 6.39) from the lower (poor) to the higher (rich) income quantiles.

The results (in odds ratios), indicate that likelihood of inclusion increases multiplicatively by over 8 point (baseline) and approximately 9.8 (follow-up model) for each mobile cellular usage for financial transaction. The marginal effect (ME= 0.396) of mobile facility usage in financial transactions for the follow-up model (column 5) is found to be stronger than internet usage (ME= 0.172). The level of significance reflects the robustness of the outcome on mobile phone usage relative to the use of internet. This further confirms the previous observation that mobile phone penetration in Ghana drives inclusion via DFS compared to internet usage. Triki and Faye (2013) find comparable results for Kenya.

Account ownership with MNOs (non-bank-based) and with a financial intermediary (bank-based) are subsequently used as dependent variables provide an opportunity to investigate which emerging route of offering digital financial services promises greater inclusion outcome in Ghana. The traditional (bank-based) mode of delivering DFS differs significantly from non-bank-based DFS offered by MNOs, which appear to be pro-poor and non-discriminatory. The income quintile has no significant impact on financial inclusion driven via MNO's DFS. Neither age nor income status determines whether individuals can use mobile-based DFS as shown in Table 4 (columns 4 & 5). This pro-poor inclusion promotes further inclusive-growth, resulting from innovative means of rendering financial services to the unbanked.

<<<<<<INSERT TABLE 3>>>>>>>>

Financial inclusion promoted by financial institutions significantly discriminates against the lower income quintiles households (see Table 4, columns 2 & 3). Baseline model estimates show significant likelihood of financial inclusion among the richer income quintiles. Participation in the formal financial sector in Ghana, until recently, required individuals to have a source of income. Although this requirement is being relaxed, following growing competition in the sector, the notion that the formal banks will refrain from serving the poor remains (Carbo *et al.* 2007; Dev 2006). Noticeably, there is a similar result for age of the respondents. Participation in the formal financial sector appears to have an age bias. By contrast, the only requirement for owning mobile-money account in Ghana is a registered SIM card.

The strength of mobile-based DFS as an emerging trend in deepening financial inclusion compared with the bank-based (debit/credit cards usage) is established. This operationally defines the contemporaneous trade-offs between mobile-based DFS and bank-based DFS. The contemporaneous trade-offs are observed as the likelihood of inclusion increases with the mobile money usage (non-bank-based DFS) from the baseline year (2011) to the follow-up year (2014). Simultaneously, the likelihood of inclusion reduces with bank-based DFS over the same time spectrum. This appears consistent across the three equations (6,7 & 8) reported on Table 4. For clarity, the effect observed of the bank-based DFS (debit/credit cards usage) defines the contemporaneous trade-offs between mobile-based DFS and bank-based DFS. The contemporaneous trade-off is observable as the likelihood of inclusion increases with the mobile money usage (non-bank-based DFS) from the baseline year (2011) to the follow-up year (2014). Simultaneously, the likelihood of inclusion reduces with bank-based DFS over the same time spectrum, as summarised on Table 5. The trade-offs observed is expected to inform policy concerning which of the routes of offering DFS in Ghana positively influence the unbanked.

<<<<<<<<<<<<Figure 2 >>>>>>>>>>>

Figure 2; Shows the average marginal effect of usage of technological amenities and financial inclusion, using the base year global Findex data (2011) data. Figure 3 below shows comparable outcome using the follow-up (2014) Findex data.

<<<<<<<<<<<<Figure 3 >>>>>>>>>>>

The difference is the inclusion of internet variable on which data was available in the follow-up period. The zero (dotted horizontal line) is the dividing policy benchmark. The further up the line an indicator lies suggests stronger financial inclusion likelihood. Consequently, users of the technological amenities, individuals with tertiary level education and those within the rich quintile are strongly found to have high probability of being financially included.

<<<<<<INSERT TABLE 4>>>>>>>>

<<<<<<INSERT TABLE 5>>>>>>>>

Robustness checks: Difference-in-difference Estimation method

One further robustness check, using Difference-In-Difference (DID) estimation affirms the observed trade-offs between Bank-based and Non-bank-based DFS is consistent across the two data spectra (2011-2014). The positive significant coefficient of variable "_diff" **(0.210)** in Table 7 (Column 3), confirms the positive significant trend of mobile money usage over the period (2011-2014). However, the usage of bank-based DFS facilities shows a negative trend (**-0.172**) as one moves from the baseline to the follow-up period.

<<<<<<INSERT TABLE 6>>>>>>>>

SUMMARY

Overcoming structural rigidities, financial market imperfections and vast informalities endemic in LICs assists integration of the poor into sharing inclusive growth. Indeed, an inclusive and a broadened financial system will promote growth. Financial inclusion promotes growth through a broadening of the system and technology can be a major catalyst for greater financial inclusion.

The study confirms the significant role technological deepening plays in advancing financial inclusion in Ghana, with potentially wider applicability to other LICs. Further research is necessary to determine the generalisability of these Ghanaian findings. Theory and prior research point towards the likelihood of the results obtained and the careful use of control variables increases the potential for similar studies in other LICs obtaining similar results.

As delivery of digital financial services is made accessible and affordable for people who were previously 'unbanked,' the take up increases rapidly. Financial inclusion and broader participation through mobile cellular penetration and internet usage reduces both transaction and information costs of rendering financial services, including to the poor. The resultant benefits of cost reduction in providing services through expanding technological amenities flow to financial services' providers and recipients.

An inclusive financial system is more likely when policy makers and relevant industry players collaborate to create a technologically conducive atmosphere. An agenda toward financial inclusion and technological advancement in LICs is unlikely to be fruitful if pursued in isolation. Striking a healthy balance between pursuing an inclusive financial system, pro-poor growth and a technologically advanced system is essential. Each aspect has a part to contribute.

Paying attention to the observable trade-offs in emerging modes of delivering financial services to the marginalised is important to attain inclusive and pro-poor growth. The drive towards inclusion made possible by the mobile phone platform does not discriminate along income, class or age group lines. Policy-makers, donors and industry players may need to pay attention to technological deepening in order to achieve a broader and inclusive financial system.

REFERENCES

Adam, L. and Wood, F. 1999: An investigation of the impact of information and communication technologies in sub-Saharan Africa. *Journal of information Science* 25(4), 307-318.

Allen, F., Demirguc-Kunt, A., Klapper, L. and Pería, M.S.M. 2016: The foundations of financial inclusion: Understanding ownership and use of formal accounts. *Journal of financial Intermediation*(ISSN: 1042-9573).

Andrianaivo, M. and Kpodar, K. 2012: Mobile phones, financial inclusion, and growth. *Review of Economics and Institutions* 3(2), 30.

Ang, J.B. 2011: Financial development, liberalization and technological deepening. *European Economic Review* 55(5), 688-701.

Angrist, J.D. and Pischke, J.-S. 2008: *Mostly harmless econometrics: An empiricist's companion*. New Jersey, USA.: Princeton University Press.

Annim, S., Awusabo-Asare, K., Abane, A., Amonoo, E. and Acheampong, I. 2014: Poverty Assessment and a Comparative Study of Rural Microfinance Institutions and Government Programmes in Ghana. Inter-university Consortium for Political and Social Research (ICPSR) [distributor].

Aportela, F. 1999: Effects of financial access on savings by low-income people. USA: MIT Department of Economics Dissertation.

Ashraf, N., Karlan, D. and Yin, W. 2010: Female empowerment: Impact of a commitment savings product in the Philippines. *World Development* 38(3), 333-344.

Brown, S. and Taylor, K. 2011: The saving behavior of children: Analysis of British panel data.

Cameron, A.C. and Trivedi, P.K. 2005: *Microeconometrics: methods and applications*. New York, USA: Cambridge University Press.

Carbo, S., Gardener, E.P. and Molyneux, P. 2007: Financial exclusion in Europe. *Public Money and Management* 27(1), 21-27.

Demirgüç-Kunt, A. and Klapper, L.F. 2012: Financial inclusion in Africa: an overview. *World Bank Policy Research Working Paper*(6088).

Demirgüç-Kunt, A., Klapper, L.F. and Singer, D. 2013: Financial inclusion and legal discrimination against women: evidence from developing countries. *World Bank Policy Research Working Paper*(6416).

Demirgüç-Kunt, A., Levine, R. and Detragiache, E. 2008: Finance and economic development: The role of government. *Policy Working Paper* 3955.

Detragiache, E., Gupta, P. and Tressel, T. 2005: Finance in lower-income countries: An empirical exploration.
Dev, S.M. 2006: Financial inclusion: Issues and challenges. *Economic and political weekly*, 4310-4313.
Diniz, E., Birochi, R. and Pozzebon, M. 2012: Triggers and barriers to financial inclusion: The use of ICT-based branchless banking in an Amazon county. *Electronic Commerce Research and Applications* 11(5), 484-494.
Djankov, S., McLiesh, C. and Shleifer, A. 2007: Private credit in 129 countries. *Journal of Financial Economics* 84(2), 299-329.
Dong, Y. and Men, C. 2014: SME Financing in Emerging Markets: Firm Characteristics, Banking Structure and Institutions. *Emerging Markets Finance and Trade* 50(1), 120-149.
Donovan, K. 2012: Mobile money for financial inclusion. *Information and communication for development*, 61-73.
Drygas, H. 1983: Sufficiency and completeness in the general Gauss-Markov model. *Sankhyā: The Indian Journal of Statistics, Series A*, 88-98.
Dupas, P. and Robinson, J. 2013: Savings constraints and microenterprise development: Evidence from a field experiment in Kenya. *American Economic Journal: Applied Economics* 5(1), 163-192.
Friedline, T. 2012: Predicting children's savings: The role of parents' savings for transferring financial advantage and opportunities for financial inclusion. *Children and Youth Services Review* 34(1), 144-154.
Friedline, T., Johnson, P. and Hughes, R. 2014: Toward healthy balance sheets: Are savings accounts a gateway to young adults' asset diversification and accumulation? *Federal Reserve Bank of St. Louis Review* 96(4), 359-389.
Gelos, R.G. and Roldós, J. 2004: Consolidation and market structure in emerging market banking systems. *Emerging Markets Review* 5(1), 39-59.
Greeson, J.K., Usher, L. and Grinstein-Weiss, M. 2010: One adult who is crazy about you: Can natural mentoring relationships increase assets among young adults with and without foster care experience? *Children and Youth Services Review* 32(4), 565-577.
Gujarati, D.N. and Porter, D.C. 1999: *Essentials of econometrics* (Vol. 4th ed.). New York, NY USA: McGraw-Hill/Irwin, The McGraw-Hill Companies, Inc.
Hannig, A. and Jansen, S. 2010: Financial inclusion and financial stability: current policy issues. *ADBI working paper series* No. 259.
Harville, D. 1976: Extension of the Gauss-Markov theorem to include the estimation of random effects. *The Annals of Statistics*, 384-395.
Hosmer Jr, D.W., Lemeshow, S. and Sturdivant, R.X. 2013: *Applied logistic regression* (Vol. 398). USA: John Wiley & Sons.
Jack, W. and Suri, T. 2011: *Mobile money: the economics of M-PESA*. Cambridge, MA. USA. National Bureau of Economic Research.
Jappelli, T. and Pagano, M. 2002: Information sharing, lending and defaults: Cross-country evidence. *Journal of Banking & Finance* 26(10), 2017-2045.
Jensen, R. 2007: The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector. *The quarterly journal of economics*, 879-924.
Kendall, J., Mylenko, N. and Ponce, A. 2010: Measuring financial access around the world. *World Bank Policy Research Working Paper Series,* 5253.
Kim, J., LaTaillade, J. and Kim, H. 2011: Family processes and adolescents' financial behaviors. *Journal of family and economic issues* 32(4), 668-679.
Kpodar, K. and Andrianaivo, M. 2011a: *ICT, financial inclusion, and growth evidence from African countries*. USA. International Monetary Fund. 1455225010.
Kpodar, K. and Andrianaivo, M. 2011b: *ICT, financial inclusion, and growth evidence from African countries*: International Monetary Fund.
Levine, R. 2005: Finance and growth: theory and evidence. *Handbook of economic growth* 1, 865-934.
Mandell, L. 2005: Financial literacy: Does it matter. *Buffalo, NY: University of Buffalo. April, 2005*.
Mundial, B. 2014: World Development Indicators 2014. *Relaciones Internacionales.* Retreived in 15 June, 2016, from https://openknowledge.worldbank.org/bitstream/handle/10986/18237/9781464801631.pdf

Norton, S.W. 1992: Transaction costs, telecommunications, and the microeconomics of macroeconomic growth. *Economic Development and Cultural Change* 41(1), 175-196.
Rasmussen, S.F. 2010: Mobile Banking in 2020. *CGAP Advancing financial access for the world's poor.* http://www. *cgap. org/p/site/c/home*.
Stiglitz, J.E. and Weiss, A. 1981: Credit rationing in markets with imperfect information. *The American economic review* 71(3), 393-410.
Stock, J.H., Watson, M.W. and Addison-Wesley, P. 2007: *Introduction to econometrics* (Vol. August 2, 2014; ISBN-13: 978-0201715958). USA: Pearson; 3rd edition
Thrikawala, S.S. 2016: Corporate Governance and Performance of Microfinance Institutions (Mfis): A Comparative Study in Sri Lanka and India, University of Waikato.
Triki, T. and Faye, I. 2013: Financial inclusion in Africa. *African Development Bank: Tunis*.
Waverman, L., Meschi, M. and Fuss, M. 2005: The impact of telecoms on economic growth in developing countries. *The Vodafone policy paper series* 2(03), 10-24.
Zyskind, G. and Martin, F.B. 1969: On best linear estimation and general Gauss-Markov theorem in linear models with arbitrary nonnegative covariance structure. *SIAM Journal on Applied Mathematics* 17(6), 1190-1202.

APPENDIX

Table A.1: Definition of Key variables used in the Empirical econometric estimations

Variable	Definition	Source
Mobile Subscription per capita (Mobsqrt)	ICT: Mobile cellular subscriptions (per 100 people) -square root transformation	International Telecommunication Union (ITU)
Internet per head (INT_sq)	ICT: Internet users (per 100 people) Square transformation	International Telecommunication Union (ITU)
U-rate	Unemployment, total (% of total labour force) (modelled ILO estimate)	WDI (World Bank)
LOGEFI	Economic Freedom Index (overall score)-natural long	The Heritage Foundation/Wall Street
GDP_pcg	GDP per capita growth (annual %)	WDI/Financial Structure database (World Bank)
Private Credit to GDP	Domestic credit to private sector (% of GDP)	WDI/Financial Structure database (World Bank)
Mobusage	The use of mobile money for the financial transactions	FINDEX/World Bank
INTusage	The use of internet for the financial transactions	FINDEX/World Bank
Income dummies	Within-economy income quintile	FINDEX/World Bank
Educational level dummies	Respondent education level	FINDEX/World Bank
Age	Respondent age	FINDEX/World Bank
FI (Account Ownership)	Has an account at a financial institution/post office/MFI/mobile money (composite indicator)	FINDEX/World Bank

MODEL DIAGNOSTIC TESTS

a) OLS Model

At 90 percent we are confident that the macro-model has homoscedastic error term. By estimating with heteroscedasticity-robust standard errors (VCE robust), the apparent heteroscedasticity at 5 percent is dealt with (Stock *et al.* 2007). Again, the Ramsey reset test for the model suggests that there is no evidence of omitted-variables bias, and as such, no additional variables needed (p-value of 0.295). At 5 percent significant level, we are 95 percent confident the model is correctly specified.

All data points appear to be within a range suggestive of the absence of any potential outlier problem. Ensuring that no single observation within the data has a significant leverage on the estimates is key. Both leverage of the residuals and Cook's D test are used. There were no key influential observations that could influence the model outcome (see Figures A 2a & b).

Using Shapiro-Wilk W test for normality in the data, we are 99 percent confident that the residuals are normally distributed (p-value of 0.308). Graphical checks of non-normality at both the middle and tail (qnorm) of the data confirm this. The mean variance inflation factor (VIF) of 7.48 is an indication that there is no problem of serious multicollinearity within the fitted model, though we do not suggest complete orthogonality among the predictor variables.

At 5 percent level of significance, we are able to observe that both mobile cellular and internet subscriptions rate do jointly have significant impact on financial inclusion using the F statistics.

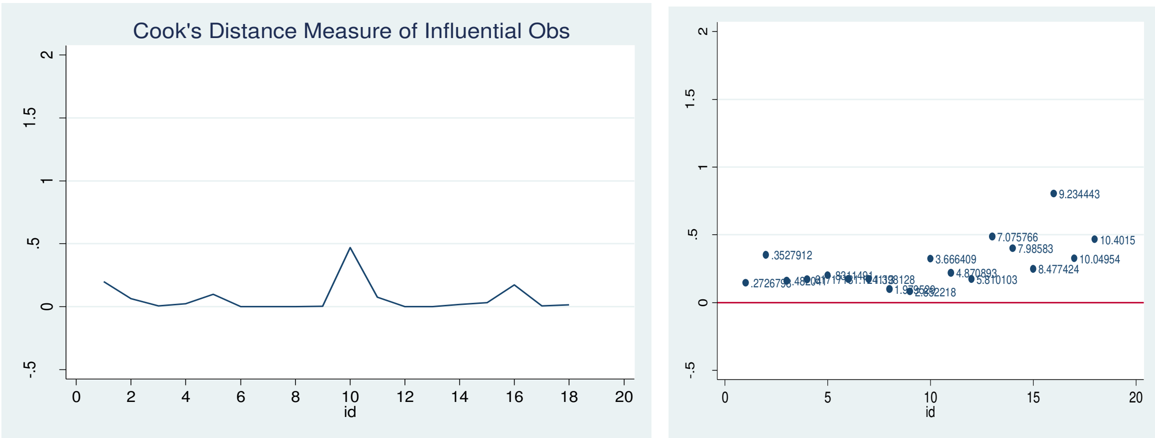


Figure A.1: Diagnosis of influential observations (author's analysis using the WDI-macro-data)

Treatment of missing data

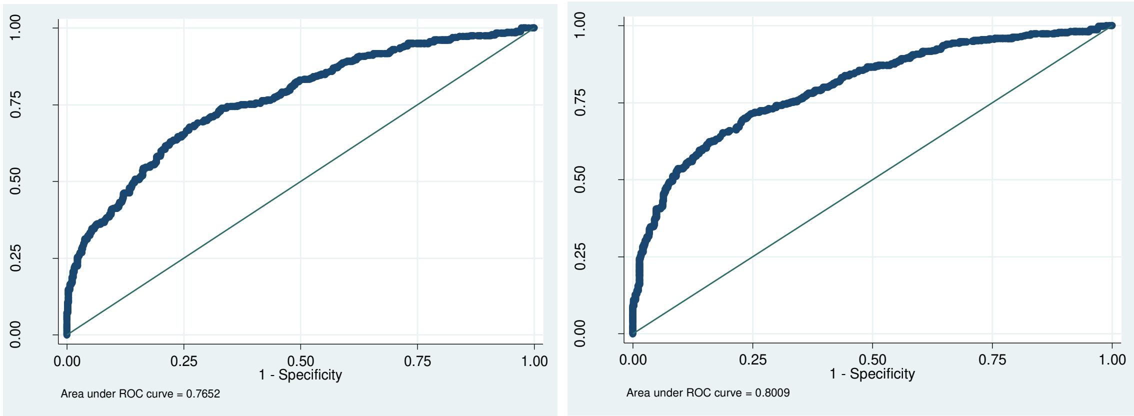
The trend of the governance data allowed for the three years that data were missing to be replaced. A simple average of the years preceding and following the missing year was used following this formulation ($t_m=(y_{t-1}+y_{t+1})/2$). In an event that the variable missing had no earlier datum, the succeeding year's data were used (Thrikawala 2016).

Logistic Regression model

A test on specification error was performed to ensure that the choice of logit as the link function fit the data well. In view of this, it was assumed that there were no relevant variable(s) omitted and the link function was correctly specified. This is informed by the predictive power of "_hat" (p-value =0.000) and the variable '_hatsq" having no significant predictive power (p-value = 0.786).

Both Pearson's and Hosmer and Lemeshow's goodness-of-fit were performed to ensure the model fit well. The p-values of approx. 0.91 for the Hosmer and Lemeshow's, and 0.36 for the Pearson's–X^2 tests, are indicative that the estimated model fits the data well (Hosmer Jr *et al.* 2013). Also, the models' mean VIF of 1.11 and the tolerance measure suggest that there is no problem of multicollinearity.

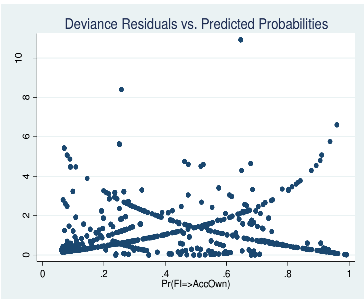
The model's predictive accuracy was assessed using sensitivity and specificity. The receiver operating characteristic (ROC) curve was used. The curves help in examining the predictive ability of the fitted model. This helps to ensure that those included financially are correctly classified as such. The area under ROC curve of 0.76 which increased to 0.8 after dealing with few influential observations (IOs), suggests that the fitted model has fairly strong predictive power (Hosmer Jr, Lemeshow, & Sturdivant, 2013) (See Figure A 3).

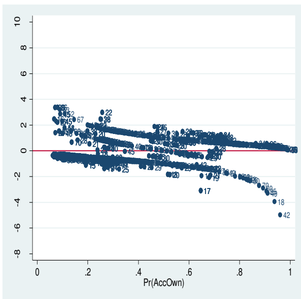


a. Prior to dealing with the IOs b. After dealing with IOs

Figure A.2: ROC Curves for the fitted regression model [before (b) and after (b) dropping off influential observations]

Detection of some influential observations that could potentially have high leverage on the model's outcome is key to the logit model. Using three basic building blocks for logistic regression diagnostics (Pearson residual, deviance residual and Pregibon leverage), observations that could potentially have high leverage on the model outcome were rigorously examined and given attention. Again, ensuring that the log-odds transformed model produced a linear association between the predicted variable and the covariates, Lowes graph was produced, which reasonably indicates that the relationship is linear (See Figure A.3.5).





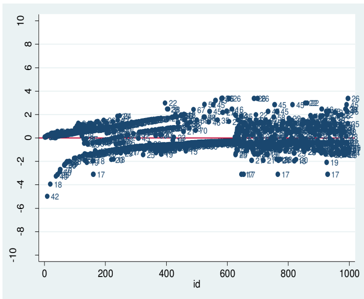
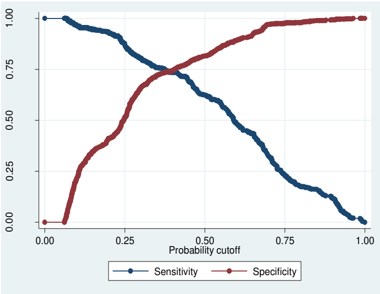
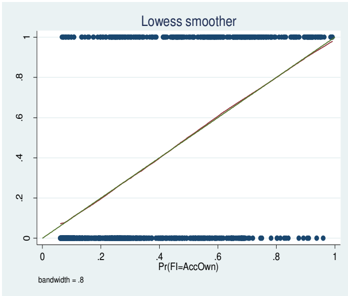


Fig. A.3.1 Fig. A.3.2 Fig. A.3.3





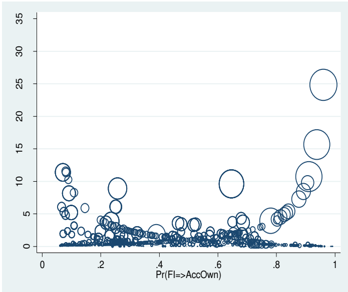


Fig. A.3.4 Fig. A.3.5 Fig. A.3.6

Figure A.3: Key diagnostics for Logistics Regression Model

Full Contact details of the Corresponding Authors (*) and Co-authors are below:

*Corresponding Author: ***Francis K. Agyekum-PhD*** (Valley View University, Accra, Ghana) (afk.ohene@gmail.com),

Co-authors: Stuart Locke-Professor of Finance (Tel: +64(07)8384331, Email: smlocke@waikato.ac.nz) & Nirosha Hewa-Wellalage, PhD-Senior Lecturer (nirosha@waikato.ac.nz). The School of Accounting, Finance and Economics, University of Waikato, Hamilton, New Zealand.