DETERMINANTS OF BANK ADOPTION OF BRANCHLESS BANKING INNOVATIONS: EVIDENCE FROM MALAWI

by

Yananga Alick Phiri

Submitted in fulfilment of the requirements for the Degree of Doctor of Philosophy in Business Studies

in the

Department of Economics

Nottingham Business School

at the

Nottingham Trent University

Nottingham May 2022

Copyright statement

Declaration

I declare that, except where explicit reference is made to the contribution of others, this dissertation is the result of my own work and has not been submitted for any other degree at the Nottingham Trent University or any other institution.

Abstract

The research investigates the drivers of bank adoption of branchless banking innovations (BBI) in Malawi. The interest in this investigation stems from the potential of BBI to contribute to solving some of the barriers to financial inclusion, a significant challenge for most African countries. However, due to data accessibility challenges in developing countries, much of the existing empirical literature on the financial services providers' side of BBI has focused on developed and emerging economies. Leveraging a unique dataset of Malawi's banking sector made available by the financial sector regulator, the research examines more dimensions of BBI than have most previous studies. The study digs further into the drivers of BBI by drawing a distinction between physical and remote BBI, a novel distinction in this field of research.

The study adopts multiple econometric models and establishes regulation and bank size as the key drivers. Firstly, given the dynamic nature of innovation and risk, bolstering the relevance of regulation of BBI in helping institutions to manage innovation related risks requires an understanding of the unique risks that are faced in the local context. As BBI transcends many sectors, policy recommendations hinge on increased collaboration between the different sectoral regulators of BBI and the regulated institutions in the BBI ecosystem. Secondly, small banks are found to be rapid adopters of both physical and remote BBI. Scaling up BBI in the face of financial stability considerations therefore requires re-opening the banking sector to smaller financially sound institutions.

Divergent findings on the impact of branch intensity on adoption of different forms of BBI are another crucial finding with important lesson for bank strategy. The positive association between branch intensity and physical BBI indicates that banks with extensive networks of branches can leverage their branding and physical presence to enhance financial inclusion among low-end retail consumers using physical BBI. On the other hand, banks with a small network of branches would benefit more from remote BBI strategies.

In terms of bank ownership, the findings that government ownership in banks has a positive impact on the adoption of only some forms of BBI and a negative impact on other forms do not provide strong support for scaling up BBI strategy through the ownership channel. The findings that foreign ownership and BHC membership’s beneficial effects on BBI adoption emanates from the proliferation of small banks, that are rapid adopters, strengthens the case for further opening the sector to bolster competition.

Acknowledgements

This research project has taught me so much more there is to learn, unlearn and re-learn about BBI and the research techniques thereof. Importantly, it has revealed the value of abiding faith in the face of the uncertainties that characterise the non-linear path to the pursuit of knowledge; for that matter during the pandemic. When I take stock of so many souls that have departed along this way, it becomes clear that completion of this work would not have been possible except for the unwavering support of so many, so selfless.

In this regard, I would like to thank my employer, the RBM, for awarding me the scholarship. Staying true to this funding pledge can never be easy when the pandemic necessitated a lot of austerity measures on the part of public institutions, as nations needed to salvage the society's wider social good. Granting access to publicly unavailable data, within the bounds of confidentiality, has also become an important metric in enabling novel contributions of this research to knowledge on the fast-paced field of BBI.

My professional networks at the University of Cambridge Centre for Alternate Finance, Tufts University Fletcher Leadership Program for Financial Inclusion, and the Digital Frontiers Institute provided invaluable perspectives and materials that helped me to strike a delicate balance between practice and the econometrics that ensued. Most importantly, my research supervisors at the Nottingham Business School namely: Prof Robert Ackrill, Dr Yousef Makhlouf, and Dr Emmanuel Amissah, deserve special mention for honing many of the insights presented in this thesis, ensuring clarity of expression and providing the constant guidance on the intellectual rigour commensurate with economics research of PhD level. Many thanks also to my independent assessor, Prof. Thorsten Chmura, for the constructive feedback and quality assurance throughout the process. I take responsibility for any remaining errors.

Episodes as these broaden our grasp of life and the treasures that make the world a priceless place. In this light, I acknowledge the value of the institution of family, by thanking my amazing wife Nengezi for her profound love, hard work and sacrifices for the family. Your enduring faith and non-conformist ideas on the global order, particularly during the pandemic, are a soothing symphony that kept us calm during the busts and booms of navigating the *sometimes-unpalatable-yet-constructive-critique*, quintessential to the academia. Desideratus, our son, has been a constant companion, growing each day alongside the unfolding of this thesis. Because of his mother's dedication to his homework, Desi has developed a strong love of reading and writing; and this made dad’s working from home during lockdowns to be more enriching. My mother Draida’s daily devotion and prayers, combined with the support system provided by Zikani and Thandie, have been the foundation of our completeness. There are simply not enough words to express my gratitude.

In the end, my late father Isaac was a firm believer in the emancipation that education can bestow. Because this research represents yet another watershed moment on the road to setting freedom free, I consider this thesis to be a thank you letter to you, Ada (dad). Like Isaac Newton, I believe that only by standing on the shoulders of giants have I been able to see further. May God therefore grant his grace so that the publishing of this work should help reposition me to be such shoulder where others would leverage to see further and farther.

Table of contents

List of figures

List of tables

List of abbreviations

AIC	Akaike Information Criterion
AML/CFT	Anti-Money Laundering and Combating of Financing of Terrorism
ARDL	Auto Regressive Distributed Lag
ATM	Auto-Teller Machine
BBI	Branchless Banking Innovations
BHC	Bank Holding Company
DFE	Dynamic Fixed Effects
DOI	Diffusion of Innovation
EDI	Electronic Data Interchange
ECM	Error Correction Model
FE	Fixed Effects
FWER	Family Wise Error Rate
KYC	Know Your Customer
ICT	Information Communication Technology
ITU	International Telecommunications Union
MACRA	Malawi Communication Regulatory Authority
MG	Mean Group
MIS	Management Information Systems
OLS	Ordinary Least Square
PMG	Pool Mean Group
PCA	Principal Component Analysis
RBM	Reserve Bank of Malawi
SADC	Southern Africa Development Community
SSA	Sub-Sahara Africa
TELCO	Telecommunications Company
TOE	Technology Organisation Environment

Chapter 1 : Introduction

1.1 Introduction

This chapter introduces the research by providing a brief background to the topic of Branchless Banking Innovations (BBI) and how it fits into the broader discussion of financial inclusion, economic development and poverty reduction. It also presents some stylised facts about the problem statement, the gaps that exist in the research and how the current research can help to fill the gaps and ultimately contribute to knowledge. In addition, the chapter outlines the research objectives as well as the data and methodological approaches applied to achieve those objectives. The key hypotheses being tested, main findings from the research, and general inferences that may be drawn from the findings are presented in this chapter. The chapter also lays out the structure for the remainder of the thesis.

1.2 Background to the Research

Financial innovation has been a topic of growing interest for financial systems both in the developed and developing countries. Financial innovation is defined as the act of creating/introducing new financial instruments, technologies, institutions and markets (Cooper, 1998; Bátiz-Lazo and Woldesenbet, 2006). Branchless Banking Innovations (BBI) are one of the growing forms of innovations in the financial services front. These are the range of delivery channels that allow customers to access formal financial services without the traditional need to enter a bank branch (Stapleton, 2013; Mustafa and Waheed, 2016; Kochar, 2018). A distinction is made between product innovation and process innovation. Product/service innovation has been defined as new products/services introduced to suit users or market needs. In the context of BBI, product/service innovation includes the advent of new products such as smart cards, points-of-sale devices; or new services such as banking through agents, mobile phone-based banking, internet banking and on-line securities trading (Frame and White, 2004).

On the other hand, process innovation hinges on new elements introduced into the processes within the organisation to develop new capabilities with the view to driving operational efficiency (Ettlie and Reza, 1992; Bátiz-Lazo and Wood, 2002; Bátiz-Lazo and Woldesenbet, 2006). In the context of BBI, these include electronic cheque clearing systems, electronic record keeping for securities, and real time gross settlement processes. In this regard, as financial institutions must first adopt new ICT platforms, new skills, and new processes in order to enable the operationalization of branchless banking delivery channels, BBI encompasses both product innovation and process innovation.

The goal of this research is to analyse the factors that influence bank adoption of different forms of BBI in developing countries. In this regard, the study develops an empirical model for the drivers of bank adoption of BBI for a nascent banking system in Malawi, a typical developing country context. By investigating multiple dimensions of BBI, such as ATM, agent, internet, and mobile banking innovation, the present study provides a more comprehensive view of the dynamic, fast-paced nature of BBI.

The study delves deeper by categorising BBI based on how different components of each BBI resonate with different customers in various socioeconomic conditions. In this sense, we distinguish between physical and remote BBI, which is a novel distinction in this field. In this context, physical BBI such as ATM and agent banking innovations are the primary forms of BBI for consumers where bank branding and physical interaction are important. This is critical given the low consumer trust in e-commerce and the lack of access to crucial infrastructure for processing e-commerce among many consumers in most developing countries (Nitsure, 2003; Allen et al., 2014; Chikalipah, 2017). Physical BBI is also important given the cash-based nature of most developing countries' agrarian economic systems, where payments entail depositing cash at one end and withdrawing it at the receiving end (FinMark Trust, 2012; Buckley et al., 2015). Remote BBI on the other hand are the opposite of physical BBI as they enable access to financial services from the comfort of one’s home, school or place of work etc, without the need to travel to be in physical contact with a bank ATM or a bank agent, however close (Kimenyi and Ndung’u, 2009; Gosavi, 2015; Montfaucon, 2020).

The interest in the investigation on the drivers of bank adoption of BBI stems from the potential of BBI to contribute to financial inclusion[1]. Financial inclusion is a multi-

---

[1] Accessibility of financial service points has been cited as the top among the various barriers to financial access in Malawi (Oxford Policy Management, 2009; FinMark Trust, 2014; Lapukeni, 2015).

dimensional construct but broadly summed up as the percentage of people and businesses who have access to, and usage of, formal financial services (Demirgüç-Kunt and Klapper, 2013; World Bank, 2014; Sharma, 2016; Zins and Weill, 2016; Lenka and Sharma, 2017). Following the 2007-2008 global financial crisis, many developing countries and multilateral organisations envisioned financial inclusion as part of the solution to the glaring problem of socioeconomic inequality (Sakariya, 2013; Sahay et al., 2015). For instance, the G20 leaders met in Seoul in 2010 and pledged to advance financial inclusion around the world by forming the Global Partnership for Financial Inclusion (Soederberg, 2013; Chen and Divanbeigi, 2019). The creation of the Financial Inclusion Action Plan in 2017, which positions financial inclusion as a core element of the 2030 Agenda for Sustainable Development, reaffirms this commitment (Soederberg, 2013; Ahamed et al., 2021). Academic research makes a powerful case for financial inclusion as a critical developmental metric. According to this narrative, three broad channels have been identified in the literature, viz: (i) improving citizen productivity and welfare (Beck et al., 2005; Beck et al., 2007; Allen et al., 2014; Bruhn and Love, 2014; World Bank, 2014; Sharma, 2016; Lenka and Sharma, 2017; Demirgüç-Kunt et al., 2018; Agur et al., 2020; Bennie, 2021: Gutiérrez-Romero and Ahamed; 2021), (ii) fostering financial stability (Kabango, 2009; Khan, 2012; Han and Melecky, 2013; Mbutor and Uba 2013; Mehrotra and Yetman, 2015; Evans, 2016; Musau et al., 2018; Turkson et al., 2020), and (iii) supporting initiatives to tackle money laundering and financing of illegal activities (Koker, 2011; Sarma and Pais, 2011; Shehu, 2012; Esoimeme, 2017).

1.3 Statement of the Problem

Despite the above-mentioned developmental benefits of financial inclusion, most Sub-Sahara African (SSA) countries' financial systems are shallow and far from being inclusive (Mlachila and Yabara 2013; Beck et al., 2015; Chikalipah, 2017; Makina, 2017; Turkson et al., 2020). It is estimated that 500 million African adults, or roughly one-quarter of the adult population, do not have access to formal financial services. This compares to a global average of 41 percent for developing countries (Demirgüç-Kunt et al., 2018). While the average in Southern Africa is 51 percent, the average for Central Africa is only 11 percent, making it even lower than the Africa average. In context, financial inclusion in Malawi remains low compared with other countries in the Central and Southern Africa region. For instance, by 2014, the percentage of the total adult population not served by the formal financial system was 47 percent; compared to only 16 percent for Republic of South Africa; 27 percent for Namibia; 37 percent for Swaziland (Eswathini); 33 percent for Botswana; and 19 percent for Lesotho. Thus, while 53 percent had access to formal financial system in Malawi, only 32 percent of the total adult population had an account with a banking institution. This is against 75 percent for Republic of South Africa; 62 percent for Namibia; 44 percent for Swaziland; 41 percent for Botswana; and 38 percent for Lesotho (Finmark Trust, 2014).

For most SSA countries including Malawi, banking services have traditionally been provided through the brick-and-mortar branch model (Mlachila and Yabara 2013; Beck et al., 2015; Chikalipah, 2017; Makina, 2017). Because they denote a bank's presence, the physical branches have been crucial in growing the bank's brand and arguably, bolstering consumer trust through direct personal contact between the bank staff and the financial consumers. Besides, the branches have served as a critical platform for BBI such as ATM and agent banking, to gain operational support and handle customer complaints. Bank branches have also flourished since most BBI have yet to mature to the point where their product scope matches or exceeds that which is accessible through the bank branches. However, the establishment of branches tends to be costly. The sunk costs of opening and operating a branch are significant, owing to regulatory requirements for financial safety and soundness, as well as other standards set by town/city assembly authorities and government agencies (Oxford Policy Management, 2009). The labour-intensive nature of managing typically low-value-high-volume transactions contributes to the costly operation of branches, particularly in rural areas where other overheads result from having parallel energy sources in the face of erratic energy supplies and unreliable infrastructure in general (Government of Malawi, 2017).

Malawi's economy is based on agriculture, and the country's rural population accounts for 88 percent of the total population. Given the high cost of establishing branches, it has been argued that the generally small and irregular financial transactions of the typical rural poor, the majority of whom rely on seasonal agriculture, cause formal financial institutions to perceive them as unprofitable customers under the dominant branch-led models (Oxford Policy Management, 2009; Allen et al., 2014). As a result, most SSA countries including Malawi have a concentration of bank branches in urban and semi-urban areas, with little reach into rural areas. This issue has not only created a distance barrier for rural residents to obtain financial services, but it has also increased the cost of delivery of financial services, rendering them unaffordable to consumers (Beck et al., 2005; Beck et al., 2007; Zins and Weill, 2016). Further, it limits the financial service providers' understanding of both the financial needs and the credit worthiness of the rural population. The end result is poor product design that results in delivery of products that are out of synch with the needs of the consumers, resulting in low uptake (Beck et al., 2007; World Bank, 2014; Chikalipah, 2017).

The potential for BBI to address some of the above listed barriers to financial inclusion is clearly revealed in the literature. Firstly, by allowing banks to collect more information about their customers through digital trails, BBI enables banks to know their customers better, thereby allowing development of financial products that are tailored to the specific needs of diverse customers (Mas, 2016). Secondly, BBI removes the need to travel long distances to access banking services (Dermish et al., 2012; Suri and Jack, 2016; Montfaucon, 2020). Thirdly, BBI allows banks to cut costs by eliminating the need for them to open branches in the sparsely-populated-difficult-to-reach rural areas (Berger et al, 2001; Mas 2009; Stapleton, 2013; Buckley et al., 2015; Gosavi, 2015). The cost savings inherent in BBI models can help to alleviate the affordability challenge faced by the poor, in the process making financial products more accessible (Alexandre et al., 2011; Buckley et al., 2015; Makina, 2017; Cull et al., 2018; Demirgüç-Kunt et al., 2018).

1.4 Gap in the Research

Given the aforementioned benefits of BBI for financial inclusion (which are not directly addressed empirically in this research), what we have here is a research that seeks to understand the factors that drive adoption of BBI among financial services providers. Considering that financial exclusion is a serious concern in the majority of SSA countries as highlighted above, the current research is crucial for policymakers because it would feed into financial institution strategy and policy changes that could accelerate adoption of BBI and in the process contribute to financial inclusion. Despite this significance, there are still gaps in the extant empirical literature.

Firstly, the dominant focus of the existing literature on BBI has been on the consumers' side (Brown and Molla, 2005; Gerrard et al., 2006; Clemes et al., 2012). There is relatively limited empirical literature on the providers' side. Understanding the consumer side of BBI is important, but it is not sufficient, given that the financial institutions that deliver BBI are not only diverse but they also have their own set of dynamics and incentives that would have implications on propensity to deliver BBI strategies (Furst et al., 2002; Frame and White, 2004; Stone et al., 2009; Dermish et al., 2012).

Secondly, due to data accessibility challenges in developing countries, much of the existing empirical literature on the financial services providers' side of BBI has focused on developed and emerging economies[2]. This makes the findings not easily generalisable to developing countries, given the stark differences in digitisation of economic systems, technological infrastructure development, and the state of development of financial systems.

Thirdly, these studies from the developed and emerging economies provide mixed evidence about the different determinants of bank adoption of BBI. For instance, the literature shows different impacts of branch intensity on internet banking technologies (see, Gourlay and Pentecost, 2002; Corrocher, 2006; Malhotra and Singh, 2010). Meanwhile, mixed evidence is also established about the impact of macro technology (see, Gourlay and Pentecost, 2002; Corrocher, 2006).

Fourthly, while different studies have explored drivers of adoption of different forms of BBI, to the best of our knowledge, there has been no attempt to explore the drivers of BBI in ways that classify BBI based on how the BBI features make it suited for the unique clientele and their social economic setting. This granular investigation is critical because the importance of understanding BBI stems from its potential to promote financial inclusion, as discussed in Section 1.2.

---

[2] The paucity of empirical research that tests hypotheses or provides quantitative analysis of financial innovation has been mentioned in the literature, as has the scarcity of data in the financial sector. The urgency for financial regulators to make publicly available data for researchers and academics, within the bounds of confidentiality commitments, is a key recommendation from earlier literature (See, Furst et al., 2002; Frame and White, 2004).

1.5 Contribution to Knowledge

The current research contributes to closing the above-mentioned knowledge gap in several ways.

Firstly, it investigates the factors that influence financial institutions' adoption of BBI, focusing on the banking sector in Malawi, a typical SSA developing country. Malawi is an intriguing case because it embodies characteristics shared by the majority of SSA countries, including a highly concentrated banking sector, a predominantly cash economy, progress towards greater mobile phone usage, very high levels of financial exclusion, low economic development, glaring inequality and high poverty rates[3]. In comparison to the findings from developed countries, the findings from such a study may be more easily generalised to other developing countries.

Secondly, leveraging a unique quarterly dataset of Malawi's banking sector made available by the financial sector regulator the Reserve Bank of Malawi (RBM), the current research examines more dimensions of BBI than have most previous studies, which focused on only one type of BBI at a time. By examining more dimensions of BBI, namely ATM, agent, internet and mobile banking innovation, the current research provides a more comprehensive picture of the dynamic, fast paced nature of BBI. Recognising the diversity of the customers targeted by the financial inclusion agenda, the study digs further into the drivers of BBI by separating BBI into categories based on how aspects of each BBI resonate

[3] Malawi is one of the world's most densely inhabited and least developed countries, ranking 172 out of 189 countries in the 2019 United Nations Human Development Index. In 2019, its GDP per capita was US$411, the lowest among the countries of the Southern Africa Development Community (SADC). According to the World Bank's World Development Indicators, inequality is substantial, with a Gini coefficient of 0.45 in 2016. Half of the population lives below the international poverty line of US$1.90 per day and is therefore in extreme poverty. Its banking sector is small and highly concentrated (Tsoka, 2006; Kaluwa and Chirwa, 2017). Three largest banks controlled 60.4 percent of the banking system's total assets as at end of 2020. By 2019, Malawi had 2 commercial bank branches per 100,000 population, the sixth lowest figure in the world. In terms of mobile money accounts, 20.3 percent of the adult population had a mobile money account in Malawi in 2017 (very close to the SSA average of 20.9 percent excluding high income countries).

with various consumers in different economic contexts. In this sense, we a distinction is drawn between physical and remote BBI, a novel distinction in this field of research.

On the one hand, physical BBI, such as ATM and agent banking innovations, are the primary forms of BBI for consumers where bank branding and physical interaction are important. This is critical given the low consumer trust in e-commerce and the lack of access to crucial infrastructure for processing e-commerce among many consumers in most developing countries (Nitsure, 2003; Allen et al., 2014; Chikalipah, 2017; Jiya et al., 2021). Physical BBI is also important given the cash-based nature of most developing countries' agrarian economic systems, where payments entail depositing cash at one end and withdrawing it at the receiving end (FinMark Trust, 2012; Buckley et al., 2015).

On the other hand, remote BBI are the opposite of physical BBI as they enable access to financial services from the comfort of one's home, school or place of work etc, without needing to travel to be in physical contact with a bank ATM or a bank agent, as is the case with physical BBI. In this regard, the ubiquity of the mobile telephone and the internet are helping transition economies towards cashless strategies, therefore making space for remote BBI (Kimenyi and Ndung'u, 2009; Gosavi, 2015; Suri and Jack, 2016; Asongu and Nwachukwu, 2019; Edo et al., 2019; Montfaucon, 2020). The Covid pandemic's constraints on people's movement and contacts have highlighted the benefits of remote BBI even more. Remote BBI has helped preserve the functioning of financial systems, as well as protecting people and businesses during a time of declining demand (Agur et al., 2020; Gutiérrez-Romero and Ahamed, 2021). Furthermore, remote BBI has allowed governments and humanitarian organisations to offer financial transfers and other social-economic benefits to vulnerable individuals in a more timely and safe manner (Agur et al., 2020; Benni, 2021).

To the best of our knowledge, no study has been conducted to analyse BBI drivers based on the physical-remote distinction, due to a lack of publicly available high-quality data. This distinction is vital for financial inclusion considering that physical and remote BBI, as shown above, relate to different economic set ups and different consumer segments, yet both exist within the context of developing countries that have low financial inclusion rates. Testing whether the drivers differ with the different forms of BBI is therefore important in informing how financial service providers can leverage their unique characteristics to deploy the different categories of BBI depending on the type of consumers being targeted.

Thirdly, this study makes a significant addition to the literature by formulating novel hypotheses that use dynamic models to explore potential differences in short and long-run outcomes, that have not been adequately addressed in previous studies. This is crucial because in economics and finance, interactions between distinct variables are not necessarily instantaneous. In this sense, understanding whether specific policy initiatives are appropriate as short-term or long-term remedies demands distinguishing between long-run and short-run interactions.

Fourthly, Malawi like most SSA countries, has witnessed the emergence of different forms of bank ownership on the back of the financial sector liberalisation reforms implemented under International Monetary Fund/World Bank Structural Adjustment Programmes and the World Trade Organisation's General Agreement on Trade in Services (Chirwa and Mlachira, 2004; Nkowani, 2008; Kaluwa and Chirwa, 2017). Much of the empirical research on the relationship between bank ownership and adoption of innovation has only tested whether Bank Holding Company (BHC) membership increases bank likelihood to adopt innovation (Furst et al., 2002; Courchane et al., 2002; Nickerson and Sullivan, 2003; De Young et al., 2007; Sullivan and Wang, 2020). Also, there have been numerous studies exploring the impact of foreign ownership of banks on the credit risk and profitability of domestic banking systems (Claessens et al., 2001; Clarke et al., 2001; De Haas and Naaborg, 2005; De Haas and Van Lelyveld, 2006; Wu et al., 2017). However, little is empirically known about the implications of foreign bank ownership and government ownership on domestic banking sector operational risk, let alone the adoption of BBI. The current study tests these hypotheses for Malawi's banking system.

Over and above the academic significance, the research firstly avails banking strategists with empirical evidence that can inform how banks can exploit their distinctive advantages to deploy the form of BBI that suits their firm characteristics, target clientele and operating environment[4]. Secondly, testing if different forms of bank ownership can impact differently the adoption of different forms of BBI adds novelty to the body of knowledge that should inform regulatory policy around bank licensing. Lastly, to the extent that the research explores strategies for accelerating diffusion of BBI, the benefits to the consumer are enormous since BBI helps to address some barriers that consumers face in accessing formal financial services. In the final analysis, as most of the financially excluded population are women and the rural poor, the research can contribute to Malawi's efforts towards the attainment of the United National Sustainable Development Goals 1, 5 and 10 on poverty eradication, gender equality and reduction of inequality, respectively.

1.6 Research Objectives and Research Questions

The main objective of this research is to develop a framework for analysing what drives adoption of innovation in financial institutions in developing countries. In particular, the research draws on existing literature to analyse factors that drive banking institution to adopt BBI in Malawi.

The following are the specific objectives of the research:

a) To investigate dimensions and forms of BBI in Malawi;
b) To test if the drivers of bank adoption of BBI in Malawi vary between physical BBI and remote BBI;
c) To test if different forms of bank ownership matter for bank adoption of BBI.

In this regard, the research seeks to answer the following questions:

---

[4] Malawi commercial banks' operational expenses, which are high by international standards, have made banking services prohibitively expensive, particularly for the rural poor (Government of Malawi, 2017). Implementing business models that reduce operating costs may reposition banks to shift their strategy away from overexposure to traditional low-volume/high-value corporate customers and toward more retail high-volume/low-value retail customers, who account for the majority of the country's agro-based economy. Indeed, because of their low labour intensity, innovations in the provision of financial services can assist banks in lowering their operating costs. More importantly, by providing a cost-effective complement the traditional brick-and-mortar branch model, these innovative delivery channels can assist in addressing the problem of financial exclusion caused by the high operational costs associated with mobilising small value-high volume banking outside of high population density areas.

a) What are the dimensions of BBI in Malawi?
b) What drives bank adoption of BBI in Malawi?
c) Do these drivers vary between physical BBI and remote BBI?
d) What bank ownership structures are conducive for rapid adoption of which form of BBI?
e) What are the implications of the findings on financial institution strategy and financial inclusion policy?

1.7 Summary of Methods and Data

The research utilises a panel of secondary data of all banks present in Malawi over the period 2001 to 2020. Bank-specific variables are built from quarterly data on balance sheet items and income statements of banks submitted to the Reserve Bank of Malawi. These plus data on market concentration and BBI related regulation are drawn from databases of the Reserve Bank of Malawi, being the regulator of financial institutions in Malawi. They are however not publicly available. Annual data on macro-level technological development come from the Malawi Communication Regulatory Authority and the Malawian Government's National Statistics Office databases, converted to quarterly data using the quadratic match sum function in Eviews software.

In that context, the study adopts the Pool Mean Group (PMG) Estimator technique within the Auto Regressive Distributed Lag (ARDL) approach proposed by Pesaran et al. (1999). The PMG technique is applied as it introduces heterogeneity into the dynamic analysis of data. Other than acknowledging that the relationship between variables is not always instantaneous in the economics and finance literature, adopting dynamic models is a crucial step in resolving some of the shortfalls of the static models, rendering them more suited to the analysis of our dataset. Firstly, the ARDL approach is asymptotically efficient and comparatively more robust in small or finite samples (Pattichis, 1999; Sakyi, 2011). Secondly, it can be used regardless of whether the regressors are I(0), I(1) or mutually integrated (Sakyi, 2011). Thirdly, the technique helps to address problems caused by autocorrelation and endogeneity (Pesaran et al., 2001; Sakyi, 2011). Fourthly, it estimates both short and long run relationships at the same time.

This entire study is thus focused on logical positivism, with econometric methods being used to analyse secondary data that has been routed into theory. Positivism is a natural scientist political philosophy that works with observable social facts to derive law-like generalisations from causal relationships in the data (Gill and Johnson, 2020). It promises unambiguous and accurate knowledge, focusing on strictly scientific methodologies to generate pure data and facts that are free from human bias. In terms of approach to theory development, positivism takes a deductive approach to theory formation in that it primarily relies on established theory and hypotheses, which are mostly built through a study of literature. The objective is to analyse evidence, in the process testing hypotheses and theories (Saunders et al., 2016).

1.8 Summary of Key Findings

The major conclusions from this research are that the key drivers of BBI adoption are bank size and proportionate regulation of BBI. While the impact of these drivers is consistent across most of the BBI, the impact of other drivers such as bank technology, retail portfolio, bank funding, and market concentration varies across BBI types. Furthermore, foreign entry and BHC membership influence BBI adoption primarily by increasing the number of small banks that are rapid adopters of BBI. The impact of government ownership on BBI adoption is limited. These findings have important implications for bank strategy and financial inclusion policy.

Firstly, the importance of non-prudential regulation of BBI is indisputable, given that its positive impact is consistent across most BBI. For mobile phone banking, the impact is statistically significant even after adjusting for FWER. It is acknowledged that non-prudential regulation of BBI in Malawi has frequently been a strategic adoption of regulatory frameworks implemented in other jurisdictions where BBI has been adopted much earlier. Given the dynamic nature of innovation and risk, strengthening the relevance of BBI's non-prudential regulation in assisting institutions to manage innovation-related risks necessitates domesticating the regulation. This can only be accomplished if the unique risks that are faced in the local context are understood. Considering that BBI transcends many sectors, the policy recommendation hinges on increased collaboration between the different sectoral regulators of BBI and the regulated institutions in the BBI ecosystem. More importantly, there is need to invest in systems for automated submission of performance and regulation related data by the financial institutions to the lead regulator to enable the multiple sector regulators to access data relevant to their respective regulatory needs from a common database. These reforms will be critical in ensuring that regulators have a better and timely grasp of emerging BBI risks in the local ecosystem. With a greater understanding of the prevailing risks, regulators can more pragmatically design policies that aid financial institutions to handle the particular risks associated with innovative delivery channels.

A second important policy issue raised by the findings is the impact of bank size. The finding that small banks are more likely to deploy both physical and remote BBI illustrates the potential for small banks to leverage innovation to reach out to retail customers who are typically overlooked or underserved by large banks. However, as with the banking sectors of other developing nations, Malawi's banking sector has seen multiple bank mergers and acquisitions of small banks as a strategic response to Malawi's ratification of the Basel II Accord in 2008. This is in the context of improving the stability of financial systems. Considering that small banks, not big banks, are the rapid adopters of BBI according to our research findings, it can be argued that these mergers and acquisitions potentially undermine the potential for BBI and thus limit the scope for BBI. Harnessing the potential of mobile phone banking innovation and other BBI in the face of Basel II financial stability considerations therefore requires re-opening the banking sector to smaller financially sound institutions. In this regard, reforms that introduce differentiated licensing and capital adequacy standards for different classes of banks will enable more small but financially sound institutions to enter the sector, thereby accelerating BBI driven financial inclusion. Additionally, the finding that market concentration has a detrimental influence on bank adoption of physical and remote BBI supports the aforementioned policy recommendation to open up the banking sector to more new, small entrants. This is in light of the fact that the two largest banks in Malawi control a disproportionate amount of the country's banking market (Kaluwa and Chirwa, 2017). As large banks have been found to be slow adopters of BBI, reforms to reduce market concentration by opening up the sector further can help spur adoption of both physical and remote BBI.

Thirdly, the inverse relationship between bank funding and all forms of BBI adoption is noteworthy. For adoption of mobile banking innovation, the finding is statistically significant even after adjusting for FWER. This attests to the role of management innovativeness in steering technological innovation. However, this is with the exception of ATM banking innovation, which, as one of the earliest forms of BBI, has arguably become a standard for every banking institution providing retail banking services. A crucial policy inference that can be drawn from this resides in shareholders of banks ensuring that personnel appointed to drive mobile phone banking or other innovative delivery strategies of the banks are only those with a high aptitude towards innovation. In this regard, ensuring a minimum level of educational and professional competence for individuals driving the bank's strategy at the management or board level would be a critical step toward the implementation of new strategies such as BBI by the bank.

Divergent findings on the impact of branch intensity on adoption of different forms of BBI are another crucial lesson for bank strategy. The positive association between branch intensity and physical BBI indicates that banks with extensive networks of branches can leverage their branding and physical presence among low-end retail consumers using ATM and agent banking innovations. Disenfranchising the bank branch model, in this regard, will impede progress toward the establishment of physical BBI, which is ideal for low-end retail customers who still prefer to deal in cash. This brings up an important point about the need to relax regulatory criteria for branch establishment. To the extent that such regulatory relaxation minimises the cost of establishing a bank branch, the benefits for financial inclusion would be enormous in the context of incentivising banks to expand their branch networks. On the other hand, another strategic insight emanating from the preceding findings is that banks with a small network of branches would benefit from remote BBI strategies. Moreover, since these financial transactions tend primarily to be digital, adopting remote BBI would help remedy the cash handling and social distance challenges associated with branch banking.

A further conclusion drawn from the findings is that government direct participation in the financial sector through ownership in institutions can help improve adoption of only some forms of BBI. Government direct participation in the financial services through ownership in financial institutions may therefore not be the most effective strategy to pursue the BBI strategy. Apart from that, findings further suggest that the beneficial effect of foreign entry on adoption of BBI can be traced back to the proliferation of small banks that adopt BBI more rapidly. It has been demonstrated in the literature that small banks use BBI to provide financial services to retail customer segments that are generally ignored by large banks. Paradoxically, for Malawi many of these small banks are owned by foreign investors. This, along with the findings regarding the role of BHC membership, adds to our earlier recommendation that the financial sector be further opened up to various types of shareholding, as they lead to the proliferation of small banks. This has the potential to solve market distortions arising from the market dominance by the two largest banks in Malawi.

1.9 Structure of the Thesis

This thesis is divided into six chapters. Chapter 1 introduces the research by discussing the aims and objectives of the study, the background to the research and more broadly, the research gaps that the study seeks to address, the data used and the methodological approaches taken and the key findings from the study.

Chapter 2 delves deeper into the scholarly significance of the research problem. It accomplishes this by discussing the Technology Organisation Environment (TOE) framework as a theoretical underpinning for the adoption of innovation, over and above summarising the central models underlying institutional level theories of innovation. It critically examines previous empirical studies in order to identify key themes emerging from the BBI literature and to highlight more deeply the gaps that the current research seeks to fill.

Chapter 3 contextualises the discussion by explaining the various forms of BBI in Malawi, thereby assisting in answering the study's first research question. This sets the stage for an empirical examination of the factors influencing BBI in Chapter 4. In this context, Chapter 4 discusses the data and methodological approaches in more detail, to develop an empirical model for the drivers of bank adoption of BBI. It thus answers the study’s second and third research questions.

Chapter 5 builds on the methodological approaches used in Chapter 4 to establish how the different types of bank ownership impact the adoption of different forms of BBI. It thus answers the study’s fourth research question regarding what forms of bank ownership are conductive for adoption of BBI.

Chapter 6 summarises the current research in terms of the major findings and the conclusions that are drawn from the findings. An important aspect of the chapter relates to the policy implications that can be drawn from the study findings, the contribution to knowledge as well as scope for future research.

Chapter 2: Literature Review

2.1 Introduction

The objective of this chapter is to establish the scholarly significance of the research problem. It does this in several ways. Firstly, it summarises the central models behind institutional level theories of innovation. Secondly, it discusses the Technology Organisation Environment (TOE) Model as a theoretical underpinning on the adoption of innovation. More importantly, the chapter draws on the TOE to critically analyses previous empirical studies, in the process identifying the key themes that emerge from the BBI literature as well as highlighting the gaps that the current research seeks to fill.

The study brings together the various strands of BBI research, both from the perspective of financial consumers and financial service providers. The central idea that comes out from the review is that while there is considerable research on what drives consumer adoption of BBI, empirical enquiry on the incentives for financial services providers to implement BBI remains limited. Also, and partly because of a lack of publicly available data in developing countries, much of this empirical research relates to developed countries and emerging economies; and with mixed outcomes on the drivers of bank adoption of financial innovation. This raises the question of the transferability and generalisability of results to developing countries, where financial systems are very different in terms of their development as well as state of inclusion.

Crucially, the survey of literature reflects on the debates on the interaction between the traditional *bricks-and-mortar* branch strategy and the various dimensions of BBI. However different the interaction, what comes out prominently in the literature is the unambiguous view that BBI have become an important metric, complementing the role of the traditional bank branch model in addressing outreach challenges for improved access to, and usage of, formal financial services. Against this background, the review notes that an empirical enquiry into what drives BBI should therefore be an important starting point in building a body of knowledge that can help inform public policy to address the major challenges of financial exclusion, poverty and inequality in developing countries.

Furthermore, the review acknowledges the numerous financial sector reforms that have been undertaken, altering the ownership architecture of the financial institutions in the developing countries. While the relationships have been examined between these different ownership forms and credit risk, financial stability, profitability and competition, their impact on operational risk and more specifically on adoption of BBI, remains untested.

2.2 Theoretical Underpinnings

Enquiry into what drives financial innovation, in particular BBI, can be from the perspective of consumers on the one hand, and financial institutions as providers on the other. The former dimension is broad and largely hinges on customer segmentation in terms of attitudes regarding the innovative distribution channels over the traditional branch channels (Laforet and Li., 2005; Gerrard et al., 2006; Pikkarainen et al., 2006). Others delve more into the demographic characteristics of those consumers that adopt BBI faster (Harridge-March et al., 2008; Al-Somali et al., 2009). The providers' side of BBI on the other hand, hinges on push factors, covering the firm characteristics that compel or provide financial institutions with a distinctive advantage, enabling them to adopt BBI strategies much more rapidly or to a larger scale than other institutions. The providers' side also explores the macroeconomic and market dynamics that incentivise financial institutions' adoption of financial innovations. The following section discusses the theoretical underpinning for the adoption of BBI.

The key feature of the provider side theories hinges on the institutional dynamics that matter for firms that innovate, reflected in large part by the income statement and balance sheet indicators; as well as the infrastructural, regulatory, technological, market considerations that are conducive for the firms to innovate. Suffice it to mention that the discussion of supply of innovations in the context of the financial services sector relates more on the diffusion of innovation which hinges more specifically on the spread of the innovations across an industry or population of potential adopters after the first adoption (Hannan and McDowell, 1987). This view is important considering the tendency among financial institutions not to invest in Research and Development or engage in the actual product development to the levels obtaining in other sectors such as manufacturing (Frame and White, 2004). Moreover, although the original developers of the financial innovation may theoretically have proprietary rights, in practice, property rights to prevent rapid copying of product ideas by rivals in the sector are largely absent, particularly if regulatory frameworks allow for common standards, which may mean putting the innovation into the public domain (Tufano, 1989; Llewellyn, 1992).

2.2.1 Models of Technological Diffusion

The debates on the technological diffusion draw heavily on the pioneering work of Joseph Schumpeter, positing a linear progression from invention to imitation/diffusion. Critical to the technological diffusion are the epidemic models that primarily discuss how technology spreads from adopters to non-adopters. These models belong to a broader class of population models, focussing on explaining the percentage of population of firms who have adopted the modern technology at a point in time (Sarkar, 1998). Besides the epidemic models, two broad strands of theories, namely the neoclassical equilibrium and the evolutionary disequilibrium approaches, have emerged from the criticisms of the epidemic models (Karshenas, 1995; Sarkar, 1998). The models are discussed in greater depth in the sections that follow.

Firstly, the epidemic models are based on the contagion hypothesis, which compares the propagation of technological innovation to the spread of an infectious disease; in the sense that the number of adopters of an innovation grows over time as non-adopters in a fixed population interact with adopters and collect information on the innovation. It is therefore based on the idea that the lack of knowledge available about new technology, how to use it, and what it does, is what slows down adoption. The standard logistic S-shaped curve results from the theoretical formulation of epidemic models (Sarkar, 1998). In the early stages of diffusion, a considerable portion of the population are non-users, which makes it easier to pass on information, even though the take up is slow since only a few users exist to pass on the information. However, in the later stages of diffusion, there are many users who can pass on the content, but their chances of reaching one of the few remaining non-users is slim, resulting in a low rate of adoption. In the middle, adoption rates are much higher since many users are more likely to encounter and convert one or more of the many non-users.

Secondly, the Neoclassical Equilibrium models on the other hand are based on the tenets of neoclassical theory, namely: equilibrium, infinite rationality, and full information. Under this narrative, the diffusion mechanism is described by a series of changing static equilibria in which agents are perfectly adjusted at each point in time; decision makers are indefinitely rational; and agents are presumed to have perfect information on the nature, existence and returns of the new innovations to the economy. Within the broader realm of the neoclassical equilibrium models are two broad models viz, probit models and game theoretic models.

The probit models assume that various companies will choose to implement modern technologies at separate times, depending on their priorities and capabilities. Under this narrative, firms differ in their characteristics, which affect their speed and probability of implementing the modern technology (David, 1969; Davies and Davies, 1979; Stoneman, 1980). Companies will pursue innovation only when the disparity between these characteristics exceeds a certain threshold. In this sense, because the threshold for adoption is not a single value that is appropriate for all members of the population at any given time, all potential adopters do not decide to adopt at the same time (Sarkar, 1998). In this regard, the population of potential adopters can be categorised into two groups at any given time, namely: the adopters who benefit from adoption, and the non-adopters whose benefit from adoption is negative. The former group will embrace the innovation and thus constitute the equilibrium level of adopters in that period. The shift in the equilibrium level of diffusion between the periods emanates from exogenous changes in either the economic or technical environment (Stoneman and Ireland, 1983; David and Olsen, 1984; Geroski, 2000; Stock et al., 2002).

On the other hand, diffusion under the game theoretic models derives from the tactical conduct among potential adopters; deciding on the optimal time to adopt an innovation with the objective of staying ahead of the competition. Reinganum (1981a, 1981b) analyses the diffusion mechanism by looking at a capital-embodied process innovation whose adoption cost falls over time while the value obtained from adoption declines as the number of users rises. In comparison to probit models, where the advantages of adoption are independent of the number of other users of innovation, game theory assumes interdependence between adopters. Unlike probit models, game theory looks at firms as homogenous in terms of their costs. Furthermore, the theory assumes that companies have perfect knowledge on technology, that they maximise the present discounted value of income, and that they engage in competitive behaviour in an oligopolistic market. Even if firms are similar, the equilibrium would result in different adoption dates for firms, resulting in a staggered diffusion pattern. This outcome, in which firms that are similar ex-ante end up behaving differently in equilibrium, is in stark contrast with the probit model (Karshenas, 1995; Sarkar, 1998). Under a probit model the expectation of complete knowledge, blended with the assumption of identical firms, would necessitate identical adoption dates, ruling out the possibility of a diffusion curve. Under game theory, adoption outcomes are guided by the presence of strategic alliance and solid commitment to adoption deadlines.

The above models have been applied to empirically analyses the various institutional level frameworks. The most notable among this framework has been the Technology Organisation Environmental (TOE) Framework. It is therefore vital to go into greater detail about this framework because it serves as the foundation for the analytical approach used in this research.

2.2.2 The Technology Organisation Environment (TOE) Framework

The TOE framework constitutes the main theoretical framework for our analysis. This is against the background that much of the empirical literature of institutional adoption of innovation have been premised on it (Zhu et al., 2003; Brown and Molla, 2005; Chipeta and Muthinja, 2018). The TOE describes how the characteristics of technology, the different contexts of the organisation, and the environment within which that organisation operates, affect the organisation's adoption and implementation of innovation (Tornatzky et al., 1990; Zhu et al., 2013; Muthinja and Chipeta, 2018). In this regard, the TOE framework is well suited for understanding the adoption of financial innovation from the perspective of financial services providers, which is the subject of this study. As an organisation-level theory, the TOE framework describes three broad elements of the firm that affect adoption decisions, namely: technological, organisational, and environmental contexts (Wang et al., 2010).

a) The technological context

In the technological context, the model considers how existing technologies at the firm level can affect innovation by imposing a broad limit on the scale and speed of technological progress that the firm can pursue (Collins et al., 1988). In this regard, companies that use advanced technology have a strategic advantage over those that use obsolete hardware and software (Wang et al, 2010). Crucial to the technological context is not just the technology that the firm is currently using, but more importantly the emerging technologies, or technologies that are available in the market, from which the firm can draw (Collins et al., 1988; Baker, 2012). These have an impact on innovations as well by demonstrating to companies how technology can help them change and adapt.

Technologies outside the company but available for the firm can be divided into three main categories, viz: those that produce incremental changes, those that produce synthetic changes, and those that produce discontinuous changes (Tushman and Nadler, 1986). The first group includes technologies that add new features or new iterations of already-existing ones; and represent the least change and least risk to the organisation. Second, those that create synthetic change stand for a moderate change in the middle where pre-existing concepts or technologies are combined in a novel way. The third category represents a substantial and radical change from the processes and technology currently in use. In this sense, industries marked by technological innovations that result in incremental and even synthetic change allow for a measured pace of adoption. However, industries characterized by technological innovations that result in discontinuous change necessitate firms making quick and decisive adoption decisions in order to maintain and improve competitive standing (Tushman and Anderson, 2018). Also critical in this regard is the consideration of how a particular technology is widely adopted among similar firms in the market. This is important not only for the ease with which the infrastructure can be serviced, but also for the network externalities. The concept of network externalities relates to how a particular user of a technology derives value from that technology if the technology is used by a large number of other users (Koellinger, 2008; Muthinja and Chipeta, 2018).

b) The organisational context

The organisational context refers to the resources and characteristics of the company, including firm size, slack resources, intra-firm communication processes, and quality of human capital that help an organisation to adopt innovation faster (Chau and Tam, 1997; Stock et al., 2002).

Under the TOE, the organizational context influences adoption decisions in a number of different ways. Firstly, mechanisms that connect an organization's internal divisions have been argued to encourage innovation (Tushman and Nadler, 2018). Also, rapid adoption is associated with the presence of informal linking agents such as product champions and gate keepers.

The relationship between organizational structure and the adoption of innovations has also been studied more broadly. This includes organizational structures that encourage teamwork, lateral communication, and some degree of flexibility in employee responsibility. Organic and decentralised organisational frameworks, for example, are linked to innovation acceptance (Tornatzky et al., 1990). Communication processes within an organization can also foster or stifle innovation. Top management can foster innovation by nurturing an organizational environment that welcomes change and encourages innovations that advance the firm's core values, mission, and vision (Tushman and Nadler, 1986).

Other aspects of the organizational context that have received a lot of attention include slack and firm size. It is unclear whether size and innovation are related. On the one hand, it is claimed that large companies are quick to adopt new technologies, despite the fact that much of the research in this area has been criticized because size is frequently a crude proxy for more specific underlying organizational factors, such as the availability of specific resources. Also, while earlier studies found slack to promote adoption, it has been argued by other studies that slack is not necessary for innovation to occur (Tornatzky et al., 1990; Bultum, 2014).

c) The environmental context

Finally, the environmental context is extensive and has included, among other things, the industry structure, regulation, technological growth, and market inefficiency. (Calomiris, 2009; Lerner and Tufano, 2011; Di Stefano et al., 2012).

Industry trends may have a variety of effects on innovation acceptance. Earlier research, for example, saw fierce competition as a motivator for innovation, owing to the potential of innovation in accelerating business development (Mansfield, 1977). Recent studies have made arguments about how a large market share can incentivise investment in costly technology that is required to support innovation (Aghion et al., 2005; Hughes and Lonie, 2007; Mas and Ng'weno, 2010; Argent et al., 2013). Furthermore, evidence suggests that the role of dominant firms in the value chain influences the innovation of other value chain partners (Kamath and Liker, 1994). These findings, however, are not conclusive, as other studies have shown that a lack of competition tends to stifle the incentive to innovate (Hannan and McDowell, 1984; Hannan and McDowell, 1987; Frame and White, 2004; Önder and Özyıldırım, 2019).

In terms of industry life cycle, it has been argued that firms in rapidly growing industries tend to innovate more quickly. However, in mature or declining industries, innovation practices are seldom straightforward (Tornatzky et al., 1990). Some firms use an industry's declining trend to innovate through efficiency initiatives or by expanding into new lines of business. Other businesses may avoid investing in innovation in order to cut costs.

Apart from that, technology support infrastructure has an impact on innovation. Firms that must pay high wages for skilled labour are frequently forced to innovate via labour-saving innovations (Levin et al., 1987). The availability of skilled labour as well as consultants or other providers of technology services promotes innovation (Rees et al, 1984). Regarding regulation, various channels have been cited in relation to innovation. The direction of the relationship depends on the nature and intention of regulation. Firstly, certain types of government taxation and control have the same property as tacit taxes in that they prevent businesses from maximising profits (Khraisha and Arthur, 2018). Regulatory enforcement increases certain costs, forcing businesses to innovate in order to reduce or offset the costs associated with regulatory compliance (Wall, 2014). Under the Kane's circumvention innovation theory, institutions are compelled to innovate with the view to circumventing burdensome regulation; and this has often been referred to as regulatory dialectic (Frame and White, 2014; Khraisha and Arthur, 2018). Thus, the burden that full compliance imposes on the institution's efforts to create value and manage risk, increases the propensity of an institution to circumvent a regulation (Kane, 2014). Secondly, legislation will encourage innovation by enhancing clarity on what constitutes as acceptable activities and more crucially by helping consumers and service providers to manage the risks that are inherent in the process of implementing innovations (Calomiris, 2009; Awrey, 2013). Finally, some regulations have been argued to stifle innovation. Arguments in this regard have been made about how laws that prohibits banks from owning insurance companies, tend to stifle any innovations that would have resulted from this shared ownership (Frame and White, 2004). Therefore, governmental regulation can either promote or prevent innovation.

2.2.3 The TOE Framework vis-à-vis other institutional level frameworks

A brief comparison of the TOE framework to other institutional level frameworks in terms of similarities, strengths, and weaknesses enables an understanding of why the TOE framework is an excellent place to start when investigating key factors underlying firm decisions to adopt innovation.

Firstly, the TOE is comprehensive in its coverage of the fundamental concepts that underly other models that take the institutional view of innovation such as the Lacovou et al, (1995) Model. The Lacovou et al (1995) framework examines inter-organisational structural characteristics that affect firms' adoption of Information Communication Technology (ICT) innovations in the context of Electronic Data Interchange (EDI). Under this model, organisational readiness, external pressure, and perceived benefits are the three prominent drivers influencing EDI adoption in small firms (Lacovou et al., 1995; Oliveira and Martins, 2011). In the TOE framework, organisational readiness is a factor in the organisational context, whereas external pressure is a factor in the environmental context. The concept of perceived benefits refers to the degree to which an organisation recognises the relative benefit that EDI technology can deliver to an organisation. In this regard, the concept of perceived benefits is included in the TOE framework as technological context (Cooper and Zmud,1990; Thong,1999).

Secondly, the Institutional framework is primarily based on the notion that institutional environments play a critical role in defining an organization's behaviour and structure (Scott and Christensen, 1995; DiMaggio and Powell, 1983; Oliveira and Martins, 2011). In this sense, the theory's primary focus on the environment as a sole factor that underpins the organization's proclivity to innovate. This makes it to be inferior to the TOE, which is more comprehensive in its scope in so far as it looks at adoption of innovation not only in the context of the environment, but also in the context of technological aspects and organizational characteristics.

Thirdly, the TOE framework is generic and highly applicable to studies on various types of innovations, various national/cultural contexts, and various industries, all of which have slightly different sets of technical, organisational, and environmental contexts defined and analysed (Zhu et al., 2003; Zhu et al., 2013). For instance, Srivastava and Teo (2006) used the TOE to examine the factors that have contributed to the development of e-government in 115 different countries. Scott (2007) conducted a study to examine the drivers, facilitators, inhibitors, and advantages of e-transformation based on the TOE. Yeh, Lee, and Pai (2015) used the TOE framework to analyse the variables affecting the e-business IT capabilities of major Taiwanese ICT companies. The factors influencing hotels' adoption of mobile reservation systems were investigated by Wang et al., (2016) using the TOE framework. Chong et al., (2017) have used TOE framework to conduct a meta-analysis of eco-effectiveness. Hue (2019) adopted the TOE framework in their empirical analysis of the factors that influence innovation in Vietnamese manufacturing firms. More recently, Kulkarmi and Patil (2020) investigated the adoption of blockchain technology for banking services in India using the TOE theory. The TOE was used by Ediriweera and Wiewiora (2021) to examine the constraints and opportunities for technology adoption in the mining sector. In order to analyse the emergence of remote work as a new norm during the Covid pandemic in Hong-kong, Ng et al., (2022) applied the TOE framework. A global study on the variables influencing hotel managers' intentions to adopt robotic technologies was conducted by Pizam et al. in 2022. In order to evaluate the prerequisites for the pedagogical use of digital tools in the Nigerian higher education sector, Orji et al., (2022) applied the TOE. The TOE framework was also applied by Gupta et al in 2022 to look at evidence of artificial intelligence adoption in the insurance industry in India. From this we see that TOE has broad applicability and poses explanatory power across a wide range of innovations, industries and geographical regions. Since its inception, the TOE has remained one of the widely applied theories of institutional adoption of innovation.

These characteristics justify the use of the TOE framework in our investigation of the factors that influence bank implementation of BBI strategies. In this regard, the TOE framework is an excellent place to start when examining key factors underpinning decisions to adopt innovation by firms given its strengths over other institutional level models earlier discussed.

2.3 Empirical Analysis

A major flaw in the TOE model has been noted as the failure of the framework to explicitly state the variables and primary constructs in the innovation adoption nexus, which has led to different studies having different sets of determinants of adoption within the three contexts (Wang et al., 2010). In light of this, in order to use the TOE theoretical framework to deductively formulate the research hypotheses, the approach of this study, as has been for most recent studies, is to restrict the analysis to only those variables that have received the most citations in the empirical literature. In this regard, we go into greater detailed discussion of these variables, broadly divided into firm-level factors and macro-level factors.

2.3.1 Firm-level Factors

a) Firm size

By way of background, the firm size hypothesis was first set forth by Joseph Schumpeter and elaborated by John Kenneth Galbraith (Stock et al., 2002). More broadly, the Galbraith-Schumpeter hypothesis considers a firm's optimal size in the context of the degree of economies of scale that the firm enjoys in the process of generating and implementing new technologies. According to this school of thought, larger companies are best positioned to implement technologically superior equipment and processes, which reposition them to harness substantive cost reductions while at the same time strategically positioning them to adapt to external changes.

The intuition underpinning this nexus is multi-pronged; and broadly summed up in Brown (1981), Hannan and McDowell (1984), Frame and White (2004), as follows. Large companies, as opposed to small firms, face less risk in embracing technologies because they either have management that is optimistic about emerging technology; or they derive maximum returns on investment in innovation, leveraging their abundant financial and better-informed human capital. Furthermore, larger companies have the requisite market power with which to outperform small rivals; they profit from economies of scale resulting from the various activities that they engage in and to which technologies can be applied. More importantly, they harness the risk diversification benefits arising from pursuit of a range of uncorrelated ventures.

While the above nexus between firm size and adoption of innovation was primarily premised on the empirical studies in the manufacturing firms, for financial institutions the unique nature of the intermediation business has necessitated a considerable level of regulation, including in the context of the channels through which large firm impacts innovation, as discussed above. Firstly, prudential regulation requires bank risk appetite to be backed by adequate capitalisation, policies, and controls. To the extent that regulation requires both large and small banks to maintain capital ratios consistent with their level of risk, it can be assumed that a bank's willingness to accept risk, including that resulting from the implementation of BBI, would be primarily contingent not on the bank's size but on the bank's compliance with capital adequacy regulation. Secondly, regulatory architecture potentially limits the extent to which firm size impacts adoption of innovation via the complementarity between innovation and the numerous activities that large firms undertake.

In the context of financial services, we note that the key activities that banks undertake, for which digital innovation can be complementary, are rarely exclusive to large banks. This is because these activities are often infrastructural initiatives driven by the financial regulator, and thus cut across all banks regardless of size. Notable among the core activities are the interoperability of financial processes across banks, connectivity to automated systems for bulk payments, credit referencing, automated regulatory reporting, risk monitoring and control. Thirdly, prudential regulation can also limit the technical capability effect of large firms adopting innovation faster than small firms. Regulators set the "fit and probity" requirements that provide minimum required standards for assessing suitability of individuals appointed into key managerial positions in banks. To the extent that these standards are applied to all banks regardless of size, large banks may not have a significant edge over small banks in the adoption of digital innovations.

The hypothesis that emanates from the above three perspectives is that stringent prudential regulation in the financial sectors, particularly of developing countries, can limit the magnitude and channels with which firm size would traditionally positively impact the adoption of innovation by banks. It therefore remains to be tested whether, in developing countries, the highly regulated nature of the banking industry relative to other sectors of the economy would potentially limit or alter the transmission mechanisms through which firm size impacts adoption of innovation in the banking sector, relative to the other less regulated sectors such as manufacturing.

However, adding to the validity that firm size is not unambiguously positively related with the adoption of BBI as the Galbraith-Schumpeter hypothesis has us believe, is the empirical evidence of a weak or conflicting relationship. For instance, empirical studies established that the adoption time minimised in medium sized banks in Spain and in the United States of America (Escuer et al., 1991; Hunter and Timme, 1991). The premise in the earlier empirical literature regarding this divergent view is that small and medium institutions adopt innovation faster, driven by a strong quest for growth or simply due to faster decision making in the absence of tedious bureaucracies that tend to increase as institutions become larger (Segers, 1993; Nooteboom, 1994).

Furthermore, since larger companies also engage in more activities than small businesses, they are more likely to have fragmented and incompatible processes, which may make innovation adoption more difficult (Zhu et al., 2006). The implication of this is that larger banks will take longer to embrace innovation because they will have to first re-orient their current ICT infrastructure and corporate culture to enable BBI strategies (Sullivan and Wang, 2020).

Moreover, the fabric of innovation in financial services generally does not embody onerous barriers relating to proprietary rights or investment in research and development, as is the case in other industries such as the manufacturing sector. This point about how simple it is for other players to copy financial inventions is underpinned in the view that patents for most financial innovations are highly litigable, and therefore financial innovations are usually considered ineligible for patent protection (Tufano, 1989; Llewellyn, 1992; Lerner, 2006; Lerner, 2010). Taken together, the result is that even small firms can implement BBI faster and with relative ease, including by merely copying the various forms of innovations that have been tried and tested elsewhere.

The above conflicting arguments notwithstanding, we find widespread evidence in the empirical literature of banking institutions in Western Europe, United Kingdom, United States of America, India and Italy, about the positive effect of firm size and banking sector adoption of a variety of BBI such as video banking, internet banking, credit cards, ATM banking, and cell phone banking, consistent with the Galbraith-Schumpeter hypothesis (Hannan and McDowell, 1984; Hannan and McDowell, 1987; Pennings and Harianto, 1992; Sharma, 1993; Buzzacchi et al., 1995; Courchane et al., 2002; Gourlay and Pentecost, 2002; Corrocher, 2006; De Young et al., 2007; Malhotra and Singh, 2010; Kaur and Kaur, 2018; Dorfleitner et al., 2019). However, this evidence only relates to emerging economies like India and developed countries, mostly Italy, the UK and the USA, with none focusing specifically on developing countries. For this reason, the focus of this study is on the banking sector of developing countries, where such studies have been sparse.

b) Technological development at the firm level

The ratio of total investment in systems and equipment to total assets has been used by most studies in the empirical literature to represent technological developments at the firm level (Pennings and Harianto, 1992; Furst et al., 2002; Malhotra and Singh, 2010). To account for the fact that behind every technology there is human capital, other studies have used the ratio of ICT infrastructure plus ICT personnel costs divided by total assets (Ammar and Ahmed, 2016; Chipeta and Muthinja, 2018; Muthinja and Chipeta, 2018).

Based on these measures, studies using separate samples of banks in Sudan, United States of America, Zimbabwe and China and transitional economies have established a positive impact of firm level technology on adoption of various forms of BBI such as internet banking, cell phone banking, agency banking, ATM banking and internet banking; providing support for the view that firms that use superior technology have a strategic advantage over those that rely on obsolete hardware and software (Pennings and Harianto, 1992; Furst et al., 2002; Frame and White, 2004; Brown and Molla, 2005; Thulani et al., 2009; Malhotra and Singh, 2010; Ammar and Ahmed, 2016). The plausibility of this relationship derives from the ease with which innovations are compatible and integrated to superior technologies than to outdated hardware and software (Furst et al., 2002; Muthinja and Chipeta, 2018).

However, we also note from the empirical literature that the above narrative of a positive relationship between firm technology and adoption of innovation can become complex. This is against the background that it is easier for new entrants to invest in the kind of technology that is compatible with BBI than it is for incumbents to reconfigure their existing technological structure to suit the more innovative BBI strategies (Sullivan and Wang, 2020). Added to that, BBI are not homogeneous and therefore their technological pre-requisites may vary.

The implication is that firms that seek to harness BBI should either have existing technologies that are compatible with the kind of innovations that they seek to adopt; or should be able to tap from the market the technologies that would be compatible (Carlson et al., 2001; Dermish et al., 2012; Muthinja and Chipeta, 2018). Consequently, the growing dependence of small and new firms on external sources of technology innovations tends to nuance the positive effect of firm size on institutional adoption of digital finance innovations, as both large and small firms can access technology from the market (Pennings and Harianto, 1992; Buzzachi et al., 1995).

By the same argument, there has been general acknowledgement of the growing trend among banks, both large and small, to deliver financial services in partnership with telecommunications companies and Fintechs (Carlson et al., 2001; Thakor, 2012; Thakor, 2020). These collaborations have been motivated by synergies based on the former's risk management expertise and liquidity availability, while the latter's competencies stem from their extensive network of agents, large customer base, and, most importantly, superior technologies. What remains to be seen is whether the superior technologies brought to the partnership by Fintechs and telecommunications companies will potentially alter, in some forms of BBI, the traditional narrative of the positive relationship between bank level technology and adoption of innovation.

c) Customer demand

Another key factor in harnessing the potential of financial innovation relates to the business strategy of the banks, in particular the bank's product mix. Thus, while the ratio of demand deposit to total deposit proxies bank product mix, it invariably represents demand pull in the adoption of BBI (Saloner and Shepard, 1995; Malhotra and Singh, 2010). This is not surprising bearing in mind that profit maximising firms shape their product mix in response to patterns in consumer demand.

It is acknowledged that payments and withdrawals from checking accounts represent the most common transactions performed under most BBI (Hannan and McDowell, 1984; Corrocher, 2006). Thus, the more retail customers a bank has, the higher the volumes of payments and withdrawals would be processed through BBI if available. All the more reason that the size of a bank's retail customer base at the firm level has been found in the empirical literature to be an important positive factor in adoption of BBI by banks (Barras, 1990; Saloner and Shepard, 1995; Malhotra and Singh, 2010). The foregoing narrative confirms that product mix, reflective of a bank's focus on retail customers, is important in incentivising banks to implement BBI.

However, it should be noted from the empirical studies that demographic characteristics such as literacy, income and level of technology usage are important in determining consumer adoption of innovations ((Bhattacherjee, 2001; Marangunić and Granić, 2015; Evans, 2018). The age of an individual, for example, has been found to be a significant barrier to debit card adoption (Carow and Staten, 1999; Mantel and McHugh, 2001). However, age was inversely related to the adoption of internet banking (Brown and Molla, 2005; Brown et al., 2009; Clemes et al., 2012). Several studies established adoption of internet banking innovation to be higher among educated individuals than the less educated (Brown and Molla, 2005; Gerrard et al., 2006; Clemes et al., 2012). This was set against the backdrop of low-education customers being less likely to embrace internet banking innovation due to a lack of computer literacy and skills, making internet banking innovation seem complicated to them (Clemes et al., 2012; Zins and Weill, 2016; Kodongo, 2018). The literature is replete with studies that validate the positive relationship between individual's income and adoption of BBI. For example, high-income earners have been found to use debit cards more often than low-income earners (Carow and Staten, 1999; Mantel and McHugh, 2001). A similar connection established between income and internet banking adoption, against the background that high-income individuals are more likely to own a computer and pay for internet access than low-income individuals (Black et al., 2001; Brown and Molla, 2005). In terms of gender, females have been found to be greater adopters of BBI than males (Mantel and McHugh, 2001; Clemes et al., 2012).

The preceding section has provided an overview of BBI from the point of view of the consumer. The implication of this is that demand conditions such as literacy levels, income levels and level of technology usage can also be important in shaping how size of bank retail customer base can impact adoption and diffusion of BBI in the financial sector.

d) Branch network

Management is an important aspect of consideration in the diffusion of BBI. Under this narrative, the efficiency of management in controlling operational costs becomes an important factor in the quest by banks to implement BBI (Ammar and Ahmed, 2016; Muthinja and Chipeta, 2018).

It is acknowledged that high transaction costs, to a large degree, emerge from the huge operating costs arising from the traditional business models employed by banks. These models are often characterised by high-cost branch structures and ICT platforms that are primarily configured for high-value, low-volume, corporate transactions, but when extended to low-value, high-volume, retail clients, necessitates higher labour intensity, making the distribution process more costly. The connection between adoption of innovation and the management of operating expenses stems from BBI's ability to serve as a speedy and low-cost delivery channel vis-à-vis the conventional brick and mortar branch model (Tufano, 2003; Alexandre et al., 2011; Mas, 2016).

Connecting to the larger debate on cost efficiency is the degree of substitutability between BBI and the traditional bank branch network. Branch intensity has been represented in the empirical literature by either the number of branches of a bank expressed as a ratio of total number of bank branches in the sector or the number of branches as a ratio of total assets (Saloner and Shepard, 1995; Frame and White, 2004; Corrocher, 2006; Malhotra and Singh, 2010).

The promise of these BBI in offering cost effectiveness in delivery of financial services should ordinarily imply a negative relationship between branch network and diffusion of BBI (Furst et al., 2002; Frame and White, 2004). For example, banks that spend a lot of money on premises and fixed assets may see internet banking (or other kinds of remote BBI) as a way to cut down on the costs of maintaining their existing branch network (Frame and White, 2004; Malhotra and Singh, 2010).

However, a key consideration in the empirical literature relates to whether the reduction in costs arising from BBI can in the short to medium run far outweigh the sunk costs relating to existing bank branch establishment (Ingham and Thompson, 1993). The implication of this is that if the cost savings do not outweigh the sunk cost of bank branch establishment, BBI should be implemented only as a complement, rather than as a replacement for, traditional bank branch strategy in the short run (Malhotra and Singh, 2010).

Apart from the cost consideration of the existing branch network, the negative nexus between branch network and adoption of BBI may also arise from the existing gap that a particular bank has in terms of bank branch establishment. Under this narrative, banks that have a limited branch footprint may seek to implement remote BBI models such as internet banking and mobile phone banking innovations, in order to expand their frontiers and reach out to niche markets (Furst et al., 2002). However, for a sample of Italian banks that have a wide network of branches, the incentive to adopt remote forms of BBI in order to grow their customer base was not established, suggesting that the large branch intensity already provides them the branding and physical contact advantage with which to establish more loyal customer base (Corrocher, 2006).

The above negative relationship notwithstanding, two strands of thinking that are premised on the heterogeneity of BBI suggest that the relationship may not necessary be negative. One school of thought looks at the support that BBI derive from the branches. It has been argued that the value of a network/innovation increases in proportion to the number of outlets where that innovation can be accessed. Arguably, branch network proxies the network size considering that branches are typical location for most ATMs (Saloner and Shepard, 1995). In this regard, ATM innovation tends to be positively related with branch intensity, reflecting the presence of network effects (Saloner and Shepard, 1995; Hester et al., 2001; Frame and White, 2004; Kulkarni and Warke, 2015).

The second strand of thought, nuancing the negative relationship between branch models and BBI, draws heavily from the degree of non-substitutability between branches and the innovative channels, particularly in the context of the services that are best delivered under a particular form of BBI vis-à-vis through a bank branch. Financial institutions are increasingly adopting a multi-channel approach, combining the traditional bank branch model with alternative distribution channels. This paradigm is based on the realisation that each model is well suited to a specific type of customer and can be applied to a specific set of financial products and services. In some jurisdictions, such as Europe and North America, branch network rationalisation has been driven by the growth of cost-effective electronic and tele-mediated forms of distribution. Nonetheless, face-to-face interaction between consumers and bank staff at a branch remains an important part of the mortgage transaction (Willis et al., 2001).

In light of this, we can see from this extensive literature that the relationship between the brick-and-mortar branch model and the spread of BBI models is not always unambiguously inverse, as the cost-effectiveness narrative would have us conclude. At best, the relationship can be complicated by the emergence of more financial products requiring unique delivery channels, as well as the increasing heterogeneity of customers. However the relationship, the place of BBI in bolstering the financial inclusion efforts accruing from branch intensity is undeniable.

e) Bank funding, profitability, and innovative management

Profitability is a broad concept. However, much of the studies on bank profitability have used Return on Assets and Return on Equity as proxy for profitability (Saloner and Shephard, 1995; Hester et al., 2001). Return on Assets, in this context, tests a bank's management's ability to generate income from the bank's assets (Sundararajan et al., 2002; Athanasoglou et al., 2008). This ratio is not free from bias as it overlooks the impact of off-balance sheet activities on the bank’s profitability. Nonetheless, it has been used in the majority of studies, owing to the fact that conventional banks' intermediation is heavily reliant on balance sheet activities such as credit assets and deposit liabilities (Anbar and Alper, 2011; Owoputi et al., 2014).

Separate studies among banking institutions in the United States of America, United Kingdom and Kenya have established a positive relationship between profitability and adoption of ATM and internet banking (Sinha and Chandrashekanran, 1992; Gourlay and Pentecost, 2002; Muthinja and Chipeta, 2018). A common argument across these studies is that this nexus reflects the goal among the profitable banks to consolidate their competitive position by adopting BBI. The potential of BBI to bolster profitability can be looked at in the context of their cost effectiveness (Pennings and Harianto, 1992; Furst et al., 2002; Frame and White, 2004; Malhotra and Singh, 2010).

However plausible, implied in this view is the flawed assumption that adoption of BBI should therefore be exclusive to the profitable banks that have a competitive position to consolidate. That is to say, loss-making or less profitable banks may not be drawn into implementing BBI strategy so as also to improve on their profitability. At any rate, findings from other studies among banks in the United Kingdom, United States of America and Italy diminish the threshold of profitability as a statistically significant factor driving diffusion of internet banking innovation (Buzzacchi et al., 1995; Bughin, 2001; Corrocher, 2006; Malhotra and Singh, 2010; Sullivan and Wang, 2020).

The more plausible alternate view about the positive link between bank profitability and adoption of BBI is founded on the assumption that profitable banks are not constrained to adopt BBI, since they are able to fund investment in new technology using internally generated funds (Hannan and McDowell, 1984; Gourlay and Pentecost, 2002). Although profitability has been used in the empirical literature to describe the capacity to finance innovation with internally generated funds, it is arguably not the best indicator of internally generated funding when compared to bank cash-flow. Probably owing to the lack of publicly available data on bank cash flows, profitability indicators have been used to proxy internally generated funds. A more plausible proxy would be reinvested earnings, which in essence constitutes capital rather than profit. In this regard, caution must be taken when using profitability measures to proxy presence or absence of firm limitations to fund innovations using internally generated funds.

Extending the discussion about funding implications on BBI is the perspective that considers the innovativeness of bank management through the lens of the bank's extent of reliance on deposits to fund its assets. Most banks depend on deposits as their primary source of asset funding (Gourlay and Pentecost, 2002; Cull and Peria, 2013; Asongu and Nwachukwu, 2018). An important point that must be highlighted is that deposits are less costly since the interest paid on them is mostly lower than the rate that banks will have to pay to receive financing through external credit lines or capitalisation.

As a result, banks that are less dependent on conventional funding sources are seen as having more innovative management, as they prefer to follow a more aggressive overall business strategy in order to achieve higher returns that can offset the high-cost funding (Furst et al., 2002). Several empirical studies have found an inverse association between conventional funding (measured by the deposit-to-asset ratio) and the spread of BBI, which supports this viewpoint (Sinha and Chandrashekaran, 1992; Furst et al., 2002). However, as noted by Malhotra and Singh (2010), most studies that have included this variable as a potential contributing factor to bank adoption of internet banking have found it lacking in explanatory power.

2.3.2. Macro-level Drivers

a) Regulation

The empirical literature has analysed the role of an enabling regulatory environment from the point of view of managing risk arising from innovation to both the consumers and the providers. Under this narrative, proactive rather than preventive regulation, when applied proportionately, has an effect in bolstering consumer trust as well as ensuring financial system integrity (Lumpkin, 2010). Proportionate regulation is defined as regulation whose costs to the regulator, regulated institutions, and consumers are proportionate to the risks being addressed, given the expected benefits (Jenkins, 2008; Lauer and Tarazi, 2012). Innovations, if unregulated, have been feared to heighten money laundering and operational risks, which may breed financial system instability and loss of integrity. At the consumer level, unregulated innovation can result in undesirable distributional outcomes hinging on product misrepresentation, deceptive marketing or indeed delivery of products that are inappropriate to certain consumers (Barth et al., 2008). These can result in loss of consumer trust in formal financial services (Lee and Chih, 2013).

According to the literature, there are two broad criteria for describing regulation as enabling for BBI. The first criterion hinges on the removal of entry barriers, allowing non-bank institutions to provide BBI in the same way that traditional banks do (Gutierrez and Singh, 2013). The second criterion is the implementation of a risk-based regulatory approach, so that non-bank operators with lower financial stability risks are regulated with a lighter touch in the context of prudential standards; and low risk activities are subjected to less stringent regulatory requirements, such as simplified Know-Your-Customer (KYC) standards for low end consumers (Alexandre and Eisenhart, 2012; Gutierrez and Singh, 2013; Buckley et al., 2015).

Another important dimension to enabling regulation identified in the literature hinges on non-prudential regulation. Central among them include ensuring that the different classes of service providers have the necessary capacities to engage in the activities for which they have been approved to offer; providing clarity around permissible activities; reducing information asymmetry through enhanced disclosure requirements and implementation of market conduct surveillance programs (Calomiris, 2009; Ahmed and Ammar, 2016; Triki et al., 2017).

A further dimension to the relationship between regulation and bank adoption of BBI relates to the extent to which the minimum standards for a bank branch establishment are stringent (Hannan and Mc Dowell, 1984). To the banks, the onerous requirements for setting up a bank branch tend to raise the cost of delivery of bank services. On that basis, to avert such costs resulting from the burdensome requirements, banks are compelled to implement innovative strategies that enable them to deliver similar services more cost effectively in an unregulated space up to a point where regulation has to catch up with the innovations but not in ways as to be as burdensome as under the bank branch set up.

Regardless of the various schools of thought on how regulation influences innovation, it is widely agreed that publicly available data on financial regulation are sparse. This could explain why, in comparison to other industries such as manufacturing, research on the relationship between regulation and innovation in financial services has been limited (Frame and White, 2004). The uniqueness of our database enables us to address this gap.

b) Technological developments

The state of development of infrastructure at national level defines the possibility frontiers within which businesses can connect with one another (Pennings and Harianto, 1992).

Hypotheses have been made about the importance of technological linkages between firms for their ability to innovate (Pennings and Harianto, 1992; Muthinja and Chipeta, 2018). Besides connectivity and access considerations, the technologies available in the market provide a pool that firms can tap from in order to upgrade their existing technologies to create an ICT infrastructure that can integrate with new innovations (Koellinger, 2008; Muthinja and Chipeta, 2018).

Against all this background, high levels of technological development at the macro level have been considered to be necessary for the implementation of innovative BBI models. However, the empirical literature provides mixed results. For instance, using a duration model, Corrocher (2006) found macro technology to be positively associated with adoption of internet banking innovation among the Italian banks. However, for the adoption of ATM innovation, Gourlay and Pentecoast (2002) found that the price of technology had no significant impact among banks in the United Kingdom. Using Generalised Method of Moments, Muthinja and Chipeta (2018) found a positive impact of macro technology on adoption of mobile phone banking innovation among Kenyan banks. However, the impact on agent banking, ATM banking and internet banking innovations was negative.

c) The Nature of the Market

The relationship between the nature of the market and its impact on BBI has been a matter of wide debate. The key areas of empirical consideration have been around market structure, market size and market growth.

The role of market structure as a determinant of innovation has been the subject of several theoretical contributions. Earlier research claims absence of economic basis connecting the reward from innovation with market structure (Reinganum, 1981; Kamien and Schwartz; 1982). However, subsequent research shows that banks in more concentrated markets have a higher conditional probability of adoption, implying the possibility of a Schumpeterian-style trade-off between any static efficiency gains from efforts to de-concentrate local banking markets and a potential loss in technological progressiveness (Hannan and McDowell, 1987). This hypothesis looks at market power as vital in enabling firms to generate sufficient returns from investing in innovation. In this sense, large market share would justify investment in costly technology necessary to support BBI (Hughes and Lonie, 2007; Mas and Ng'weno, 2010; Argent et al., 2013)

On the other hand, low levels of competition, according to more recent literature, lead to monopolistic power which exacerbates a variety of banking system inefficiencies manifest in poor product design, costly service delivery strategies and, consequently, high pricing of services (Önder and Özyıldırım, 2019). In terms of market size and market growth, the former has been argued to provide a higher return on successful innovative efforts, whereas the latter provides rents that can finance the innovation (Hannan and McDowell, 1984; Frame and White, 2004).

2.4 Bank Ownership

There is considerable interest in the literature on how the ownership form of a bank impacts the business of banking, particularly in the context of risk management and financial performance. The interest in this nexus draws heavily on the emergence of different forms of bank ownership structures, against the background of the financial reforms that most developing countries have undertaken, either as part of International Monetary Fund/World Bank funded Structural Adjustment Programs or, more recently, as part of the ongoing developments under the Basel Accord.

In the context of ownership impact on financial innovation, the literature has predominantly looked at whether a bank is a member of a holding company or not (Courchane et al., 2002; Furst et al., 2002; Nickerson and Sullivan, 2003; De Young et al., 2007; Sullivan and Wang, 2020). The hypothesis relating to the dichotomy between foreign, government and private ownership on bank adoption of BBI appears largely untested; other than being merely implied from the governance, skills transfer and profit motive narratives.

2.4.1 Bank Holding Company (BHC) Membership

There is widespread evidence supporting the view that a bank that is a member of a BHC is more likely to adopt BBI than independent banks, because of synergies prevalent within the group that make adoption of innovation to be perceived as less risky (Hannan and McDowell, 1984; Hannan and McDowell, 1987; Sinha and Chandrashekaran, 1992; Furst et al., 2002; Courchane et al., 2002; Frame and White, 2004; Sullivan and Wang, 2020).

This view is grounded in various premises. For example, a bank can benefit from lower costs resulting from shared platforms used to provide innovative services, if a holding company has a subsidiary ICT company. Furthermore, if the holding company has bank subsidiaries in other jurisdictions or subsidiaries that provide various types of financial services, it is possible that a bank within the group will profit from the experiences of other subsidiaries.

While the numerous above cited studies have provided evidence to support this nexus, worth highlighting is the caution against generalising the positive relationship between BHC membership and the adoption of innovation (Hannan and McDowell, 1987). This is against the background that organisational differences may also exist in the banks that are members of BHC and that the impact of those differences can alter the magnitude with which BHC membership can impact adoption of innovation.

2.4.2 Foreign Ownership

The economic impact of foreign bank penetration on host markets has been extensively researched. The literature hinges on the beneficial effect of foreign bank entry on host country's financial sector credit stability, efficiency, profitability, competition, quality of infrastructure and expanded access (Claessens et al., 2001; Clarke et al., 2001; De Haas and Naaborg, 2005).

Also widely documented is the spillover effect of the entrants' know-how, and expertise. This draws heavily on the foreign bank's application of innovations that have been tried and tested in other established jurisdictions where the parent of the foreign bank has subsidiaries (Thorne, 1993; Cull and Soledad Martinez Peria, 2010). Skills transfer can be harnessed through staff movements between the foreign bank and the other domestic banks that have emulated the innovations introduced into the market by the foreign bank.

The implied assumption underlying the preceding narrative is that foreign banks have a comparative advantage in terms of expertise in innovation and risk management (Hue, 2019). From the perspective of BBI, an important implication is whether the foreign banks can introduce, into the domestic market, new forms of BBI leveraging the experiences in other established markets where the foreign bank has business operations. However, on the other hand there is a body of literature arguing that domestic banks have better knowledge of the domestic market than do the foreign banks at the time of entry (Claessens et al., 2001; Kosmidou et al., 2004). Bearing testimony to this is the evidence of foreign banks' reluctance, vis-à-vis the domestic banks, to engage in business models that target opaque customers who are perceived to be risky in the absence of hard data on their financial activities (Mian, 2006; Sengupta, 2007; Gormley, 2010; Giannetti and Ongena, 2012)[5]. In this context, it has been stated that cream skimming strategies among the foreign banks, focusing on high-value or low-cost consumers while disregarding those deemed risky or less profitable, creates competition pressures on domestic banks by stealing corporate customers. In the end, to consolidate their market share, domestic banks have no choice but to expand their efforts towards the otherwise opaque retail clients about whom they have soft information (Stiglitz, 2002; Wu et al., 2017).

The implications for BBI hinge on two empirical questions. Firstly, does foreign bank presence crowd out implementation of BBI as a strategy that primarily targets retail customers who are perceived as risky by foreign banks? Secondly, do competition pressures from foreign banks compel domestic banks to consolidate their market share by following their foreign competitors in providing new services that frequently require cutting-edge technology?

An important insight highlighted in the literature on foreign bank ownership is how the form in which the foreign bank entered the domestic market, as well as the financial condition of the foreign bank's parent institution, both matter for the impact of foreign bank ownership on the domestic economy. The impact is greater if the foreign bank is a subsidiary of a foreign conglomerate, as it will receive more consistent financial and technical assistance from the parent; and if the foreign bank enters the host market in the form of greenfield investment rather than through mergers and acquisition (De Haas and Naaborg, 2005; De Haas and Van Lelyveld, 2006; Wu et al., 2017). Takeover foreign banks, according to this narrative, have more independence to make quick business decisions, whereas greenfield foreign banks are more driven by parent entities. This is because, in the case of takeovers, local management is frequently maintained for a significant period of time before risk management processes can be fully matched with those of the parent bank. Many greenfield foreign banks, on the other hand, are firmly ingrained in the parent company's structure, with home country executives frequently dispatched to build up the new institution while still employing the parent bank's risk management procedures.

---

[5] Little wonder, there has not been a significant association between foreign ownership of banks and financial inclusion (Sarma and Pais, 2011).

In the end, what comes clear from this analysis is that while the economic impact of foreign bank penetration on host markets has been extensively documented, the impact of foreign bank presence on the risk of domestic banks is still ambiguous, both theoretically and empirically. More importantly, considerable focus of this impact on domestic banks' risk has been around profitability and credit risk, while the operational risk dimension remains empirically untested.

On that basis, a study that tests the nexus between foreign ownership and adoption of BBI can help us to answer key questions on whether the foreign banks can introduce, into the domestic market, new forms of BBI leveraging the experiences in other established markets where the foreign bank has business operations; or whether foreign bank presence crowds out implementation of BBI as a strategy that primarily targets retail customers who are perceived as risky by foreign banks. This inquiry sets the stage for further investigation into whether competition from foreign players compels domestic financial institutions to adopt cutting-edge innovation in order to consolidate their market share.

2.4.3 Government Ownership

The debate on the role of state ownership of enterprises has been well documented in the literature. These have broadly rested on three alternative theories, namely the social view, the political view, and the agency view.

Firstly, the social view advocates for government control of businesses as a means of addressing market flaws and imperfections such as monopoly power and externalities, while also maximising social welfare (Stiglitz and Weiss, 1981; Greenwald and Stiglitz, 1986; Shleifer, 1998; Atkinson and Stiglitz, 2015). Inferred from this narrative, government ownership therefore would arguably compel service delivery even to sparsely populated areas, which private entities would deem risky and unprofitable.

Secondly, the agency view is compatible with the social view only to the degree that both schools see government ownership as attempting to address market failures by implementing activities that bolster social welfare. The point of departure, however, is that the agency view acknowledges that government has its own failures, implying that the social view's conclusions are overly positive. The agency view cites state ownership as being prone to exacerbating corruption and misallocation (Banerjee, 1997; Hart et al., 1997). Specifically, managerial incentives in state-owned enterprises are typically weakened due to government bureaucracy and the various non-measurable goals that state enterprises aim to maximise (Tirole, 1994). Thus, while social welfare interests may be compelling for government ownership, the agency view is that mis-governance may occur in the misallocation of resources because public managers divert resources for private use (Banerjee, 1997).

Thirdly, the political view shares the agency view that mis-governance can exist in the misallocation of resources if government owns enterprises. Unlike the agency view, which blames any misallocation of resources on a lack of managerial motivation, the political view premises this misallocation of resources on political capture, in which politicians' self-interest redirect state funds to areas where there is political benefaction, or to fund allies at the expense of social welfare maximisation (Shleifer and Vishny, 1994; Shleifer, 1998; La Porta et al., 2002; Sapienza, 2004; Clarke et al., 2005; Dinç, 2005).

In the context of banks as enterprises, there is widespread evidence regarding how state control causes banks to underperform (Barth et al., 2004; Beck et al., 2004; Berger et al., 2004). The evidence of the underperformance of government owned banks has been multi-pronged. Firstly, state owned banks are associated with low levels of financial development (Barth et al., 2001). Secondly, there is evidence with regard to greater credit risk and financial loss position of government-owned banks vis-à-vis the private sector banks (Iannotta et al., 2007; Cornett et al., 2010).

It has been widely argued that government ownership affects bank risk taking due to weak managerial incentives, political interference, poor governance and capitalisation (Gourlay and Pentecost, 2002; La Porta et al., 2002; Barth et al., 2004; Beck et al., 2004; Dinç, 2005; Shen and Lin, 2012). Further, it is also documented that government investment decisions in firms are seldom driven by the profit motive; and that its preoccupation with broader political objectives, either national or private, can crowd out commitment towards business strategies in the government owned banks (Altunbas et al., 2001; Barth et al., 2004; Beck et al., 2004; Athanasoglou et al., 2008; Hagendorff, 2014). Arguably, the above premises boil down to the agency view and political view on state ownership of enterprises.

While there is much evidence associating state ownership of banks with underperformance, the impact of government ownership of banks on bank adoption of innovation, let alone BBI, is largely untested. Testing the impact of government ownership on bank adoption of BBI would add to the body of knowledge on how policy can help address the agency and political aspects of state ownership on enterprises can be averted, to bolster the social welfare maximisation objective.

2.5 Conclusion

This review of the literature has been undertaken with the objective of establishing the scholarly significance of the research problem, by analysing previous research around BBI, discussing the conceptual framework and theoretical underpinnings and, most importantly, highlighting the gaps that exist in the literature. The study has brought together the various strands of BBI research, both from the perspective of financial service customers and financial service providers.

Consumer-side research has looked at a variety of topics, including consumer perceptions of BBI, adoption barriers, and how demographic factors including gender, income, and education levels have influenced adoption trends. What this study reveals is that customer-side BBI studies are numerous, and that they have advanced our understanding of the demand-side of BBI. However, there have been relatively few empirical studies undertaken from the perspective of financial service providers in developing countries. Most studies that do exist have focused on developed economies such as Italy, Spain, the United Kingdom and the United States of America, and emerging markets such as China, and jurisdictions with well-developed financial structures and substantial progress in digital finance, such as India. At any rate, these studies provide mixed results making it even more difficult to be generalised for Sub-Saharan Africa.

The few studies that have been conducted for Africa's developing countries have often been descriptive in nature. Furthermore, the few studies that have taken an institutional perspective have often relied on bank managers' viewpoints obtained through formal questionnaires, which are prone to respondent biases. More recently, other studies have relied on published annual data that often do not span a long period of time. Thus, there is a striking dearth of studies on the financial services providers' side that use more granular yet reliable data to understand the firm level drivers of BBI, particularly the often less inclusive, less mature, and small banking systems of developing countries, where payment transactions are predominantly cash based.

Secondly, most of the previous empirical studies have analysed individually one form of BBI. Considering that BBI are of different forms and that these forms suit differently the different categories of customers, a study that comprehensively captures more forms of BBI should be more informative and robust in guiding public policy that seeks to incentivise bank implementation of BBI strategies to bolster financial inclusion. The quest to understand these incentives is an important gap in research that was identified in the literature (see, Frame and White, 2004; Dermish et al., 2012).

Lastly, it is acknowledged that various reforms have been implemented in financial systems of most developing countries, altering the financial sector architecture from predominantly government ownership of banks to either private ownership, foreign banks, listed banks and more recently, banks belonging to holding companies. This notwithstanding, the foregoing survey of literature notes that many of the empirical studies on the relationship between bank ownership and adoption of innovation have often confined themselves to testing whether a bank being the member of a holding company increases its likelihood to adopt innovation. Also, while there have been numerous studies exploring the impact of foreign ownership of banks on the credit risk and profitability of domestic banking systems, to the best of our knowledge there has been little focus on the implications of foreign bank ownership and government ownership on domestic banking sector operational risk, let alone on the adoption of BBI. These hypotheses remain largely untested for developing countries with small and less developed financial systems.

A shareholder with a higher percentage of shares in a bank would be more motivated and empowered to oversee the bank's management in implementing a plan that aligns with the shareholders' broader vision. Testing whether the various forms of bank ownership impact adoption of BBI by banks would be novel and critical in informing policy around bank licensing and shareholding regulatory requirements; and how the tone of financial inclusion needs of developing countries can be set right at the point of entry into the financial systems in developing countries.

In the final analysis, the gaps and ambiguities found in the preceding literature review provide strong motivation for further research into the factors that drive banks in developing countries to implement BBI strategies.

Chapter 3: Dimensions of BBI in Malawi

3.1 Introduction

The preceding chapter has helped to establish the scholarly significance of the research problem by first discussing the TOE as a theoretical underpinning on the adoption of innovation by firms. Secondly, by drawing on the TOE to analyse previous empirical studies, Chapter 2 helped identify key themes that emerge from the BBI literature and highlight the gaps that are being addressed in the current research.

Chapter 3 puts the current research into perspective by discussing the various classifications of BBI, the trends in the implementation of the different forms of BBI as well as the patterns of adoption across the different banks in Malawi. By looking into the Malawi context, the chapter provides justification for the choice of the different forms of BBI employed in this research and how the data create scope for more detailed quantitative analytical enquiry that is undertaken in Chapter 4 and further, in Chapter 5. The significant elements of the data used in this research are restricted access and cannot be reproduced under the Data Provider Agreement.

3.2 Overview of the Malawi Banking sector

An overview of the Malawi banking sector provides an important starting point to the understanding of the broad developments in the context of financial innovations in Malawi; and how lessons learnt from this sector can be applied to the other sub-sectors of the financial system such as the micro finance, insurance and capital markets.

The banking sector is important for several reasons. Firstly, the banking sector in Malawi is the largest subsector of the Malawi financial system; accounting for more than 60 percent of the total assets of the financial system, 92 percent of total credit and 89 percent of total deposits. According to the Reserve Bank of Malawi (2020), the total assets held by the banking system as of December 2019 was estimated at MK1, 890.2 billion (about US$2.455 billion); against MK878.1 billion (about US$ 1.14 billion) for Pensions Sector; MK55.8 billion (about US$ 0.07 billion) for General Insurance Sector, MK731.9 billion (about US$ 0.95 billion) for Life Insurance Sector and MK43.8 billion (about US$ 0.06 billion) for the microfinance sector. Secondly, the banking sector impacts the provision of all financial services, both directly and indirectly. Banks provide direct savings, credit, and payment services and many also serve as agents for insurance companies. Banks serve more Malawians adults than any other financial service provider, according to FinScope 2014. For instance, 27% of adults use banks in some way compared to 17% for other non-bank formal providers and 25% for informal providers.

The above notwithstanding, the banking sector in Malawi remains relatively small in comparison with other countries in the region with similar characteristics. This is despite the entry of foreign banks both in the form of takeovers and greenfield investments. Due to stringent regulatory controls, market dominance by government-owned banks was not uncommon in Africa's banking systems throughout the 1980s. It was necessary to facilitate the entry of new participants into the sector in order to create a more stable and competitive financial system that would improve quality, access, and utilisation of formal financial services. In this regard, Malawi's financial sector liberalisation reforms, which began in the early 1990s under the IMF/World Bank Structural Adjustment Program and the country's obligations under the World Trade Organization's General Agreement on Trade in Services (GATS), both paved way for the entry of foreign banks (Chirwa and Mlachira, 2004; Nkowani, 2008). The first foreign shareholders entered the market in 1994. At that point, Malawi had only two banks. However, by 2005 the number had increased to 14. It later dropped to 9 as at the end of 2019, on account of numerous mergers and acquisitions.

According to the Reserve Bank of Malawi (2020), five of the nine banks in 2019 were privately owned by Malawians and accounted for 57.4 percent of total net assets, up from 56.4 percent in 2018. The remaining 42.6 percent of total net assets in 2019 was on account of 4 foreign banks. Their share of total net assets in 2018 was 43.6 percent. The growth of holding corporations as a method to capture synergies in the context of shared technology, management knowledge, and other business related forward and backward linkages within the group has been evident in Sub Sahara Africa region. For Malawi, while it is mostly the foreign banks that are subsidiaries of financial conglomerates or bank holding companies, the development has not spared the local investors who have followed from the foreign investors to establish bank holding companies to exploit the synergies. Despite financial liberalisation and the attendant entry of diverse categories of banks, the problems of market concentration, limited competition, high costs and limited financial inclusion continue to exist. As has been discussed in the preceding chapters, these have been shown in the development finance literature from elsewhere to be of interest in the implementation of BBI.

Profitability in the banking sector is relatively high compared to other financial subsectors, with average Return on Equity (ROE) of 20.1 in 2015; 20.4 in 2016; 15.7 in 2017; 17.3 in 2018; 20.5 in 2019 and 25.5 percent. The business model of banks in Malawi has historically focused on interest, investment, and forex revenue with only 6% of revenue being from fees and commissions. While high profitability has attracted new entrants into the banking sector, non-price monopolistic competition has tended to limit new entrants' expansion, resulting in a duopolistic market structure (Kaluwa and Chirwa, 2017).

The restrictions placed by the Data Provider Agreement prevent the provision of highly disaggregated data per bank. It is therefore not possible to rank the individual banks by size or any relevant information that does not compromise confidentiality. However, Table 3.1 provides summary of the aggregate share of assets and deposits of 3 large banks as a percentage of the entire banking sector in Malawi; depicting the highly concentrated nature of the sector.

Table 3.1 The 3 largest banks as a percentage of total banking sector in Malawi

Year	Asset	Deposits
2014	63.80	65.65
2015	62.10	61.70
2016	59.60	61.92
2017	66.10	60.29
2018	57.49	57.70
2019	55.17	56.00
2020	58.50	58.6

Source: Author calculation based on Reserve Bank of Malawi data

In addition, Table 3.2 shows the size of assets and deposits of bank 3 as a percentage of assets and deposits of bank 2. This highlights the oligopolistic nature of the sector and how the bank size narrative should therefore matter in the exploration of the diffusion and adoption of BBI.

Table 3.2 Size of bank 3 as a percentage of bank 2

Year	Assets	Deposits
2014	39.3	35.0
2015	40.8	36.4
2016	30.2	31.2
2017	26.5	30.0
2018	33.4	42.9
2019	41.4	49.3
2020	44.9	48.2

Source: Author calculation based on Reserve Bank of Malawi data

As already alluded to, the Malawi banking sector is small relative to other banking sectors within the Sub Sahara Africa region (Tsoka, 2006; Kaluwa and Chirwa, 2017). An important question rests on whether such small market would limit the business viability for banks to invest in costly technology necessary for the implementation of innovative delivery strategies. In that regard, would market concentration infer a large secure market for which investment of costly technological investment supportive of branchless banking innovations would be financially viable? Or would market concentration disincentivise market efficiency and limit scope for innovation? These questions remain largely untested.

In Malawi, conventional brick and mortar branches have long served as the primary means of providing banking services. The bank branch model, which signifies a bank's presence, has been essential in building the bank's brand. For other BBI, like ATMs and agent banking, to gain operational support and address customer complaints, the bank branch model continues to be a crucial platform. Bank branches have remained an important mode of providing financial services, particularly among those who are less likely to use new channels, such as the elderly and those with low literacy. Given Malawi's high poverty rates and rural population, it is estimated that 99 percent of financial transactions were cash-based; however, there has been a remarkable improvement in the uptake of digital payment technologies by 2017; owing to significant regulatory reforms and infrastructure developments (Malawi Government, 2017). Nonetheless, the majority of BBI have not yet reached a stage of development where their product scope is equal to or greater than that of traditional bank branches, so bank branches continue to thrive. Table 3.2 compares Malawi's digital adoption to the Sub-Saharan African average. With the exception of using the internet to pay bills or buy products and services online, the rest of the dimensions of digital uptake indicate that Malawi has lagged behind in terms of digital adoption.

Table 3.3 Uptake of digital payments in Malawi in relation to Sub Sahara Africa

Digital payments in the past year (% age 15+)	Malawi	Sub-Saharan
Made or received digital payments	27.6	34.4
Used an account to pay utility bills	4.5	7.7
Used an account to receive private sector wages	4.9	5.7
Used an account to receive government payments	4.4	7.3
Used the internet to pay bills or to buy something online	8.3	7.6
Used a mobile phone or the internet to access an account	20.1	20.8
Used a debit or credit card to make a purchase	2.0	7.5

Source: *Demirgüç-Kunt, Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. World Bank: Washington, DC.*

This notwithstanding, the establishment of branches have tended to be costly. The sunk costs of opening a branch are considerable, for example, because of the financial regulator's safety regulations, as well as other standards set by the Town/City Assembly authorities and other government agencies. Banks' ability to grow beyond big cities and towns has been hampered by these exorbitant costs. The establishment of bank branches in rural areas has been deemed commercially unviable due to the generally low and irregular transactions among rural people, the majority of whom rely on seasonal agriculture. In spite of this, government ownership in banks has helped bolster establishment of branch outreach with the view to advancing government’s social welfare maximisation objective of ensuring that banking services are availed even to the remote areas where traditionally pure economic merits would deem them as risky and costly to reach.

3.3 BBI Classifications

BBI are in different forms, and their model classifications are equally disparate. One classification looks at BBI from the lens of the category of institution promoting the scheme (Lyman et al., 2006; Siedek, 2008; Mwando, 2013). Under this perspective, BBI are categorised as either bank-led models, bank-focused models or non-bank models.

The bank-led model entails a bank as a principal deploying financial services to its existing customers in ways that heavily rely on third parties/agents as customer focal points. Customers have a clear contractual arrangement with the bank, deposit taking microfinance or any prudentially licensed institution, because it is the principal in this model. Bank focused models are a variant of the bank-led model in that consumer access to their bank accounts is restricted to the use of bank-approved ATM cards and internet networks. Non-bank models on the other hand, are transactional networks made available by telecommunications providers and other Fintechs to help customers gain access to structured financial services without having to open a bank account. In this model, the bank's role is limited to offering trust account services to the telecommunications company/subsidiary that provides mobile money services; hence, customers do not have a direct contractual relationship with the bank or prudentially regulated entity in this context.

Somewhat complementing the above classification is a different approach that distinguishes BBI based on their target customer segment, in particular whether the innovation predominantly targets consumers who already have a bank account on the one hand or those that do not have an account but have the potential to be banked (Porteous, 2006). Understood from this distinction, additive models of BBI are those channels for use by existing bank account holders and thus which benefit financial inclusion from the point of view of increased usage and improved quality of services (Saxena, 2017; Buri et al., 2019). They are additive to the extent that they ride on the existing traditional models, to offer alternative or additional channels with which to access the existing bank accounts. Transformational methods, on the other hand, are BBI that seek to reach out to markets beyond the frontiers of the existing customers of a particular provider, by providing a product that meets the known needs of those unbanked segments.

While this dichotomy is important for financial inclusion impact assessment more broadly, it nonetheless overlooks the financial inclusion implication of those unbanked that access formal financial services indirectly through use of accounts owned by their banked friends and relatives. Apart from that, this distinction is simplistic as it overlooks the dynamic nature of product development in the context of how the BBI have evolved over the years in terms of their design and service offerings; it thus blurs the dichotomy between what should be additive and what should be transformative. As discussed in Chapter 1, the current study distinguishes between physical BBI and remote BBI.

On the one hand, physical BBI are the primary forms of BBI for consumers where bank branding and physical interaction are important. Arguably, this form of BBI is important for agrarian economic systems of developing countries where financial transactions are predominantly cash based, particularly among the low-end consumers with low literacy levels (FinMark Trust, 2012; Buckley et al., 2015). This is critical given the low consumer trust in e-commerce and the lack of access to crucial infrastructure for processing e-commerce among many consumers in most developing countries (Nitsure, 2003; Kumar, 2013; Allen et al., 2014; Chikalipah, 2017).

On the other hand, remote BBI are the opposite of physical BBI as they enable access to financial services from the comfort of one's home, school or place of work, without needing to travel to be in physical contact with an ATM or a bank agent, as is the case with physical BBI. In this regard, the ubiquity of the mobile telephone and the internet are helping transition economies towards cashless strategies, therefore making space for remote BBI such as internet banking and mobile banking (Kimenyi and Ndung'u, 2009; Gosavi, 2015; Jack and Suri, 2016; Edo et al., 2019; Asongu and Nwachukwu, 2019).

While this distinction may have been heightened by the social distance implications arising from the Covid 19 pandemic, the insights from this dichotomy nonetheless have far-reaching implications for policy that seeks to deliver a financial inclusion regime that is safer health wise, as well as more relevant for the different classes of banking consumers that are targeted. The following section discusses the various forms of physical and remote BBIs in the context of Malawi in greater detail.

3.4 Physical BBI

The above attributes considered, ATM and agent banking provide good examples of physical BBI. Until recently, the former have mostly been located within branch premises, or in an area where personnel from a bank provide round the clock security or periodically visit to check functionality and liquidity (Campion and Halpern, 2001; Gourlay and Pentecost, 2002; McAndrews, 2003). The latter are physical structures such as chain stores, local grocery shops, gas stations etc, that are subcontracted by the banks and are branded accordingly. The trust that these forms of BBI provide to the consumers stems from the fact that they have physical structures and that they are operated by entrepreneurs who are well known within the area (King'ang'ai et al., 2016; Cull et al., 2018).

ATM banking is one of the earliest forms of BBI within the broader smartcard innovation (Gourlay and Pentecost, 2002). ATM banking innovation, in its current state, offers a limited range of products/services that are often basic. These include cash withdrawals, balance enquiries, mobile phone top up purchases, mini statement requests, limited cash transfers between accounts owned by the same person and in the same bank, as well as payment of utility bills. However, recently there have been developments in the ATM product space with some ATM machines accepting cash deposits, fund-withdrawal from a bank account without necessarily requiring use of an ATM card, as well as fund transfers to an account in a different bank or to a mobile money account.

ATM innovation offers enormous benefits to the various stakeholders. To begin with, ATMs are advantageous to cardholders because they reduce transportation costs and time especially with the introduction of off-site ATMs in non-branch locations near where customers live, work, and shop. These benefits are substantial, especially where regulation around interoperability results in customers of different banks being able to access banking services using the ATMs of other banks at reasonable fees (Salop, 1990; McAndrews, 1991). Secondly, retailers benefit from ATMs through increased sales arising from the consumer convenience of drawing cash from within the retail shops or their vicinity. They also provide retailers with an alternative revenue stream in the form of transaction fees received from consumers who use the retailers' ATMs (Campion and Halpern, 2001). Thirdly, financial institutions profit from lower costs of serving retail customers as a result of shorter lines in banking halls and thus easing pressure to hire more bank tellers as the customer base grows. In addition, branded off premise ATMs extend the bank's visibility and thus provide reassurance of the bank's reach beyond the branch (McAndrews, 2003). ATM technology serves as a foundation for other BBI, such as debit and credit cards, which are also available to the unbanked, thus blurring Porteous' additive/transformative dichotomy.

Malawi is still predominantly a cash-based, as seen by the numerous cash-related products offered via ATM, which is the country's most widely utilised banking technology. Malawi Country Diagnostic study of 2015 by the Bankable Frontier Associates backs up this point of view. According to the report, over 99 percent of payments initiated by individuals, businesses, and the government in 2013 were made in cash. This is also mentioned in Malawi's National Strategy for Financial Inclusion 2017, which states that as of 2017, 99 percent of transactions were still done in cash (Government of Malawi, 2017).

In terms of bank adoption of ATM banking innovation, Figure 3.1 shows that adoption is not limited to specific types of banks but is spread across all banks both large and small. Appendix 3.1 also reveals a typically positive correlation among ATM banking innovations at different institutions, reflecting that a majority of banks continue to grow the use of ATM banking techniques considering that the country remains primarily cash based (Government of Malawi, 2017). This is not withstanding a few cases in which this association is negative, particularly due to rationalisation brought about by bank mergers and acquisitions (see, Reserve Bank of Malawi, 2021).

Figure 3.1 ATM banking adoption by bank

Having discussed ATM banking innovation, the following section looks at Agent banking innovation as another dimension of physical BBI that leverages physical contact to bolster consumer trust. Bank agents are local retail outlets such as pharmacies, supermarkets, convenience stores, lottery outlets and post offices that have been contracted by banks to process clients' transactions on the bank's behalf (Kumar et al., 2006; Vutsengwa and Ngugi, 2013; Buri et al., 2018; Buri et al., 2019). An important aspect worth highlighting are the reasons why agent banking has become transformative in providing access to financial services, even over branch-based provision. Firstly, poorer rural clients often lack knowledge of financial products and rely on the trust they have in a local agent to help them complete the transaction (Vutsengwa and Ngugi, 2013; Owiti and Datche, 2015; King'ang'ai et al., 2016; Cull et al., 2018; Zaffar et al., 2019).

However, this is not to imply that agent banking is not entirely without trust issues, particularly in the early stages. For example, recent research suggests that certain small agents may refuse large deposits for fear of robbery or may refuse large withdrawals due to lack of liquidity. Clients may also be unable to conduct significant transactions with the agent due to privacy concerns, as the agent may discuss the transaction with the client's friends and family (Buri et al., 2018; Bachas et al., 2021). Evidently, what is clear from this is that agent banking involves trade-offs between low transaction costs on the one hand and low privacy and transaction limits on the other hand. These are critical issues that product developers and policy makers should be concerned with if agent banking innovation is to help bolster more sustainable usage, beyond merely increasing access to formal finance.

In terms of banks' adoption of agent banking innovation in Malawi, we see in Figure 3.2 that three of the thirteen banks did not embrace agent banking innovation. We also see that agent banking innovation is being implemented at different levels by ten banks that have adopted it. This is also reflected in Appendix 3.2 where we see both positive and negative correlations in the implementation of agent banking strategies across the banks, necessitates further enquiry into what characteristics of banks influence adoption of this innovation.

Figure 3.2 Agent banking adoption by bank

In the final analysis, a pairwise correlation analysis was performed to determine the relationship between the two types of physical BBI. The correlation matrix in Appendix 3.3 shows that, of the 13 banks, 8 have a positive correlation with regard to ATM and agent BBI implementation, while 3 have an inverse relationship. We interpret this as confirming that, as previously discussed, both types of BBI are well suited for the predominantly cash transaction customers; subject however to minor variations in the fundamental characteristics that these innovations possess, which may influence how banks adopt the two innovations.

3.5 Remote BBI

Having discussed physical BBI in the context of ATM and agent banking innovations in Malawi, it follows that we explore the remote BBI context in more detail. As earlier highlighted, internet banking and mobile phone banking are two examples of remote banking innovations to the extent that they enable consumers to access financial services without any direct interface with a physical branch infrastructure or bank ATM, bank agent (Allen et al., 2014).

A key feature of internet banking and mobile phone banking innovations resides in how both innovations have leveraged the ubiquity of technology to attract new consumers, particularly for the banks that do not have a wide network of branches (Furst et al., 2002; Corrocher,2006; Malhotra and Singh, 2010). However similar, internet banking has been growing in importance as a channel for banking, both for the retail as well as the corporate clients. On the other hand, mobile phone banking has mostly been exclusive to retail customers in so far as large corporates would find it risky for company business transactions to be made via a personal mobile phone. Moreover, transactional limits for mobile phone banking tend to be lower than those applicable to internet banking and therefore to the detriment of corporate business financial needs[6]. This disparity in internet and mobile phone banking innovations product appeal for corporate and retail consumers respectively is

[6]Mobile phone banking nonetheless provides an indirect avenue through which the corporates can receive bill payments from retail consumers of the corporate's products and services.

reflected in the increasingly inverse relationship between internet banking and mobile phone banking as remote BBI. According to Appendix 3.4, six banks have an inverse relationship between their internet banking and mobile phone banking strategies, five banks have a positive relationship, and two banks do not have enough data to draw correlation insights. In contrast, physical BBI in Appendix 3.3 had mostly positive correlation between ATM and agent banking strategies because both forms target same customer segment, the retail clientele.

Internet banking refers to the use of the internet as a delivery channel for banking services such as checking bank account information, funds transfer and bill payments through bank websites (Yiu et al., 2007; Clemes et al., 2012). In terms of bank implementation, Appendix 3.5 shows both positive and negative correlations in the implementation of internet banking strategies across the banks. More importantly, we see in Figure 3.3 that internet banking has been registering exponential growth, both in terms of volume of transactions and number of subscribers in Malawi. This development can be attributed to regulatory reforms and infrastructure developments. The Reserve Bank of Malawi's establishment of the National Switch (Natswitch) in 2015, which marked a significant shift in Malawi's payment systems, is notable in this regard. The switch presented an important opportunity to expand the reach of financial infrastructure. All banks and mobile network operators were included in the switch. RBM established a national taskforce on electronic payments the same year in order to increase the use of electronic payments. In terms of regulation, the National Payment Systems Bill became law in 2016, providing greater transparency and clarity regarding RBM oversight of payment systems, and the Communications Act was amended in 2016 to regulate and monitor the provision of communications services, including mobile money operators. The Electronic Transactions and Cyber-security Act was also passed that year, and it provides for the verification of electronic signatures for use in electronic transactions, among other things. This contributed to steering the growth of online transactions. In 2017, the RBM issued the Interoperability of Retail Payments Directive, which established minimum requirements for retail payment system interoperability.

Figure 3.3 Internet banking subscribers & volumes

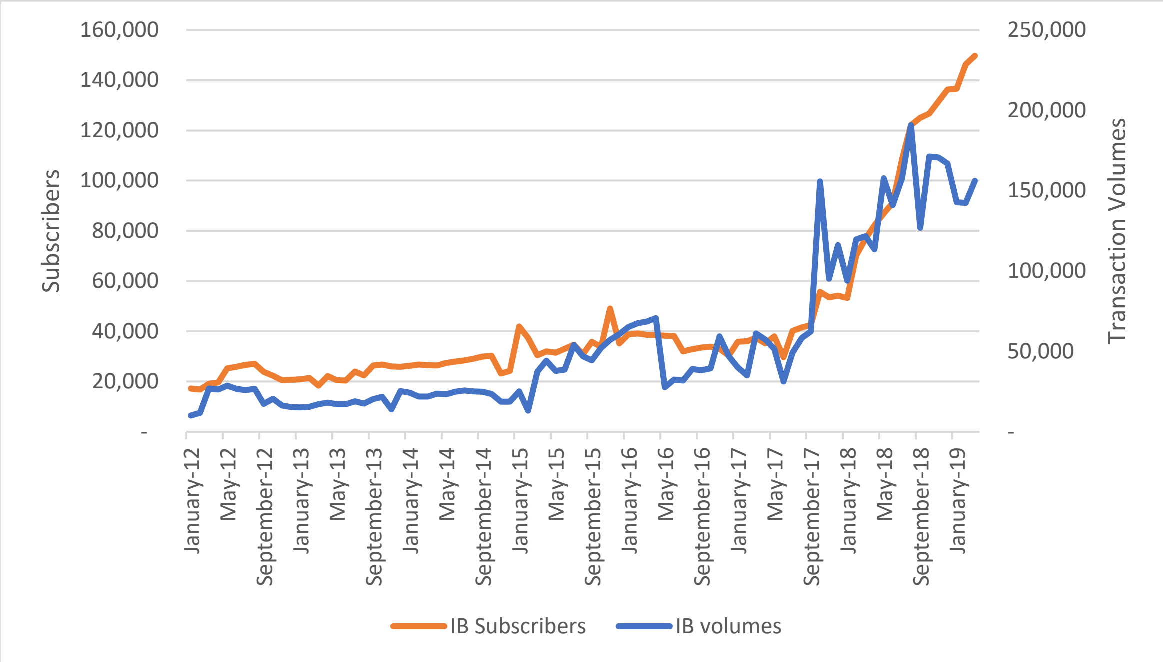


Figure 3.4 depicts a further diagnosis in the context of adoption of internet banking innovation by bank. A key pattern that emerges from the figure relates to greater and rapid adoption of internet banking by two banks, compared to the remaining eleven banks. The banking sector in Malawi is dominated by the two largest banks, which account for more than half of corporate clients (Kaluwa and Chirwa, 2017). Considering that internet banking is the innovation of preference for corporates, over the other forms of BBI such as mobile phone banking which often have lower transaction limits as earlier noted, it can be surmised that the two large adopters of internet banking above are the two largest banks. Large banks have been argued to preferentially target corporates for their high-value/low-volume transactions, as opposed to retail clients, whose transactions are typically low-value/high volume and are perceived to be riskier (Kabango, 2009; Dermish et al., 2012; Turkson et al., 2020).

Figure 3.4 Internet banking adoption by bank

The preceding discussion of internet banking innovation as a dimension of remote BBI necessitates an examination of another form of remote BBI, namely mobile phone banking. Mobile phone banking is where services like those under internet banking are delivered via a mobile phone. In essence, with a mobile phone a consumer can undertake internet banking transactions leveraging internet connectivity via the smartphone. Apart from that, mobile phones have enabled banks to provide financial services via bank apps that can be downloaded onto mobile phones. Recently, banks have been able to provide basic financial services through the WhatsApp platform.

In addition, and perhaps more importantly, basic mobile phones allow consumers to conduct financial transactions without the need for internet connectivity or data on their phone. In this sense, consumers can conduct financial transactions by utilising what is known as Unstructured Supplementary Service Data (USSD). These are the communication protocols that GSM cellular phones use to communicate with the computers of mobile network operators in order to deliver mobile money services via codes (Mazer and Rowan, 2016). Unlike the Short Message Service (SMS), which allows consumers to conduct basic financial transactions, the USSD message establishes a real-time connection that allows consumers to interact with their bank by selecting options from various menus on their mobile phone (Robb and Vilakazi, 2016).

The USSD has been argued to be a better communication tool for increasing low-income customers' access to and use of financial services than smartphone apps that require internet connectivity or SMS, which have security and user experience concerns (Kanjo et al., 2017). This is despite the concerns raised about MNOs with telecommunications market power restricting other players' access to their USSD by charging a high price or providing low-quality USSD (Hanouch, 2015; Robb and Vilakazi, 2016). Because it restricts competitor access to the USSD, it tends to stymie scale in financial service delivery.

In Malawi, banks offer mobile banking services via the various channels discussed above. Figures 3.5 and 3.6 below depict a growing trend in both bank-led and Telco-led mobile banking innovation, both in terms of transaction volumes and number of subscribers.

Figure 3.5 Bank led mobile phone banking innovation

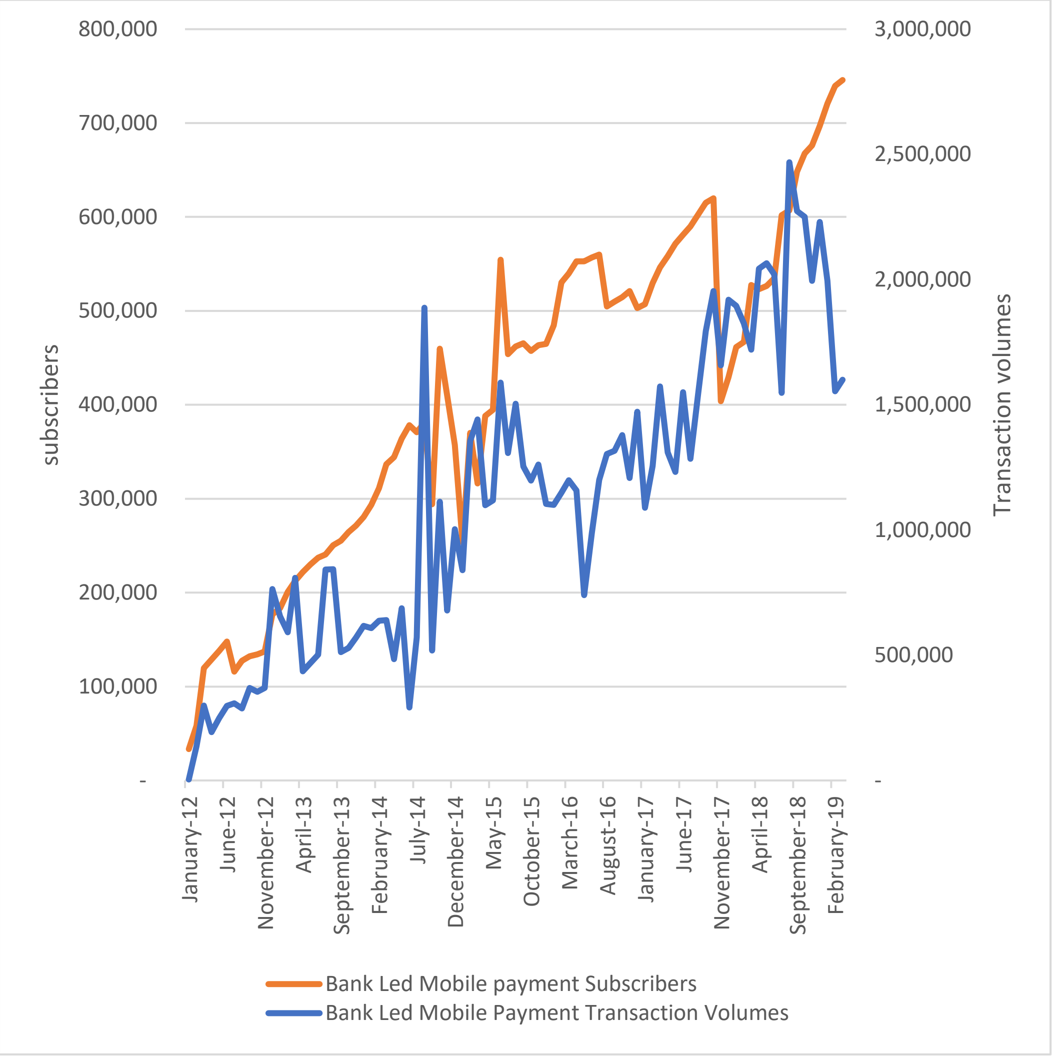
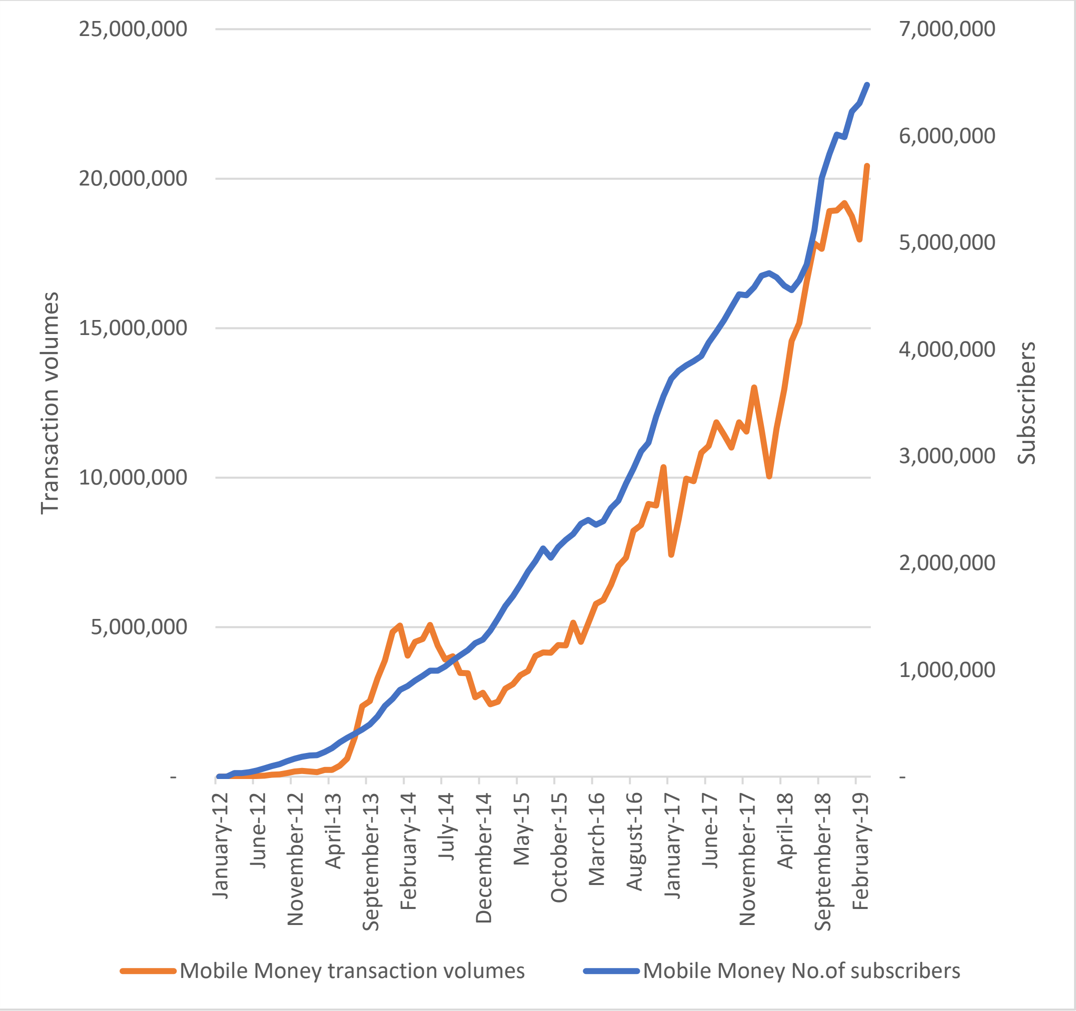
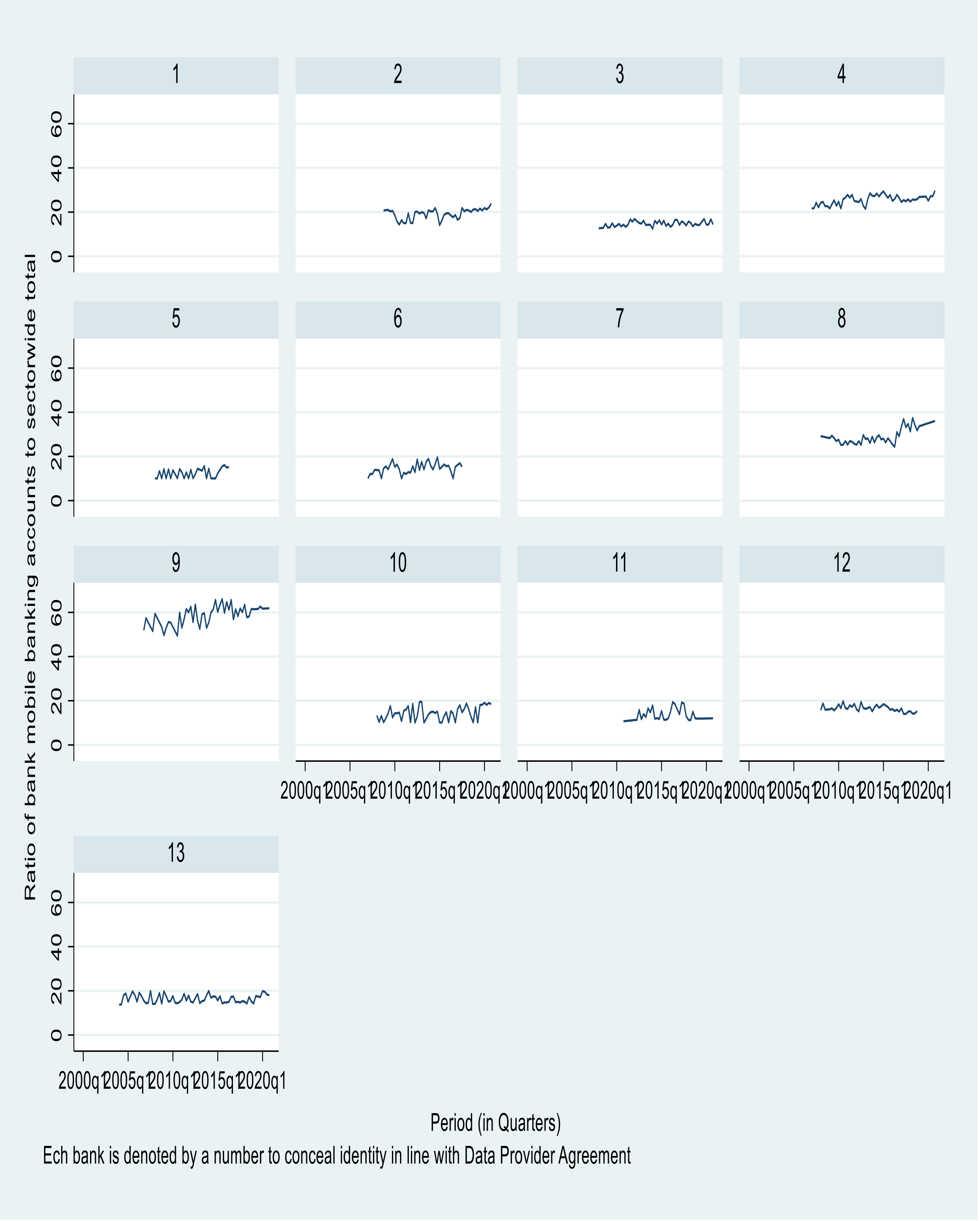


Figure 3.6 TELCO led mobile phone banking innovation



In the context of the adoption of mobile banking innovations by bank, from Appendix 3.6 we see both positive and negative correlation in the implementation of mobile phone banking strategies across the banks. Also, noteworthy from Figure 3.7 is that banks tend to fall within the same range in terms of adoption of mobile banking innovation. This is with the exception of one bank whose higher rates of adoption have been at the back of partnerships with donor funded non-governmental organisations to deliver financial products tailored for small scale businesses, women and youths especially in the rural areas. This is consistent with recent findings that show a positive relationship between the number of mobile phones per household and the likelihood of obtaining a loan (Montfaucon, 2020).

Figure 3.7 Adoption of mobile phone banking innovation by bank



Suffice it to note that the extent to which mobile money, and BBI more broadly, can sustainably deliver a more inclusive and cashless society, particularly to rural areas, would to a greater part depend on the underlying communications infrastructure and cost-effective business models for electronic service. This view is fortified by the fact that the relevant infrastructure, such as internet and mobile telephony in Malawi, have been rated among the most exorbitantly priced in the world (Government of Malawi, 2021; Makoza, 2021; World Bank, 2021).

A priori, the implication of the high mobile phone charges is that the financial inclusion benefits from mobile banking innovations would only accrue to the rich. However, for Malawi, a predominantly rural agriculture-based economy, the cost of accessing formal financial services through traditional bank branches is equally high, both in terms of the transportation cost to the distant bank branch and the opportunity cost in terms of time lost from productive activities such as farming (Dabalen et al., 2017). Thus, for most Malawians, the cost to access bank infrastructure far outweighs the direct cost of a bank or mobile money account (Government of Malawi, 2017). Similar trends have been documented for most developing countries.

Considering that the cost of accessing bank branches far outweighs the cost of transacting through mobile money innovations, it is surmised that the currently high cost of mobile phone services cannot completely deter the potential for BBI to impact positively on the development of more inclusive financial systems. This view is fortified in similar experiences of the Philippines, where mobile technology has lowered the cost of banking transactions such as cash deposit or withdrawal through mobile phone (Ivatury and Mas, 2008). Also, there is evidence that the cost of setting up a BBI model in Brazil formed only 0.5 percent of the cost of establishing a traditional bank branch (Kumar et al., 2006). Moreover, mobile banking is only one component in the broader cocktail of heterogeneous BBI for which individual preferences would dictate how they can be applied to serve their best interests in reducing the barriers relating to forgone time and long distance to get to a bank branch in the rural areas.

Notwithstanding the above cited *distance-and-forgone-time* gains from BBI, Malawi’s authorities have acknowledged the need to address the cost barrier to accessing formal financial services among the low-end consumers. Most notably, the Registrar of

Financial Institutions issued a decree in August 2017 prohibiting financial institutions from charging account maintenance fees on savings and on ordinary current accounts. Apart from that, Government has been negotiating with the mobile telecommunication companies to reduce the price of some of their products, particularly those targeting the rural and the poor.

In the financial analysis, considering that mobile penetration rates in Malawi are higher than the percentage of people who have access to formal financial services (19 percent), it can be argued that mobile phones provide an important access point for formal financial services if cost-effective business models are used to help alleviate the affordability issue that arises from low incomes among consumers, over and above addressing existing bottlenecks such as low financial literacy rates that hamper consumer trust in innovative technologies (Greenacre, 2014).

3.6 Conclusion

This chapter has put the research into perspective by discussing the various classifications of BBI. It has also looked into the Malawi context to BBI to provide justification for the various forms of BBI analysed in this research. This sets the tone for the quantitative analysis that follows in the next chapters.

Chapter 4: Static & Dynamic Model Approaches to the Analysis of Bank Adoption of BBI

4.1 Introduction

This chapter builds on the gaps and ambiguities identified in the literature, discussed in the Chapter 2, to analyse what drives adoption of BBI among the banking institutions in Malawi. Building on the contextual framework in Chapter 3, this chapter seeks to answer two of the study's research questions. Firstly, it seeks to establish from the widely cited variables, what factors drive bank adoption of BBI in Malawi. Further, it explores whether these factors vary between physical and remote BBI.

Using a panel of quarterly secondary data of all banks present in Malawi over the period 2001-2020, the chapter adopts the static model approach as a starting point, before delving into more rigorous analysis using the Auto Regressive Distributed Lag (ARDL) model, a widely used dynamic model. The ARDL model has several qualities that make it better suitable for analysing our dataset. For instance, it distinguishes between dependent and explanatory factors, thereby removing concerns about autocorrelation and endogeneity (Pesaran et al., 2001; Sakyi, 2011). Apart from that, it assesses both short and long run relationships at the same time, and can be used regardless of whether the regressors are I(0), I(1)(Sakyi, 2011). Additionally, it is asymptotically efficient and more robust in small and finite samples (Pattichis, 1999, Mah, 2000).

A key finding from the analysis is that bank adoption of both physical and remote BBI is largely a positive function of regulation and a negative function of bank size. Our findings also show that other drivers, such as bank technology, branch intensity, retail portfolio, management innovativeness market concentration and macro technology, have different impacts on physical and remote BBI. In this regard, we argue that regulation benefits financial institutions by lowering the risks associated with adoption of BBI, in line with the financial innovation literature (Boyd et al., 1998; Barth et al., 2008; Lumpkin, 2010, Gutierrez and Singh, 2013; Lee and Chih, 2013; Enyang Besong et al., 2021). Furthermore, we argue that small banks are more likely to adopt both physical and remote BBI because they often have less bureaucracy or fragmented and incompatible processes consistent with earlier literature on institutions (Segers, 1993; Nooteboom, 1994; Zhu et al., 2006; Sullivan and Wang, 2020). This allows them to use innovation to expand their market share by tapping into customer segments that are often underserved by large banks.

Divergent findings on the impact of branch intensity on adoption of different types of BBI are another crucial lesson for bank strategy. The positive relationship between branch intensity and physical BBI suggests that banks with large branch networks can use their branding and physical presence to enhance financial inclusion among the low end less sophisticated customers who use physical BBI (Saloner and Shepard, 1995). Unlike banks with a larger branch network, banks with fewer branches have less advantages in terms of physical presence and branding with which to create consumer trust among low-income rural consumers. They therefore would gain from remote BBI strategies, that provide them lower cost alternative with which to be accessed by the consumers (Corrocher, 2006; Furst et al., 2002; Malhotra and Singh, 2010).

The remainder of the chapter is structured as follows: Section 4.2 discusses the data and methodological approach. This is followed by a presentation of the empirical findings in Section 4.3 and a discussion of the empirical findings in Section 4.4. Section 4.5 provides policy implications drawn from the findings and a Conclusion is made in Section 4.6.

4.2 Data and Research Methods

4.2.1. Data

The study utilises a panel of quarterly secondary data of all banks present in Malawi over the period 2001-2020[7]. Panel data refers to cross sectional units that have been surveyed over time. Panel data give the analysis several advantages over cross sectional or time series data, from the point of view of increasing sample size, more variability, more degrees of freedom, and accounting for heterogeneity in the cross-sections. More specifically, panel data can address a broader range of issues relative to sole reliance on pure time series or pure cross-sectional data alone. The increase in the number of degrees of freedom enables meaningful hypothesis tests regarding how variables change over time. With pure time-series data, one would require a longer run of data to get enough observations (Baltagi, 2008;

[7] By 2020, the number of banks had fallen from 13 to 9 due to mergers and acquisitions.

Wooldridge, 2009). Panel analysis can also assist in reducing the impact of certain forms of omitted variable bias in regression results. It also introduces additional variations that can potentially mitigate multi-collinearity, a widespread problem in time series modelling (Wooldridge, 2009; Brooks, 2019).

Bank-specific variables are built from quarterly data on balance sheet items and income statements of banks submitted to the Reserve Bank of Malawi. These plus data on market concentration and BBI related regulation are drawn from databases of the Reserve Bank of Malawi, being the regulator of financial institutions in Malawi. In this sense, the above data are submitted by the banks to the regulator and in more granular form than can be publicly accessed through the annual reports of the individual banks. They are therefore the same data from which annual reports by the respective banks are generated, and thus should provide better coverage of what would arguably constitute the financial services providers' side of BBI. The above data are more comprehensive than what banks make publicly available. Their submission is audited, governed by law and validated by the regulators through stringent off site and on-site examinations. In this sense, it is much appropriate to collect and use statistical data in our research than the interview or qualitative survey data. They are however proprietary, not publicly available and so their dissemination is subject to Data Provider Agreement.

The following is a detailed description of the variables in terms of their definition, measurement and previous related studies that used them:

a) The dependent variable is branchless banking innovation. As discussed in Chapter 1, we offer a novel distinction between physical and remote forms of BBI; with ATM and agent banking innovations representing the former and mobile phone and internet banking innovations representing the latter. Consistent with previous literature (see: Escuer et al., 1991; Corrocher, 2006; Muthinja and Chipeta, 2018; Dorfleitner et al., 2019), ATM Banking Innovation is represented by the number of a bank's Auto-Teller Machines expressed as a percentage of the sector wide total. Agent banking innovation is represented by the number of a bank's agent outlets expressed as a percentage of the sector wide total. Internet banking innovation is represented in the literature by the number of a bank's internet enabled accounts expressed as a percentage of the sector wide total. Mobile Phone Banking Innovation is represented by the number of a bank's mobile phone-enabled accounts expressed as a percentage of the sector wide total.

b) Bank technology: Management Information Systems (MIS) is the backbone that allows branches and headquarters to communicate. MIS is required to meet the challenges of delivering financial services, particularly through the plurality of BBI. Banks in Malawi have been upgrading their MIS systems on a regular basis to meet the needs of the developing market as well as regulatory requirements. Malawi's ratification of the Basel II accord, for example, compelled banks upgrading their technology infrastructure in order to improve risk management, fraud control, and regulatory reporting. The need to adjust technology to adapt to low-value, high-volume transaction requirements is also critical. For high-volume/ low-value retail customers, the implication of implementing a low-volume/high value platform is high overheads arising from the need to increase labour intensity. All this necessitates the use of advanced technologies. T24 and Flexcube, for example, are common core banking systems that enable interconnection with existing and emerging BBI related payment systems. Given the low levels of technological development at the national level, these platforms and almost all other supporting technologies are imported. Other than personnel expenditures, bank technology accounts for a large portion of most banks' overhead costs in Malawi.

The ratio of total investment in systems and equipment to total assets has been used by most studies in the empirical literature to represent technological developments at the firm level (Pennings and Harianto, 1992; Furst et al., 2002; Malhotra and Singh, 2010). To account for the fact that behind every technology there is human capital, other studies have used the sum of ICT infrastructure costs plus personnel costs divided by total assets (Ammar and Ahmed, 2016; Chipeta and Muthinja, 2018; Muthinja and Chipeta, 2018). In this regard, this research drew on the above literature to measure bank technology by the value of a bank's ICT infrastructure and personnel costs expressed as a ratio of its total assets. The greater the value of this metric, the more advanced a bank's technology is, offering it a strategic advantage over competitors who rely on outdated hardware and software (Frame and White, 2004; Brown and Molla, 2005; Thulani et al., 2009; Malhotra and Singh, 2010; Ammar and Ahmed, 2016). The validity of this link stems from the ease with which innovations may be integrated and compatible with superior technology (Furst et al., 2002; Muthinja and Chipeta, 2018).

c) Branch intensity: Branch intensity has been represented in the empirical literature by either the number of branches of a bank expressed as a ratio of total number of bank branches in the sector or the number of branches as a ratio of total assets (Saloner and Shepard, 1995; Frame and White, 2004; Corrocher, 2006; Malhotra and Singh, 2010). Consistent with this literature, we measure branch intensity by the number of branches a bank as a percentage of its total assets. The higher the percentage, the larger the bank's branch network.

d) Retail portfolio*:* We represent retail portfolio by the share of demand deposits of a bank as a percentage of the bank's total deposits. This measure has been applied in similar research (see, Barras, 1990; Saloner and Shepard, 1995; Malhotra and Singh, 2010). Payments and withdrawals from checking accounts are regarded to be the most typical transactions undertaken under most BBI (Hannan and McDowell, 1984; Corrocher, 2006).

e) Bank funding: Bank funding, measured by the total deposits as a percentage of a bank's total assets, has been used in the empirical literature to proxy management innovativeness (Furst et al., 2002; Malhotra and Singh, 2010). As deposits constitute the traditional source of funding for assets by banks, banks that rely less on deposits to finance assets are perceived to have more innovative management, as they prefer to follow a more aggressive overall business strategy in order to achieve higher returns that can offset the high-cost funding (Cull and Peria, 2013; Asongu and Nwachukwu, 2018). A management team that is innovative is better positioned to drive a more innovative business strategy than management that is not innovative. The lower the ratio, the more innovative the bank's management.

f) Bank size: Bank size is represented in the literature by the logarithm of total assets for a bank. The evidence in the literature suggests that large banks are associated with higher adoption rates of innovation (Gourlay and Pentecost, 2002; Corrocher, 2006; Kaur and Kaur, 2018; Dorfleitner et al., 2019; Sullivan and Wang, 2020). This is because huge firms benefit from economies of scale as a result of the multiple activities they engage in, which would profit from innovation. This is in addition to the risk diversification benefits that come with a diverse range of business activities (Hannan and McDowell, 1984; Frame and White, 2004).

g) Market concentration: Market concentration is represented in the literature by the 3-bank concentration ratio of total deposits (Hannan and McDowell, 1984). In our case, a three-firm ratio is ideal because for developing countries like Malawi where industries typically have fewer firms, concentration ratios based on more than three firms may result in a ratio equal to 1.0 (Kabango, 2009). The Malawi banking sector is highly concentrated; with three largest banks owning 60.4 percent of the banking system's total assets as of the end of 2020; 59.6 percent as at end 2015, and 63.8 percent held in 2010 (Reserve Bank of Malawi, 2021). Furthermore, as the value is limited between 1.0 and 0 linear forms become less effective. In this regard, we convert the 3-firm ratio to logarithmic form, as previous related studies have done (see, Bottazzi et al., 2007; Campos and Iooty, 2007; Das and Pant, 2006).

h) Regulation: Regulation has been argued to spur innovation if it bolsters consumer trust through consumer protection, over and above helping the regulated institutions to manage risks inherent in the adoption of innovation (Barth et al., 2008; Calomiris, 2009; Lumpkin, 2010; Ammar and Ahmed, 2016; Triki et al., 2017). Proportionate regulation is defined as regulation whose costs to the regulator, regulated institutions, and consumers are proportional to the risks being addressed, taking into account the expected benefits (Jenkins, 2008; Lauer and Tarazi, 2012).

The scope of the regulation in the context of proportionality to risk has been multifaceted, including, but by far not limited to simplified KYC and a focus on the financial service offered rather than the financial provider alone (Muthiora, 2015; Ondiege, 2010; Buckley et al., 2015; Ondiege, 2015; Mutsonziwa and Maposa, 2016). More importantly, a test-and-learn approach that allows for experimentation has been cited as another important aspect of BBI regulation in this regard (Mlachira and Yabara, 2013).

For Malawi, reforms in the regulation frameworks specific on ATM banking innovation, agent banking innovation, internet banking innovation and mobile banking innovation have been undergoing. The Reserve Bank of Malawi on regular basis has been undertaking surveys to assess financial institutions' perception on the proportionality of these pieces of regulation. In this sense, each regulatory framework has been scored on the above proportionality considerations. These thus constitute variables representing regulations for each of the BBI. To measure regulation, a BBI regulation index variable is constructed as linear combinations of the scores to the specific regulatory frameworks, using the principal component analysis (PCA). A priori, a higher index signifies better regulatory environment and should therefore be associated with rapid adoption of BBI.

PCA is the process of computing the principal components and using them to perform a change of basis on the data. The principal components are a sequence of ρ, unit vectors where the i-th vector is the direction of a line that best fits the data while being orthogonal to the first i-1 vectors. In this sense, a line of best fit is defined as one that minimizes the average squared distance from the points to the line. The first principal component of a set of ρ variables, is the derived variable formed as a linear combination of the original variables that explains the most variance. The second principal component explains the most variance in what is left once the effect of the first component is removed, and we may proceed through ρ iterations until all the variance is explained. PCA is most commonly used when many of the variables are highly correlated with each other and it is desirable to reduce their number to an independent set. PCA is used for dimensionality reduction, filtering noise in the data, by projecting each data point onto only the first few principal components to obtain lower-dimensional data while preserving as much of the data's variation as possible. The first principal component can equivalently be defined as a direction that maximizes the variance of the projected data. The *i-th* principal component can be taken as a direction orthogonal to the first *i-1* principal components that maximizes the variance of the projected data. The principal components are eigenvectors of the data’s covariance matrix.

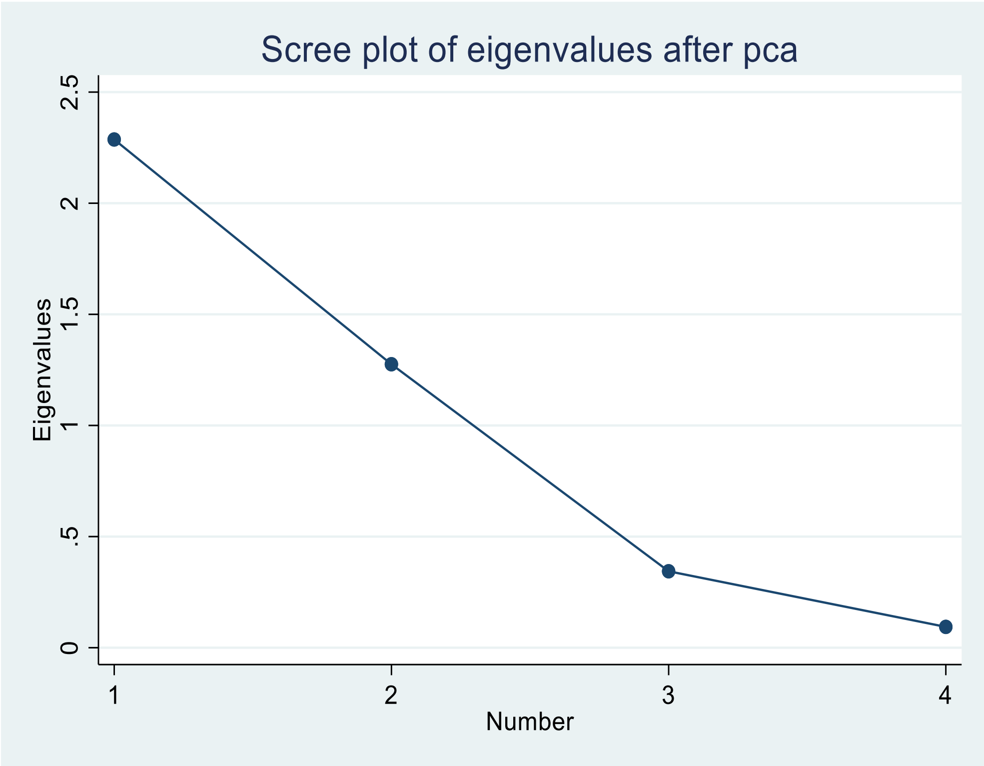
Table 4. 1 Principal Components for the regulation index

Principal component/correlation		Number of observations		=	413
		Number of components		=	4
		Trace		=	4
Rotation: (unrotated = principal)		Rho		=	1.00
	Component	Eigenvalue	Difference	Proportion	Cumulative
	Comp 1	2.29	1.01	0.57	0.57
	Comp 2	1.28	0.93	0.31	0.89
	Comp 3	0.34	0.25	0.09	0.98
	Comp 4	0.09	.	0.02	1.00
Principal components (eigenvalues)					
Variable	Component1	Component 2	Component 3	Component 4	Unexplained
ATM regulation	0.58	0.33	-0.41	-0.62	0
Agent Regulation	0.48	-0.48	0.68	-0.25	0
Internet banking Regulation	0.28	0.76	0.47	0.35	0
Mobile phone banking Regulation	0.59	-0.28	-0.38	0.65	0

From Table 4.1, the column 2 contains eigenvalues. The eigenvectors and eigenvalues are computed from the covariance matrix in order to determine the principal components of the data. Each eigenvector has an eigenvalue, and the number of eigenvalues is equal to the number of dimensions in the data. Eigenvectors and eigenvalues indicate how much variance is carried by each principal component. The principal components are presented in order of significance by ranking eigenvectors in order of their eigenvalues, from highest to lowest. The rule of thumb is that only those eigenvalues with a value greater than one produce better components. Here, we see that it is the first 2 components that have an eigenvalue of greater than 1, namely 2.29 and 1.28. Column 4 is the proportion, and it displays the percentage of data variation that that each component captures. Here, we see that the proportion of the first two components is 57 percent and 32 percent, respectively. This suggests that our PCA should be based solely on the first two components. The latter section of the table shows how much each variable contributes to each component.

The scree plot in Fig. 4.1, which places components 1 and 2 on the horizontal axis and their respective eigenvalues 2.29 and 1.28 on the vertical axis, graphically supports the findings that components 1 and 2 make up the largest contribution.

Figure 4.1: Scree plot of eigenvalues for the regulation index



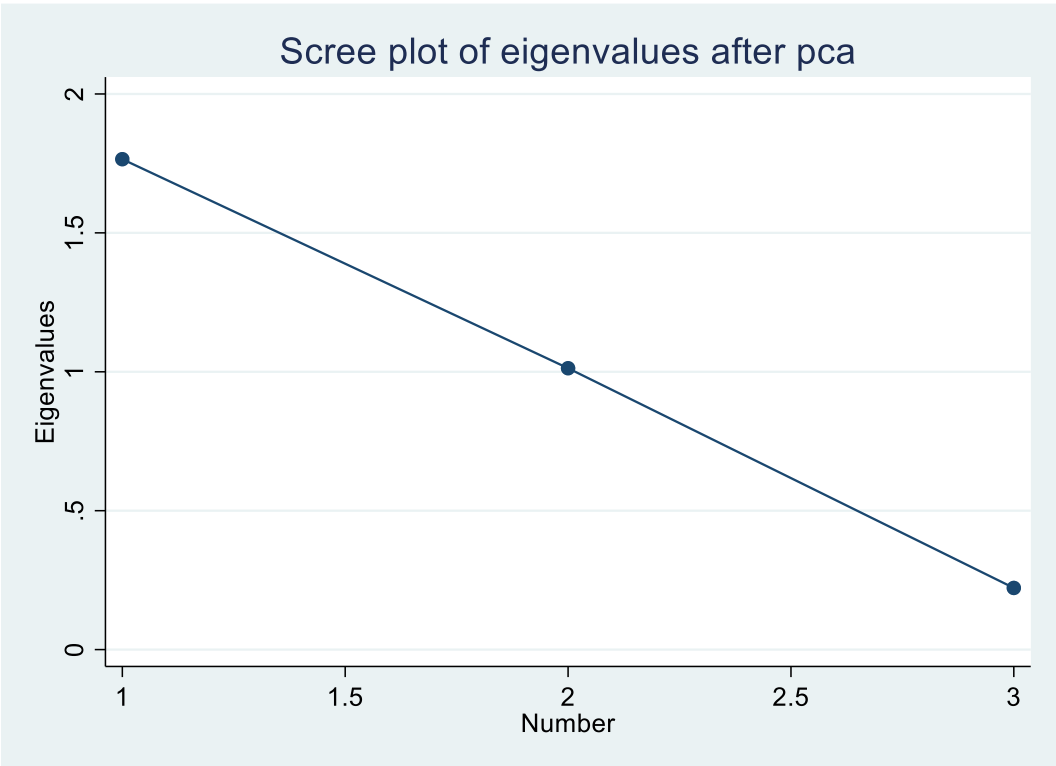
i) Macro technology: An aggregate index developed using PCA covering the logarithm of the number of fixed telephone subscriptions, internet subscriptions and cell-phone subscriptions, per 100 inhabitants. In this regard, the higher index implies improved state of technology. Column 2 of Table 4.2 contains eigenvalues. Here, we can see that the first two components, 1.77 and 1.01, have eigenvalues greater than one. Column 4 displays the proportion of data variation that each component captures. We can see that the proportions of the first two components are 59 and 34 percent, respectively. This suggests that our PCA should be based solely on the first two components. The final section of the table shows how much each variable contributes to each component.

Table 4. 2 Principal components for the macro-technology index

Principal component/correlation		Number of observations	=	949
		Number of components	=	3
		Trace	=	3
Rotation: (unrotated = principal)		Rho	=	1.00
	Component	Eigenvalue	Difference	Proportion	Cumulative
	Comp 1	1.77	0.75	0.59	0.59
	Comp 2	1.01	0.79	0.34	0.93
	Comp 3	0.22	-	0.07	1.00
Principal components (eigenvalues)					
Variable	Component 1	Component 2	Component 3	Unexplained	
Std cell phone	0.71	0.01	-0.70	0	
Std internet	0.63	-0.47	0.62	0	
Std groundline	0.32	0.88	0.34	0	

The scree plot in Fig. 4.2, which places components 1 and 2 on the horizontal axis and their respective eigenvalues of 1.77 and 1.01 on the vertical axis, graphically supports the findings that components 1 and 2 make up the majority of the contribution.

Figure 4.2: Scree plot of eigenvalues for the macro technology index



Malawi lags behind its counterparts in the development of its telecoms and other digital services markets. In the 2016 edition of the International Telecommunication Union's (ITU) Global ICT Development Index, the country is placed 168th out of 175 countries. According to the ITU, mobile penetration remains low, with 36 percent of the population having a subscription, compared to 53 percent for nations with similar GDP per capita and the 80 percent average for Africa as of the end of 2015. With as many as 12 competitors offering wireless broadband services, the internet industry is very competitive. However, the benefits of this competition appear to be limited to major cities and towns, as only 7 percent of homes reported having internet connection in 2015. Access to digital technologies and services in Malawi is limited due to high costs, limited availability of high-quality broadband connectivity, as well as a lack of human and institutional capacity.

Having described the variables in terms of their definitions, measurement and related literature, the next step is the descriptive analysis of the data. This is crucial as it provides important insights regarding the nature of the data. In this regard, we explore the descriptive statistics and correlation matrix of the variables drawing on the summaries presented in Tables 4.3and 4.4.

Table 4. 3 Descriptive statistics

	Observations	Mean	Standard Deviation
ATM Banking Innovation	902	19.80	8.01
Agent Banking Innovation	655	23.87	7.09
Mobile Banking Innovation	548	22.29	13.62
Internet Banking Innovation	792	21.24	11.41
Bank Technology	961	12.76	3.45
Branch Intensity	961	8.51	3.94
Retail Portfolio	961	33.97	12.16
Bank Funding	961	56.79	8.80
Bank Size	961	4.56	1.06
Market Concentration	961	56.21	2.55
Macro Technology	961	10.02	1.01
Regulation	961	9.58	0.55

From the descriptive statistics, the following observations can be made. Firstly, the mean values for ATM, agent, internet and mobile phone banking innovations are 19.80; 23.87; 21.24 and 22.29, respectively. While the mean values of the different forms of BBI do not vary significantly across the spectrum of innovations, their variability depicts two distinct groups. This is evidenced from the respective standard deviations that measure how the data in the respective variables vary from their respective means. Internet and mobile banking innovations have wider variations compared with ATM and agent banking innovations; providing a preliminary indication of the extent to which remote BBI have been adopted disproportionately across the different banking institutions and over time; compared to physical BBI which have been adopted by most banks and implemented relatively more evenly over a longer period. The standard deviations for the members of the former group are 11.41 and 13.62 respectively; against 8.01 and 7.09 for the members in the latter group.

Secondly, in terms of bank level drivers, the standard deviations for bank size, bank technology and branch intensity variables provide important insights. From the standard deviations of these variables, it is clear that there are no substantial variations in the banks from the mean. Probably due to the prudentially regulated nature of the sector, banks of different sizes implement virtually similar technologies which could also impact their branch intensity strategies. A key variation in bank characteristics is noted in the innovativeness of management and the implementation of retail business strategies. The standard deviation of 8.80 and 12.16 for bank funding and retail portfolio variables compared to that of the other variable suggests the presence of some banks whose management innovativeness and retail strategies have marked departure from the mean.

In the final analysis, what comes out clearly from the above descriptive analysis is the wide variation both in the drivers and in some dimensions of BBI, indicative of a wide enough heterogeneity to warrant application of models beyond mere pooling of data.

Having considered the descriptive statistics, the next step is to undertake correlation analysis of the variables to check if there is any risk of multicollinearity among the regressors. More importantly, the correlation analysis enables us to see if there are any commonalities in the implementation of different forms of both physical and remote BBI. From the Correlation Matrix presented in Table 4.4, none of the regressors have a pairwise correlation coefficient with other regressors exceeding the 0.60 threshold, implying no risk of multicollinearity. The relationship between the regressands is also noteworthy. Physical BBI, namely ATM and agent banking innovations are positively related. The same is true for remote BBI namely, internet and mobile banking innovations being positively related with each other. This provides preliminary support confirming common traits among the various forms of physical and remote BBI. It is also worth noting the negative, albeit non-statistically significant, correlation between agent and internet banking innovations.

We further note that physical BBIs are positively correlated with branch intensity. The correlation coefficient between branch intensity and internet banking innovation has a negative sign, albeit not significant at the 5 percent level. In general, the correlation matrix shows initial evidence supporting the idea that branch intensity would be positively related with physical BBIs and negatively with remote BBI. This is one of the aspects that need to be investigated formally; given that the case for BBI has often tended to be made in the context of the branch model. There is a positive correlation between bank technology, retail portfolio, bank size and all the dimensions of BBI understudy. These are statistically significant, with the exception of the correlation between bank size and agent banking innovation. On the other hand, we see from the correlation matrix, a statistically significant negative correlation between bank funding and all dimensions of BBI. With regard to the macro-level factors, we see that none of the variables has a statistically significant correlation with any of the dimensions of BBI under study. Formal investigation of the relationship between the different variables cited in the literature and the different forms of BBI is based on Auto Regressive Distributed Lag (ARDL) models.

Table 4. 4 Correlation matrix

	ATM Banking	Agent Banking	Internet Banking	Mobile Phone Banking	Bank technology	Branch intensity	Bank retail portfolio	Bank funding	Bank size	Market concentration	Regulation	Macro technology
Agent Banking	0.41***											
Internet Banking	0.71***	-0.01										
Mobile Phone Banking	0.70***	0.73***	0.17***									
Bank technology	0.53***	0.41***	0.43***	0.25***								
Branch intensity	0.23***	0.60***	-0.08	0.66***	0.21***							
Bank retail portfolio	0.42***	0.28***	0.38***	0.16***	0.65***	0.07**						
Bank funding	-0.58***	-0.16***	-0.34***	-0.56***	-0.29***	-0.05	-0.10***					
Bank size	0.69***	0.04	0.72***	0.39***	0.56***	-0.07**	0.49***	-0.49***				
Market concentration	0.01	-0.01	0.02	-0.01	-0.09***	0.03	-0.04	0.03	-0.22***			
Regulation	-0.02	-0.06	-0.04	0.05	0.14***	0.02	0.01	-0.02	0.26***	-0.13***		
Macro technology	-0.02	0.01	-0.03	0.00	0.04	-0.05	0.00	0.01	0.16***	-0.33***	0.05	

****, **, * denote significance levels at 0.01, 0.05 and 0.10, respectively.*

4.2.2 Hypothesis Development

Drawing on the literature discussed in detail in Chapter 2, the research develops and tests several hypotheses.

Firstly, banks with more advanced technology have been argued in the literature to have strategic advantage over competitors who rely on outdated hardware and software (Frame and White, 2004; Brown and Molla, 2005; Thulani et al., 2009; Malhotra and Singh, 2010; Ammar and Ahmed, 2016). The validity of this link stems from the ease with which innovations may be integrated and compatible with superior technology (Furst et al., 2002; Muthinja and Chipeta, 2018). This leads us to develop and test the first hypothesis (H1), that bank adoption of BBI is a positive function of bank level technology. That said, it has been argued in the literature that it is easier for new entrants to invest in BBI-compatible technology than it is for incumbents to reconfigure their existing technological structure to suit more innovative BBI strategies (Sullivan and Wang, 2020). Furthermore, because BBI are not uniform, their technological requirements may differ. The relationship is complicated further when financial services are delivered in collaboration with non-bank actors whose technology/ICT quality may differ from the bank's (Carlson et al., 2001; Dermish et al., 2012).

Secondly, large banks, according to the literature, have higher rates of innovation adoption because of the economies of scale and risk diversification benefits that reside in the multiple activities that the large banks undertake (Hannan and McDowell, 1984; Frame and White, 2004; Corrocher, 2006; Kaur and Kaur, 2018; Dorfleitner et al., 2019; Sullivan and Wang, 2020). In this sense, we develop and test the second hypothesis (H2) that bank size has a positive impact on adoption of BBI. Despite this, it has been established that small and medium-sized banks have a faster adoption time for new innovations, owing to either a strong ambition for expansion or just speedier decision-making in the absence of burdensome bureaucracy that tends to rise as institutions grow larger (Hunter and Timme, 1991; Escuer et al., 1991). Furthermore, the claim that larger firms engage in more activities than smaller firms has sparked debate over whether large firms are more likely to have fragmented and incompatible internal processes, making innovation adoption more difficult unless and until their corporate culture and ICT infrastructure are re-oriented (Zhu et al., 2006; Sullivan and Wang, 2020). *A priori*, the impact of bank size on adoption of BBI is therefore ambiguous.

Thirdly, the greater the number of retail customers a bank has, the greater the volume of payments and withdrawals that would be processed through BBI if it was available. In this way, the large share of retail portfolio, symbolising large consumer demand, strengthens the business case for banks to adopt BBI. (Barras, 1990; Saloner and Shepard, 1995; Malhotra and Singh, 2010). In this sense, we develop and test the third hypothesis(H3) that high share of retail portfolio has positive impact on adoption of BBI.

Fourthly, it has been cited in the empirical literature that a management team that is innovative is better positioned to drive a more innovative business strategy than management that is less innovative (Furst et al., 2002). An important point that must be highlighted is that deposits are less costly since the interest paid on them is mostly lower than the rate that banks will have to pay to receive financing through external credit lines or capitalisation. In this sense, most banks tend to fund their assets using deposits (Gourlay and Pentecost, 2002; Cull and Peria, 2013; Asongu and Nwachukwu, 2018). As a result, banks that are less dependent on conventional funding sources are seen as having more innovative management, as they prefer to follow a more aggressive overall business strategy in order to achieve higher returns that can offset the high-cost funding (Furst et al., 2002). Several empirical studies have found an inverse association between conventional funding (measured by the deposit-to-asset ratio) and the spread of BBI, which supports this viewpoint (Sinha and Chandrashekaran, 1992; Furst et al., 2002). Against this background, we develop and test a fourth hypothesis (H4) that a more innovative management (proxied by a lower ratio of deposit to assets) has a positive impact on the adoption of BBI.

The promise of these BBI in providing cost-effective financial service delivery should imply a negative relationship between branch network and adoption of BBI. (Furst et al., 2002; Frame and White, 2004; (Malhotra and Singh, 2010)). In this regard, we test the fifth hypothesis (H5) that branch intensity is inversely associated with adoption of BBI. That said, banks with a limited branch footprint may seek to implement BBI models in order to expand their frontiers (Furst et al., 2002). Also, branch intensity has been argued to provide the network effects for ATM innovation (Saloner and Shepard,1995). As a result of this extensive literature, the impact of branch intensity on adoption of BBI may not be ascertained, *a priori*.

Sixth, regulation has been argued to spur innovation if it bolsters consumer trust through consumer protection, over and above helping the regulated institutions to manage risks inherent in the adoption of innovation (Barth et al., 2008; Calomiris, 2009; Lumpkin, 2010; Gutierrez and Singh, 2013; Ammar and Ahmed, 2016; Triki et al., 2017). Simplified KYC and a focus on the financial service offered rather than the financial provider alone are key among the many aspects of proportionality of regulation (Muthiora, 2015; Ondiege, 2010; Buckley et al., 2015; Ondiege, 2015; Mutsonziwa and Maposa, 2016). A test-and-learn approach has been cited as another important aspect of BBI regulation in this regard (Mlachira and Yabara, 2013). On this basis, we develop and test the sixth hypothesis (H6) that a higher index of regulation, signifying proportionate application of regulation, is positively associated with high adoption of BBI.

Furthermore, large market share would justify investment in costly technology necessary to support BBI (Hughes and Lonie, 2007; Mas and Ng'weno, 2010; Argent et al., 2013). In this sense, we develop a seventh hypothesis (H7) that market share is positively related with adoption of BBI. At the same time, the lack of competition stifles incentive to innovate to remain in business (Hannan and McDowell, 1984; Hannan and McDowell, 1987; Frame and White, 2004; Önder and Özyıldırım, 2019). In this sense, the *a priori* expectation on the impact of market concentration is ambiguous.

Lastly, the state of development of infrastructure at national level defines the possibility frontiers within which businesses can connect with one another (Pennings and Harianto, 1992). Arguments have been made about the importance of technological linkages between firms for their ability to innovate (Pennings and Harianto, 1992; Muthinja and Chipeta, 2018). Besides connectivity and access considerations, the technologies available in the market provide a pool that firms can tap from in order to upgrade their existing technologies to create an ICT infrastructure that can integrate with new innovations (Koellinger, 2008; Muthinja and Chipeta, 2018). On the strength of the foregoing, we develop and test the eighth hypothesis (H8) that high levels of technological development at the macro level have a positive impact on adoption of BBI.

4.2.3 Model Specification

The following is the baseline empirical model for the examination of the drivers of bank adoption of BBI.

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \mu_{it} \tag{4.1}$$

where $Y_{i,t}$ represents a vector of dimensions of BBI for bank *i* over time *t*. $\alpha_i$is the constant term. β_1 and β_2 are coefficients of the bank characteristics and macro-level factors, respectively. X is a vector of bank characteristics (namely; bank technology, branch intensity, bank retail portfolio, bank funding and bank size) that vary cross-sectionally and over time *t*. Z is a set of macro-level factors, namely market concentration, regulation and macro technology, that vary overtime but are constant cross-sectionally. These are the control variables. Besides these, the Pool Mean Group (PMG) estimations upon which our analyses are based, have been re-estimated by including remote BBI as other control variables in the physical BBI estimations; and vice versa for remote BBI estimations. μ_{it} is the error term.

To formally test the above hypotheses, we first adopt static model approaches, namely Pooled Ordinary Least Square (OLS) and Fixed Effects (FE) methods. In both cases, we use Driscoll-Kraay standard errors because they are heteroskedasticity-consistent and robust to general forms of cross-sectional and temporal dependence when time dimensions become large (Driscoll and Kraay, 1998). As a robustness check, we further re-estimate the Pooled OLS and FE models using lagged regressors, to compensate for any endogeneity as recommended by Wigley (2017) and Huang (2020). Static model estimation is thus a useful step in offering basic analysis before moving on to dynamic models, which are the bedrock of our analysis. In this regard, before delving further into dynamic models, it is necessary to first discuss static models and their shortcomings, as well as how the dynamic model can assist remedy these flaws.

Firstly, pooled regression is a typical OLS estimation method to the extent that it estimates a single equation on all of the data at once; by merging both cross-sectional and time-series observations in a single column in the *y* dataset, as well as all observations on each explanatory variable in a single column in the *x* matrix (Wooldridge, 2009). As a result, it implicitly assumes that the average values and relationships of the variables are consistent throughout time and across all cross-sectional units in the sample. This is expressed by common intercept and slope coefficients for all cross-sectional units. This is a simplistic restriction because it overlooks the heterogeneity that exists among the various cross-sectional units. While pooled OLS estimation is simple to perform under a single equation model, under multiple regression, outliers, non-normality of residuals, multi-collinearity, and missing data can all have an impact on the OLS estimate of regression weights (Wooldridge, 2009). Because OLS estimators are sensitive to outliers, which are common in panel data, using the OLS approach to estimate pooled regression puts our study at risk of obtaining coefficient values that do not sufficiently reflect the underlying statistical relationship (Wooldridge, 2009; Alam, 2011). In this light, Pooled Least Square estimation serves just as a starting point for our estimations, not as the framework for our analysis. Within the broader static models, our basis for analysis is the Fixed Effects (FE) method, owing to its superiority over Pooled Least Square as discussed below.

Secondly, the FE model, unlike the Pooled OLS approach, allows for individual specific intercepts while assuming common slopes and variance for the estimator (Wooldridge, 2009). To demonstrate this point, consider the following econometric formulation of the panel data analysis in Equation 4.2:

$$Y_{i,t} = \alpha + \beta X_{i,t} + u_{i,t} \tag{4.2}$$

From the above representation, we decompose the disturbance term $u_{i,t}$ into an individual specific effect v_i, and the remainder disturbance, $\mu_{i,t}$. The latter disturbance term captures everything that is left unexplained about $Y_{i,t}$ and varies over time and over entities.

$$u_{i,t} = v_i + \mu_{i,t} \tag{4.3}$$

As a result, we may rewrite Equation 4.3 by substituting for $u_{i,t}$ to get Equation 4.4 as follows:

$$Y_{i,t} = \alpha + \beta X_{i,t} + v_i + \mu_{i,t} \tag{4.4}$$

In this regard, v_i represents all the variables that affect $Y_{i,t}$ cross sectionally but are time invariant. Time-fixed effects, like cross-sectional fixed effects, can be modelled when the average value of $Y_{i,t}$ changes with time but not cross-sectionally. Here, the intercepts are allowed to change over time, but are considered to be the same across all cross-sectional units at any one time. A time-fixed effects model would be expressed in econometric terms in Equation 4.5 as follows:

$$Y_{i,t} = \alpha + \beta X_{i,t} + \theta_t + \mu_{i,t} \quad (4.5)$$

Where θ_t is a time-varying effect capturing all the variables that affect $Y_{i,t}$ and that vary over time but are constant cross-sectionally.

While static models are popular because of the ease of their assumptions and application, they do have significant weaknesses, as previously indicated. For example, Pooled OLS uses the same intercept and slope coefficients for all cross sections and ignores individual variance. The FE model, on the other hand, assumes that the estimator has similar slopes and variance but country-specific intercepts (Baltagi, 2008). The parameter estimates generated by the fixed effects model are skewed when some regressors are endogenous and related to the error term.

In the domain of the random effects model, there is an underlying assumption of strict exogeneity. The model's time invariance assumption, on the other hand, is untenable (Arellano, 2003). Furthermore, static models may produce erroneous conclusions by failing to discriminate between potential short-run and long-run relationships (Loayza and Ranciere, 2006). When using traditional panel models, static models can cause substantial bias in cross-sectional dynamics by assuming all coefficients are the same (Holly and Raissi, 2009; Samargandi et al., 2015). Because of these flaws, we need to expand our research by including dynamic panel models.

Furthermore, it is increasingly acknowledged in the economics and finance literature that relationships between variables are not always instantaneous. Because of a variety of factors, the impact of adoption drivers on financial innovations can be prolonged and thus felt over time. The finance literature provides a number of reasons for this, including information asymmetry, structural and institutional rigidities related to R&D expenditure decisions, and the time it takes for businesses to expand to the point where they can marshal the resources needed to invest in financial innovation (Baltagi, 2008; German-Soto and Flores, 2015).

To account for this time element, distributed-lag models are frequently used. Under these models, the lag polynomial *(L)* is applied to the explanatory variable *x* to describe the pattern of the regressor x's impact on the regressand *y* over time, as seen in Equation 4.6 below:

$$y_t = \alpha + \beta(L)x_t + \varepsilon_t = \alpha + \sum_{i=0}^{\infty} \beta_l\, x_{t-l} + \varepsilon_t \qquad (4.6)$$

Because estimating an infinite number of terms of β coefficients in the preceding Equation 4.6 is difficult, different studies have adopted the Koyck dynamic model specification (see German-Soto and Flores, 2015; Muthinja and Chipeta, 2018). The model assumes that lag effects are geometrically reduced, and that each value of β is lower than the one before it. The lag on y is gradually reduced while keeping a constant factor, say λ, so that Equation 4.6 now looks as follows:

$$\lambda y_{t-1} = \lambda\alpha + \lambda\beta_0 x_{t-1} + \beta_0\lambda^2 x_{t-2} + \beta_0\lambda^3 x_{t-3} + \cdots \ldots + \lambda\varepsilon_{t-1} \qquad (4.7)$$

The following Koyck transformation in Equation 4.8 is obtained by subtracting Equation 4.7 from Equation 4.6 and rearranging terms:

$$y_t = \alpha(1-\lambda) + \lambda y_{t-1} + \beta_0 x_t + v_t \qquad (4.8)$$

Where $v_t = (\varepsilon_t - \lambda\varepsilon_{t-1})$, i.e., a moving average of ε_t and ε_{t-1}. The transformation produces an autoregressive model since one lag of the dependent variable is added as an explanatory variable. The Koyck transformation solves two problems: Firstly, it requires only the estimates for α, β_0, and λ; and secondly, Equation 4.8 solves the possible problem of multicollinearity by considering only one period of *x* in the model rather than its multiple prior values (Franses and Van Oest, 2004). Equation 4.9 below is an extension of model in Equation 4.8, as it that contains more than one regressor:

$$y_t = \alpha(1-\lambda) + \lambda\, y_{t-1} + \beta_0 x_t + \gamma_0 z_t + v_t \qquad (4.9)$$

Equation 4.9 is written as follows for panel data:

$$y_{it} = \alpha(1-\lambda) + \lambda\, y_{it-1} + \sum_{k-1}^{K} \beta_k\, x_{it} + \eta_i + \varphi_t + v_{it} \qquad (4.10)$$

Where the residuals $v_{it} = (\varepsilon_{it} - \lambda\varepsilon_{it-1})$ follow an MA (1) process and the individual and time effects, namely, η_i and φ_t, are considered. Up to *K* explicative variables are included in Equation 4.10, and the v_{it} is assumed to be independently distributed across individuals with a zero mean. However, because the lagged dependent variable y_{it-1} as a regressor on the right-hand side is almost never strictly exogenous, as required by the OLS estimator, Equations 4.9 and 4.10 have a problem of consistent estimation. As a result, the error terms are correlated with the lagged dependent variable y_{it-1}; rendering the OLS estimator biased and inconsistent (Baltagi, 2008).

In panel data, pervasive cross-sectional dependency can emerge when all components in the same cross-section are correlated; often due to the impact of specific unseen common factors that affect each of the cross-sectional units or spatial effects or could arise as a result of interactions within social economic networks (Chudik et al, 2013; Gaibulloev et al, 2014). This issue is addressed by Pesaran (2006) and Bai (2009) by including Z_t , covering common factors in the panel regressions. If these common components are excluded from the model and are correlated with the regressors, the exogeneity condition $E(\alpha_i x_{it}) = 0$ is violated, rendering the estimators for FE and RE inconsistent (Philips and Su, 2003; Philips and Su, 2007; Sarafidis and Robertson, 2009; Tsionas, 2019).

Endogeneity occurs when one or more explanatory variables are influenced by one or more variables within the model, resulting in a correlation between the explanatory variable and the regression model's error term. Key among the factors contributing to endogeneity are the exclusion of an important variable in the model (omitted variable bias) and when the dependent variable is a predictor of the independent variable on which it depends (simultaneity bias). The presence of simultaneity bias tends to exaggerate the impact of the independent variables in a model (Athanasoglou et al., 2008; Neaime and Gaysset, 2018).

Several solutions have been proposed to deal with the problem of endogeneity bias, notably the Instrumental Variable (IV) method, the Generalised Method of Moments (GMM) and ARDL models. GMM only models the short run and is ideal where *N* is greater than *T* (Roodman, 2009; Makhlouf et al., 2020). In our case, *T* is larger than *N* and thus GMM risks generating spurious results. These therefore render GMM to be less appropriate for our purposes. At the same time, employing the instrumental variable approach may confront us with challenges with regard to lack of instruments. A more appropriate alternative is the ARDL model, as will be discussed in the following section.

ARDL models are standard least squares regressions in which the dependent and independent variables are related not just contemporaneously, but also historically. In light of this, ARDL models incorporate lags of both the dependent and explanatory variables as regressors (Greene, 2008). The ARDL models have several advantages that render them more suited to the analysis of our dataset. Firstly, they provide unbiased and efficient estimates. They are asymptotically efficient and comparatively more robust in small or finite samples (Pattichis, 1999, Mah, 2000; Sakyi, 2011). Secondly, they can be used regardless of whether the regressors are I(0), I(1) or mutually integrated; however, none of the explanatory variables must be of a higher order than I(1) (Sakyi, 2011). Thirdly, the ARDL models can distinguish between dependent and explanatory variables, thus eliminating problems caused by autocorrelation and endogeneity (Pesaran et al., 2001; Sakyi, 2011). Fourthly, they estimate both short and long run relationships at the same time. A simple linear transformation may be used to generate the Error Correction Model (ECM) from the ARDL models, which blend short run corrections with long run equilibrium without compromising long run information (Sakyi, 2011). The associated ECM has enough lags to describe the data generation process in general to specific modelling frameworks. This allows for long-run estimations to be drawn, whereas other classic cointegration techniques do not allow for such inferences.

A general ARDL (p, q, q, …., q) model by Pesaran et al. (1999) is given in Equation 4.11 as follows:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij}\, y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij}\, x_{i,t-j} + \mu_i + \varepsilon_{it}\ , \qquad (4.11)$$

Where y_{it} denotes the dependent variables for group *I*; and x_{ij} $(kx1)$ is the vector of the explanatory variables for group *i*. The coefficients of the lagged dependent variables λ_{ij} are scalars. δ_{ij} are (*k x 1*) coefficient vectors. Groups are denoted by *i* = 1, 2, …. *N*; while and the time periods by t = 1, 2, ….*T*; μ_i represents the fixed effects. For notational convenience, a common *T* and *p* can be used across groups, and a common *q* across groups and regressors. It is convenient to work with the reparameterisation of Equation 4.11 in order to structure the long and short run cointegration panel model in Equation 4.12 as follows:

$$\Delta y_{it} = \left(\varphi_i y_{i,t-1} + \beta'_i x_{it}\right) + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta\, y_{i,t-j} + \sum_{j=0}^{q-1} \delta^{*\prime}_{ij}\, \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (4.12)$$

Where: *i* = 1,2, …., *N;* *t* = 1, 2, …..*T;*

$\Delta y_{it} = y_{it} - y_{it-1}$; $\varphi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij}$;

$\beta_i = \sum_{j=0}^{q} \delta_{ij}$; $\lambda^*_{ij} = -\sum_{m=j+1}^{p} \lambda_{im}$; with j = 1, 2, …., p-1

And $\delta^{*\prime}_{ij} = -\sum_{m=j+1}^{q} \delta_{im}$. with j = 1,2, ……., q-1.

Pesaran et al. (1999) propose the Mean Group (MG) and the Pooled Mean Group (PMG) as two estimators. The former is more consistent if both the slope and the intercepts are permitted to vary between cross-sectional units, whereas the latter is consistent if long-run slope homogeneity is assumed. Below is a full discussion of each of the estimators.

Firstly, the MG estimator models *N* separate regressions for the panel comprising *N* number of groups and T number of time series observations in each group; and from there calculates the unweighted mean for the respective coefficients (Pesaran and Smith, 1995; Blackburne and Frank, 2007). The *N* in the MG estimator should be at least 20, to reduce sensitivity to outliers and small model permutations (Samargandi et al., 2015). All parameters, intercepts, short-run coefficients, long-run coefficients, and error variances cannot vary between groups (Pesaran et al., 1999). Because the MG estimator does not use the panel dimension of the data to account for the fact that some parameters may not be the same across groups, the MG estimators do not constitute the core of our analytical framework. They are incorporated in our analysis only for comparison purposes. The PMG estimator is what forms the basis for our analytical framework as it introduces heterogeneity into the dynamic analysis of data. In this regard, it is critical that the PMG be discussed in further depth in the next paragraph.

It is acknowledged that standard regression estimation of ARDL models in panel settings with individual effects is tricky due to the bias triggered by the correlation between the mean-differenced regressors and the error term. While this bias disappears as the number of time-series observations *T* increases, it cannot be rectified by increasing the number of cross-sectional groups, *N* (Baltagi et al., 2009; Woodridge, 2009). To address this problem, a number of small-*T*-large-*N* dynamic panel data GMM estimators such as the Arellano-Bond have been developed (see, Arellano and Bover, 1995). Where the dataset has large *T*, the dynamic GMM become problematic as the assumptions underlying the model become inappropriate. The asymptotics of a Pooled Mean Group (PMG) estimator developed by Pesaran et al. (1999) provide a more plausible alternative in such a scenario. It is for this reason that the PMG estimators, within the variety of dynamic models, will form the basis of our analysis.

Under the PMG estimation, the error terms are assumed to be serially uncorrelated and distributed independently of the regressors, such that the explanatory variables are exogenous (Lee and Wang, 2015). In addition, the dependent and explanatory variables have a long-term association. The PMG estimator takes the cointegration form of the simple ARDL model and adapts it for a panel setting by allowing the intercepts, short run coefficients and cointegration terms to differ across cross-sections (Blackburne and Frank, 2007; Bangake and Eggoh, 2012). However, the long-run coefficients are taken to be identical across the cross sections (Pesaran et al., 1999; Baltagi et al., 2009). The PMG estimator refers to the pooling that is implied by the homogeneity restriction on the long-run coefficients on the one hand, and the averaging across groups required to determine the means of the estimated error-correction coefficients and other short-run model parameters on the other hand (Pesaran et al., 1999).

The expectation that long-run equilibrium relationships between variables can be identical across groups has been justified for a variety of reasons. Common regulation and technology that are applied in the same way to all cross-section groups are examples of these. However, the case for assuming that short-run dynamics and error variances should be the same is generally weak. The dynamic specification can also vary between groups since short-run slope coefficients are not entirely expected to always be identical (Pesaran et al., 1999).

Besides the MG and PMG, another alternative estimator is the Dynamic Fixed Effects (DFE) estimator. The DFE estimator, like the PMG, limits the coefficients of the cointegrating vector to be equal across all panels. In addition, the DFE model requires that the coefficient of the speed of adjustment and short-run coefficients to be similar. The intercepts, however, vary by cross sectional unit (Pesaran et al., 1999; Loayaza and Ranciere, 2004; Blackburne and Frank, 2007; Lee and Wang, 2015).

To establish the existence of a long run relationship between the different drivers of bank adoption of BBI, we convert our baseline model in Equation 4.12 into a broad ARDL model represented by Equation 4.13 as follows:

$$\Delta BBI_{i,t} = \lambda_i \left[BBI_{i,t-1} - \left\{ \beta_{i,0} + \beta_{i,1} X_{i,t-1} \right\} \right] + \sum_{j=1}^{p-1} \theta_{i,j}\, \Delta BBI_{i,t-j} + \sum_{j=0}^{p-1} \eta_{i,j}\, \Delta X_{i,t-j} + \epsilon_{i,t} \qquad (4.13)$$

where BBI is dimension of branchless banking innovation (in logs) for bank *i* at quarter *t*. X is a vector of potential determinants of adoption of BBI (in logs). θ is the short run coefficient of the lagged dependent variable while η refers to short run coefficients of the other regressors. β represents the long-run coefficients. λ is the coefficient of speed of adjustment to the long-run equilibrium. The first term on the right-hand side of Equation 4.13 will capture any long-run relationship between BBI and the different drivers of BBI adoption. As the system is expected to return to the long-run equilibrium, we expect $\lambda<0$. *p* are lags for the dependent variable and *q* are the lags of the independent variables

Choice of the optimal lag structure is a crucial step in the development of the ARDL model. Data limitations influence the imposition of a lag structure. For instance, loss of degrees of freedom and risk of autocorrelation may justify constraining the lag structure. A common lag structure across the cross-sections can be imposed if the time dimension is not long enough as to overstretch the lags (Pesaran et al., 1999; Loayza and Ranciere, 2006). In this regard, we impose a ARDL lag structure of $p=1$ and $q=1$ (for all regressors) based on the Akaike Information Criterion (AIC). This restriction is consistent with previous ARDL literature (see, Ojede and Yamarik, 2012; Samargandi et al., 2015 and Makhlouf et al., 2020).

The Hausman Test is a formal test that compares the consistency and efficiency of the PMG estimator to the MG estimator or the DFE estimator. It tests the Null Hypothesis that there is no significant difference between the PMG estimator and the MG estimator, or between the PMG estimator and the DFE estimator. The alternate hypothesis is that the difference between the estimators is significant. A p-value greater than 0.05 means that the null hypothesis cannot be rejected at 5 percent significant level and thus the PMG estimator is efficient and therefore our preferred model for estimation. However, models fitted on our data fail to meet the asymptotic assumptions of the Hausman Test.

We are mindful of the literature that states that the MG estimator should not be used until *T* is large enough in proportion to *N* (Pesaran and Smith, 1995; Pesaran et al., 1996). When *T* is small, the bias in the mean coefficient of the lagged dependent variable tends to be significant, according to this strand of literature. In this regard, the MG estimator is susceptible to both outliers and small model permutations (Favara, 2003; Martínez-Zarzoso and Bengochea-Morancho, 2004). The MG estimator produces consistent estimates of the long-run coefficients' mean, efficient only if the slope heterogeneity assumption holds. Under slope homogeneity, it is the pooled estimators that are consistent and effective.

As we consider the banking institutions in Malawi only, we expect our sample to be homogenous with respect to firm characteristics that are bounded by common prudential regulation more specifically, and common business operating environment more generally consistent with Samargandi et al., (2015). However, in the short-run, there is bound to be bank-specific heterogeneity due to the effect of diverse resource endowment, distinct target niches, different managerial attitudes towards innovations and risk, as well as different strategies for managing overhead expenses. Under the assumption of long-run homogeneity, the PMG estimator becomes more relevant for our investigation because it provides more efficient estimates than the MG estimator (Samargandi et al., 2015).

The PMG approach is less prone to be vulnerable to small model permutations that compromise the MG approach (Makhlouf et al., 2020). Moreover, the time span for this study is 20 years (approximately 80 quarters) and the MG estimator may thus lack degrees of freedom. At any rate, the negative and significant error correction coefficient across all estimators suggests that the null hypothesis of no long run relation is rejected. Analogous to the literature in that regard, we therefore explore the different ARDL models but focus more on PMG estimation as our benchmark model.

4.3. Empirical Findings

This section presents empirical findings from the different models that have been estimated as discussed above. We first explore the Pooled OLS estimations as the starting point of our empirical enquiry. We further explore the results from the FE Model. As earlier discussed, the FE model is based on more realistic assumptions compared with the Pooled OLS Method. This is important for our dataset considering that our sample comprises banking institutions of diverse sizes and characteristics as well as with varying magnitudes and rates of adoption of BBI.

Crucially, we extend the analysis beyond the static models to consider dynamic models. Not only is this motivated by the quest to deal with the possible risk of endogeneity, but more importantly to recognise that relationships among financial phenomena tend not to be instantaneous. In this regard, MG, DFE and PMG Models are estimated. As alluded to in

Section 4.2, the PMG estimations form the basis for our analytical framework among the class of dynamic models.

4.3.1 Pooled OLS Estimation

The empirical findings from estimation of Pooled OLS method are presented in Table 4.5 overleaf.

Table 4. 5 Pooled OLS results for the drivers of adoption of physical & remote BBI

	PHYSICAL BBI		REMOTE BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile phone Banking
Bank size	4.75*** (0.31)	-0.68** (0.27)	9.29*** (0.42)	2.97*** (0.57)
Bank technology	0.19*** (0.05)	0.68*** (0.13)	0.27* (0.14)	-0.30 (0.22)
Branch intensity	0.64*** (0.06)	1.02*** (0.07)	0.03 (0.05)	2.64*** (0.07)
Retail portfolio	0.01 (0.03)	0.14*** (0.03)	-0.09*** (0.02)	0.09 (0.08)
Bank funding	-0.20*** (0.21)	-0.08* (0.04)	0.10** (0.04)	-0.49*** (0.07)
Market concentration	0.31*** (0.10)	-0.06 (0.08)	0.43** (0.16)	0.03 (0.08)
Regulation	-2.27*** (0.59)	0.31 (0.46)	-2.98*** (0.90)	0.28 (0.57)
Macro technology	-0.43* (0.23)	0.52** (0.25)	-0.98** (0.37)	0.14 (0.13)
Constant	7.33 (8.38)	2.54 (7.88)	-14.31 (14.51)	8.00 (7.41)
Observations	902	655	792	548
Groups	13	10	13	11

*Driscoll-Kraay Standard errors in parentheses are heteroskedasticity- consistent and robust to general forms of cross-sectional and temporal dependence; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Firstly, we find evidence of a positive impact of bank technology on the adoption of both physical and remote banking innovations. *Ceteris paribus*, a one percent increase in bank technology leads to an increase in the adoption of ATM banking innovation, agent Banking Innovation and internet banking innovation by 0.19 percent, 0.68 percent, 0.27 percent, respectively. The impact on adoption of mobile phone banking is statistically insignificant and negative.

Secondly, we note the positive impact of branch intensity on the adoption of both physical and remote BBI. A one percent increase in branch intensity leads to an increase in the adoption ATM banking, agent banking and mobile phone banking innovations by 0.64

percent, 1.02 percent, and 2.64 percent, respectively. The impact on adoption of internet banking innovation is positive, but statistically insignificant.

Thirdly, we find that market concentration impacts positively on the adoption of both physical and remote BBI. A one percent increase in market concentration leads to a 0.31 percent increase in the adoption of ATM banking innovation and a 0.43 percent increase in the adoption of internet banking innovation. The study does not find any evidence of a statistically significant impact of market concentration on the adoption of agent banking and mobile phone banking innovations.

Fourthly, we find that an increase in regulation results in a decrease in bank adoption of both physical and remote BBI. A one percent increase in the index regulation leads to a 2.27 percent decrease in the adoption of ATM banking innovation and 2.98 percent drop in adoption of internet banking innovation.

The study establishes mixed findings on the impact of bank size, retail portfolio and macro technology. In this regard, we find that bank size impacts positively the adoption of remote BBI. Specifically, we find that a one percent increase in bank size increases bank adoption of Internet banking and Mobile banking innovations by 9.29 percent and 2.97 percent, respectively. However, the impact of physical BBI is mixed. A one percent increase in bank size leads to a 4.75 percent increase in the adoption of ATM banking innovation; and a 0.68 percent decrease in bank adoption of agent banking innovation.

Apart from that, a one percent increase in bank retail portfolio leads to an increase in agent banking innovation by 0.14 percent and a decrease in adoption of internet banking innovation by 0.09 percent. Bank funding inversely impacts the adoption of ATM, agent and mobile banking innovations, as expected. A one percent increase in bank funding results in a drop in bank adoption of ATM, agent and mobile banking innovations by 0.20 percent, 0.08 percent, and 0.49 percent, respectively. However, a one percent increase in bank funding results in a 0.10 percent increase in adoption of internet banking innovation. Lastly, a percentage increase in macro technology increases bank adoption of agent banking innovation by 0.52 percent and reduces the adoption of ATM banking and internet banking innovations by 0.43 percent and 0.98 percent, respectively.

To compensate for any endogeneity, we re-estimated the Pooled OLS model using lagged regressors in line with Wigley (2017) and Huang (2020). As can be noted from the robustness results presented in Appendix 4.1, the impact of the variables are consistent with those from the pooled OLS estimations discussed above.

4.3.2 FE Estimation

We extend the analysis to capture the heterogeneity among the banks using FE methods. The results are presented in Table 4.6.

Table 4. 6 FE results for drivers of adoption of physical & remote BBI

	PHYSICAL BBI		REMOTE BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile phone Banking
Bank size	-0.15 (0.16)	0.40* (0.20)	0.11 (0.22)	-0.45 (0.50)
Bank technology	-0.12** (0.05)	-0.13* (0.06)	0.06 (0.06)	0.05 (0.10)
Branch intensity	0.13* (0.06)	-0.01 (0.08)	-0.06 (0.06)	-0.20 (0.12)
Retail portfolio	0.10*** (0.02)	0.03 (0.03)	0.02 (0.03)	0.05 (0.04)
Bank funding	0.00 (0.02)	0.00 (0.03)	-0.01 (0.02)	-0.04 (0.04)
Market concentration	0.01 (0.03)	-0.08** (0.02)	-0.09*** (0.03)	-0.04 (0.05)
Regulation	0.23 (0.19)	0.65*** (0.16)	0.84*** (0.20)	1.80** (0.39)
Macro technology	0.04 (0.08)	0.16** (0.05)	-0.08 (0.05)	0.02 (0.02)
Constant	14.77*** (3.01)	19.35*** (2.01)	18.33*** (2.67)	10.35 (5.95)
Observations	902	655	792	548
Groups	13	10	13	11

*Driscoll-Kraay Standard errors in parentheses are heteroskedasticity- consistent and robust to general forms of cross-sectional and temporal dependence; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Firstly, we find evidence of an inverse impact of bank technology on adoption of both forms of physical BBI, namely ATM and agent banking innovations. A one percent increase in bank technology leads to a decline in the adoption of ATM banking innovation by 0.12 percent and agent banking innovation by 0.13 percent. However, the impact of bank technology on adoption of remote BBI, namely internet and mobile phone banking innovations, is positive but not statistically significant.

Secondly, the impact of regulation is positive both for physical BBI and remote BBI. A one percent increase in the index of regulation results in an increase in adoption of agent banking innovation by 0.65 percent, internet banking innovation by 0.84 percent, mobile phone banking innovation by 1.80 percent. Also, a one percent increase in the index of regulation increases bank adoption by ATM banking innovation by 0.23 percent. However, this impact is not statistically significant.

Thirdly, market concentration negatively impacts the adoption of remote BBI. A one percent increase in market concentration leads to a drop in adoption of internet and mobile phone banking innovations by 0.09 percent and 0.04 percent. The latter impact is statistically insignificant. The impact of market concentration on physical BBI is mixed; negative for adoption of agent banking innovation and positive, but statistically insignificant, for adoption of ATM banking innovation.

Fourthly, the impact of bank size, branch intensity, retail portfolio and macro technology are significant only for one form of innovation. The impact of bank size is found to be statistically significant only for the adoption of agent banking innovation; with a one percent increase in bank size leading to an increase in adoption of agent banking innovation by 0.40 percent.

Similarly, a one percent increase in branch intensity increases bank adoption of ATM banking innovation by 0.13 percent. The impact on adoption of agent banking and remote BBIs is negative, but statistically insignificant.

Furthermore, the impact of retail portfolio is felt only for ATM banking innovation. Specifically, a one percent increase in retail portfolio increases bank adoption of ATM banking innovation by 0.10 percent. However positive, the impact on the rest of the forms of BBI is statistically insignificant. The same is true for macro technology, where the impact is felt only for agent banking innovation. A one percent rise in macro technology increases bank adoption of agent banking innovation by 0.16 percent.

Finally, as demonstrated in Appendix 4.2, the findings of re-estimations using lagged regressors are consistent with the statistical significance and coefficient sign of the variables in the above estimations.

4.3.3 ARDL Model Estimations

The summary findings from the estimation of ARDL models for drivers of physical BBI and remote BBIs are presented in Tables 4.7 and 4.8, respectively. Within each table, we present results from the PMG estimation (which forms the analytical basis for our study), the DFE estimation and MG estimation. For all the models estimated, the respective error correction terms are negative, less than 2 in absolute terms and statistically significant at 1 percent. These attributes confirm the existence of cointegration between the variables.

a) Physical BBI

From Table 4.7, we note that the key drivers of bank adoption of physical BBI are bank size, bank technology, regulation and market concentration. For our benchmark model, the statistical significance of bank technology and regulation are consistent across both types of physical BBI in the long run; and market concentration being consistent across both types of BBI in the short run.

Firstly, we find that at the 10 percent significance level a one percent increase in bank size resulted in a 0.73 percent drop in the adoption of agent banking innovation in the long run. In the short run, the study finds no evidence of a statistically significant impact of bank size on the adoption of agent banking. For the adoption of ATM banking innovation, the long run impact of bank size is negative for all models. For our benchmark model, this impact is statistically insignificant. The short run impact of bank size is negative but statistically insignificant.

Secondly, consistent with the negative impact of bank technology established under FE estimations, the results from the PMG estimation establishes that bank technology exerts a negative impact on bank adoption of both ATM and agent banking innovations in the long run. At the 5 percent significance level, holding other factors constant, a one percent increase in bank technology decreases bank adoption of ATM banking and agent banking innovations by 0.09 percent and 0.19 percent, respectively. The long-run negative impact of bank technology on the adoption of both ATM and agent banking innovations is robust under the DFE and MG. In the short run, the study does not find any statistically significant evidence of bank technology impacting adoption of ATM banking innovation, although the coefficients were negative and statistically significant under DFE. However, for agent banking, a one percent increase in bank technology is found to increase bank adoption of agent banking innovation by 0.05 percent, under our benchmark PMG model. The positive impact is also found under the PMG, DFE and MG estimations.

Thirdly, as with the positive impact of regulation established under FE estimation, the PMG finds evidence of the long run impact of regulation on bank adoption of physical BBI. Specifically, a one percent increase in the index of regulation increases bank adoption of ATM and agent banking innovations by 0.45 percent and 0.59 percent, respectively. The long run positive impact is also established under the other dynamic estimations. However, there is no evidence of a statistically significant short run impact of regulation on bank adoption of physical BBI under DFE and MG.

Fourthly, the PMG estimation provides mixed outcomes on the impact of market concentration on adoption of different forms of physical BBI. On the one hand, the PMG estimation confirms the negative impact of market concentration on adoption of agent banking innovation that is found under FE estimation. *Ceteris paribus*, a one percent increase in market concentration lowers the adoption of agent banking innovation by 0.05 percent in the short run and by 0.20 percent in the long run. For ATM banking innovation on the other hand, at the one percent significance level, a one percent increase in market concentration increases adoption of ATM banking innovation by 0.05 percent in the short run. However, in the long run, the impact of market concentration is negative and statistically insignificant. Also noteworthy are the mixed outcomes on the impact of bank funding and branch intensity. The study finds no evidence of a statistically significant impact of bank funding on ATM banking innovation, either in the short run or long run. The same is true for adoption of agent banking innovation in the long run. Here, the impact is negative but not statistically significant. However, in the short run, a one percent increase in bank funding lowers bank adoption of agent banking innovation by 0.03 percent, significant at the 10 percent level.

Lastly, unlike FE estimation that establishes a statistically significant positive impact of branch intensity only on the adoption of ATM innovation, the PMG estimation establishes a long run positive impact of branch intensity on the adoption of both ATM and agent banking innovations. However, the impact in both cases is not statistically significant. A statistically insignificant impact is also noted in the short run, where an increase in branch intensity lowers bank adoption of ATM and agent banking innovations. Furthermore, just as the FE estimation establishes positive impact of macro technology on both ATM and agent banking innovations, it is statistically significant only for the latter. The impact on both forms of physical BBI is also positive in the short run and long run under PMG estimation, however not statistically significant.

Table 4. 7 ARDL results for drivers of adoption of physical BBI

Long-run coefficients						
	ATM Banking Innovation			Agent Banking Innovation		
	PMG	DFE	MG	PMG	DFE	MG
Bank size	-0.33 (0.16)	-0.28 (0.51)	-1.35 (-1.21)	-0.73* (0.39)	0.07 (0.46)	-0.26 (0.57)
Bank technology	-0.09** (0.04)	-0.13 (0.13)	-0.08 (-0.64)	-0.19** (0.10)	-0.27** (0.11)	-0.03 (0.12)
Branch intensity	0.06 (0.04)	0.09 (0.13)	0.31 (1.16)	0.06 (0.10)	-0.02 (0.11)	0.49** (0.12)
Retail portfolio	0.01 (0.01)	0.10* (0.06)	-0.01 (-0.14)	0.02 (0.04)	0.04 (0.05)	0.01 (0.15)
Bank funding	0.00 (0.00)	-0.04 (0.05)	0.06 (0.91)	-0.05 (0.03)	0.03 (0.04)	0.03 (0.06)
Market concentration	-0.04 (0.05)	0.06 (0.06)	0.03 (0.62)	-0.20** (0.07)	-0.13 (0.08)	0.01 (0.06)
Regulation	0.45*** (0.45)	0.48 (0.46)	-0.43 (-0.81)	0.59* (0.35)	0.82** (0.38)	0.36 0.09)
Macro technology	0.08 (0.08)	0.17 (0.23)	0.03 (0.30)	0.17 (0.15)	0.12 (0.18)	0.03 (0.14)

Table 4.7 ARDL results for drivers of adoption of physical BBI (cont'd)

Short -run coefficients						
	ATM Banking Innovation			Agent Banking Innovation		
	PMG	DFE	MG	PMG	DFE	MG
Error-correction coefficient	-0.48*** (0.10)	-0.27*** (0.02)	-0.77*** (0.04)	-0.39*** (0.07)	-0.40*** (0.03)	-0.58*** (0.08)
Δ Dependent variable (-1)	-	-	-	-	-	-
Δ Bank size	-0.15 (0.27)	0.09 (0.27)	0.20 (0.76)	0.63 (0.45)	0.60* (0.33)	0.69 (0.87)
Δ Bank technology	0.00 (0.04)	-0.06* (0.04)	0.04 (0.92)	0.05** (0.02)	0.07* (0.04)	0.01 (0.06)
Δ Branch intensity	-0.12 (0.08)	-0.06 (0.06)	-0.17 (0.06)	-0.06 (0.09)	-0.02 (0.08)	-0.19 (0.14)
Δ Retail portfolio	-0.01 (0.03)	-0.03 (0.02)	0.03 (0.05)	-0.03 (0.03)	-0.02 (0.02)	-0.04 (0.04)
Δ Bank funding	0.00 (0.02)	0.01 (0.02)	-0.01 (0.14)	-0.03* (0.02)	-0.03* (0.02)	-0.04 (0.02)
Δ Market concentration	0.05*** (0.01)	0.05* (0.03)	0.02 (0.19)	-0.05*** (0.20)	-0.07** (0.03)	0.00 (0.02)
Δ Regulation	-0.38 (0.39)	-0.43 (0.33)	-0.27 (0.30)	0.07 (0.19)	0.18 (0.39)	-0.30 (0.25)
Δ Macro technology	0.05 (0.06)	0.05 (0.08)	0.01 (0.16)	0.03 (0.11)	0.04 (0.09)	0.02 (0.12)
Constant	7.37*** (1.23)	3.02 (2.48)	15.94 (3.15)	13.84*** (2.63)	9.11*** (2.97)	9.80 (0.06)
Observations	888	888	874	645	645	645
Groups	13	13	13	10	10	10

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 Based on AIC. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

a) Remote BBI

From Table 4.8, we note consistency in the negative impact of bank size across the different forms of remote BBI in the short run. Holding other factors constant, a one percent increase in bank size reduces bank adoption of internet and mobile phone banking innovations by 1.04 percent and 2.61 percent, respectively. A similar negative impact is established for adoption of both forms of remote BBI in the long run, although it is insignificant in both cases.

Secondly, while FE estimation establishes a negative impact of branch intensity on adoption of both forms of remote BBI, albeit statistically insignificant, for PMG estimation the negative relationship between branch intensity and adoption of remote BBI is confirmed only in the long run. Here, the statistical significance is established only for adoption of mobile phone banking where, holding other factors constant, a one percent increase in branch intensity lowers mobile phone banking adoption by 0.53 percent, at one percent significance level. This statistically significant long run inverse impact is also established under DFE. In the short run, the impact is positive for both forms of remote BBI in the case of our benchmark model, however those results are statistically insignificant.

Furthermore, for the short run we find that a one percent increase in retail portfolio results in a 0.08 percent drop in bank adoption of mobile phone banking innovation, at the 10 percent significant level. This statistically significant negative impact is also established under DFE and MG estimations. However, the study fails to establish evidence of a statistically significant impact of retail portfolio on adoption of remote BBIs in the long run under PMG, DFE or MG.

Consistent with the inverse relationship between market concentration and adoption of internet banking innovation under FE estimation, we find under PMG estimation that at the 5 percent significance level, a one percent increase in market concentration lowers bank adoption of internet banking innovation by 0.04 percent in the short run. The study does not establish any statistically significant impact on adoption of internet banking in the long run using our benchmark model. However, under DFE and MG the impact is negative and positive respectively, albeit statistically insignificant in both cases. For the adoption of mobile phone banking innovation, the impact is negative and statistically insignificant, both in the short run and long run.

As with FE estimation, where regulation positively impacts bank adoption of remote BBIs, we note under PMG estimation that at the one percent significance level, a one percent increase in the index of regulation increases bank adoption of mobile phone banking innovation by 1.03 percent in the long run. The positive impact is also statistically significant under DFE and MG. However, no statistically significant impact is established for mobile phone banking innovation in the short run under PMG, DFE and MG. For internet banking innovation the impact is not statistically significant, either in the short run or long run.

Likewise, evidence of a statistically significant impact of macro technology is established only for the adoption of internet banking innovation in the long run. At the 10 percent significance level, a unit increase in the index of macro technology lowers bank adoption of internet banking innovation by 0.09 percent. This is true for PMG, DFE and MG. In the short run, the impact is negative but statistically insignificant. For mobile phone banking, the impact of macro technology is found to be negative but statistically insignificant under PMG in the long run. In the short run the impact of macro technology is found to be positive but statistically insignificant.

The same is true for bank funding, where the statistically significant negative impact on adoption of mobile phone banking innovation (established under FE estimation) is confirmed under PMG estimation, but only in the long run. In both the short and long run, the impact on internet banking innovation is not statistically significant. A one percent increase in bank funding leads to a 0.10 percent decline in the adoption of mobile phone banking innovation, at the 10 percent significance level. Lastly, just as the FE estimation establishes a statistically insignificant impact of bank technology on both forms of remote BBI, albeit with a positive sign; for PMG estimation both the long run and short run impacts on remote BBIs are insignificant, albeit positive for the adoption of internet banking innovation in the short run.

Table 4. 8 ARDL results for drivers of adoption of remote BBI

Long-run coefficients						
	Internet Banking Innovation			Mobile-phone Banking Innovation		
	PMG	DFE	MG	PMG	DFE	MG
Bank size	-0.01 (0.15)	0.13 (0.41)	1.40 (1.16)	-0.43 (0.48)	-0.58 (0.62)	0.06 (1.10)
Bank technology	0.00 (0.03)	0.09 (0.09)	0.02 (0.19)	0.00 (0.06)	0.08 (0.11)	0.26 (0.19)
Branch intensity	-0.03 (0.09)	-0.07 (0.10)	0.12** (1.89)	-0.53*** (0.08)	-0.26* (0.14)	0.13 (0.67)
Retail portfolio	-0.02 (0.02)	0.02 (0.04)	0.05 (0.98)	0.00 (0.04)	0.08 (0.06)	0.01 (0.10)
Bank funding	0.00 (0.01)	0.00 (0.04)	-0.05 (0.16)	-0.07** (0.03)	-0.06 (0.05)	0.00 (0.68)
Market concentration	0.00 (0.02)	-0.12 (0.07)	0.02 (0.50)	-0.03 (0.05)	-0.11 (0.09)	-0.06 (0.57)
Regulation	-0.07 (0.12)	0.78** (0.34)	0.76 (1.33)	1.03*** (0.26)	1.93*** (0.39)	1.50** (1.15)
Macro technology	-0.09* (0.05)	-0.07 (0.16)	-0.14** (0.10)	-0.15 (0.09)	0.10 (0.17)	0.23 (1.41)

Table 4. 8 ARDL results for drivers of adoption of remote BBI (cont'd)

Short -run coefficients						
	Internet Banking Innovation			Mobile-Phone Banking Innovation		
	PMG	DFE	MG	PMG	DFE	MG
Error-correction coefficient	-0.73*** (0.10)	-0.43*** (0.03)	-1.02*** 1.67)	-0.63*** (0.08)	-0.61*** (0.04)	-0.90*** (0.05)
Δ Dependent variable (-1)			-			-
Δ Bank size	-1.04** (0.51)	-0.29 (0.31)	-1.15** (1.10)	-2.61* (1.52)	-0.90 (0.63)	-2.89 (0.70)
Δ Bank technology	0.03 (0.04)	-0.01 (0.04)	0.05 (0.81)	0.00 (0.05)	-0.09 (0.07)	-0.11 (0.10)
Δ Branch intensity	0.07 (0.10)	-0.08 (0.07)	-0.03 (0.10)	0.13 (0.10)	-0.01 (0.13)	-0.63 (0.15)
Δ Retail portfolio	0.01 (0.02)	0.00 (0.02)	-0.02 (0.05)	-0.08* (0.12)	-0.08** (0.04)	-0.08* (0.13)
Δ Bank funding	-0.04 (0.03)	-0.03 (0.02)	-0.02 (0.50)	0.02 (0.04)	-0.02 (0.03)	0.02 (0.07)
ΔMarket concentration	-0.04** (0.13)	0.02 (0.03)	-0.04 (0.70)	0.02 (0.04)	0.05 (0.05)	0.06 (1.37)
Δ Regulation	-0.06 (0.37)	-0.06 (0.36)	-0.65* (0.09)	-0.09 (0.45)	-0.31 (0.52)	-0.19 (0.10)
Δ Macro technology	-0.13 (0.13)	-0.07** (0.08)	-0.12 (0.01)	0.13 (0.15)	-0.02 (0.12)	-0.04 (0.12)
Constant	13.53*** (1.27)	8.45*** (2.77)	1.21 (0.17)	14.59*** (2.61)	7.95* (4.38)	6.71 (2.66)
Observations	778	778	764	537	537	537
Groups	13	13	13	11	11	11

Robust standard errors in in parentheses. The lag structure is p=1 and q=1 Based on AIC. $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3.4 Robustness Check Estimations

One important contribution of this study is that it examines BBI drivers from a broader perspective, looking at more dimensions of BBI than have previous studies. In this sense, it draws a novel distinction between physical BBI and remote BBI, informed by literature indicating that these forms of BBI are distinctively different in their characteristics and abilities, and therefore appealing to different consumers. Arguably, this strand of literature therefore suggests that the consumers of BBI, as the BBI themselves, are not homogenous. However, as this claim is only inferred from the literature, but not empirically tested in this study, the likelihood of physical BBI consumers and remote BBI consumers not being mutually exclusive cannot be ruled out. While the focus of this study is on physical and remote forms of BBI as mutually exclusive dependent variables, rather than the heterogeneous BBI consumers, it still makes statistical sense to acknowledge the likelihood that bank implementation of physical BBI would be influenced by how it has implemented remote BBI, and vice versa. As a robustness check, the PMG estimations upon which our analyses are based, have been re-estimated by including remote BBI as a control variable in the physical BBI estimations; and *vice versa* for remote BBI estimations. This is in addition to macro variables that also serve as control variables.

The summary findings from the estimation of the PMG models for drivers of physical BBI and remote BBIs are presented in Tables 4.9. For all the models estimated, the respective error correction terms are negative, less than 2 in absolute terms and statistically significant at 1 percent. These attributes confirm the existence of cointegration between the variables.

In terms of the long run relationship, we note from Table 4.9, that internet banking innovation impacts positively the adoption of both ATM and Agent banking innovations. However, this impact is not statistically significant. Evidence of the statistically significant long run impact is established for mobile banking innovation. The impact of mobile phone banking innovation is negative for the adoption of ATM banking innovation and positive for the adoption of agent banking innovation. Specifically, at 5 percent significance level, a one percent increase in mobile banking innovation leads to a 0.04 percent drop in ATM banking innovation. At 1 percent significance level, a one percent increase in mobile banking innovation leads to a 0.24 percent increase in the adoption of agent banking innovation. For remote BBI, we note that statistically significant impact is only established for the ATM-

Mobile banking nexus. Specifically, at 10 percent confidence interval, a one percent increase in ATM banking innovation leads to a 0.08 percent increase in the adoption of mobile phone banking innovation.

Also noteworthy are the other drivers of adoption whose impact have been established to be consistent with those reported in the previous analyses. As in our benchmark models, the robustness test findings show the long run impact of bank size to be negative on the adoption of both forms of physical BBI. Same holds for bank technology, branch intensity, market concentration and macro technology. However, a negative and statistically significant impact is established for retail portfolio on adoption of ATM banking innovation, contrary to our earlier findings. The impact on adoption of agent banking innovation are consistent with the previous established findings. Unlike the previous estimations where regulation was found to be positive and statistically significant, the robustness findings show the impact of regulation to be negative for adoption of ATM banking and positive for adoption of agent banking, but statistically insignificant in both cases.

For remote BBI, consistent results are established for the impact on branch intensity and regulation. For a one percent increase in branch intensity results in a 0.58 decline in adoption of mobile phone banking innovation, significant at 1 percent confidence level. However the impact of adoption of internet banking is positive, unlike negative in our earlier estimations; but statistically insignificant in both cases. Furthermore, there is evidence of statistically significant impact of regulation of adoption of mobile phone banking innovation, consistent with the earlier estimations. Specifically, a one percent increase in regulation leads to an increase in the adoption of mobile phone banking innovation by 0.90 percent, at 1 percent significance level. For the adoption of internet banking the robustness results are equally consistent with the previous results, with the exception here that the results are statistically significant. A one percent increase in regulation results in a 0.46 percent decline in the adoption of internet banking innovation, at 5 percent significance level. As in the previous estimations, the impact of the rest of the variables such as bank size, bank technology market concentration, and microtechnology is statistically insignificant. Bank funding, however, has a statistically significant positive impact on adoption of internet banking innovation under the robustness check estimation (i.e. 0.03 at 1 percent significant level), while zero impact was established in the previous estimations.

As regards the short run, robustness test estimations fail to establish any evidence of statistically significant impact of remote BBI on adoption of physical BBI and vice versa. In addition, just as in our benchmark model, the robustness check estimation establishes market concentration as the only statistically significant variable in the ATM banking estimation. At 1 percent significance level, a one percent increase in market concentration results in an increase in adoption of ATM banking innovation by 0.06 percent. Also, the robustness test estimation confirms bank technology as a statistically determinant of the adoption of agent banking innovation in the short run. At 10 percent significance level, a one percent increase in bank technology leads to an increase in adoption of agent banking by 0.11 percent. Unlike the benchmark equation that established a negative-yet-statistically-insignificant impact of retail portfolio, the robustness check estimations shows this negative relationship as being statistically significant. At 1 percent significance level, a one percent increase in retail portfolio leads to a 0.12 percent drop in adoption of agent banking innovation. That said, market concentration is found to have no impact on the adoption of agent banking innovation in the robustness check estimation. However, the impact in the benchmark model was found to be negative and statistically significant.

In terms of remote BBI, the robustness check estimations confirm the statistically significant negative impact of bank size that was established under the benchmark model. The robustness check estimations also corroborate the benchmark models' findings on the impact on the rest of the variables.

The negative impact of mobile banking innovation on adoption of ATM banking innovation is not surprising considering that the ubiquity of the mobile telephony has shifted some financial consumers from transacting on ATMs to mobile phone banking platforms. This collaborates the view that remote BBI can substitute physical BBI. Simultaneously, ATM banking innovations have been found to positively impact adoption of mobile phone banking innovation, against the background that ATMs have undergone transformation allowing transactions to be linked to mobile phones. However, the findings that mobile phone banking has a positive impact on the adoption of agent banking innovation can be explained by the fact that most agent banking innovations include mobile phone banking in their value proposition. This highlights the extent to which physical BBI can leverage remote BBI to deliver financial services to low end consumers in rural areas.

Table 4. 9 Pooled Mean Group results for drivers of adoption of BBI

Long run coefficients					
Physical BBI			Remote BBI		
	ATM Banking innovation	Agent Banking innovation		Internet Banking Innovation	Mobile banking innovation
Bank size	-1.67*** (0.27)	-0.66 (0.57)	Bank size	0.14 (0.19)	-0.66 (0.52)
Bank technology	-0.06** (0.03)	-0.18 (0.12)	Bank technology	0.03 (0.04)	0.06 (0.07)
Branch intensity	0.01 (0.04)	-0.06 (0.12)	Branch intensity	0.03 (0.03)	-0.58*** (0.08)
Retail portfolio	-0.04*** (0.01)	0.09 (0.06)	Retail portfolio	-0.03 (0.02)	-0.04 (0.05)
Bank funding	-0.01 (0.01)	-0.03 (0.06)	Bank funding	0.03*** (0.01)	-0.05 (0.04)
Market concentration	-0.06*** (0.02)	-0.13 (0.09)	Market concentration	0.00 (0.03)	-0.04 (0.06)
Regulation	-0.05 (0.08)	0.55 (0.48)	Regulation	-0.46** (0.18)	0.90*** (0.30)
Macro technology	0.01 (0.03)	0.18 (0.17)	Macro technology	-0.04 (0.07)	-0.17 (0.11)
Internet banking	0.05 (0.05)	0.11 (0.10)	ATM banking	-0.01 (0.03)	0.08* (0.05)
Mobile banking	-0.04** (0.02)	0.24*** (0.08)	Agent banking	0.03 (0.04)	-0.05 (0.06)

Table 4.9 Pooled Mean Group results for drivers of adoption of BBI (cont'd)

Short run coefficients					
Physical BBI			Remote BBI		
	ATM Banking innovation	Agent Banking innovation		Internet Banking Innovation	Mobile banking innovation
Error-correction coefficient	-0.57*** (4.67)	-0.45*** (0.08)	Error-correction coefficient	-0.67*** (0.13)	-0.60*** (0.09)
Δ Bank size	-0.33 (0.48)	-0.18 (0.87)	Δ Bank size	-1.47** (0.70)	-1.42 (1.41)
Δ Bank technology	-0.03 (0.05)	0.11* (0.06)	Δ Bank technology	0.04 (0.05)	0.03 (0.17)
Δ Branch intensity	0.01 (0.12)	-0.05 (0.14)	Δ Branch intensity	0.03 (0.13)	0.29 (0.18)
Δ Retail portfolio	0.01 (0.04)	-0.12*** (0.04)	Δ Retail portfolio	0.01 (0.02)	-0.06 (0.06)
Δ Bank funding	0.01 (0.02)	-0.01 (0.02)	Δ Bank funding	-0.06** (0.03)	0.02 (0.04)
Δ Market concentration	0.06*** (0.02)	0.00 (0.02)	Δ Market concentration	-0.048 (0.02)	0.01 (0.03)
Δ Regulation	-0.36 (0.45)	0.13 (0.25)	Δ Regulation	-0.05 (0.49)	-0.53 (0.48)
Δ Macro technology	0.07 (0.07)	0.10 (0.12)	Δ Macro technology	-0.19 (0.17)	0.05 (0.17)
Δ internet banking	-0.03 (0.06)	0.00 (0.06)	Δ ATM banking	0.00 (0.89)	-0.02 (0.03)
Δ Mobile banking	0.02 (0.03)	-0.09 (0.08)	Δ Agent banking	-0.84 (0.89)	-0.12 (0.09)
Constant	17.62*** (3.43)	9.97*** (2.46)	Constant	12.83*** (1.65)	17.20*** (3.60)
Observations	530	405	Observations	627	405
Groups	11	8	Groups	10	8

Robust standard errors in parentheses. The lag structure is p=1 and q=1 Based on AIC. $* p < 0.10$, $** p < 0.05$, $*** p < 0.01$.

4.3.5 Holm-Bonferroni Correction

As this research examines drivers of different dimensions of BBI, it is vital to recognize the risk of family wise error rate (FWER) that would result from such multiple comparison approach. Precautions should also be taken to reduce this risk, particularly in the PMG estimations on which our analyses are based.

The Bonferroni-Holm method is employed to resolve the problem of multiple comparisons. It is one of many approaches for controlling the family-wise error rate (FWER) by adjusting the rejection criteria for each of the individual hypotheses. The FWER is the probability that one or more Type I errors will occur. The methodology is named after Sture Holm, who codified it, and Carlo Emilio Bonferroni. The Bonferroni correction, when used with multiple tests, reduces the likelihood of obtaining a statistically significant result, also known as a Type I error (Marcus et al., 1976; Holm, 1979). However, despite its simplicity, the Bonferroni method lacks statistical power and is less effective than the Holm-Bonferroni method (Hommel, 1988; Newson, 2010). The Holm-Bonferroni adjustment to the Bonferroni method is shown below.

Let $P_{1,}, \dots \dots, P_{m,}$ be *m* p-values, sorted into order lowest-to-highest with $H_{1,}, \dots H_{m,}$ as their corresponding null hypotheses. The idea is to have the FWER to be no higher than a certain pre-specified significance level, α. The formula to calculate the Holm-Bonferroni is presented as equation 4.14 below:

$$Target\ alpha\ level \Big/ [n - rank\ number\ of\ pair(by\ degree\ of\ significance) + 1]$$

Where:

Target alpha level = overall alpha level (usually .05),

n = number of tests.

This method ensures that the FWER is at most αin the strong sense. According to Hommel, (1988) and Newson (2010), the method works through the following steps:

(i) Is $P_{1,} < \frac{\alpha}{m}$? If so, reject $H_{1,}$ and continue to the next step, otherwise EXIT.

(ii) Is $P_{2,} < \frac{\alpha}{m-1}$? If so, reject $H_{2,}$ also, and continue to the next step, otherwise EXIT.

(iii) And so on: for each P value, test whether $P_{k,} < \frac{\alpha}{m+1-k}$. If so, reject $H_{k,}$ and continue to examine the larger P values, otherwise EXIT.

The results from the PMG estimations in Tables 4.7 and 4.8, adjusted for FWER are presented in Table 4.10 below. For physical BBI, the adjusted results confirm statistically significant negative impact of market concentration on adoption of agent banking innovation in both in the long run and in the short run. Also noteworthy is the positive impact of market concentration on the adoption of ATM banking innovation in the short run. For remote BBI, the results confirm the statistically significant negative impact of branch intensity and bank funding on adoption of mobile banking innovation in the long run. The results also confirm the statistically significant positive impact of regulation on the adoption of mobile phone banking innovation in the long run.

Table 4. 10 PMG results after Holm-Bonferroni correction

Long run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking innovation	Agent Banking innovation	Internet Banking Innovation	Mobile banking innovation
Bank size	-0.01 (0.15)	-0.73 (0.39)	-0.01 (0.15)	-0.43 (0.48)
Bank technology	0.00 (0.03)	-0.19 (0.10)	0.00 (0.03)	0.00 (0.06)
Branch intensity	-0.03 ()	0.06 (0.10)	-0.03 ()	-0.53* (0.08)
Retail portfolio	-0.02 (0.02)	0.02 (0.04)	-0.02 (0.02)	0.00 (0.04)
Bank funding	0.00 (0.01)	-0.05 (0.03)	0.00 (0.01)	-0.07* (0.03)
Market concentration	0.00 (0.02)	-0.20* (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	-0.07 (0.12)	0.59 (0.35)	-0.07 (0.12)	1.03* (0.26)
Macro technology	-0.09 (0.05)	0.17 (0.15)	-0.09 (0.05)	-0.15 (0.09)

Table 4.10 PMG results after Holm-Bonferroni correction (cont'd)

Short run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking innovation	Agent Banking innovation	Internet Banking Innovation	Mobile banking innovation
Error-correction coefficient	-0.48* (0.10)	-0.39* (0.07)	-0.73* (0.10)	-0.63* (0.08)
Δ Bank size	-0.15 (0.27)	0.63 (0.45)	-1.04 (0.51)	-2.61 (1.52)
Δ Bank technology	0.00 (0.04)	0.05 (0.02)	0.03 (0.04)	0.00 (0.05)
Δ Branch intensity	-0.12 (0.08)	-0.06 (0.09)	0.07 (0.10)	0.13 (0.10)
Δ Retail portfolio	-0.01 (0.03)	-0.03 (0.03)	0.01 (0.02)	-0.08 (0.12)
Δ Bank funding	0.00 (0.02)	-0.03 (0.02)	-0.04 (0.03)	0.02 (0.04)
Δ Market concentration	0.05* (0.01)	-0.05* (0.20)	-0.04 (0.13)	0.02 (0.04)
Δ Regulation	-0.38 (0.39)	0.07 (0.19)	-0.06 (0.37)	-0.09 (0.45)
Δ Macro technology	0.05 (0.06)	0.03 (0.11)	-0.13 (0.13)	0.13 (0.15)
Constant	7.37* (1.23)	13.84* (2.63)	13.53* (1.27)	14.59* (2.61)
Observations	888	645	778	537
Groups	13	10	13	11

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

Also noteworthy are the results in Table 4.11 in respect of the robustness test estimations in Table 4.9 but adjusted for FWER. According to these results, the statistically significant negative impact of bank size and retail portfolio on adoption of physical BBI is confirmed for ATM banking innovation in the long run. The results also confirm the statistically significant long run negative impact of market concentration on the adoption of both ATM and agent banking innovations. In the short run, the findings confirm the negative impact of retail portfolio on adoption of agent banking innovation and the positive impact of market concentration on adoption of ATM banking innovation. More crucially, the findings show no evidence of the impact of remote BBI on adoption of physical BBI both in the long run and short run.

For remote BBI, the findings confirm evidence of statistically significant negative impact of branch intensity on adoption of mobile phone banking innovation and the positive impact of bank funding on adoption of internet banking innovation. It also confirms the statistically significant impact of regulation as being negative for the adoption of internet banking and positive for the adoption of mobile phone banking, in the long run. In addition, the results show no evidence of statistically significant impact of physical BBI on adoption of remote BBI in the short run. However, in the long run, the findings show that ATM banking innovation has a statistically significant positive impact on adoption of mobile phone banking innovation.

Table 4. 11 Robustness Check PMG results after Holm-Bonferroni correction

Long run coefficients					
Physical BBI			Remote BBI		
	ATM Banking innovation	Agent Banking innovation		Internet Banking Innovation	Mobile banking innovation
Bank size	-1.67* (0.27)	-0.66 (0.57)	Bank size	0.14 (0.19)	-0.66 (0.52)
Bank technology	-0.06 (0.03)	-0.18 (0.12)	Bank technology	0.03 (0.04)	0.06 (0.07)
Branch intensity	0.01 (0.04)	-0.06 (0.12)	Branch intensity	0.03 (0.03)	-0.58* (0.08)
Retail portfolio	-0.04* (0.01)	0.09 (0.06)	Retail portfolio	-0.03 (0.02)	-0.04 (0.05)
Bank funding	-0.01 (0.01)	-0.03 (0.06)	Bank funding	0.03* (0.01)	-0.05 (0.04)
Market concentration	-0.06* (0.02)	-0.13* (0.09)	Market concentration	0.00 (0.03)	-0.04 (0.06)
Regulation	-0.05 (0.08)	0.55 (0.48)	Regulation	-0.46* (0.18)	0.90* (0.30)
Macro technology	0.01 (0.03)	0.18 (0.17)	Macro technology	-0.04 (0.07)	-0.17 (0.11)
Internet banking	0.05 (0.05)	0.11 (0.10)	ATM banking	-0.01 (0.03)	0.08* (0.05)
Mobile banking	-0.04 (0.02)	0.24 (0.08)	Agent banking	0.03 (0.04)	-0.05 (0.06)

Table 4.11 Robustness Check PMG results after Holm-Bonferroni correction (cont'd)

Short run coefficients					
Physical BBI			Remote BBI		
	ATM Banking innovation	Agent Banking innovation		Internet Banking Innovation	Mobile banking innovation
Error-correction coefficient	-0.57* (4.67)	-0.45* (0.08)	Error-correction coefficient	-0.67* (0.13)	-0.60* (0.09)
Δ Bank size	-0.33 (0.48)	-0.18 (0.87)	Δ Bank size	-1.47 (0.70)	-1.42 (1.41)
Δ Bank technology	-0.03 (0.05)	0.11 (0.06)	Δ Bank technology	0.04 (0.05)	0.03 (0.17)
Δ Branch intensity	0.01 (0.12)	-0.05 (0.14)	Δ Branch intensity	0.03 (0.13)	0.29 (0.18)
Δ Retail portfolio	0.01 (0.04)	-0.12* (0.04)	Δ Retail portfolio	0.01 (0.02)	-0.06 (0.06)
Δ Bank funding	0.01 (0.02)	-0.01 (0.02)	Δ Bank funding	-0.06 (0.03)	0.02 (0.04)
Δ Market concentration	0.06* (0.02)	0.00 (0.02)	Δ Market concentration	-0.05 (0.02)	0.01 (0.03)
Δ Regulation	-0.36 (0.45)	0.13 (0.25)	Δ Regulation	-0.05 (0.49)	-0.53 (0.48)
Δ Macro technology	0.07 (0.07)	0.10 (0.12)	Δ Macro technology	-0.19 (0.17)	0.05 (0.17)
Δ internet banking	-0.03 (0.06)	0.00 (0.06)	Δ ATM banking	0.00 (0.89)	-0.02 (0.03)
Δ Mobile banking	0.02 (0.03)	-0.09 (0.08)	Δ Agent banking	-0.84 (0.89)	-0.12 (0.09)
Constant	17.62* (3.43)	9.97* (2.46)	Constant	12.83* (1.65)	17.20* (3.60)
Observations	530	405	Observations	627	405
Groups	11	8	Groups	10	8

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

4.4 Discussion of the Empirical Findings

As alluded to in Section 4.2, the PMG model form the bedrock of our analysis. From the foregoing detailed ARDL results, we isolate salient findings which can be discussed in the context of Malawi and in relation to the hypotheses and findings from previous research.

Firstly, the study finds that adoption of both physical and remote BBIs is a positive function of regulation, in line with sixth hypothesis (H6). The finding is robust for mobile phone banking in the long run, even after adjusting for FWER both under the main analytical model as well as the robustness test model. This corroborates earlier literature attesting to the beneficial effect of regulation in reducing the risks of financial innovation, both to consumers and providers alike (Boyd et al., 1998; Barth et al., 2008; Gutierrez and Singh, 2013; Lee and Chih, 2013; Naghavi et al., 2016; Burns, 2018; Enyang Besong et al., 2021). Unregulated financial innovations have been found to be impediments to financial inclusion because they expose financial institutions to operational and integrity risks arising from increased financial fraud and money laundering crimes (Lumpkin, 2010). Unregulated financial innovations can lead to product misrepresentation at the consumer level, resulting in a loss of consumer trust in formal financial services (Bath et al., 2008; Lee and Chih, 2013).

BBI in SSA including Malawi, is more about adapting what is already being implemented in other jurisdictions, rather than inventions in the strictest sense of new product development (Madise, 2019). Equally, the regulatory approach to BBI increasingly follows best practice and guidance from standard-setting bodies and lessons learnt from jurisdictions that have already tried and tested regulatory frameworks on similar BBI (Muthiora 2015, Ondiege 2010; Ondiege, 2015; Mutsonziwa and Maposa, 2016). In this regard, the traditional one-size-fits-all approach has been replaced by lighter-touch, risk-based regulation focusing more on the financial service and less on the financial service provider, inter-alia through measures for disclosure and transparency; a non-exhaustive list of permissible activities; simplified Know Your Customer (KYC) requirements for low end consumers, requirements for the interoperability of BBI and to an extent, a level of clarity on eligibility criteria for financial service providers. Further, measures have been taken to coordinate the activities of the multiple regulators operating in Malawi’s financial sector. As a result, the regulatory framework achieves its objective of supporting the financial institutions' risk management needs around BBI (Buckley et al., 2015; Reserve Bank of Malawi, 2021).

Secondly, we note a general inverse relationship between bank size and adoption of physical BBIs in the long run; and the adoption of remote BBIs in the short run. This is contrary to second hypothesis (H2) and the general conclusion of the earlier academic research that argues for a positive relationship between firm size and adoption of innovation (Brown, 1981; Hannan and McDowell, 1984; Frame and White, 2004). This view draws heavily from the Galbraith-Schumpeter hypothesis. According to this theory, rapid adoption of technological innovation among the major industrial enterprises rests in their abundant financial and human capital that enables them to engage in a wide range of activities resulting in economies of scale. As innovation can be applied to these numerous activities, adoption of innovation becomes less risky for the major industrial enterprises compared to the smaller enterprises. However counter-intuitive, our study findings of a negative impact of bank size on adoption of BBI are not uncommon in the literature (see, Escuer et al., 1991; Hunter and Timme, 1991). According to the literature, underpinning this negative impact of bank size is the strong quest among small banks to grow their market share by adopting the kind of innovations that help them to tap into the customer segments that are often underserved by the large banks. Under this narrative, small banks are less bureaucratic and can thus more easily decide on adopting innovations much faster than the larger banks that tend to have fragmented and incompatible processes (Segers, 1993; Nooteboom, 1994; Zhu et al., 2006; Sullivan and Wang, 2020). While this finding is robust for adoption of ATM banking innovation after adjusting for FWER in the robustness test estimations, for the main analytical model, the impact of bank size after adjusting for FWER is found not to be statistically significant.

Over and above the preceding findings that are consistent across the different forms of BBI, an important finding of the study relates to how some factors vary in their impact on the adoption of the different forms of BBI. This enables us to answer one of the research questions regarding whether the drivers vary with varying forms of BBI. In this regard, we note as follows:

Firstly, physical BBI is positively related to branch intensity, contrary to fifth hypothesis (H5) that branch intensity is negatively related with adoption of BBI. In so far as bank branches are also often the prime location for most ATMs, the findings suggest the presence of network effects, whereby the value of an innovation increases in proportion to the number of outlets from where the innovation can be accessed (Saloner and Shepard, 1995). This impact however is not statistically significant after adjusting for FWER. On the other hand, the long run impact of branch intensity on remote BBI is negative including after adjusting for FWER both in the main analytical model as well as in the robustness test model. This is consistent with Corrocher (2006) and Malhotra and Singh (2010). The findings suggest that remote BBI is a substitute for physical branches where banks have a less extensive branch network (Furst et al., 2002).

Secondly, we note a general decline in adoption of both physical and remote BBI as bank funding increases; consistent with fourth hypothesis (H4) and the previous literature that cites the role of innovativeness of management in spurring adoption of BBI (Sinha and Chandrashekaran, 1992; Furst et al., 2002). For mobile phone banking innovation in the long run, the findings are robust even after adjusting for FWER in the main analytical model. However, we fail to find any impact of management innovativeness on the adoption of ATM banking innovation. This is not surprising considering that as one of the earliest forms of BBI, ATM banking innovation has now become a fundamental requirement to banking service delivery, with all banks in Malawi incorporating it in their retail banking strategy. However, this is not to suggest that ATM banking has lost its novelty. It has evolved from simply being a cash dispenser to become the facilitator of utility bill payments, purchase of lottery tickets and mobile phone airtime as well as transfer of funds between bank accounts within the same bank. Certain ATMs have recently been configured to allow customers to deposit cash into their bank accounts. However, what our findings suggest is that in order for banks to implement these add-ons to their ATM banking strategy, innovativeness of the management of the bank is not a significant driver.

Thirdly, the impact of market concentration is mixed across the different dependent variables and between long and short run. For instance, in the long run it is generally negative but only statistically significant for adoption of agent banking innovation, including after adjusting for FWER in the main analytical model. For the robustness check estimation, the statistically significant negative impact is robust both ATM banking and agent banking innovations, including after adjusting for FWER. In the short run, it is negative and statistically significant for the adoption of agent and internet banking innovations. It is also positive and statistically significant for the adoption of ATM banking innovation and positive and statistically insignificant for the adoption of mobile phone banking innovation. After adjusting for FWER, the impact is statistically significant only for ATM and agent banking innovations. The positive short run impact on the adoption of ATM banking innovation is consistent with the earlier literature on the role of market share in enabling firms to exploit the gains from the investment in innovation (Raider, 1998; Botello-Peñaloza and Guerrero-Rincón, 2019). However, the findings of a generally inverse impact of market concentration on the other forms of BBI add to the evidence on how anti-competitive market practices can distort efficiency, including by stifling innovation that resides in competition.

Fourthly, contrary to first hypothesis (H1) that bank technology is positively related with adoption of BBI, our results show a negative impact of bank technology on adoption of ATM and agent based BBI in the long run; suggesting that investment in physical BBI is more likely for banks with less investment in their own technology. The expected positive impact is established only for adoption of agent banking innovation in the short run. However, all these results are not statistically significant after adjusting for FWER. For remote BBI, bank technology exerts no impact. In the literature, innovations are found to be more compatible and easily integrated with superior technologies; suggesting a positive relationship between bank technology and innovation (Furst et al., 2002; Frame and White, 2004; Brown and Molla, 2005; Malhotra and Singh, 2010). However, bank technology has been argued to be traditionally configured for low volume/high value corporate transactions, rather than the high volume/low value retail transactions that the BBI tend to target (Dermish et al., 2012). These findings highlight a new perspective regarding innovations not being homogeneous, particularly with regard to their technological needs. In this regard, the results suggest that some forms of physical BBI do not require sophisticated technologies beyond what traditionally obtains in typical banking institutions. This should not be confounding considering the basic nature of the payment transactions that are undertaken through agent banking platforms. In this regard, the evidence suggests that banks with low investment in their own technology are better placed to adopt physical BBI.

Last but not least, consistent with third hypothesis (H3), the literature is replete with findings of a positive impact of the retail portfolio on bank adoption of BBI, suggesting that consumer demand matters for bank decisions to implement BBI (Hannan and McDowell, 1984; Barras,1990; Saloner and Shepard, 1995; Corrocher, 2006; Malhotra and Singh, 2010). However, our research establishes mixed findings on the impact of retail portfolio on the different forms of BBI. For physical BBI, we find that the impact of retail portfolio on bank adoption of both ATM and agent banking innovations is negative in the short run, but positive in the long run. In both cases, the results are not statistically significant after adjusting for FWER in the main analytical model. For remote BBI, we find that retail portfolio positively impacts the adoption of internet banking innovation in the short run, and negatively in the short run. However, all the above findings are statistically insignificant. As regards the adoption of mobile phone banking, we note that there is no long run impact of retail portfolio. However, in the short run, we find evidence of a statistically significant negative impact of retail portfolio. This becomes statistically insignificant when we adjust for FWER.

We also note that macro technology impacts positively the adoption of physical BBI and negatively the adoption of remote BBI. However, the impact is statistically significant only for internet banking in the long run under PMG estimation, and for agent banking innovation under FE estimation. After adjusting for FWER in the main analytical model as well as in the robustness check estimations, both these become statistically insignificant. As has been alluded to in the literature review, the above mixed findings are not uncommon in the literature (see Gourlay and Pentecost,2002; Corrocher, 2006; Muthinja and Chipeta, 2018).

Lastly, mobile banking innovation is found to negatively impact the adoption of ATM banking innovation. This is against the background that the ubiquity of the mobile telephony has shifted some financial consumers from transacting on ATMs to mobile phone banking platforms. In this sense, remote BBI can substitute physical BBI. At the same time, a positive impact of ATM banking innovations on the adoption of mobile phone banking innovation is established, against the background that ATMs have undergone transformation allowing transactions to be linked to mobile phones. The finding that mobile phone banking has a positive impact on the adoption of agent banking innovation can be explained by the fact that most agent banking innovations have mobile phone banking embedded in their value propositions. This highlights the extent to which physical BBI can leverage remote BBI to deliver financial services to low end consumers in rural areas.

4.5. Policy Implications

As discussed in Chapter 1, the potential for BBI to contribute to financial inclusion has motivated the investigation of the drivers of bank adoption of BBI. To begin with, BBI eliminates the need to travel long distances in order to obtain financial services (Dermish et al., 2012; Suri and Jack, 2016; Montfaucon, 2020). Second, BBI allows banks to cut overhead costs by reducing the need to open branches in rural areas that are sparsely populated and difficult to reach (Berger et al, 2001; Mas 2009; Stapleton, 2013; Gosavi, 2015; Buckley et al., 2015). The cost savings inherent in BBI models can help to alleviate the affordability challenge faced by the poor because banks are obligated to pass on the cost savings benefits through lowering the price of financial products (Alexandre et al., 2011; Buckley et al., 2015; Makina, 2017; Cull et al., 2018; Demirgüç-Kunt et al., 2018). Furthermore, the digital trails that come with BBI usage have improved banks' knowledge of their customers. With better knowledge of their customers, banks are able to develop financial products that are tailored to the specific needs of diverse customers (Mas, 2016).

Against this background, the findings from this chapter provide important insights, both for banks seeking to implement BBI as a business strategy; and for public policy that seeks to incentivise the adoption of BBI to address the problem of low financial inclusion. Below is a discussion of the strategy and policy implications drawn from the study findings.

Firstly, the importance of proportionate regulation is indisputable, given that the positive impact of regulation is established for most of the dimensions of BBI studied, in line with hypothesis 6 (H6). In this regard, if financial services strategies on BBI are to have a substantial influence on financial inclusion, public policy would do well to prioritise proportionality in the implementation of non-prudential regulation for BBI. As earlier noted, regional regulatory benchmarking has seen most SSA Africa countries including Malawi implementing a lighter touch approach to regulation of BBI. The scope of the regulation in the context of proportionality to risk has been multifaceted, including, but by far not limited to simplified KYC and a focus on the financial service offered rather than the financial provider alone (Muthiora, 2015; Ondiege, 2010; Buckley et al., 2015; Ondiege, 2015; Mutsonziwa and Maposa, 2016). More importantly, a test-and-learn approach that allows for experimentation has been cited as another important aspect of BBI regulation in this regard (Mlachira and Yabara, 2013). Given the dynamic nature of both innovation and risk, enhancing the relevance of regulation in assisting financial institutions to manage innovation-related risks necessitates increased collaboration between regulators and regulated institutions.

In this regard, there is need to invest in systems for automated submission of performance and regulatory data by the financial institutions to the lead regulator. The system should also make it easier for different sector regulators to access these data from a common database, rather than requiring regulated institutions to file periodic data with each sector regulator separately. In addition to reducing the time and costs of regulatory compliance on the part of financial institutions, these reforms will be crucial in ensuring that regulators have a better understanding of emerging risks in the local context. With a better understanding of the current risks, regulators can develop regulations that help financial institutions manage the unique risks associated with new delivery strategies, rather than unduly stifle innovation.

Secondly, contrary to Hypothesis 2 (H2), the research fails to find evidence of a positive impact of bank size on adoption of BBI. The fact that small banks are more likely to use both physical and remote BBI illustrates the potential for small banks to reach out to customers who are typically overlooked or underserved by large banks, leveraging innovation. However, Malawi's banking sector, like the financial sectors of most developing countries, has seen several bank mergers and acquisitions in as a strategic response to Malawi's adoption of the Basel II Accord, in 2008, in order to bolster financial system stability. Virtually all banks that were acquired by the larger banks were smaller banks with capital adequacy shortfalls (Reserve Bank of Malawi, 2021). Considering that small banks, not big banks, are the rapid adopters of BBI according to our research findings, it can be argued that these mergers and acquisitions potentially undermine the potential for BBI and in the process, efforts towards higher financial inclusion rates. Scaling up BBI in the face of Basel II financial stability considerations therefore requires re-opening the banking sector to smaller financially sound institutions. In this regard, reforms that introduce differentiated capital adequacy and licensing standards for different classes of banks will allow more small-yet-financially sound institutions to enter the market, thereby accelerating BBI driven financial inclusion. This viewpoint is consistent with an earlier recommendation made by Mlachira and Yabara (2013), who acknowledged the need to open up the financial sector to more competition despite the threats to financial stability.

The quest for regulation that strikes a delicate balance between financial stability and the creation of more inclusive financial systems has been widely acknowledged as a topic of significant interest in the recent literature (see, Ahamed et al., 2021). Our results also validate the need to adopt a new approach to regulation, where the stringency of regulatory standards applicable to a bank ought to be premised on the systemic importance of that bank. In other words, those banks seen as too big to fail need not be regulated by the same standards applicable to the smaller banks, as the latter are not systemically important. This proportionate stance to regulation will create space for the small banks to thrive and implement rapid adoption of BBI and in the process contribute to narrowing the financial inclusion gap. The findings of the negative impact of market concentration on bank adoption of physical and remote BBI render support to the above policy recommendation regarding opening up the sector to more new, small entrants in the banking sector. This is against the background that the concentrated nature of Malawi's banking sector derives from the market dominance of the two largest banks (Kaluwa and Chirwa, 2017). As large banks have been found to be slow adopters of BBI, reforms to gradually reduce market concentration by opening up the sector further can help spur adoption of both physical and remote BBIs.

Thirdly, the finding that increased bank technology is associated with decreased adoption of physical BBI (but with no impact on remote BBI) highlights the heterogeneity among BBI, particularly in the context of the intensity of their technological requirements. Contrary to Hypothesis 1 (H1), the results show that physical BBI are less intense in their technology requirements, given the basic financial services delivered under ATM and agents. In this regard, the evidence suggests that banks with low investment in their own technology are better placed to adopt physical BBI.

Considering that banking technologies are generally configured for low volume/high value transactions of corporates, rather than low value/high volume transactions of retail clientele; the non-positive findings open us to new possibilities (not empirically tested in this research) on whether banks seeking to accelerate adoption of BBI would do well not to depend on their traditional technologies, but rather explore wider technological synergies through outsourcing or partnerships with third party providers such as telecommunications companies (TELCO) and financial technology (Fintech) companies[8]. Through their mobile network operator (MNO) subsidiaries, TELCO have been argued in the literature to overcome infrastructural deficiencies and achieve scale even in the poorest and most remote rural areas of SSA (Gutierrez and Singh, 2013; Mothobi and Grzybowski, 2017). Against this background, partnerships between TELCO and fintechs on the one hand and traditional financial institutions on the other, can help accelerate adoption of BBI given that banks will benefit from the fintechs' technological competencies and the TELCO's large customer base,

[8]Fintech is defined as the use of technology to deliver new and improved financial services (Thakor, 2020).

while the TELCO and fintechs will benefit from the banking institutions' distinct advantages in liquidity and risk management (Philippon, 2016; Buchak et al., 2018; Bollaert et al., 2021). As this is only inferred from the vast body of literature, it remains vital that future research should empirically test how the fintechs and mobile money operators can impact the relationship between bank technology and bank adoption of BBI.

Fourthly, noteworthy is the inverse relationship between bank funding and the adoption of all forms of BBI, attesting to the role of management innovativeness in steering innovation as per Hypothesis 4 (H4). This is with the exception of ATM banking innovation which, being one of the earliest forms of BBI, has arguably become a norm to every banking institution offering retail banking services. A crucial policy inference that can be drawn from this resides in shareholders of banks ensuring that personnel appointed to drive the strategy of the banks are only those with a high aptitude towards innovation. In this regard, ensuring a minimum threshold of educational and professional qualification for those driving the strategy of the bank at the level of management or board membership would be a crucial step towards bank implementation of innovative strategies including BBI.

Another important insight for bank strategy relates to the divergent findings on the impact of branch intensity on adoption of different forms of BBI. The positive association between branch intensity and physical BBI indicates that banks with extensive networks of branches can leverage their branding and physical presence to enhance financial inclusion among the low-end consumers using ATM and agent banking innovations. The positive impact of branch intensity on adoption of physical BBI clearly shows that disenfranchising the bank branch model would therefore hinder progress towards the development of physical BBI, let alone financial inclusion of the low-end consumers who still prefer to transact in cash.

This raises an important issue about the need to soften regulatory requirements for branch establishment. To the extent that such policy reduces the cost of establishing a bank branch, the benefits for financial inclusion would be enormous in the context of incentivising banks to widen their networks of branches, while at the same time freeing resources towards further investment in BBI strategies. On the other hand, another strategic insight emanating from the study findings is that banks with a small network of branches would benefit from remote BBI strategies. Moreover, since these financial transactions tend primarily to be digital, adopting remote BBI would help the cash handling and social distance challenges associated with branch banking.

4.6. Conclusion

The chapter has examined the drivers of bank adoption of BBI in a country with high levels of financial exclusion. The FE approach was employed as a launching pad for more thorough investigation using the ARDL models. The ARDL models offer a number of characteristics that make them a better fit for analysing our dataset. Firstly, they eradicate concerns about autocorrelation and endogeneity (Pesaran et al., 2001; Sakyi, 2011). Secondly, they enable analysis of both short and long run relationships simultaneously, and can be used regardless of whether the regressors are I(0) or I(1), but not I(2) (Sakyi, 2011). Lastly, they are asymptotically efficient and more robust in small and finite samples (Pattichis, 1999, Mah, 2000).

Using a unique set of quarterly data for Malawi, we have distinguished between physical and remote form of BBI to answer two research questions regarding what drives bank adoption of BBI; and whether these drivers vary with form of BBI. With regard to the first research question, the chapter’s finding indicate that BBI is largely a positive function of regulation and a negative function of bank size. These factors have been found to be consistent across the different forms of BBI. As regards the second research question, the chapter findings reveal that other drivers, namely bank technology, branch intensity, retail portfolio, management innovativeness, market concentration and macro technology, differ in their impact between physical BBI and remote BBI, in terms of statistical significance and coefficient sign, confirming heterogeneity in BBI, let alone the extent to which bank incentives to adopt the innovations vary accordingly.

The findings offer important insights for bank strategy as well as for public policy seeking to bolster financial inclusion through bank implementation of BBI. Central among these is the need to ensure that regulation is continuously adapted to address the particular BBI risks obtaining in the local context. To this end, enhanced collaboration between regulators and the regulated institutions would be vital in ensuring that regulators have better understanding of the risks and thus better placed to design regulations that are relevant for institutions management of BBI risk. A second key consideration hinges on opening up the banking sector to more small banks which have been found to be rapid adopters of BBI. For banks, the strategic insights hinge on deploying physical BBI in the case of banks with wide network of branches, while banks with smaller network of branches to leverage remote BBI.

In the final analysis, we acknowledge the numerous arguments in the literature that associate large firms with increased financial innovations (Brown, 1981; Hannan and McDowell, 1984; Frame and White, 2004). Against this background, the chapter's findings of a negative impact of bank size on the adoption of BBI challenge theory and are an important contribution to knowledge, particularly about financial innovation in financial systems of developing countries where riskiness of customers is premised primarily on hard data. In that regard, small banks tend to implement BBI more rapidly to tap into the retail segment often underserved by the large banks who target the large corporates for which they have hard data.

These findings raise important questions about whether there are common characteristics underlying small banks to impact the adoption of BBI in Malawi. This is particularly important considering that the banking sectors of most Sub-Saharan Africa countries, including Malawi, have seen significant changes in the ownership structure of banks as a result of the various reforms implemented in the sector. In Malawi, a fundamental aspect of this ownership trajectory has been the government ceding ownership stakes in the two largest banks, followed by smaller banks, in order to open the industry to foreign investors. Not only have small banks emerged in this regard, but there has also been an increasing trend toward the formation of holding companies to own some banks.

The literature is replete with hypotheses about the beneficial impact of foreign ownership on management innovation in host countries; the beneficial impact of funding synergies and technological spillover from holding companies; and the government's social and inclusion agenda. However, in the context of BBI, these hypotheses are largely untested. It would be critical if these hypotheses could be tested in order to help explain some of the findings in this chapter, particularly the impact of bank size and bank funding on the adoption of various BBI. As a result, the following chapter expands on this research to investigate whether different types of bank ownership have any effect on bank adoption of BBI.

Chapter 5: Bank Ownership & the Adoption of BBI

5.1 Introduction

This chapter answers the third research question by examining the impact of various forms of bank ownership on BBI adoption. In this context, the chapter seeks to establish whether different forms of bank ownership influence BBI adoption differently, and thus to determine which forms of bank ownership are amenable to BBI adoption. This investigation builds on the preceding chapter that sought to answer two of the three research questions, hinging on what drives banks to adopt BBI; and whether these drivers vary with different forms of BBI.

While the findings revealed that some drivers matter differently between physical and remote BBI, a general conclusion of the preceding chapter is that adoption of BBI whether physical or remote, is largely a positive function of regulation and a negative function of bank size. According to the literature, firm size has a positive impact on the adoption of innovation, owing to large firms' superior financial and managerial resources, as well as economies of scale stemming from the numerous activities undertaken by large firms (Brown, 1981; Hannan and McDowell, 1984; Frame and White, 2004; Malhotra and Singh, 2010; Kaur and Kaur, 2018; Dorfleitner et al., 2019). In this way, large firm size reduces the risk of adopting innovation.

Given this body of research indicating that large organisations are more likely to adopt innovation, the breakthrough in the preceding chapter that bank size has a negative impact on BBI adoption is an important contribution to knowledge, particularly with regard to the risk narrative that underpins the firm size/innovation nexus. While the findings in the preceding chapter are perplexing, they are nonetheless not uncommon. For instance, empirical studies established that the adoption time minimised in medium sized banks in Spain and in the United States of America (Escuer et al., 1991; Hunter and Timme, 1991). Earlier literature discussed in Chapter 2 has demonstrated how less bureaucratic structures of the small firms has contributed to faster decision-making among the small firms, rendering them to be more agile *vis-à-vis* the large firms (Segers, 1993; Nooteboom, 1994; Zhu et al., 2006; Sullivan and Wang, 2020). This bureaucracy-decision-making narrative, however persuasive, does not appear to explain the paradox in the context of innovation and risk. This lacuna compels a deeper enquiry into the banking structure to establish if there could be further elements that could underpin the firm-size-risk hypothesis to adoption of innovation.

The literature on bank ownership provides motivation to explore further this risk perspective to adoption of innovation. As stated in Chapter 2, the literature has demonstrated how various forms of bank ownership tend to create risk management implications in the various dimensions of financial services. Specific insights have been noted regarding how the agency and political views on state ownership of enterprises endanger the government's social welfare maximisation objectives. The debates over the implications of foreign entry on host financial systems are also noteworthy, as are the notions of technological know-how derived from experiences in multiple operating jurisdictions versus a lack of knowledge of the local context. Even more widely discussed are the business and technological synergies that result from an entity being a subsidiary within a conglomerate or under a holding company. However pertinent, these dimensions in the context of adoption of BBI remain untested. The data on the ownership trajectory in the Malawi banking sector enable us to test the above dimensions.

As noted in Chapter 1, Malawi, like most Sub-Saharan African countries, has witnessed the emergence of different forms of bank ownership on the back of the financial sector liberalisation reforms implemented under International Monetary Fund/World Bank funded Structural Adjustment Programs, under the World Trade Organisation’s General Agreement on Trade in Services and, more recently, as part of the ongoing developments under the Basel Accord. In Malawi the state has actively participated in the ownership of banking institutions, arguably with the view to influencing strategy towards the social welfare maximisation interest (Chirwa and Mlachira, 2004; Nkowani, 2008). However, over time, the government has ceded a significant ownership stake in the two largest banks, and latterly subjected its one wholly owned bank and one majority owned bank to acquisition by existing private banks. Nonetheless, it has continued to hold a minority stake in some banks. A common feature about this privatisation of state-owned institutions has been the opening up the banking sector to foreign entrants. Not only have small and medium sized banks emerged in this regard, but there has also been an increasing trend toward the formation of holding companies to own some banks, both large and small.

This chapter uses data on three types of bank ownership, namely government ownership, foreign ownership, and BHC ownership, to test the following hypotheses:

H8 Government ownership impacts positively the adoption of BBI in line with the social welfare maximisation view (Brownbridge and Harvey, 1998; Peachey and Roe, 2006; Demirgüç-Kunt et al., 2008; Atkinson and Stiglitz, 2015; Neuberger, 2015).

H9 Bank adoption of BBI is a positive function of foreign entry, BHC membership against the background of know-how, technological, strategic and business synergies resident in group operations in various jurisdictions and sectors (Courchane et al., 2002; Frame and White, 2004; Cull and Soledad Martinez Peria, 2010; Sullivan and Wang, 2020).

In this context, we investigate the relationship by employing a FE model with heteroskedasticity robust standard errors (Driscoll and Kraay, 1998). We then broaden the analyses to include dynamic models, which serve as the foundation for our analyses. In particular, we use the ARDL models. As discussed in the previous chapter, the ARDL models have several advantages that make them suitable for analysing our dataset. Firstly, they are asymptotically efficient and comparatively more robust in small or finite samples (Pattichis, 1999, Mah, 2000; Sakyi, 2011). Secondly, they can be used regardless of whether the regressors are I(0), I(1) or mutually integrated (Sakyi, 2011). Thirdly, they eliminate the risk of autocorrelation and endogeneity (Pesaran et al., 2001; Sakyi, 2011). Fourthly, they estimate both short and long run relationships at the same time.

Key findings emerge. Firstly, and consistent with the social welfare maximisation hypothesis, we find evidence of a positive impact of government ownership on bank adoption of ATM and internet banking innovations in the short run. In the long run, the positive impact of government ownership on adoption of ATM banking innovation is positive but prominent for banks with a narrow network of branches. Secondly, we find evidence of the impact of foreign entry as being negative for the adoption of mobile phone banking innovation and positive for the adoption of ATM banking innovation, in the long run. However, this positive impact on ATM banking adoption is prominent only among the small banks. There is no statistically significant evidence of the impact of government ownership on the adoption of the other forms of BBI.

Thirdly, evidence of a direct impact of BHC ownership is established to be positive only for the adoption of mobile phone banking innovation, in the long run. In terms of indirect impact, BHC membership negatively impacts the adoption of ATM and agent banking innovations, through bank size. As noted from the previous chapter, there is a negative but very negligible correlation between BHC membership and bank size. Mixed results are established with regard to the effect of the interaction between BHC ownership and bank technology on adoption of BBI. While this impact is negative for the adoption of ATM banking innovation in the short run, for the long run we note the impact to be positive on the adoption of agent banking innovation and negative for the adoption of mobile phone banking innovation.

A general conclusion from this investigation is that government ownership in banks leads to rapid adoption of only some forms of BBI, with the impact on the other forms of BBI being negative or not statistically significant. In this regard, government ownership's beneficial effect in achieving the goal of social welfare maximisation via greater financial inclusion is limited. Government's direct participation in the financial system through ownership in financial institutions may therefore not be an effective strategy for pursuing the financial inclusion agenda. A further inference from the results relates to how government banks' over-reliance on the costly branch strategy has nuanced the need to deploy BBI. While state ownership can help government achieve social welfare maximisation objective such as financial inclusion, the central bank's implementation of capital adequacy and risk management regulations, without forbearance towards state owned financial institutions, is critical to insulating government owned banks from the risks of agency and political considerations inherent in state ownership of enterprises.

A further conclusion drawn from the findings is that foreign ownership's beneficial impact on financial inclusion may be traced back to its impact on the proliferation of small banks. This, combined with the findings about the role of BHC membership, adds to our earlier conclusion that the financial sector needs to be opened up further to other forms of shareholding, as this leads to the proliferation of small banks. Small banks have been found to be rapid adopters of BBI in the long run. This has the ability to alleviate market distortions brought about by the market dominance of the two largest banks in Malawi (Chirwa and Mlachira, 2004; Kaluwa and Chirwa, 2017). Also noteworthy is the beneficial long run implication of BHC membership on adoption of BBI, particularly as financial transactions undertaken by the member subsidiaries within the group become more digitised.

The rest of the chapter is divided into three broad sections, reflecting the form of bank ownership being evaluated. Section 5.2 evaluates the impact of government ownership on adoption of BBI, followed by the analysis of the impact of foreign ownership in Section 5.3. An examination of the impact of BHC ownership is presented in Section 5.4. Section 5.5. is the chapter's conclusion, providing a broad summary of the key findings and what they mean for financial sector strategy and policy.

5.2 Government Ownership

5.2.1. Background to State Ownership in Financial Institutions

As stated in Chapter 1, financial inclusion has enormous socioeconomic benefits, such as providing impoverished households, particularly women, with a secure platform for basic payments, savings, and access to credit for consumption smoothing, social services, and entrepreneurship (World Bank, 2014; Demirgüç-Kunt et al., 2018). It contributes to credit risk diversification and financial stability. Financial inclusion improves states' ability to detect money laundering and criminal transactions by integrating the cash economy into the digital economy. Because of the potential developmental benefits, financial inclusion has arguably become a social welfare maximisation agenda for governments in most developing countries, pursued from a public policy perspective (Brownbridge and Harvey, 1998; Peachey and Roe, 2006; Demirgüç-Kunt et al., 2008; Neuberger, 2015). There has not been much recent empirical research to inform whether the policy approach can be bolstered with direct state involvement in the operation of financial institutions. As mentioned in Chapter 1, BBI has become an important strategy for achieving financial inclusion. This section takes advantage of the government's involvement in bank ownership in Malawi to determine whether BBI-led financial inclusion can be realised through ownership of financial institutions.

We test the hypothesis that bank adoption of BBI is a positive function of government ownership. This is premised on the social view that posits the market failure correction role of government (Stiglitz and Weiss, 1981; Greenwald and Stiglitz, 1986; Shleifer, 1998; Atkinson and Stiglitz, 2015). Under this perspective, government ownership of banks seeks to correct the market failure where the purely business-oriented banks tend to refrain from extending financial services to the difficult to reach remote areas or find the rural inhabitants to be too risky. However, *a priori* the expected sign of government ownership can be ambiguous, drawing on the agency and political views, summed up as low capitalisation, poor governance, and weak managerial incentives (Banerjee, 1997; Hart et al., 1997; La Porta et al., 2002; Barth et al., 2004; Beck et al., 2004; Berger et al., 2004; Dinç, 2005; Shen and Lin, 2012; Hagendorff, 2014). Collectively, these have the potential to undermine a bank's ability to embrace new risks, including in this case those relating to implementation of BBI strategies to bolster financial inclusion.

5.2.2. Model Specification

To examine the impact of state ownership on bank adoption of BBI, we start with the FE model with heteroskedasticity robust standard errors (Driscoll and Kraay, 1998). Our baseline empirical model is given in Equation 5.1 as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \beta_3 Gov_{it} + \mu_{it} \quad (5.1)$$

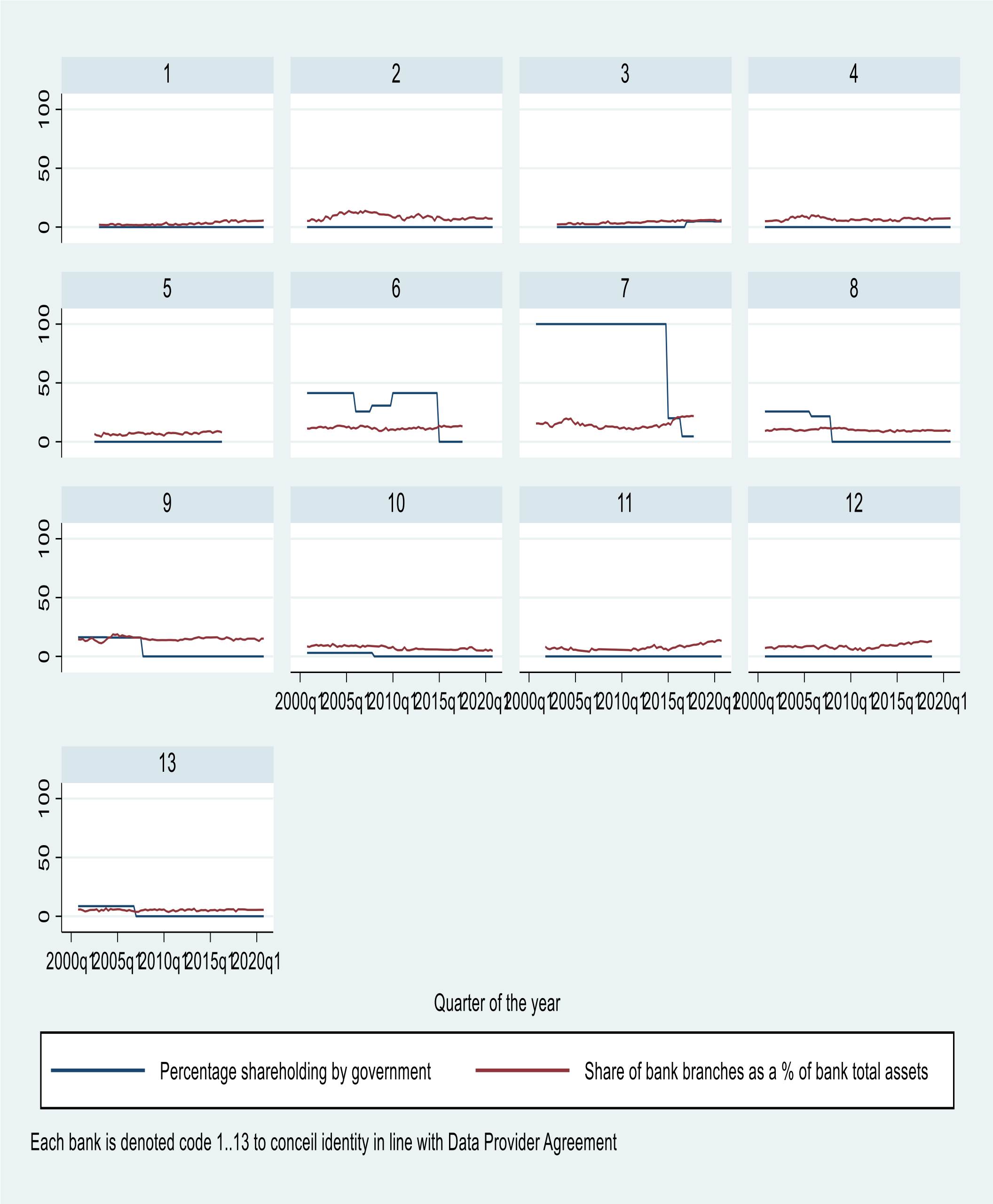
Where, $Y_{i,t}$ represents a vector of dimensions of BBI for bank *i* over time *t. X* is a vector of bank characteristics (bank technology, branch intensity, bank retail portfolio, bank funding and bank size) that vary cross-sectionally and over time *t.* Z is a set of macro-level factors: (market concentration, regulation and macro technology), that vary overtime but are constant cross-sectionally. μ_{it} is the error term.

Crucially, we include a variable Gov_{it} to capture the percentage shareholding in the bank *i* over time *t*, attributed to Government. The percentages approach allows us to capture variations in ownership more accurately, both cross-sectionally and over time, than would the dummy approach. Previously related studies have often adopted the dummy approach due to the scarcity of data. The dummy approach typically denotes 1to represent a specific ownership category and 0 otherwise (Malhotra and Singh, 2010; Muthinja and Chipeta, 2018).

Secondly, we conjecture that the relationship between state ownership and bank adoption of BBI could be via its interaction with bank level characteristics. We therefore interact government ownership with branch intensity. Prior to the advent of BBI, financial inclusion was traditionally accomplished through brick-and-mortar branch outreach strategies (Devlin, 1995; Devlin 2005; Frame and White, 2004; Kulkarni and Warke, 2015).

The establishment of bank branches has been deemed commercially unviable in rural areas due to the generally low and irregular transactions among rural people, the majority of whom rely on seasonal agriculture. In spite of this, government owned banks have tended to establish branches in the rural areas with the view to ensuring that banking services are availed even to the remote areas where traditionally pure economic merits would deem them as risky and costly to reach. On this basis, we believe that the influence of government ownership on BBI adoption stems from how these innovations combine with the traditional brick-and-mortar branch outreach strategies that government banks have invested substantially in. Fig 5.1 shows the relationship between government ownership variable and branch intensity variable. From the slope analysis, we note that interaction exists for 6 of the 13 banks as the two variables have different cross-sectional and intertemporal relationships. However, we note that the lines representing the two variables are nearly identical in remaining banks.

Figure 5.1 Government ownership & branch intensity interaction term



To test this hypothesis, we introduce the state ownership-branch intensity interaction term (GovXBranch) to Equation 5.1. This transformation leads us to Equation 5.2 as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \beta_3 Gov_{it} + \beta_4 GovXBranch_{it} + \mu_{it} \qquad (5.2)$$

Building on the FE model, we extend the analysis to cover dynamic model. In this context, we adopt the panel ARDL models proposed by Pesaran et al. (1999). As argued in the previous chapter, the ARDL models have several advantages that make them suitable for analysing our dataset. Firstly, they are asymptotically efficient and comparatively more robust in small or finite samples (Pattichis, 1999, Mah, 2000; Sakyi, 2011). Secondly, they can be used regardless of whether the regressors are I (0), I (1) or mutually integrated (Sakyi, 2011). Thirdly, they eliminate the risk of autocorrelation and endogeneity (Pesaran et al., 2001; Sakyi, 2011). Fourthly, they estimate both short and long run relationships at the same time. Against this background, the ARDL models form the framework for our analysis.

Pesaran, Shin, and Smith (1999) introduce dynamic heterogeneous panel regressions in an error-correction form using an ARDL (*p*, *q*) approach, where *p* are lags for the dependent variable and *q* are the lags of the independent variables. Consistent with Samargandi et al., 2015 and Makhlouf et al., 2020, this in our case can be expressed as follows:

$$\Delta BBI_{i,t} = \lambda_i\left[BBI_{i,t-1} - \left\{\beta_{i,0} + \beta_{i,1}X_{i,t-1}\right\}\right] + \sum_{j=1}^{p-1}\theta_{i,j}\,\Delta BBI_{i,t-j} + \sum_{j=0}^{p-1}\eta_{i,j}\,\Delta X_{i,t-j} + \epsilon_{i,t} \qquad (5.3)$$

where BBI is dimension of branchless banking innovation (in logs) for bank *i* at quarter *t*. X is a vector of potential determinants of adoption of BBI (in logs) including government ownership as our key variable of interest. θ is the short run coefficient of the lagged dependent variable while η refers to short run coefficients of the other regressors. β represents the long-run coefficients. λ is the coefficient of speed of adjustment to the long-run equilibrium. The first term on the right-hand side of Equation 5.3 will capture any long-run relationship between government ownership and adoption of BBI. As the system is expected to return to the long-run equilibrium, we expect $\lambda<0$.

Within the ARDL models, we employ the PMG estimation for its efficiency gains under the assumption of long run homogeneity. The PMG technique is applied as it introduces heterogeneity into the dynamic analysis of data. The PMG estimator of Pesaran et al., (1999) assumes the long run coefficients are homogenous across the cross-sectional units (banks in this case), but allows for heterogeneity in the short run coefficients, the intercepts, the speed of adjustment coefficients and the error variances. As argued by Samargandi et al. (2015) and Makhlouf et al. (2020), such an approach makes sense if we have reason to assume that the long-run relationship between bank ownership and BBI is the same across our Malawi banks, which appears feasible *ex ante*, especially if we allow the short-run trajectories to diverge. In the long run, the sample is expected to be homogenous with respect to firm characteristics that are bounded by common prudential regulation, common macro technological infrastructure and common business operating environment more generally. However, in the short-run, bank-specific heterogeneity arises against the backdrop of differences in bank size, bank capitalisation and financial resource endowment, different target niches, different managerial attitudes towards innovations and risk, as well as different strategies for managing overhead expenses.

5.2.3. Empirical Findings

FE Model estimations

Summary findings from the FE Model estimation of the impact of government ownership on bank adoption of physical BBI and remote BBI are presented in Table 5.1 and Table 5.2, respectively.

a) Physical BBI

Firstly, the results in Table 5.1 show that bank adoption of ATM banking innovation is a negative function of bank technology and a positive function of branch intensity and retail portfolio. These are the only control variables that are found to be statistically significant. Specifically, at 5 percent significance level, a one percent decrease in bank technology increases adoption of ATM banking innovation by 0.12 percent; while a one percent increase in branch intensity increases adoption of ATM banking innovation by 0.15 percent, *ceteris paribus*. At one percent significance level, a one percent increase in retail portfolio increases adoption of ATM banking innovation by 0.11 percent, *ceteris paribus*.

For our key variable of interest, we find evidence of the direct impact of government ownership on adoption of ATM banking innovation. A one percent increase in government ownership results in a 0.01 percent increase in the adoption of ATM banking innovation. We further note that after interacting government ownership with branch intensity, the coefficient of government ownership increases to 0.09, significant at one percent. However, the coefficient of the interaction term is -0.01, also significant at one percent. This suggests that the positive effect of government ownership on adoption of ATM banking innovation becomes smaller for banks that have high branch intensity. In other words, the relationship between government ownership and adoption of ATM innovation is more pronounced among banks with a relatively smaller network of branches.

Secondly, the results in Table 5.1 show that bank adoption of agent banking innovation is a negative function of bank technology and market concentration; and a positive function of bank size, regulation and macro technology. These are the only control variables that are found to be statistically significant. Specifically, at 10 percent significance level, a one percent decrease in bank technology increases adoption of agent banking innovation by 0.13 percent. At one percent significance level, a one percent decrease in market concentration increases adoption of agent banking innovation by 0.08 percent, *ceteris paribus*. At 10 percent significance level, a one percent increase in bank size increases adoption of agent banking innovation by 0.45 percent, ceteris paribus. Furthermore, at one percent significance level, a one percent increase in the index for regulation increases adoption of agent banking innovation by 0.70 percent, while a one percent increase in macro technology increases adoption of agent banking innovation by 0.15 percent.

For our key variable of interest, the evidence shows no direct impact of government ownership on adoption of agent banking innovation. The coefficient of government ownership is positive albeit not statistically significant. After interacting government ownership with branch intensity, the coefficient of government ownership increases to 0.08, and becomes statistically significant at 5 percent. However, the coefficient of the interaction term is insignificant. This suggests that branch intensity is inconsequential to the above effect of government ownership on adoption of agent banking innovation. In sum, the results suggest that using the FE methods does not provide any evidence of the impact of government ownership on adoption of agent banking innovation as being via branch intensity. It only shows the direct positive impact of government ownership on bank adoption of agent banking innovation.

Table 5. 1 FE results of government ownership & adoption of physical BBI

	ATM Banking		Agent Banking	
Government *branch intensity	-	-0.01*** (0.00)	-	0.00 (0.00)
Government	0.01*** (0.00)	0.09*** (0.02)	0.01 (0.01)	0.08** (0.03)
Bank size	-0.13 (0.15)	-0.15 (0.16)	0.45* (0.21)	0.42* (0.22)
Bank technology	-0.12** (0.05)	-0.08 (0.05)	-0.13* (0.06)	-0.09 (0.06)
Branch intensity	0.15** (0.07)	0.22*** (0.06)	0.02 (0.08)	0.10 (0.08)
Retail portfolio	0.11*** (0.02)	0.10*** (0.02)	0.04 (0.03)	0.03 (0.03)
Bank funding	0.00 (0.02)	-0.02 (0.02)	0.00 (0.03)	-0.02 (0.03)
Market concentration	0.01 (0.03)	0.01 (0.03)	-0.08*** (0.02)	-0.07** (0.02)
Regulation	0.27 (0.21)	0.22 (0.20)	0.70*** (0.17)	0.63*** (0.15)
Macro technology	0.03 (0.08)	0.02 (0.07)	0.15*** (0.05)	0.14** (0.06)
Constant	14.09*** (2.89)	14.20*** (2.86)	18.15*** (2.01)	18.77*** (2.09)
Observations	902	902	655	655
Groups	13	13	10	10

*Driscoll-Kraay Standard errors in parentheses are heteroskedasticity- consistent and robust to general forms of cross-sectional and temporal dependence; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

b) Remote BBI

Firstly, the results in Table 5.2 show that bank adoption of internet banking innovation is a negative function of branch intensity, market concentration, macro technology and a positive function of regulation. These are the only control variables that are found to be statistically significant. Specifically, at one percent significance level, a one percent decrease in branch intensity increases adoption of internet banking innovation by 0.19 percent; while a one percent decrease in market concentration increases adoption of internet banking innovation by 0.11 percent and a one percent decrease in macro technology increases adoption of internet banking innovation by 0.05 percent, *ceteris paribus*. At one percent significance level, a one percent increase in the index of regulation increases adoption of internet banking innovation by 0.88 percent, *ceteris paribus*.

For our key variable of interest, we note that the coefficient of government ownership is negative but not statistically significant. However, after interacting government ownership with branch intensity, the negative coefficient of government ownership variable becomes statistically significant. Specifically, at one percent significance level, a one percent increase in government ownership results in a 0.11 percent decline in adoption of internet banking innovation. However, the coefficient of the interaction term is 0.01, significant at 1 percent. This suggests that the negative effect of government ownership on adoption of internet banking innovation becomes larger for banks that have high branch intensity. Thus, the negative relationship between government ownership and adoption of internet innovation is more pronounced among banks with relatively large network of branches.

Secondly, the results in Table 5.2 show that bank adoption of mobile phone banking innovation is a negative function of market concentration and a positive function of regulation. These are the only control variables that are found to be statistically significant. Specifically, at one percent significance level, a one percent decrease in market concentration increases adoption of mobile phone banking innovation by 0.04 percent, *ceteris paribus*. Furthermore, at one percent significance level, a one percent increase in the index for regulation increases adoption of mobile phone banking innovation by 1.78 percent.

For our key variable of interest, before interacting government ownership with branch intensity, we note that the coefficient of government ownership is positive but not statistically significant. After interacting government ownership with branch intensity, the coefficient of government ownership variable remains positive but becomes statistically significant. Specifically, at 5 percent significance level, a one percent increase in government ownership results in a 0.25 increase in adoption of mobile phone banking innovation. However, the coefficient of the interaction term is -0.02, significant at 5 percent. This suggests that the positive effect of government ownership on adoption of mobile phone banking innovation is more pronounced among banks with small network of branches.

Overall, under FE methods, we observe a positive impact of government ownership on bank adoption of physical BBI, consistent with the social view of state ownership. The positive impact of government ownership on ATM banking innovation is found to be strongest among banks with a smaller network of branches. However, the positive impact of government ownership on agent banking innovation is unaffected by the size of the branch network.

For remote BBI the impact of government ownership is mixed. On the one hand, the impact of government ownership on bank adoption of internet banking innovation is negative, with this impact being prominent for banks that have a large network of branches. On the other hand, the impact of government ownership on bank adoption of mobile phone banking is positive, with this positive impact being larger for banks with a limited branch network.

Table 5. 2 FE results of government ownership & adoption of remote BBI

	Internet Banking		Mobile phone Banking	
Government *branch intensity	-	0.01*** (0.00)	-	-0.02** (0.01)
Government	-0.01 (0.01)	-0.11*** (0.02)	0.02 (0.02)	0.25** (0.10)
Bank size	0.07 (0.22)	0.10 (0.21)	-0.39 (0.47)	-0.20 (0.43)
Bank technology	0.06 (0.06)	0.01 (0.05)	0.06 (0.10)	0.09 (0.10)
Branch intensity	-0.09 (0.06)	-0.19*** (0.05)	-0.19 (0.13)	-0.16 (0.13)
Retail portfolio	0.01 (0.03)	0.02 (0.03)	0.06 (0.04)	0.04 (0.04)
Bank funding	-0.01 (0.02)	0.02 (0.02)	-0.04 (0.04)	-0.04 (0.04)
Market concentration	-0.09*** (0.02)	-0.11*** (0.02)	-0.05 (0.05)	-0.04*** (0.05)
Regulation	0.79*** (0.19)	0.88*** (0.19)	1.83*** (0.38)	1.78*** (0.37)
Macro technology	-0.08 (0.05)	-0.05** (0.05)	0.02 (0.10)	0.03 (0.09)
Constant	19.31*** (2.69)	18.54*** (2.66)	9.57*** (5.70)	8.48 (5.23)
Observations	792	792	548	548
Groups	13	13	11	11

*Driscoll-Kraay Standard errors in parentheses are heteroskedasticity- consistent and robust to general forms of cross-sectional and temporal dependence; * p < 0.10, ** p < 0.05, *** p < 0.01.*

PMG Estimations

Turning now to PMG estimations of the impact of government ownership on bank adoption of BBI, we start with an examination of the direct impact of government ownership on bank adoption of BBI in Tables 5.3a and 5.3b before looking at the indirect impact in Table 5.4a and 5.4b.

a) Direct impact

The results of each form of BBI innovation are presented under the respective column headings in Tables 5.3a and 5.3b. The top part of the table displays the long-run coefficients, while the bottom part presents the coefficients of the short run. For all regressions the estimated error-correlation coefficients are negative and highly significant. The null hypothesis of no long run relationship is therefore rejected.

For the control variables, regulation is, as expected, positively related with adoption of ATM banking, agent banking and mobile phone banking, in the long run. However, in the short run, there is no evidence of a statistically significant impact of regulation on bank adoption of BBI. Evidence of a statistically significant impact of market concentration on adoption of branchless banking innovation is established in the short run for ATM and internet banking innovations; positive and negative respectively. However, in the long run, the impact is negative for agent banking innovation.

The statistically significant inverse relationship between bank funding and adoption of BBI is established only for mobile phone banking in the long run, and agent banking and internet banking in the short run. For retail portfolio, the impact is felt only in the short run, on mobile banking innovation. A one percent increase in retail portfolio results in a decrease in bank adoption of mobile banking innovation by 0.08 percent. Evidence of statistically significant negative impact of branch intensity on adoption of BBI is established for mobile phone banking innovation in the long run.

Bank technology impacts positively the adoption of agent banking innovation in the short run. However, in the long run the statistically significant impact of bank technology is negative and only on ATM and agent banking innovations. The impact of bank size on adoption of BBI is negative and statistically significant for ATM innovation in the long run, and internet banking and mobile phone banking, in the short run.

Lastly, for our variable of interest, we find that the impact of government ownership on adoption of different forms of BBI is mixed. In the long run, the direct impact of government ownership on adoption of different forms of BBI is found not to be statistically significant. However, in the short run we find evidence of a positive and statistically significant impact of government ownership on bank adoption of ATM banking innovation and internet banking innovations. Specifically, at the 10 percent significance level, a one percent increase in government ownership is found to increase the adoption of ATM banking innovation by 0.08 percent from the mean; and the adoption of internet banking innovation by 0.05 percent. The short run impact of government ownership on adoption of ATM banking innovation is confirmed to be statistically significant even after adjusting for FWER. However, the impact of government ownership on adoption of internet banking innovation is no longer statistically significant when we adjust for FWER in Table 5.3b. There is no evidence of statistically significant direct impact of government ownership on adoption of agent banking and mobile phone banking innovations in the short run. Albeit statistically insignificant, a one percent increase in government ownership is found to increase the adoption of agent banking and mobile phone banking innovations by 0.61 percent and 0.03 percent, respectively. In this sense, the impact of government ownership should not be statistically significant if we adjust for FWER. This is confirmed in Table 5.3b.

Table 5. 3a PMG results of direct impact of government ownership on adoption of BBI

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Government ownership	0.01 (0.01)	0.01 (0.02)	0.00 (0.00)	0.01 (0.02)
Bank size	-0.33** (0.16)	-0.74** (0.39)	-0.01 (0.15)	-0.69 (0.48)
Bank technology	-0.09** (0.04)	-0.21** (0.10)	0.00 (0.03)	0.01 (0.06)
Branch intensity	0.07 (0.04)	0.06 (0.10)	-0.03 (0.03)	-0.53*** (0.08)
Retail portfolio	0.01 (0.01)	0.4 (0.05)	-0.02 (0.02)	-0.02 (0.05)
Bank funding	0.00 (0.02)	-0.04 (0.03)	0.00 (0.01)	-0.09*** (0.03)
Market concentration	-0.06 (0.03)	-0.22*** (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	0.46*** (0.15)	0.68** (0.36)	-0.10 (0.12)	1.00*** (0.26)
Macro technology	0.06 (0.07)	0.15 (0.15)	-0.08* (0.05)	-0.15 (0.10)

Table 5. 3a PMG results of direct impact of government ownership on adoption of BBI (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.48*** (0.10)	-0.39*** (0.07)	-0.74*** (0.10)	-0.63*** (0.08)
Δ Government ownership	0.08* (0.04)	0.61 (0.06)	0.05* (0.03)	0.03 (0.07)
Δ Bank size	0.00 (0.25)	0.06** (0.50)	0.03 (0.50)	0.01 (1.56)
Δ Bank technology	-0.13 (0.04)	-0.06 (0.02)	0.06 (0.04)	0.11 (0.11)
Δ Branch intensity	-0.02 (0.08)	-0.04 (0.09)	0.01 (0.10)	-0.08* (0.13)
Δ Retail portfolio	0.00 (0.03)	-0.31** (0.04)	-0.05 (0.02)	0.03 (0.05)
Δ Bank funding	0.05*** (0.02)	0.03 (0.01)	-0.04** (0.03)	0.02 (0.05)
Δ Market concentration	-0.38 (0.01)	-0.17 (0.02)	-0.05 (0.02)	0.01 (0.04)
Δ Regulation	0.59 (0.39)	0.04 (0.18)	-0.14 (0.37)	0.16 (0.48)
Δ Macro technology	0.08* (0.06)	0.61 (0.11)	0.05* (0.12)	0.03 (0.15)
Constant	7.37*** (1.26)	13.52*** (2.59)	13.82*** (1.28)	16.83*** (2.93)
Observations	888	645	778	537

Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. $* p < 0.10$, $** p < 0.05$, $*** p < 0.01$.

Table 5.3b PMG results of direct impact after Holm-Bonferroni correction

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Government ownership	0.01 (0.01)	0.01 (0.02)	0.00 (0.00)	0.01 (0.02)
Bank size	-0.33 (0.16)	-0.74 (0.39)	-0.01 (0.15)	-0.69 (0.48)
Bank technology	-0.09 (0.04)	-0.21 (0.10)	0.00 (0.03)	0.01 (0.06)
Branch intensity	0.07 (0.04)	0.06 (0.10)	-0.03 (0.03)	-0.53* (0.08)
Retail portfolio	0.01 (0.01)	0.4 (0.05)	-0.02 (0.02)	-0.02 (0.05)
Bank funding	0.00 (0.02)	-0.04 (0.03)	0.00 (0.01)	-0.09* (0.03)
Market concentration	-0.06 (0.03)	-0.22* (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	0.46* (0.15)	0.68* (0.36)	-0.10 (0.12)	1.00* (0.26)
Macro technology	0.06 (0.07)	0.15 (0.15)	-0.08 (0.05)	-0.15 (0.10)

Table 5. 3b PMG results of direct impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.48*** (0.10)	-0.39*** (0.07)	-0.74* (0.10)	-0.63* (0.08)
Δ Government ownership	0.08* (0.04)	0.61 (0.06)	0.05 (0.03)	0.03 (0.07)
Δ Bank size	0.00 (0.25)	0.06 (0.50)	0.03 (0.50)	0.01 (1.56)
Δ Bank technology	-0.13 (0.04)	-0.06* (0.02)	0.06 (0.04)	0.11 (0.11)
Δ Branch intensity	-0.02 (0.08)	-0.04 (0.09)	0.01 (0.10)	-0.08* (0.13)
Δ Retail portfolio	0.00 (0.03)	-0.31 (0.04)	-0.05 (0.02)	0.03 (0.05)
Δ Bank funding	0.05 (0.02)	0.03 (0.01)	-0.04 (0.03)	0.02 (0.05)
Δ Market concentration	-0.38* (0.01)	-0.17 (0.02)	-0.05 (0.02)	0.01 (0.04)
Δ Regulation	0.59 (0.39)	0.04 (0.18)	-0.14 (0.37)	0.16 (0.48)
Δ Macro technology	0.08* (0.06)	0.61 (0.11)	0.05 (0.12)	0.03 (0.15)
Constant	7.37* (1.26)	13.52* (2.59)	13.82* (1.28)	16.83* (2.93)
Observations	888	645	778	537

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

b) Indirect effects

We now investigate whether government ownership has an indirect impact on bank adoption of BBI, through various firm-level factors.

In this regard, we interact the government ownership variable with the branch intensity variable. The findings are presented in Tables 5.4a and 5.4b. They show no evidence of an indirect impact of government ownership on bank adoption of any form of BBI in the short run. Also, the short run coefficient of government size becomes statistically insignificant for all the dimensions of BBI in the short run.

However, controlling for the interaction between government ownership and branch intensity provides statistically significant evidence of a direct positive relationship between government ownership and adoption of ATM banking innovation, in the long run. At the 5 percent confidence level, a one percent increase in government ownership is found to increase the adoption of ATM banking innovation by 0.09 percent from the mean.

We also establish that this impact is prominent for the banks that have a smaller network of branches, confirming the findings from the Fixed Effects analysis. In this regard, the coefficient of the interaction terms between government ownership and branch intensity is -0.01 and significant at 5 percent. This is also confirmed even after adjusting for FWER as per Table5.4b.

Table 5. 4a PMG results of indirect impact of government ownership on adoption of BBI

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Government ownership	0.09** (0.04)	0.07 (0.04)	-0.01 (0.01)	0.15 (0.13)
Government *branch intensity	-0.01** (0.00)	0.00 (0.00)	0.00 (0.00)	-0.01 (0.01)
Bank size	-0.31** (0.16)	-0.60 (0.40)	0.00 (0.15)	-0.35 (0.54)
Bank technology	-0.09** (0.04)	-0.21** (0.10)	0.00 (0.03)	0.03 (0.07)
Branch intensity	0.08* (0.05)	0.12 (0.11)	-0.04 (0.04)	-0.50*** (0.08)
Retail portfolio	0.01 (0.01)	0.04 (0.05)	-0.02 (0.02)	-0.02 (0.04)
Bank funding	0.00 (0.02)	-0.05 (0.04)	0.00 (0.01)	-0.09*** (0.03)
Market concentration	-0.05 (0.03)	-0.21*** (0.07)	0.00 (0.03)	-0.03 (0.05)
Regulation	0.45*** (0.15)	0.64* (0.37)	-0.10 (0.13)	0.93*** (0.26)
Macro technology	0.06 (0.07)	0.14 (0.15)	-0.08* (0.05)	-0.13 (0.09)

Table 5. 4a PMG results of indirect impact of government ownership on adoption of BBI (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone banking
Error-correction coefficient	-0.49*** (0.11)	-0.39*** (0.07)	-0.73*** (0.10)	-0.63*** (0.08)
Δ Government ownership	0.10 (0.10)	0.04 (0.06)	0.15 (0.10)	-0.92 (0.96)
Δ Government *branch intensity	0.00 (0.02)	0.00 (0.01)	-0.01 (0.01)	0.05 (0.06)
Δ Bank size	0.01 (0.26)	0.06** (0.49)	0.05 (0.49)	0.01 (1.59)
Δ Bank technology	-0.12 (0.04)	-0.12 (0.03)	0.11 (0.05)	0.17 (0.11)
Δ Branch intensity	-0.02 (0.11)	-0.04 (0.09)	0.01 (0.14)	-0.07 (0.14)
Δ Retail portfolio	0.00 (0.07)	-0.03** (0.04)	-0.05* (0.02)	0.02 (0.05)
Δ Bank funding	0.05*** (0.02)	0.02 (0.02)	-0.04* (0.03)	0.02 (0.04)
Δ Market concentration	-0.36 (0.01)	-0.14 (0.02)	-0.02 (0.02)	0.04 (0.15)
Δ Regulation	0.07 (0.39)	0.04 (0.19)	-0.14 (0.36)	0.15 (0.47)
Δ Macro technology	0.07 (0.06)	0.04 (0.12)	-0.14 (0.13)	0.15 (0.15)
Constant	7.32*** (1.32)	13.34*** (2.50)	13.76*** (1.29)	15.67*** (2.76)
Observations	888	645	778	537

Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. $* p < 0.10$, $** p < 0.05$, $*** p < 0.01$.

Table 5. 4b PMG results of indirect impact after Holm-Bonferroni correction

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Government ownership	0.09* (0.04)	0.07 (0.04)	-0.01 (0.01)	0.15 (0.13)
Government *branch intensity	-0.01* (0.00)	0.00 (0.00)	0.00 (0.00)	-0.01 (0.01)
Bank size	-0.31 (0.16)	-0.60 (0.40)	0.00 (0.15)	-0.35 (0.54)
Bank technology	-0.09 (0.04)	-0.21 (0.10)	0.00 (0.03)	0.03 (0.07)
Branch intensity	0.08 (0.05)	0.12 (0.11)	-0.04 (0.04)	-0.50*** (0.08)
Retail portfolio	0.01 (0.01)	0.04 (0.05)	-0.02 (0.02)	-0.02 (0.04)
Bank funding	0.00 (0.02)	-0.05 (0.04)	0.00 (0.01)	-0.09*** (0.03)
Market concentration	-0.05 (0.03)	-0.21* (0.07)	0.00 (0.03)	-0.03 (0.05)
Regulation	0.45* (0.15)	0.64* (0.37)	-0.10 (0.13)	0.93*** (0.26)
Macro technology	0.06 (0.07)	0.14 (0.15)	-0.08* (0.05)	-0.13 (0.09)

Table 5. 4b PMG results of indirect impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49** (0.11)	-0.39* (0.07)	-0.73* (0.10)	-0.63* (0.08)
Δ Government ownership	0.10 (0.10)	0.04 (0.06)	0.15 (0.10)	-0.92 (0.96)
Δ Government *branch intensity	0.00 (0.02)	0.00 (0.01)	-0.01 (0.01)	0.05 (0.06)
Δ Bank size	0.01 (0.26)	0.06 (0.49)	0.05 (0.49)	0.01 (1.59)
Δ Bank technology	-0.12 (0.04)	-0.12* (0.03)	0.11 (0.05)	0.17 (0.11)
Δ Branch intensity	-0.02 (0.11)	-0.04 (0.09)	0.01 (0.14)	-0.07 (0.14)
Δ Retail portfolio	0.00 (0.07)	-0.03 (0.04)	-0.05 (0.02)	0.02 (0.05)
Δ Bank funding	0.05 (0.02)	0.02 (0.02)	-0.04 (0.03)	0.02 (0.04)
Δ Market concentration	-0.36* (0.01)	-0.14 (0.02)	-0.02* (0.02)	0.04 (0.15)
Δ Regulation	0.07 (0.39)	0.04 (0.19)	-0.14 (0.36)	0.15 (0.47)
Δ Macro technology	0.07 (0.06)	0.04 (0.12)	-0.14 (0.13)	0.15 (0.15)
Constant	7.32* (1.32)	13.34* (2.50)	13.76* (1.29)	15.67* (2.76)
Observations	888	645	778	537

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

5.2.4. Robustness Check

As a robustness check, the relationships have been re-estimated with bank ownership represented by a dummy. Under this approach, a bank is accorded a dummy value of 1 if government ownership stake in that bank at that point is greater than 10 percent. Any ownership stake by government lower than 10 percent is designated a dummy value of zero.

This is consistent with Shleifer and Vishny (1994); Shleifer (1998); La Porta et al (2002); Sapienza (2004); Clarke et al (2005); Dinç (2005); Iannotta et al (2007); Cornett et al (2010); Atkinson and Stiglitz (2015).

a) Direct impact

The summary findings from the estimation of the direct impact of government ownership on adoption of BBI using PMG models are presented in Tables 5.5a and 5.5b. For all the models estimated, the respective error correction terms are negative, less than 2 in absolute terms and statistically significant at 1 percent. These attributes confirm the existence of cointegration between the variables.

For the control variables, the results corroborate the earlier findings of statistically significant positive impact of regulation on the adoption of ATM banking, agent banking and mobile phone banking, in the long run. However, in the short run, there is no evidence of a statistically significant impact of regulation on bank adoption of BBI. Also, evidence of a statistically significant impact of market concentration is established for the adoption of ATM banking innovation in the short run. However, in the long run, the impact is negative for ATM banking and agent banking innovations.

As in the benchmark model, robustness check estimations establish statistically significant inverse relationship between bank funding and adoption of mobile phone banking in the long run, and agent banking and internet banking in the short run. For retail portfolio, the impact is felt only in the short run, on mobile banking innovation. A one percent increase in retail portfolio results in a decrease in bank adoption of mobile banking innovation by 0.08 percent. Consistent with the benchmark model, the robustness check estimations establish evidence of statistically significant negative impact of branch intensity on adoption of mobile phone banking innovation in the long run.

Bank technology impacts positively the adoption of agent banking innovation in the short run. However, in the long run the statistically significant impact of bank technology is negative for the adoption of agent banking innovation and positive for the adoption of ATM banking innovation. The impact of bank size on adoption of BBI is negative and statistically significant for ATM innovation in the long run, and internet banking and mobile phone banking, in the short run. This is consistent with the results from the benchmark model.

Lastly, for our variable of interest, we confirm mixed outcomes established under the benchmark model. Specifically, using the dummy variable approach, the results confirm statistically significant impact of government ownership on adoption of ATM banking innovation and mobile banking innovations in the long run. At 10 percent significance level, a one percent increase in government ownership results in a 0.48 percent increase in adoption of ATM banking innovation. Also, at 5 percent significance level, a one percent increase in government ownership increases bank adoption of mobile phone banking innovation by 0.70 percent. However, in both cases, the impact is not statistically significant when we adjust for FWER in Table 5.5b.

The long run impact on agent banking innovation is positive while the impact on adoption of internet banking innovation is negative. This impact in both cases is not statistically significant. In the short run, the impact of government ownership is positive for all dimensions of BBI, but only statistically significant for the adoption of ATM banking innovation. At 10 percent significance level, a one percent increase in government ownership results in a 0.53 percent increase in the adoption of ATM banking innovation.

Table 5. 5a PMG results of direct impact of government ownership on adoption of BBI

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Government ownership	0.48* (0.28)	0.67 (0.46)	-0.49 (0.33)	0.70** (0.41)
Bank size	-0.28* (0.16)	-0.57 (0.41)	-0.03 (0.15)	-0.19 (0.53)
Bank technology	0.03** (0.05)	-0.20** (0.10)	-0.01 (0.03)	0.06 (0.07)
Branch intensity	0.03 (0.05)	0.04 (0.10)	-0.02 (0.03)	-0.51*** (0.08)
Retail portfolio	0.02 (0.02)	0.04 (0.04)	-0.02 (0.02)	-0.01 (0.04)
Bank funding	0.01 (0.02)	-0.04 (0.03)	0.00 (0.01)	-0.09*** (0.03)
Market concentration	-0.06* (0.4)	-0.22*** (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	0.53*** (0.16)	0.72** (0.35)	-0.09 (0.12)	0.92*** (0.26)
Macro technology	0.07 (0.08)	0.15 (0.15)	-0.08 (0.05)	-0.15 (0.09)

Table 5.5a PMG results of direct impact of government ownership on adoption of BBI (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49*** (0.10)	-0.39*** (0.07)	-0.74*** (0.10)	-0.63*** (0.08)
Δ Government ownership	0.53* (0.30)	0.40 (0.37)	0.36 (0.29)	0.64 (0.73)
Δ Bank size	-0.12 (0.25)	0.69 (0.49)	-1.02** (0.51)	-2.79* (1.58)
Δ Bank technology	0.01 (0.04)	0.05** (0.02)	0.03 (0.04)	0.00 (0.11)
Δ Branch intensity	-0.12 (0.08)	-0.06 (0.09)	0.06 (0.10)	0.10 (0.13)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.00 (0.02)	-0.08* (0.05)
Δ Bank funding	0.00 (0.02)	-0.03** (0.01)	-0.05* (0.03)	0.03 (0.05)
Δ Market concentration	0.06*** (0.01)	0.03 (0.02)	-0.04 (0.02)	0.02 (0.04)
Δ Regulation	-0.40 (0.39)	-0.17 (0.18)	-0.05 (0.37)	0.02 (0.48)
Δ Macro technology	0.05 (0.06)	0.03 (0.12)	-0.14* (0.12)	0.15 (0.15)
Constant	7.07*** (1.15)	13.12*** (2.50)	13.89*** (1.30)	15.16*** (2.76)
Observations	888	645	778	537
Groups	13	10	13	11

Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. $* p < 0.10$, $** p < 0.05$, $*** p < 0.01$.

Table 5. 5b PMG results of direct impact after Holm-Bonferroni correction

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Government ownership	0.48 (0.28)	0.67 (0.46)	-0.49 (0.33)	0.70 (0.41)
Bank size	-0.28 (0.16)	-0.57 (0.41)	-0.03 (0.15)	-0.19 (0.53)
Bank technology	0.03 (0.05)	-0.20 (0.10)	-0.01 (0.03)	0.06 (0.07)
Branch intensity	0.03 (0.05)	0.04 (0.10)	-0.02 (0.03)	-0.51* (0.08)
Retail portfolio	0.02 (0.02)	0.04 (0.04)	-0.02 (0.02)	-0.01 (0.04)
Bank funding	0.01 (0.02)	-0.04 (0.03)	0.00 (0.01)	-0.09 (0.03)
Market concentration	-0.06 (0.4)	-0.22* (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	0.53* (0.16)	0.72 (0.35)	-0.09 (0.12)	0.92 (0.26)
Macro technology	0.07 (0.08)	0.15 (0.15)	-0.08 (0.05)	-0.15 (0.09)

Table 5.5b PMG results of direct impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49* (0.10)	-0.39* (0.07)	-0.74* (0.10)	-0.63* (0.08)
Δ Government ownership	0.53 (0.30)	0.40 (0.37)	0.36 (0.29)	0.64 (0.73)
Δ Bank size	-0.12 (0.25)	0.69 (0.49)	-1.02 (0.51)	-2.79 (1.58)
Δ Bank technology	0.01 (0.04)	0.05* (0.02)	0.03 (0.04)	0.00 (0.11)
Δ Branch intensity	-0.12 (0.08)	-0.06 (0.09)	0.06 (0.10)	0.10 (0.13)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.00 (0.02)	-0.08 (0.05)
Δ Bank funding	0.00 (0.02)	-0.03 (0.01)	-0.05 (0.03)	0.03 (0.05)
Δ Market concentration	0.06 (0.01)	0.03 (0.02)	-0.04 (0.02)	0.02 (0.04)
Δ Regulation	-0.40 (0.39)	-0.17 (0.18)	-0.05 (0.37)	0.02 (0.48)
Δ Macro technology	0.05 (0.06)	0.03 (0.12)	-0.14* (0.12)	0.15 (0.15)
Constant	7.07* (1.15)	13.12* (2.50)	13.89* (1.30)	15.16* (2.76)
Observations	888	645	778	537
Groups	13	10	13	11

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

b) Indirect impact

Having looked at the direct impact of government ownership on adoption of BBI, a robustness check investigation on whether government ownership has an indirect impact on bank adoption of BBI, derives from the interaction between the government ownership dummy with the branch intensity variable. As is the case with the benchmark model, the robustness check findings, presented in Table 5.6a show no evidence of an indirect impact of government ownership on bank adoption of any form of BBI in the short run. Also, the short run coefficient of government size becomes statistically insignificant for all the dimensions of BBI in the short run. Furthermore, the results establish no statistically significant indirect impact of government ownership on adoption of any form of BBI, in the long run. In this sense, adjusting for FWER is not necessary.

Table 5. 6a PMG results of indirect impact of government ownership on adoption of BBI

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Government ownership	1.07 (0.94)	0.25 (0.97)	-0.04 (0.54)	1.43 (1.19)
Government *branch intensity	-0.07 (0.10)	0.05 (0.10)	-0.04 (0.05)	-0.11 (0.17)
Bank size	-0.28* (0.16)	-0.56 (0.41)	-0.01 (0.15)	-0.11 (0.54)
Bank technology	-0.09** (0.04)	-0.21** (0.11)	-0.01 (0.03)	0.06 (0.07)
Branch intensity	0.04 (0.05)	0.01 (0.10)	0.00 (0.04)	-0.50*** (0.08)
Retail portfolio	0.02 (0.02)	0.05 (0.05)	-0.02 (0.02)	-0.02 (0.04)
Bank funding	0.00 (0.02)	-0.03 (0.04)	0.00 (0.01)	-0.09*** (0.03)
Market concentration	-0.06 (0.04)	-0.23*** (0.07)	0.01 (0.02)	-0.02 (0.05)
Regulation	0.52*** (0.16)	0.82** (0.37)	-0.13 (0.12)	0.86*** (0.26)
Macro technology	0.08 (0.08)	0.16 (0.15)	-0.71 (0.05)	-0.14 (0.09)

Table 5.6a PMG results of indirect impact of government ownership on adoption of BBI (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49*** (0.10)	-0.39*** (0.07)	-0.74*** (0.10)	-0.63*** (0.08)
Δ Government ownership	0.72 (0.81)	0.39 (0.99)	0.80 (2.17)	-14.57 (15.83)
Δ Government *branch intensity	-0.01 (0.11)	-0.04 (0.08)	-0.11 (0.19)	0.89 (1.05)
Δ Bank size	-0.14 (0.26)	0.68 (0.49)	-1.03** (0.51)	-2.82** (1.60)
Δ Bank technology	0.02 (0.04)	0.07** (0.03)	0.05 (0.05)	0.00 (0.11)
Δ Branch intensity	-0.11 (0.10)	-0.06 (0.08)	0.05 (0.16)	0.16 (0.14)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.01)	-0.08 (0.05)
Δ Bank funding	0.00 (0.02)	-0.04** (0.01)	-0.05* (0.03)	0.02 (0.04)
Δ Market concentration	0.06*** (0.01)	0.03 (0.02)	-0.04** (0.02)	0.02 (0.04)
Δ Regulation	-0.39 (0.39)	-0.18 (0.19)	-0.02 (0.36)	0.05 (0.47)
Δ Macro technology	0.06 (0.06)	0.03 (0.12)	-0.14 (0.13)	0.15 (0.15)
Constant	7.03*** (1.14)	12.53*** (2.41)	13.63*** (1.31)	15.20*** (2.72)
Observations	888	645	778	537
Groups	13	10	13	11

Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. $* p < 0.10$, $** p < 0.05$, $*** p < 0.01$.

Table 5. 6 b PMG results of indirect impact after Holm-Bonferroni correction

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Government ownership	1.07 (0.94)	0.25 (0.97)	-0.04 (0.54)	1.43 (1.19)
Government *branch intensity	-0.07 (0.10)	0.05 (0.10)	-0.04 (0.05)	-0.11 (0.17)
Bank size	-0.28 (0.16)	-0.56 (0.41)	-0.01 (0.15)	-0.11 (0.54)
Bank technology	-0.09 (0.04)	-0.21 (0.11)	-0.01 (0.03)	0.06 (0.07)
Branch intensity	0.04 (0.05)	0.01 (0.10)	0.00 (0.04)	-0.50* (0.08)
Retail portfolio	0.02 (0.02)	0.05 (0.05)	-0.02 (0.02)	-0.02 (0.04)
Bank funding	0.00 (0.02)	-0.03 (0.04)	0.00 (0.01)	-0.09* (0.03)
Market concentration	-0.06 (0.04)	-0.23* (0.07)	0.01 (0.02)	-0.02 (0.05)
Regulation	0.52* (0.16)	0.82* (0.37)	-0.13 (0.12)	0.86* (0.26)
Macro technology	0.08 (0.08)	0.16 (0.15)	-0.71 (0.05)	-0.14 (0.09)

Table 5.6b PMG results of indirect impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49* (0.10)	-0.39* (0.07)	-0.74* (0.10)	-0.63* (0.08)
Δ Government ownership	0.72 (0.81)	0.39 (0.99)	0.80 (2.17)	-14.57 (15.83)
Δ Government *branch intensity	-0.01 (0.11)	-0.04 (0.08)	-0.11 (0.19)	0.89 (1.05)
Δ Bank size	-0.14 (0.26)	0.68 (0.49)	-1.03 (0.51)	-2.82 (1.60)
Δ Bank technology	0.02 (0.04)	0.07* (0.03)	0.05 (0.05)	0.00 (0.11)
Δ Branch intensity	-0.11 (0.10)	-0.06 (0.08)	0.05 (0.16)	0.16 (0.14)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.01)	-0.08 (0.05)
Δ Bank funding	0.00 (0.02)	-0.04* (0.01)	-0.05* (0.03)	0.02 (0.04)
Δ Market concentration	0.06* (0.01)	0.03 (0.02)	-0.04 (0.02)	0.02 (0.04)
Δ Regulation	-0.39 (0.39)	-0.18 (0.19)	-0.02 (0.36)	0.05 (0.47)
Δ Macro technology	0.06 (0.06)	0.03 (0.12)	-0.14 (0.13)	0.15 (0.15)
Constant	7.03* (1.14)	12.53* (2.41)	13.63* (1.31)	15.20* (2.72)
Observations	888	645	778	537

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

5.2.5. Summary

In summary, we can conclude from the PMG estimations that government ownership in banks leads to a rapid adoption of ATM and internet banking innovations in the short run. In the long run, there is also a positive impact of government ownership on bank adoption of ATM banking innovation, consistent with the social view of state ownership in institutions. The finding that this impact is prominent among those banks that have a smaller network of branches, implies that the tendency among state-owned banks to pursue a branch intensity strategy attenuates this effect. This is not surprising considering that a physical branch presence bolsters consumer trust among the low-end rural/unsophisticated consumers than can use the ATM machines. Further, the study did not find any evidence of the impact of state ownership of banks on the adoption of agent and mobile phone banking innovations.

The finding that the positive impact of government ownership on bank adoption of BBI in the long run is prominent among banks with a smaller network of branches suggests that as a long run strategy, the government can enhance financial inclusion by deploying more off-site ATMs in areas where there are few bank branches. Other than restricting ATMs to branch premises, ATMs could be installed off site in places such as retail or corner shops, shopping malls, hospitals, gas stations, church premises and university campuses. Considering that ATMs are mostly used for cash transactions, the above findings knit well with the agrarian economic systems of most Sub-Saharan Africa where financial transactions are predominantly cash based.

It is acknowledged that the government has the social welfare maximisation objective of ensuring that banking services are delivered, including in the remote areas that private banks would ordinarily perceive as costly and risky. Given that the government has typically pursued this objective through extensive branch outreach, the conclusion that rapid adoption of ATM banking innovation is associated to government ownership should come as no surprise, given that ATM banking is based on the bank branch model. Because ATMs are generally situated in bank branches, the more branches a bank has, the more ATMs it is likely to have.

However, it has been documented in literature that branch establishment entails huge sunk costs (Ingham and Thompson, 1993; Malhotra and Singh, 2010). Emphasis among the state-owned banks to establish more branches in order to increase outreach therefore potentially limits the availability of capital resources of the bank. Arguably, this will in the long run limit bank investment in the technological infrastructure needed to support emerging forms of BBI, as well as ATMs that can be deployed and monitored remotely from bank branches.

This capital constraint faced by state owned banks is the hallmark of the political view about government ownership in banks (La Porta et al., 2002; Beck et al., 2004; Shen and Lin, 2012). In this regard, where public financial resources are inadequate, as they are in most developing countries, the government's focus on broader national interests tends to strangle state-owned banks' capitalisation requirements. Implementation of BBI that are more recent than the traditional ATM strategy, demands specific governance to absorb or manage the increased risks that they entail. The reluctance of state-owned banks to embrace most newer innovations beyond ATM banking is therefore explained by the capital adequacy challenges noted above, as well as the government's unwillingness to reward management, henceforth the agency view.

If the social welfare maximisation goal of state ownership in financial institutions can help reinforce the financial inclusion goal through rapid adoption of BBI, mitigating the negative political and agency implications of state ownership is critical. Given the importance of capital adequacy in supporting financial institutions' ability to absorb risks, including those posed by BBI, state-owned banks should be held to the same standards as other banks, particularly in terms of capital adequacy and risk management. Despite being a de jure government agency, the central bank must overcome forbearance pressures when it comes to enforcing regulations on government entities.

Furthermore, the findings on the impact of the interplay between branch intensity and state ownership on ATM adoption lend credence to the preceding chapter's recommendation that bank branch restrictions be made less stringent. If regulatory requirements for bank setup are simplified, sunk costs associated with bank branch establishment will be reduced. This will free up bank resources to invest in technological infrastructure supportive of off-site ATMs and other emerging BBI such as agent and mobile phone banking, for which state ownership has been found to have no statistically significant influence.

A general conclusion from this enquiry therefore is that government direct participation in the financial sector through ownership in institutions can help improve adoption of only some of the BBI, in the process bolstering financial inclusion but in a very limited way. The impact on other forms of BBI is either negative or not statistically significant. These new findings thus lend very limited support to the post-war scenario in which a top-down state-led approach, which included nationalising banks, was the dominant mechanism of fostering social welfare maximisation (Brownbridge and Harvey, 1998; Demirgüç-Kunt et al., 2008). However, for state ownership to meaningfully help government achieve its social welfare maximisation objectives such as financial inclusion, the central bank's implementation of capital adequacy and risk management regulations, without forbearance towards state owned financial institutions, is critical to insulate banks from the risks of agency and political considerations inherent in state ownership in enterprises.

In the end, as has been acknowledged, while the Malawi government retains ownership stakes in some banks, its overall shareholding in the banking sector as a whole has been significantly reduced, consistent with global and regional trends towards market led approaches as argued in the literature (see, World Bank, 2008; Mlachira and Yahara, 2013). The result has been a shift in the ownership structure toward more foreign entrants. The next section expands on the investigation into bank ownership to see if foreign entry has influenced the adoption of BBI.

5.3 Foreign Ownership

5.3.1. Model Specification

We test the hypothesis that bank adoption of BBI is a direct function of foreign ownership. This is against the background that foreign entry delivers technological and risk management competences drawing from the foreign parent companies that have tried and tested experiences in other jurisdictions where they have been in operation (Thorne, 1993; Cull and Soledad Martinez Peria, 2010).

However, the broader literature on foreign ownership casts doubt on the certainty of this relationship. For example, there have been debates on whether the manner in which foreign investors enter a domestic market matter for bank strategy in that market (De Haas and Naaborg, 2005; De Haas and Van Lelyveld, 2006; Wu et al., 2017). According to this literature, entry strategy in the form of greenfield investment has been argued to be more effective than entry through mergers and acquisitions. In the former case, greenfield foreign banks are deeply embedded in the parent company's structure, with home country executives frequently assigned to set up the new institution while still employing the parent bank's systems and procedures. In the latter case however, the local management of take-over banks are frequently maintained for a significant period of time, and it takes time for risk management systems to be fully linked with those of the parent bank. Given these dynamics, the impact of foreign ownership on adoption of BBI is ambiguous, *a priori.*

To examine the impact of foreign ownership on bank adoption of BBI, we start with the fixed effects (FE) model with heteroskedasticity robust standard errors (Driscoll and Kraay, 1998). Our baseline empirical model is given in Equation 5.4 as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \beta_3 Foreign_{it} + \mu_{it} \quad (5.4)$$

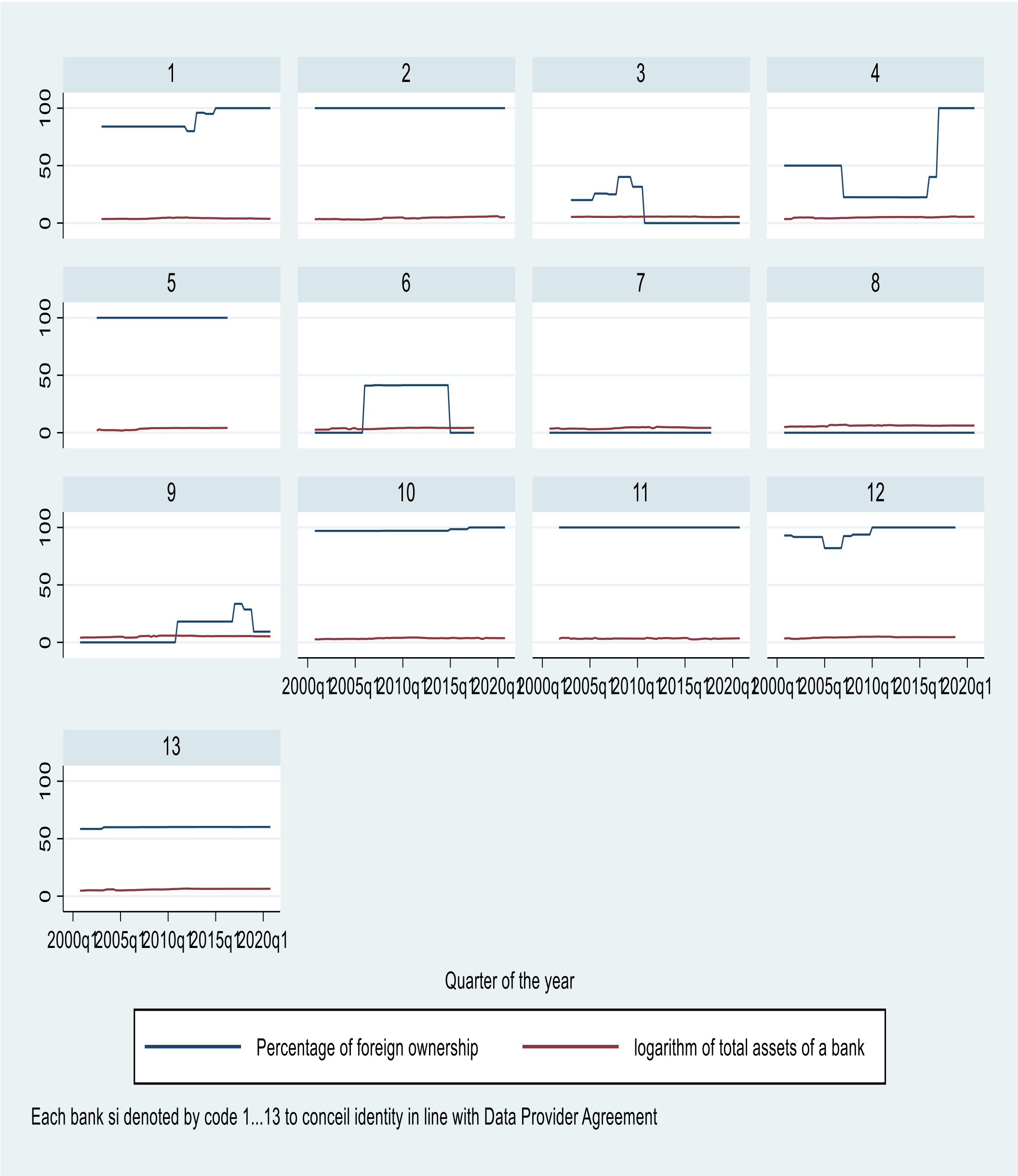
Where, $Y_{i,t}$ represents a vector of dimensions of BBI for bank *i* over time *t. X* is a vector of bank characteristics (bank technology, branch intensity, bank retail portfolio, bank funding and bank size) that vary cross-sectionally and over time *t.* Z is a set of macro-level factors: (market concentration, regulation and macro technology), that vary overtime but are constant cross-sectionally. μ_{it} is the error term. Crucially, we include a variable $Foreign_{it}$ to capture the percentage shareholding in the bank attributed to foreign shareholders in bank *i* over time *t*. Furthermore, we test whether the impact of foreign ownership on bank adoption of BBI is felt indirectly via firm specific characteristics. In that regard, we create two interaction terms.

Firstly, we interact foreign ownership with bank size. We transform Equation 5.4 by incorporating the foreign ownership-bank size interaction term (ForeignXSize). This transformation leads us to Equation 5.5 as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \beta_3 Foreign_{it} + \beta_4 ForeignXSize_{it} + \mu_{it} \quad (5.5)$$

Foreign ownership in Malawi's banking system has seen the emergence of many smaller banks, in addition to the two large banks that previously dominated the sector (Chirwa and Mlachira, 2004; Nkowani, 2008; Kaluwa and Chirwa, 2017). This is demonstrated in Fig. 5.2, which shows that interaction exists for 6 of the 13 banks as the foreign ownership and bank size variables have different cross-sectional and intertemporal relationships. We also notice that the lines representing the two variables are nearly identical in the two largest banks. The remaining five banks have the two variables spaced widely apart but nearly parallel to one another. In addition, the motivation for this interaction terms draws from previous chapter's findings of the counterintuitive inverse effect of bank size on the adoption of BBI. From the previous chapter, small banks are amenable to implementing innovations faster as a result of having less bureaucratic structures; and can seek to tap segments of the market often underserved by the large banks. We therefore hypothesise a positive relationship between the interaction term and banks' adoption of BBI.

Figure 5. 2 Foreign ownership & Bank size interaction term



Secondly, we interact foreign ownership with bank technology. This transforms Equation 5.4 by incorporating the foreign ownership-bank technology interaction term (ForeignXtech). This transformation leads us to Equation 5.6 as follows:

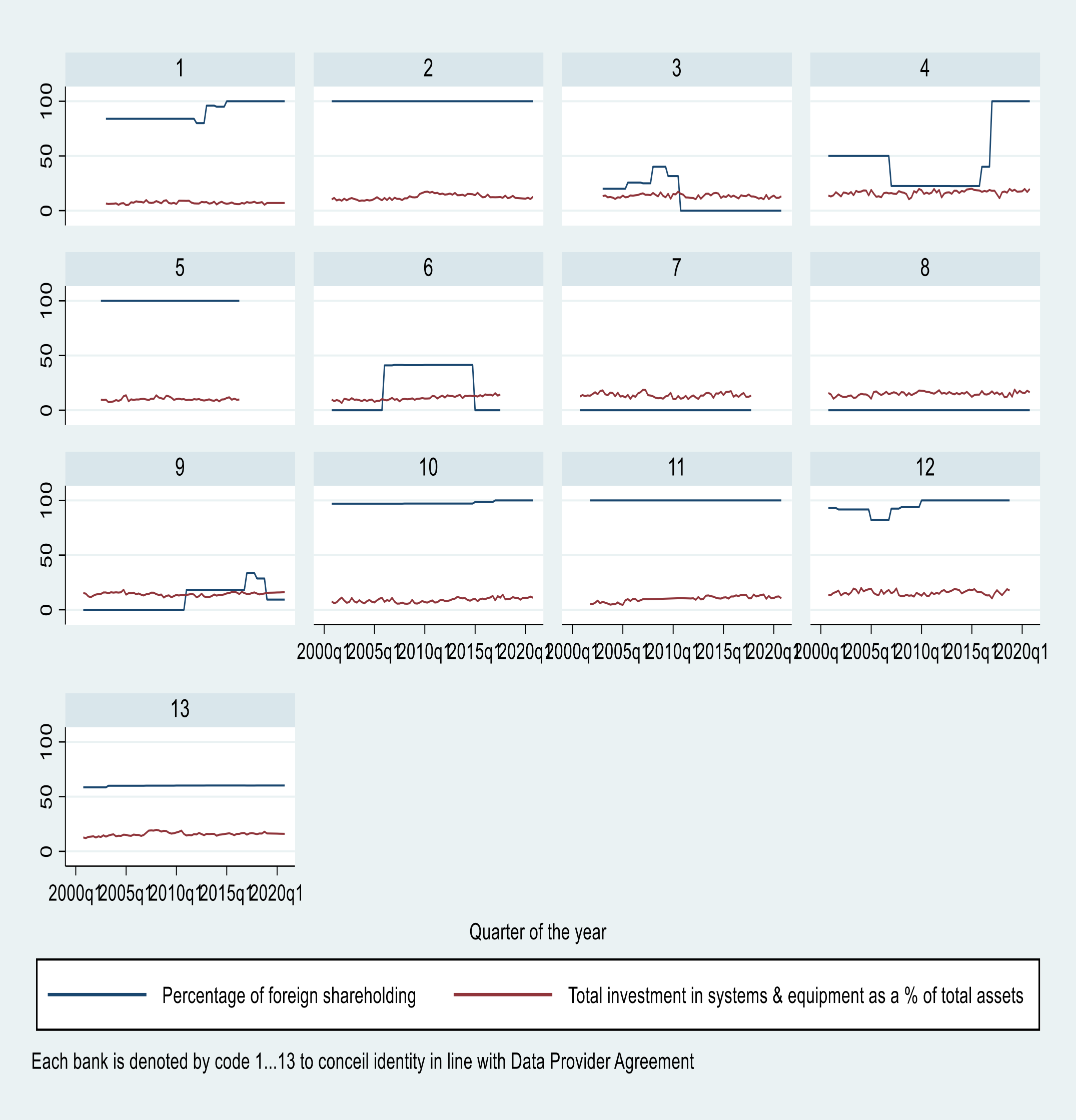
$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \beta_3 Foreign_{it} + \beta_4 ForeignXtech_{it} + \mu_{it} \qquad (5.6)$$

This is motivated by the technology spillover argument. Under this narrative, foreign entry benefits the host country with technological competences derived from the foreign jurisdiction (Thorne, 1993; Cull and Soledad Martinez Peria, 2010). Other than benefiting the subsidiary foreign institution in the host country, skills transfer can further be harnessed if staff from the local subsidiary of a foreign bank move to new institutions within the host market (Wu et al., 2017).

The above argument assumes that foreign ownership has a monopoly over technological know-how. However, claims have been made that domestically owned banks have a greater understanding of the local context and, as a result, may execute policies that benefit the local economy, such as pro-retail consumer innovations (Claessens et al., 2001; Kosmidou et al., 2004). In a similar context, it has been found that foreign entrants typically base their business decisions and risk management on hard data, which encourages them to focus on larger corporations at the expense of the poor and rural consumers who have no hard data record (Stiglitz, 2002; Sengupta, 2007; Giannetti and Ongena, 2012). The view of rural and impoverished retail consumers as riskier by foreign banks would thus limit the incentive to deploy pro-retail consumer initiatives like BBI. The relationship between the interaction term can thus be ambiguous.

Fig 5.3 is a diagrammatic representation of the interaction between foreign ownership and bank technology. From the plot, we see that the foreign ownership and bank technology lines are near parallel in 6 banks. Of the 13 banks, only 7 banks exhibit interaction with the two variables relating differently both cross sectionally and intertemporally.

Figure 5. 3 Foreign ownership & bank technology interaction term



Building on the FE model, we extend the analysis to cover the panel ARDL models. As in the preceding section, the ARDL models form the framework for our analysis. In this regard, the Pesaran et al. (1999) dynamic heterogeneous panel regression can be expressed as follows:

$$\Delta BBI_{i,t} = \lambda_i\left[BBI_{i,t-1} - \left\{\beta_{i,0} + \beta_{i,1}X_{i,t-1}\right\}\right] + \sum_{j=1}^{p-1}\theta_{i,j}\,\Delta BBI_{i,t-j} + \sum_{j=0}^{p-1}\eta_{i,j}\,\Delta X_{i,t-j} + \epsilon_{i,t} \tag{5.7}$$

where, as in Equation 5.3, BBI is dimension of branchless banking innovation (in logs) for bank i at quarter t. X is a vector of potential determinants of adoption of BBI (in logs) including foreign ownership as our key variable of interest. θ is the short run coefficient of the lagged dependent variable while η refers to short run coefficients of the other regressors.

β represents the long-run coefficients. λ is the coefficient of speed of adjustment to the long-run equilibrium. The first term on the right-hand side of Equation 5.4 will capture any long-run relationship between foreign ownership and adoption of BBI. As the system is expected to return to the long-run equilibrium, we expect $\lambda<0$. Within the ARDL framework, we employ the PMG estimation for its efficiency gains under the assumption of long run homogeneity, as discussed in the preceding section.

5.3.2. Empirical Findings

FE estimations

Summary findings from the FE Model estimation of the impact of foreign ownership on bank adoption of physical BBI and remote BBI are presented in Table 5.7 and Table 5.8, respectively.

a) Physical BBI

Firstly, the results in Table 5.7 show that bank adoption of ATM banking innovation is a negative function of bank technology and a positive function of branch intensity and retail portfolio. These are the only control variables that are found to be statistically significant. Specifically, at 5 percent significance level, a one percent decrease in bank technology increases adoption of ATM banking innovation by 0.12 percent. At ten percent significance level, a one percent increase in branch intensity increases adoption of ATM banking innovation by 0.12 percent, *ceteris paribus*. Furthermore, at one percent significance level, a one percent increase in retail portfolio increases adoption of ATM banking innovation by 0.09 percent.

For our key variable of interest, the coefficient of foreign ownership is negative and statistically significant. A one percent decrease in foreign ownership increases adoption of ATM banking innovation by 0.02 percent. We note however that after interacting foreign ownership with bank size, the coefficient of foreign ownership becomes positive but statistically insignificant. However, the coefficient of the interaction term is -0.01, statistically significant at 5 percent; suggesting that the impact of foreign ownership is indirect. In this sense, the impact of foreign ownership on bank adoption of ATM banking innovation can be seen in the context of the proliferation of small size foreign banks.

Consistent with the findings from the previous chapter, the small banks are rapid adopters of ATM banking innovation.

Also noteworthy is the positive but statistically insignificant coefficient of foreign ownership when foreign ownership is interacted with bank technology. The interaction term in this case is not statistically significant suggesting that there is no evidence of the impact of foreign ownership of adoption of ATM banking innovation, either directly or indirectly through foreign ownership influence on bank technology. This validates the earlier finding that foreign ownership impacts adoption of ATM banking innovation only to the extent that foreign entry has resulted in the proliferation of small banks that are rapid adopters of ATM banking innovation.

Secondly, as shown in Table 5.7, bank adoption of agent banking innovation is a negative function of bank technology and market concentration, but a positive function of bank size, regulation, and macro technology. These are the only control variables that are found to be statistically significant. Specifically, at 10 percent significance level, a one percent decrease in bank technology increases adoption of agent banking innovation by 0.13 percent. At 5 percent significance level, a one percent decrease in market concentration increases adoption of agent banking innovation by 0.07 percent, *ceteris paribus*. At 10 percent significance level, a one percent increase in bank size increases adoption of agent banking innovation by 0.39 percent, all else being equal. Furthermore, at one percent significance level, a one percent increase in the index for regulation increases adoption of agent banking innovation by 0.64 percent, while a one percent increase in macro technology increases adoption of agent banking innovation by 0.15 percent.

For our key variable of interest, the coefficient of foreign ownership variable is positive, but not statistically significant. The coefficient of foreign ownership variable remains statistically insignificant even after interacting foreign ownership with bank size. So too is the coefficient of the interaction term. In this regard, the research finds no evidence of the impact of foreign entry on agent banking innovation adoption, either directly or through the impact of foreign entry on the proliferation of small banks. Despite this, we can observe that when foreign ownership is interacted with bank technology, the coefficient of foreign ownership becomes negative and statistically significant, but the coefficient of the interaction term remains insignificant.

In summary, the findings indicate that using the FE methods does not provide evidence of the indirect impact of foreign ownership on agent banking innovation adoption as mediated by bank size or bank technology. It only demonstrates that the direct impact of foreign ownership on agent banking innovation adoption is negative.

Table 5. 7 FE results of foreign ownership & adoption of physical BBI

	ATM Banking			Agent Banking		
Foreign ownership *Bank size	-	-0.01** (0.00)	-	-	0.00 (0.01)	-
Foreign ownership *Bank technology	-	-	0.00 (0.00)	-	-	0.00 (0.00)
Foreign ownership	-0.02** (0.01)	0.02 (0.02)	0.01 (0.01)	0.01 (0.01)	0.00 (0.04)	-0.07*** (0.02)
Bank size	-0.13 (0.16)	0.41 (0.32)	-0.15 (0.15)	0.39* (0.21)	0.34 (0.31)	0.35 (0.21)
Bank technology	-0.12** (0.05)	-0.11** (0.05)	-0.01 (0.09)	-0.13** (0.06)	-0.14** (0.06)	-0.30*** (0.05)
Branch intensity	0.12* (0.06)	0.12* (0.06)	0.12* (0.06)	-0.01 (0.08)	-0.01 (0.08)	-0.02 (0.08)
Retail portfolio	0.09*** (0.02)	0.09*** (0.02)	0.09*** (0.02)	0.03 (0.02)	0.03 (0.03)	0.04 (0.03)
Bank funding	0.00 (0.02)	-0.01 (0.02)	0.00 (0.02)	0.00 (0.03)	0.00 (0.03)	0.01 (0.02)
Market concentration	0.00 (0.03)	0.01 (0.03)	0.00 (0.03)	-0.07** (0.02)	-0.07** (0.02)	-0.09*** (0.02)
Regulation	0.27 (0.20)	0.24 (0.21)	0.30 (0.20)	0.64*** (0.15)	0.64*** (0.16)	0.59*** (0.16)
Macro technology	0.04 (0.08)	0.03 (0.08)	0.05 (0.08)	0.15** (0.05)	0.16** (0.05)	0.16** (0.06)
Constant	15.86*** (3.40)	13.89*** (3.48)	13.96*** (3.48)	19.08*** (2.01)	19.18*** (2.15)	22.49*** (1.96)
Observations	902	902	902	655	655	655
Groups	13	13	13	10	10	10

*Driscoll-Kraay Standard errors in parentheses are heteroskedasticity- consistent and robust to general forms of cross-sectional and temporal dependence; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

b) Remote BBI

Firstly, the results in Table 5.8 show that bank adoption of internet banking innovation is a negative function of market concentration and a positive function of regulation. These are the only control variables that are found to be statistically significant. Specifically, at one percent significance level, a one percent decrease in market concentration increases adoption of internet banking innovation by 0.10 percent, *ceteris paribus*. At one percent significance level, a one percent increase in the index of regulation increases adoption of internet banking innovation by 0.84 percent, *ceteris paribus*.

For our key variable of interest, the coefficient of foreign ownership is negative and statistically insignificant. However, after interacting foreign ownership with bank size, the coefficient of foreign ownership becomes statistically insignificant. The coefficient of the interaction term is 0.02, statistically significant at one percent. This suggests that there is a negative impact of foreign ownership on adoption of internet banking innovation. Crucially this impact is prominent among large banks.

When foreign ownership is interacted with bank technology, the coefficient of foreign ownership variable becomes positive but statistically insignificant. In this situation, the interaction term is not statistically significant either, suggesting no evidence that foreign ownership impacts adoption of internet banking innovation through foreign entry's influence on bank technology.

Secondly, as shown in Table 5.8, bank adoption of mobile phone banking innovation is a positive function of regulation. This is the only control variable that is found to be statistically significant. Specifically, at one percent significance level, a one percent increases in the index of regulation results in a 1.79 percent rise in adoption of mobile phone banking innovation, *ceteris paribus*.

For our key variable of interest, the coefficient of foreign ownership variable is positive, and statistically significant at 10 percent significance level. The coefficient of foreign ownership variable becomes negative and statistically insignificant when we interact foreign ownership with bank size. The coefficient of the interaction term is positive, but statistically insignificant. In this regard, the research finds no evidence of the impact of foreign entry on mobile phone banking innovation adoption, either directly or through the impact of foreign entry on the proliferation of small banks. Despite this, we can observe that when foreign ownership is interacted with bank technology, the coefficient of foreign ownership becomes positive and statistically significant, while the coefficient of the interaction term is found to be statistically insignificant.

In conclusion, the findings show that the FE methods do not provide evidence of the indirect impact of foreign ownership on mobile phone banking innovation adoption as mediated by bank size or bank technology. It does, however, show that foreign ownership has a direct positive impact on the adoption of mobile phone banking innovation.

Table 5. 8 FE results of foreign ownership & adoption of remote BBI

	Internet Banking			Mobile phone Banking		
Foreign ownership *Bank size	-	0.02*** (0.00)	-	-	0.21 (0.02)	-
Foreign ownership * Bank technology	-	-	0.00 (0.00)	-	-	0.00 (0.00)
Foreign ownership	-0.01 (0.01)	-.10*** (0.02)	0.01 (0.01)	0.01* (0.01)	-0.09 (0.08)	0.09** (0.03)
Bank size	0.13 (0.22)	-0.64** (0.22)	0.10 (0.21)	-0.50 (0.51)	-1.93 (1.26)	-0.75 (0.49)
Bank technology	0.06 (0.06)	0.06 (0.06)	0.12 (0.07)	0.05 (0.10)	0.07 (0.08)	0.33** (0.14)
Branch intensity	-0.07 (0.06)	-0.05 (0.06)	-0.06 (0.05)	-0.19 (0.13)	-0.20 (0.13)	-0.19 (0.12)
Retail portfolio	0.01 (0.03)	0.03 (0.03)	0.01 (0.03)	0.06 (0.04)	0.06 (0.04)	0.06 (0.03)
Bank funding	-0.01 (0.02)	0.02 (0.02)	-0.01 (0.02)	-0.04 (0.03)	-0.04 (0.03)	-0.04 (0.03)
Market concentration	-0.10*** (0.03)	-0.12*** (0.03)	-0.09*** (0.03)	-0.04 (0.05)	-0.03 (0.05)	-0.03 (0.05)
Regulation	0.84*** (0.20)	0.87*** (0.19)	0.88*** (0.21)	1.79*** (0.38)	1.76*** (0.37)	1.89*** (0.38)
Macro technology	-0.08 (0.05)	-0.03 (0.06)	-0.07 (0.05)	0.02 (0.09)	0.03 (0.09)	0.01 (0.09)
Constant	18.68*** (2.53)	21.09*** (2.63)	17.56*** (2.79)	9.24 (5.71)	16.58* (8.55)	4.18 (5.94)
Observations	792	792	792	548	548	548
Groups	13	13	13	11	11	11

*Driscoll-Kraay Standard errors in parentheses are heteroskedasticity- consistent and robust to general forms of cross-sectional and temporal dependence; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

PMG estimation

Turning now to PMG estimations, we start with an examination of the direct impact of foreign ownership before looking at the indirect impact.

a) Direct impacts

Table 5.9 shows the results from the PMG estimation of the direct impact of foreign entry on bank adoption of BBI. The results of each form of BBI are presented under the respective column headings. The top part of the table displays the long-run coefficients while the bottom part presents the coefficients for the short run. For all regressions the estimated error-correlation coefficients are negative and highly significant. The null hypothesis of no long run relationship is therefore rejected.

For the control variables, regulation is, as expected, positively related with adoption of ATM banking, agent banking and mobile banking innovations, in the long run. However, we do not find any evidence of a statistically significant relationship between regulation and bank adoption of BBI in the short run. Secondly, market concentration is positively associated with the adoption of ATM banking innovation in the short run. However, in the long run, the statistically significant impact is established to be negative and only for bank adoption of agent banking innovation.

Thirdly, consistent with *a priori* expectations, bank funding impacts negatively the adoption of ATM banking, agent banking and mobile banking innovations in the long run; however, it is statistically significant only for mobile phone banking innovation. The negative impact of bank funding is also established for the adoption of internet banking innovation in the short run.

Fourthly, we find evidence of a statistically significant negative impact of branch intensity on the adoption of mobile phone banking innovation in the long run. Also noteworthy is the negative impact of an increase in retail portfolio on bank adoption of mobile phone banking innovation, however it is statistically significant only in the short run.

Bank technology impacts positively the adoption of agent banking innovation in the short run. However, in the long run the statistically significant impact of bank technology is negative for ATM and agent banking innovations. The study finds statistically significant evidence of the negative impact of bank size on adoption of ATM and agent banking innovations in the long run, and internet banking and mobile banking innovations, in the short run.

Lastly, for our main variable of interest, we find that the impact of foreign ownership on adoption of different forms of BBI is mixed. In the long run, we find evidence of a statistically significant positive impact of foreign ownership on bank adoption of ATM banking innovation. Specifically, at the one percent significance level a one percent increase in foreign ownership leads to a 0.02 percent increase in the adoption of ATM banking innovation. On the other hand, the long run impact of foreign entry on adoption of mobile phone banking innovation is negative. At the 5 percent significance level, a one percent increase in foreign ownership leads to a decline in bank adoption of mobile phone banking innovation. Suffice it to note from Table 5.9b that after adjusting for FWER, the impact of foreign entry is only significant for the adoption of ATM banking innovation in the long run.

The direct impact of foreign entry on adoption of agent banking innovation is positive, albeit not statistically significant. For the adoption of internet banking innovation, we find no evidence of a long run impact of foreign ownership. In the short run, we find no evidence of a statistically significant direct impact of foreign entry on bank adoption of any form of BBI.

Table 5. 9a PMG results of the direct impact of foreign ownership on adoption BBI

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Foreign ownership	0.02*** (0.01)	0.01 (0.01)	0.00 (0.00)	-0.02** (0.01)
Bank size	-0.26* (0.16)	-0.78** (0.40)	-0.03 (0.15)	-061 (0.46)
Bank technology	-1.00* (0.04)	-0.21** (0.10)	-0.02 (0.03)	-0.02 (0.06)
Branch intensity	0.06 (0.04)	0.07 (0.10)	-0.02 (0.03)	-0.51*** (0.08)
Retail portfolio	0.02 (0.01)	0.03 (0.04)	-0.02 (0.02)	0.01 (0.04)
Bank funding	-0.01 (0.02)	-0.06 (0.03)	0.00 (0.01)	-0.07*** (0.03)
Market concentration	-0.02 (0.04)	-0.20*** (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	0.34** (0.15)	0.64* (0.35)	-0.05 (0.12)	0.97*** (0.26)
Macro technology	0.05 (0.07)	0.15 (0.15)	-0.09* (0.05)	-0.11 (0.09)

Table 5.9a PMG results of the direct impact of foreign ownership on adoption of BBI (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49*** (0.11)	-0.39*** (0.07)	-0.71*** (0.10)	-0.63*** (0.09)
Δ Foreign ownership	-0.05 (0.08)	-0.11 (0.11)	-0.31 (0.27)	-0.25 (0.17)
Δ Bank size	-0.23 (0.31)	0.70 (0.50)	-0.90* (0.47)	-2.54* (1.47)
Δ Bank technology	0.00 (0.04)	0.05** (0.23)	0.03 (0.04)	0.01 (0.10)
Δ Branch intensity	-0.13 (0.08)	-0.05 (0.09)	0.09 (0.11)	0.12 (0.13)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.02)	-0.08* (0.05)
Δ Bank funding	0.01 (0.02)	-0.02 (0.02)	-0.05* (0.03)	0.02 (0.04)
Δ Market concentration	0.05*** (0.01)	0.03 (0.02)	-0.03* (0.02)	0.02 (0.04)
Δ Regulation	-0.36 (0.39)	-0.16 (0.19)	-0.06 (0.37)	-0.09 (0.45)
Δ Macro technology	0.06 (0.06)	0.03 (0.11)	-0.14 (0.12)	0.11 (0.15)
Constant	6.44*** (1.07)	13.88*** (2.62)	13.64*** (1.36)	15.79*** (2.55)
Observations	888	645	778	537

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Table 5. 9b PMG results of the direct impact after Holm-Bonferroni correction

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Foreign ownership	0.02* (0.01)	0.01 (0.01)	0.00 (0.00)	-0.02 (0.01)
Bank size	-0.26 (0.16)	-0.78 (0.40)	-0.03 (0.15)	-061 (0.46)
Bank technology	-1.00* (0.04)	-0.21 (0.10)	-0.02 (0.03)	-0.02 (0.06)
Branch intensity	0.06 (0.04)	0.07 (0.10)	-0.02 (0.03)	-0.51* (0.08)
Retail portfolio	0.02 (0.01)	0.03 (0.04)	-0.02 (0.02)	0.01 (0.04)
Bank funding	-0.01 (0.02)	-0.06 (0.03)	0.00 (0.01)	-0.07* (0.03)
Market concentration	-0.02 (0.04)	-0.20* (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	0.34* (0.15)	0.64* (0.35)	-0.05 (0.12)	0.97* (0.26)
Macro technology	0.05 (0.07)	0.15 (0.15)	-0.09* (0.05)	-0.11 (0.09)

Table 5.9b PMG results of the direct impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49* (0.11)	-0.39* (0.07)	-0.71* (0.10)	-0.63* (0.09)
Δ Foreign ownership	-0.05 (0.08)	-0.11 (0.11)	-0.31 (0.27)	-0.25 (0.17)
Δ Bank size	-0.23 (0.31)	0.70 (0.50)	-0.90 (0.47)	-2.54 (1.47)
Δ Bank technology	0.00 (0.04)	0.05* (0.23)	0.03 (0.04)	0.01 (0.10)
Δ Branch intensity	-0.13 (0.08)	-0.05 (0.09)	0.09 (0.11)	0.12 (0.13)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.02)	-0.08 (0.05)
Δ Bank funding	0.01 (0.02)	-0.02 (0.02)	-0.05 (0.03)	0.02 (0.04)
Δ Market concentration	0.05* (0.01)	0.03 (0.02)	-0.03 (0.02)	0.02 (0.04)
Δ Regulation	-0.36 (0.39)	-0.16 (0.19)	-0.06 (0.37)	-0.09 (0.45)
Δ Macro technology	0.06 (0.06)	0.03 (0.11)	-0.14 (0.12)	0.11 (0.15)
Constant	6.44* (1.07)	13.88* (2.62)	13.64* (1.36)	15.79* (2.55)
Observations	888	645	778	537

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

b). Indirect impact

We also test whether the impact of foreign entry on bank adoption of BBI is felt indirectly via some firm specific characteristics. In this regard, we interact foreign ownership with bank size; and foreign ownership with bank technology. We test the impact of these two interaction terms separately. The results are presented in Table 5.10a.

From Table 5.10a, we note that after controlling for the interaction term between foreign entry and bank size, the direct impact of foreign entry increases from 0.02 percent previously, to 0.43 percent, significant at 1 percent. This is also significant after adjusting for FWER in Table 5.10b. For mobile banking, the direct impact of foreign entry remains negative but becomes statistically insignificant. Importantly, we note that in the long run the impact of the interaction term becomes statistically significant only for ATM banking innovation. Specifically, a one percent increase in the interaction term leads to a decrease in adoption of ATM banking innovation by 0.01 percent, at the 10 percent confidence level. However, this becomes statistically insignificant when we adjust for FWER in 5.10b. We find no evidence of a statistically significant impact between the interaction terms on the adoption of agent, internet and mobile phone banking innovations in the long run.

In the short run, we note that after controlling for the interaction term, the direct impact of foreign entry becomes statistically significant only for internet banking innovation. At the 5 percent confidence level, a one percent increase in foreign ownership leads to a 1.05 percent decrease in adoption of internet banking innovation from the mean. This is in comparison with the statistically insignificant 0.31 percent decrease on the adoption of internet banking that was reported when we did not control for the interaction term. After adjusting for FWER, the impact becomes insignificant. We further note that there is no indirect short run impact of foreign entry via bank size. None of the coefficients of the interaction term were found to be statistically significant, across the all the different dimensions of BBI in the short run.

Furthermore, after controlling for the interaction between foreign entry and bank technology, we find no statistically significant evidence of either direct or indirect impacts of foreign entry on adoption of all forms of BBI, in the short run. However, in the long run, we note that controlling for the foreign entry-bank technology interaction term, the coefficient of foreign entry on adoption of ATM banking innovation remains 0.02 but becomes statistically insignificant. The same is true for mobile phone banking and internet banking innovations where the coefficient become statistically insignificant. However, for agent banking the coefficient for foreign entry changes from 0.01 to -0.06 and becomes statistically significant at the 5 percent confidence level. This becomes statistically insignificant when we adjust for FWER in Table 5.10b. Crucially, the coefficient on the interaction terms remains zero for all dimensions of BBI.

Table 5. 10a PMG results of the impact of foreign ownership on adoption of BBI

Long-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Foreign Ownership	0.43*** (0.01)	0.02 (0.01)	-0.03 (0.03)	-0.06** (0.03)	0.01 (0.01)	0.01 (0.01)	-0.03 (0.06)	-0.09 (0.02)
Foreign ownership *bank size	-0.01* (0.00)	-	0.01 (0.01)	-	0.00 (0.00)	-	0.00 (0.01)	-
Foreign ownership *bank technology	-	0.00 (0.00)	-	0.00 (0.00)	-	0.00 (0.00)	-	0.00 (0.00)
Bank size	0.26 (0.32)	-0.28** (0.16)	-1.12** (0.49)	-0.66* (0.39)	0.06 (0.21)	-0.05 (0.15)	-0.95 (0.87)	-0.21 (0.47)
Bank Technology	-0.12*** (0.04)	-0.15* (0.09)	-0.19* (0.10)	-0.40*** (0.12)	-0.02 (0.03)	0.03 (0.05)	-0.03 (0.06)	-0.31*** (0.09)
Branch Intensity	0.06 (0.04)	0.07 (0.04)	0.07 (0.10)	0.02 (0.10)	-0.02 (0.03)	-0.02 (0.03)	-0.53*** (0.08)	-0.47*** (0.08)
Retail portfolio	0.02 (0.01)	0.02 (0.01)	0.03 (0.04)	0.04 (0.04)	-0.02 (0.02)	-0.02 (0.02)	-0.01 (0.04)	0.35 (0.04)
Bank funding	-0.01 (0.02)	0.00 (0.02)	-0.05 (0.04)	-0.03 (0.03)	-0.01 (0.01)	0.00 (0.01)	-0.08*** (0.03)	-0.09*** (0.02)
Market concentration	-0.02 (0.03)	-0.03 (0.04)	-0.21*** (0.07)	-0.22*** (0.07)	0.00 (0.02)	-0.01 (0.02)	-0.03 (0.05)	-0.33 (0.05)
Regulation	0.40** (0.15)	0.35** (0.15)	0.65** (0.34)	0.65** (0.34)	-0.04 (0.12)	-0.04 (0.12)	1.00*** (0.26)	0.67*** (0.26)
Macro Technology	0.05 (0.07)	0.04 (0.07)	0.16 (0.15)	0.19 (0.15)	-0.11** (0.05)	-0.08* (0.05)	-0.13 (0.09)	-0.05 (0.08)

Table 5.10a PMG results of the indirect impact of foreign ownership on adoption of BBI (cont'd)

Short-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Error-correction coefficient	-0.50*** (0.11)	-0.48*** (0.11)	-0.39*** (0.07)	-0.40*** (0.07)	-0.71*** (0.10)	-0.71*** (0.10)	-0.62*** (0.09)	-0.62*** (0.09)
Δ Foreign ownership	-0.17. (0.31)	0.81 (0.75)	1.33 (0.42)	-0.34 (0.28)	-1.05** (0.54)	0.62 (0.60)	-17.41 (17.50)	-7.69 (7.38)
Δ Foreign ownership *bank size	0.02 (0.05)	-	-0.05 (0.08)	-	0.16 (0.11)	-	3.04 (3.08)	-
Δ Foreign ownership *bank technology	-	-0.07 (0.06)	-	0.02 (0.01)	-	-0.07 (0.06)	-	0.48 (0.47)
Δ Bank size	-1.10 (4.15)	-0.23 (0.32)	6.18 (6.87)	0.69 (0.51)	-16.65 (11.31)	-0.91** (0.46)	-192.03 (183.98)	-2.64 (1.66)
Δ Bank technology	0.01 (0.04)	4.45 (3.65)	0.05** (0.02)	-0.82 (0.80)	0.03 (0.04)	4.57 (3.81)	0.00 (0.11)	-28.53 (28.06)
Δ Branch Intensity	-0.12 (0.08)	-0.12 (0.07)	-0.05 (0.09)	-0.03 (0.10)	0.08 (0.11)	0.08 (0.11)	0.09 (0.13)	0.11 (0.13)
Δ Retail Portfolio	-0.02 (0.03)	-0.02 (0.03)	-0.04 (0.04)	-0.04 (0.04)	0.01 (0.02)	0.02 (0.02)	-0.08* (0.05)	-0.10** (0.05)
Δ Bank Funding	0.01 (0.02)	0.01 (0.02)	-0.03 (0.02)	-0.03** (0.02)	-0.05* (0.03)	-0.05* (0.03)	0.01 (0.04)	0.01 (0.04)
Δ Market concentration	0.05*** (0.01)	0.05*** (0.02)	0.03 (0.11)	0.31 (0.02)	-0.03 (0.02)	-0.03* (0.02)	0.03 (0.04)	0.03 (0.04)
Δ Regulation	-0.40 (0.39)	-0.32 (0.40)	-0.16 (0.19)	-0.03 (0.16)	-0.05 (0.37)	-0.11 (0.39)	-0.12 (0.45)	0.10 (0.48)
Δ Macro technology	0.06 (0.06)	0.08 (0.07)	0.03 (0.11)	0.04 (0.11)	-0.13 (0.12)	-0.15 (0.13)	0.14 (0.15)	0.12 (0.17)
Constant	5.68*** (0.95)	6.60*** (1.11)	14.45*** (2.74)	14.76*** (2.63)	13.50*** (1.33)	13.23*** (1.30)	17.11*** (2.62)	17.97*** (2.28)
Observations	888	888	645	645	778	778	537	537

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Table 5. 10b PMG results of the impact after Holm-Bonferroni correction

Long-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Foreign Ownership	0.43* (0.01)	0.02 (0.01)	-0.03 (0.03)	-0.06 (0.03)	0.01 (0.01)	0.01 (0.01)	-0.03 (0.06)	-0.09 (0.02)
Foreign ownership *bank size	-0.01 (0.00)	-	0.01 (0.01)	-	0.00 (0.00)	-	0.00 (0.01)	-
Foreign ownership *bank technology	-	0.00 (0.00)	-	0.00 (0.00)	-	0.00 (0.00)	-	0.00 (0.00)
Bank size	0.26 (0.32)	-0.28 (0.16)	-1.12* (0.49)	-0.66 (0.39)	0.06 (0.21)	-0.05 (0.15)	-0.95 (0.87)	-0.21 (0.47)
Bank Technology	-0.12* (0.04)	-0.15 (0.09)	-0.19 (0.10)	-0.40* (0.12)	-0.02 (0.03)	0.03 (0.05)	-0.03 (0.06)	-0.31* (0.09)
Branch Intensity	0.06 (0.04)	0.07 (0.04)	0.07 (0.10)	0.02 (0.10)	-0.02 (0.03)	-0.02 (0.03)	-0.53* (0.08)	-0.47* (0.08)
Retail portfolio	0.02 (0.01)	0.02 (0.01)	0.03 (0.04)	0.04 (0.04)	-0.02 (0.02)	-0.02 (0.02)	-0.01 (0.04)	0.35 (0.04)
Bank funding	-0.01 (0.02)	0.00 (0.02)	-0.05 (0.04)	-0.03 (0.03)	-0.01 (0.01)	0.00 (0.01)	-0.08* (0.03)	-0.09* (0.02)
Market concentration	-0.02 (0.03)	-0.03 (0.04)	-0.21* (0.07)	-0.22* (0.07)	0.00 (0.02)	-0.01 (0.02)	-0.03 (0.05)	-0.33 (0.05)
Regulation	0.40* (0.15)	0.35* (0.15)	0.65* (0.34)	0.65* (0.34)	-0.04 (0.12)	-0.04 (0.12)	1.00* (0.26)	0.67* (0.26)
Macro Technology	0.05 (0.07)	0.04 (0.07)	0.16 (0.15)	0.19 (0.15)	-0.11 (0.05)	-0.08 (0.05)	-0.13 (0.09)	-0.05 (0.08)

Table 5.10b PMG results of the indirect impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Error-correction coefficient	-0.50* (0.11)	-0.48* (0.11)	-0.39* (0.07)	-0.40* (0.07)	-0.71* (0.10)	-0.71* (0.10)	-0.62* (0.09)	-0.62* (0.09)
Δ Foreign ownership	-0.17. (0.31)	0.81 (0.75)	1.33 (0.42)	-0.34 (0.28)	-1.05 (0.54)	0.62 (0.60)	-17.41 (17.50)	-7.69 (7.38)
Δ Foreign ownership *bank size	0.02 (0.05)	-	-0.05 (0.08)	-	0.16 (0.11)	-	3.04 (3.08)	-
Δ Foreign ownership *bank technology	-	-0.07 (0.06)	-	0.02 (0.01)	-	-0.07 (0.06)	-	0.48 (0.47)
Δ Bank size	-1.10 (4.15)	-0.23 (0.32)	6.18 (6.87)	0.69 (0.51)	-16.65 (11.31)	-0.91 (0.46)	-192.03 (183.98)	-2.64 (1.66)
Δ Bank technology	0.01 (0.04)	4.45 (3.65)	0.05 (0.02)	-0.82 (0.80)	0.03 (0.04)	4.57 (3.81)	0.00 (0.11)	-28.53 (28.06)
Δ Branch Intensity	-0.12 (0.08)	-0.12 (0.07)	-0.05 (0.09)	-0.03 (0.10)	0.08 (0.11)	0.08 (0.11)	0.09 (0.13)	0.11 (0.13)
Δ Retail Portfolio	-0.02 (0.03)	-0.02 (0.03)	-0.04 (0.04)	-0.04 (0.04)	0.01 (0.02)	0.02 (0.02)	-0.08 (0.05)	-0.10 (0.05)
Δ Bank Funding	0.01 (0.02)	0.01 (0.02)	-0.03 (0.02)	-0.03 (0.02)	-0.05 (0.03)	-0.05 (0.03)	0.01 (0.04)	0.01 (0.04)
Δ Market concentration	0.05* (0.01)	0.05* (0.02)	0.03 (0.11)	0.31 (0.02)	-0.03 (0.02)	-0.03* (0.02)	0.03 (0.04)	0.03 (0.04)
Δ Regulation	-0.40 (0.39)	-0.32 (0.40)	-0.16 (0.19)	-0.03 (0.16)	-0.05 (0.37)	-0.11 (0.39)	-0.12 (0.45)	0.10 (0.48)
Δ Macro technology	0.06 (0.06)	0.08 (0.07)	0.03 (0.11)	0.04 (0.11)	-0.13 (0.12)	-0.15 (0.13)	0.14 (0.15)	0.12 (0.17)
Constant	5.68* (0.95)	6.60* (1.11)	14.45* (2.74)	14.76* (2.63)	13.50* (1.33)	13.23* (1.30)	17.11* (2.62)	17.97* (2.28)
Observations	888	888	645	645	778	778	537	537

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

5.3.5. Robustness check

Having presented the findings from the foreign ownership-BBI benchmark model, the next step is to present the results of the robustness check models, where dummy variables have been applied to represent foreign ownership. Under this approach, a bank is accorded a dummy value of 1, if foreign ownership stake in that bank at that point is greater than 10 percent. Any ownership stake by foreign shareholders lower than 10 percent is designated a value of zero. This is consistent with Claessens et al., (2001); Clarke et al., (2001); De Haas and Naaborg, (2005); De Haas and Van Lelyveld, (2006); Cull and Soledad Martinez Peria, (2010); Wu et al., (2017).

a) Direct impact

The summary findings from the PMG estimation of the direct impact of foreign ownership is represented are presented in Tables 5.11a. For all the models estimated, the respective error correction terms are negative, less than 2 in absolute terms and statistically significant at 1 percent. These attributes confirm the existence of cointegration between the variables.

For the control variables, the results corroborate the earlier findings of statistically significant positive impact of regulation on the adoption of ATM banking, agent banking and mobile phone banking, in the long run. However, in the short run, there is no evidence of a statistically significant impact of regulation on bank adoption of BBI. Also, evidence of a statistically significant impact of market concentration is established for the adoption of ATM banking innovation and mobile phone banking innovation, in the short run. At 1 percent significance level, a one percent increase in market concentration leads to an increase in the adoption of ATM banking innovation by 0.05 percent; and at 10 percent significance level, a one percent increase in market concentration leads to a decrease in the adoption of mobile banking innovation by 0.03 percent. However, in the long run, the impact is negative for agent banking innovation only.

As in the benchmark model, robustness check estimations establish statistically significant inverse relationship between bank funding and adoption of mobile phone banking in the long run, and agent banking in the short run. Specifically, at one percent significance level, a one percent increase in bank funding leads to a long run reduction in the adoption of mobile phone banking innovation by 0.07 percent. At 10 percent significance level, a one percent increase in bank funding results in the short run reduction in the adoption of agent banking innovation by 0.03 percent. For retail portfolio, the impact is felt only in the short run, on mobile banking innovation consistent with the benchmark model results. A one percent increase in retail portfolio results in a decrease in bank adoption of mobile banking innovation by 0.09 percent. Consistent with the benchmark model, the robustness check estimations establish evidence of statistically significant negative impact of branch intensity on adoption of mobile phone banking innovation in the long run. At one percent significance level, a one percent increase in branch intensity leads to a reduction in the adoption of mobile phone innovation by 0.52 percent.

Bank technology impacts positively the adoption of agent banking innovation in the short run. However, in the long run the statistically significant impact of bank technology is negative for the adoption of ATM banking and agent banking innovations. The impact of bank size on adoption of BBI is negative and statistically significant for ATM banking innovation and agent banking innovation, in the long run; and internet banking and mobile phone banking, innovations in the short run. This is consistent with the results from the benchmark model.

Lastly, for our main variable of interest, we confirm mixed outcomes established under the benchmark model. Specifically, using the dummy variable approach, the results confirm statistically significant impact of foreign ownership on adoption of ATM banking innovation and mobile banking innovations in the long run. At one percent significance level, a one percent increase in foreign ownership results in a 0.73 percent increase in adoption of ATM banking innovation. Also, at 5 percent significance level, a one percent decrease in foreign ownership increases bank adoption of mobile phone banking innovation by 1.09 percent. After adjusting for FWER in Table 5.11b, the impact is statistically significant only for adoption of mobile phone banking innovation. In the short run, the impact of foreign ownership is negative and statistically insignificant for all dimensions of BBI.

Table 5. 11a PMG results of the direct impact of foreign ownership on adoption BBI

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Foreign ownership	0.73** (0.33)	-0.06 (0.48)	0.28 (0.28)	-1.09*** (0.40)
Bank size	-0.31** (0.16)	-0.70* (0.39)	-0.09 (0.15)	-0.54 (0.45)
Bank technology	-0.11** (0.04)	-0.21** (0.10)	-0.02 (0.03)	-0.01 (0.06)
Branch intensity	0.06 (0.04)	0.05 (0.10)	-0.03 (0.03)	-0.52*** (0.07)
Retail portfolio	0.02 (0.02)	0.02 (0.04)	-0.01 (0.02)	0.01 (0.04)
Bank funding	-0.01 (0.02)	-0.05 (0.04)	0.00 (0.01)	-0.07*** (0.03)
Market concentration	-0.04 (0.03)	-0.21*** (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	0.43*** (0.15)	0.60* (0.35)	0.00 (0.12)	0.82*** (0.26)
Macro technology	0.06 (0.07)	0.17 (0.15)	-0.09* (0.05)	-0.12 (0.09)

Table 5.11a PMG results of the direct impact of foreign ownership on adoption of BBI (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49*** (0.11)	-0.39*** (0.07)	-0.73*** (0.10)	-0.63*** (0.09)
Δ Foreign ownership	0.28 (0.28)	-0.04 (0.13)	-0.49 (0.33)	-0.53 (0.66)
Δ Bank size	-0.18 (0.28)	0.65 (0.46)	-0.95* (0.51)	-2.59** (1.50)
Δ Bank technology	0.00 (0.04)	0.05** (0.02)	0.03 (0.04)	0.02 (0.11)
Δ Branch intensity	-0.13 (0.08)	-0.05 (0.09)	0.07 (0.10)	0.13 (0.12)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.02)	-0.09* (0.05)
Δ Bank funding	0.01 (0.02)	-0.03* (0.02)	-0.04 (0.03)	0.02 (0.04)
Δ Market concentration	0.05*** (0.01)	0.03 (0.02)	-0.03* (0.02)	0.02 (0.04)
Δ Regulation	-0.38 (0.39)	-0.16 (0.18)	-0.09 (0.37)	-0.02 (0.46)
Δ Macro technology	0.06 (0.06)	0.03 (0.11)	-0.14 (0.13)	0.12 (0.16)
Constant	7.04*** (1.21)	13.80*** (2.60)	13.30*** (1.22)	16.06*** (2.27)
Observations	888	645	778	537
Groups	13	10	13	11

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Table 5. 11b PMG results of the direct impact after Holm-Bonferroni correction

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Foreign ownership	0.73 (0.33)	-0.06 (0.48)	0.28 (0.28)	-1.09* (0.40)
Bank size	-0.31 (0.16)	-0.70 (0.39)	-0.09 (0.15)	-0.54 (0.45)
Bank technology	-0.11* (0.04)	-0.21 (0.10)	-0.02 (0.03)	-0.01 (0.06)
Branch intensity	0.06 (0.04)	0.05 (0.10)	-0.03 (0.03)	-0.52* (0.07)
Retail portfolio	0.02 (0.02)	0.02 (0.04)	-0.01 (0.02)	0.01 (0.04)
Bank funding	-0.01 (0.02)	-0.05 (0.04)	0.00 (0.01)	-0.07* (0.03)
Market concentration	-0.04 (0.03)	-0.21* (0.07)	0.00 (0.02)	-0.03 (0.05)
Regulation	0.43* (0.15)	0.60 (0.35)	0.00 (0.12)	0.82* (0.26)
Macro technology	0.06 (0.07)	0.17 (0.15)	-0.09 (0.05)	-0.12 (0.09)

Table 5.11b PMG results of the direct impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49* (0.11)	-0.39* (0.07)	-0.73* (0.10)	-0.63* (0.09)
Δ Foreign ownership	0.28 (0.28)	-0.04 (0.13)	-0.49 (0.33)	-0.53 (0.66)
Δ Bank size	-0.18 (0.28)	0.65 (0.46)	-0.95 (0.51)	-2.59 (1.50)
Δ Bank technology	0.00 (0.04)	0.05* (0.02)	0.03 (0.04)	0.02 (0.11)
Δ Branch intensity	-0.13 (0.08)	-0.05 (0.09)	0.07 (0.10)	0.13 (0.12)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.02)	-0.09* (0.05)
Δ Bank funding	0.01 (0.02)	-0.03* (0.02)	-0.04 (0.03)	0.02 (0.04)
Δ Market concentration	0.05* (0.01)	0.03 (0.02)	-0.03 (0.02)	0.02 (0.04)
Δ Regulation	-0.38 (0.39)	-0.16 (0.18)	-0.09 (0.37)	-0.02 (0.46)
Δ Macro technology	0.06 (0.06)	0.03 (0.11)	-0.14 (0.13)	0.12 (0.16)
Constant	7.04* (1.21)	13.80* (2.60)	13.30* (1.22)	16.06* (2.27)
Observations	888	645	778	537
Groups	13	10	13	11

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

b.) Indirect impacts.

From Table 5.12a, we note that after controlling for the interaction term between foreign ownership and bank size, the direct impact of foreign entry is 4.24 percent, significant at 1 percent. This becomes statistically insignificant after adjusting for FWER. For agent banking, internet banking and mobile banking, the direct impact of foreign entry remains statistically insignificant. Importantly, we note that in the long run the impact of the interaction term becomes statistically significant only for ATM banking innovation. Specifically, a one percent increase in the interaction term leads to a decrease in adoption of ATM banking innovation by 0.99 percent, at the 5 percent confidence level. After adjusting for FWER, this impact becomes statistically insignificant. We find no evidence of a statistically significant impact between the interaction terms on the adoption of agent, internet and mobile phone banking innovations in the long run. This is consistent with what was established in the benchmark model estimation in Table 5.10a.

Furthermore, after controlling for the interaction between foreign entry and bank technology, the robustness check estimations confirm the benchmark model findings of no statistically significant evidence of either direct or indirect impacts of foreign entry on adoption of ATM banking, agent banking and mobile phone banking innovations, in the short run. Results for the estimations for internet banking adoption could not be generated as numerical derivatives were approximate flat. In the long run, we note that controlling for the foreign entry-bank technology interaction term, the coefficient of foreign entry on adoption of ATM banking innovation remain statistically insignificant. However, for agent banking and mobile phone banking innovations, their coefficients for foreign entry are statistically significant. At 5 percent confidence level, a one percent increase in foreign ownership leads to a decrease in the adoption of agent banking innovation by 4.38 percent; while at 1 percent confidence level, a one percent increase in foreign ownership leads to a decrease in the adoption of mobile phone banking innovation by 8.23 percent. Crucially however, the coefficient on the interaction terms under the robustness check estimation become positive but only statistically significant for agent banking innovation and mobile phone banking innovation only. This remains statistically significant even when we adjust for FWER.

In the short run, we note that after controlling for the interaction term, the direct impact of foreign entry becomes statistically insignificant for all dimensions of BBI estimated. The robustness check estimation also confirm the absence of evidence on the indirect short run impact of foreign entry via bank size, reported in the benchmark model estimations.

Table 5. 12a PMG results of the impact of foreign ownership on adoption of BBI

Long-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Foreign Ownership	4.24*** (1.36)	0.61 (1.23)	-1.59 (1.87)	-4.38** (1.91)	0.62 (0.98)	-	0.99 (3.68)	-8.23*** (1.70)
Foreign ownership *bank size	-0.99** (0.36)	-	0.33 (0.40)	-	-0.07 (0.21)	-	-0.39 (0.68)	-
Foreign ownership *bank technology	-	0.01 (0.11)	-	0.34** (0.15)	-	-	-	0.52*** (0.12)
Bank size	0.57 (0.35)	-0.32** (0.16)	-0.96** (0.47)	-0.55 (0.39)	-0.04 (0.21)	-	-0.30 (0.74)	0.15 (0.46)
Bank Technology	-0.13*** (0.04)	-0.11 (0.10)	-0.19* (0.10)	-0.43*** (0.13)	-0.02 (0.03)	-	-0.01 (0.07)	-0.38*** (0.10)
Branch Intensity	0.04 (0.04)	0.06 (0.05)	0.06 (0.10)	0.04 (0.10)	-0.03 (0.03)	-	-0.53*** (0.07)	-0.47*** (0.08)
Retail portfolio	0.01 (0.01)	0.01 (0.01)	0.02 (0.04)	0.04 (0.04)	-0.01 (0.02)	-	0.01 (0.04)	0.04 (0.04)
Bank funding	-0.01 (0.02)	-0.01 (0.02)	-0.05 (0.04)	-0.02 (0.04)	-0.01 (0.01)	-	-0.07*** (0.03)	-0.09*** (0.02)
Market concentration	-0.04 (0.03)	-0.04 (0.03)	-0.21*** (0.07)	-0.21*** (0.07)	0.00 (0.02)	-	-0.04 (0.05)	-0.02 (0.05)
Regulation	0.48*** (0.15)	0.45*** (0.15)	0.58* (0.34)	0.65** (0.34)	-0.01 (0.12)	-	0.81*** (0.26)	0.64** (0.25)
Macro Technology	0.07 (0.07)	0.06 (0.07)	0.18 (0.15)	0.16 (0.15)	-0.09* (0.05)	-	-0.14 (0.09)	-0.07 (0.08)

Table 5.12a PMG results of the indirect impact of foreign ownership on adoption of BBI (cont'd)

Short-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Error-correction coefficient	-0.50*** (0.10)	-0.48*** (0.11)	-0.39*** (0.07)	-0.40*** (0.07)	-0.73*** (0.10)	-	-0.62*** (0.09)	-0.63*** (0.09)
Δ Foreign ownership	0.12. (2.71)	-1.12 (0.69)	1.98 (2.24)	-1.19 (0.84)	-0.46 (0.45)	-	11.41 (8.83)	-3.38 (4.16)
Δ Foreign ownership *bank size	0.09 (0.50)	-	-0.58 (0.45)	-	-0.08 (0.12)	-	-2.84 (2.11)	-
Δ Foreign ownership *bank technology	-	0.09 (0.06)	-	0.09 (0.05)	-	-	-	0.23 (0.25)
Δ Bank size	-0.32 (0.29)	-0.20 (0.30)	1.11 (0.52)	0.61 (0.45)	-0.87* (0.51)	-	-0.62 (1.76)	-2.54 (1.59)
Δ Bank technology	0.01 (0.04)	-0.03 (0.03)	0.05** (0.02)	0.02 (0.03)	0.03 (0.04)	-	0.02 (0.11)	-0.17* (0.10)
Δ Branch Intensity	-0.12 (0.08)	-0.12 (0.07)	-0.05 (0.09)	-0.05 (0.10)	0.07 (0.10)	-	0.10 (0.13)	0.10 (0.12)
Δ Retail Portfolio	-0.02 (0.02)	-0.02 (0.03)	-0.04 (0.04)	-0.04 (0.04)	0.01 (0.02)	-	-0.09** (0.05)	-0.10** (0.05)
Δ Bank Funding	0.01 (0.02)	0.00 (0.02)	-0.03* (0.02)	-0.03* (0.02)	-0.04 (0.03)	-	0.01 (0.04)	0.01 (0.04)
Δ Market concentration	0.05*** (0.01)	0.05*** (0.02)	0.03 (0.02)	0.03 (0.02)	-0.03* (0.02)	-	0.03 (0.04)	0.03 (0.04)
Δ Regulation	-0.40 (0.40)	-0.33 (0.41)	-0.17 (0.19)	-0.04 (0.15)	-0.09 (0.37)	-	-0.02 (0.46)	0.14 (0.52)
Δ Macro technology	0.05 (0.06)	0.07 (0.07)	0.02 (0.11)	0.05 (0.11)	-0.14 (0.13)	-	0.15 (0.15)	0.13 (0.18)
Constant	5.59*** (0.89)	7.02*** (1.21)	14.44*** (2.71)	14.41*** (2.62)	13.17*** (1.21)	-	15.52*** (2.20)	17.50*** (2.11)
Observations	888	888	645	645	778	-	537	537
Groups	13	13	10	10	13	-	11	11

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. * p < 0.10, ** p < 0.05, *** p < 0.01. Estimation the impact of foreign entry-bank technology interaction on adoption of internet banking innovation not possible as numerical derivatives are approximate flat.*

Table 5. 12b PMG results of the impact after Holm-Bonferroni correction

Long-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Foreign Ownership	4.24* (1.36)	0.61 (1.23)	-1.59 (1.87)	-4.38* (1.91)	0.62 (0.98)	-	0.99 (3.68)	-8.23* (1.70)
Foreign ownership *bank size	-0.99 (0.36)	-	0.33 (0.40)	-	-0.07 (0.21)	-	-0.39 (0.68)	-
Foreign ownership *bank technology	-	0.01 (0.11)	-	0.34** (0.15)	-	-	-	0.52*** (0.12)
Bank size	0.57 (0.35)	-0.32* (0.16)	-0.96 (0.47)	-0.55 (0.39)	-0.04 (0.21)	-	-0.30 (0.74)	0.15 (0.46)
Bank Technology	-0.13* (0.04)	-0.11 (0.10)	-0.19 (0.10)	-0.43* (0.13)	-0.02 (0.03)	-	-0.01 (0.07)	-0.38* (0.10)
Branch Intensity	0.04 (0.04)	0.06 (0.05)	0.06 (0.10)	0.04 (0.10)	-0.03 (0.03)	-	-0.53* (0.07)	-0.47* (0.08)
Retail portfolio	0.01 (0.01)	0.01 (0.01)	0.02 (0.04)	0.04 (0.04)	-0.01 (0.02)	-	0.01 (0.04)	0.04 (0.04)
Bank funding	-0.01 (0.02)	-0.01 (0.02)	-0.05 (0.04)	-0.02 (0.04)	-0.01 (0.01)	-	-0.07* (0.03)	-0.09* (0.02)
Market concentration	-0.04 (0.03)	-0.04 (0.03)	-0.21* (0.07)	-0.21* (0.07)	0.00 (0.02)	-	-0.04 (0.05)	-0.02 (0.05)
Regulation	0.48* (0.15)	0.45* (0.15)	0.58 (0.34)	0.65 (0.34)	-0.01 (0.12)	-	0.81* (0.26)	0.64* (0.25)
Macro Technology	0.07 (0.07)	0.06 (0.07)	0.18 (0.15)	0.16 (0.15)	-0.09 (0.05)	-	-0.14 (0.09)	-0.07 (0.08)

Table 5.12b PMG results of the indirect impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Error-correction coefficient	-0.50* (0.10)	-0.48* (0.11)	-0.39* (0.07)	-0.40* (0.07)	-0.73* (0.10)	-	-0.62* (0.09)	-0.63* (0.09)
Δ Foreign ownership	0.12. (2.71)	-1.12 (0.69)	1.98 (2.24)	-1.19 (0.84)	-0.46 (0.45)	-	11.41 (8.83)	-3.38 (4.16)
Δ Foreign ownership *bank size	0.09 (0.50)	-	-0.58 (0.45)	-	-0.08 (0.12)	-	-2.84 (2.11)	-
Δ Foreign ownership *bank technology	-	0.09 (0.06)	-	0.09 (0.05)	-	-	-	0.23 (0.25)
Δ Bank size	-0.32 (0.29)	-0.20 (0.30)	1.11 (0.52)	0.61 (0.45)	-0.87 (0.51)	-	-0.62 (1.76)	-2.54 (1.59)
Δ Bank technology	0.01 (0.04)	-0.03 (0.03)	0.05 (0.02)	0.02 (0.03)	0.03 (0.04)	-	0.02 (0.11)	-0.17 (0.10)
Δ Branch Intensity	-0.12 (0.08)	-0.12 (0.07)	-0.05 (0.09)	-0.05 (0.10)	0.07 (0.10)	-	0.10 (0.13)	0.10 (0.12)
Δ Retail Portfolio	-0.02 (0.02)	-0.02 (0.03)	-0.04 (0.04)	-0.04 (0.04)	0.01 (0.02)	-	-0.09 (0.05)	-0.10 (0.05)
Δ Bank Funding	0.01 (0.02)	0.00 (0.02)	-0.03 (0.02)	-0.03 (0.02)	-0.04 (0.03)	-	0.01 (0.04)	0.01 (0.04)
Δ Market concentration	0.05* (0.01)	0.05* (0.02)	0.03 (0.02)	0.03 (0.02)	-0.03 (0.02)	-	0.03 (0.04)	0.03 (0.04)
Δ Regulation	-0.40 (0.40)	-0.33 (0.41)	-0.17 (0.19)	-0.04 (0.15)	-0.09 (0.37)	-	-0.02 (0.46)	0.14 (0.52)
Δ Macro technology	0.05 (0.06)	0.07 (0.07)	0.02 (0.11)	0.05 (0.11)	-0.14 (0.13)	-	0.15 (0.15)	0.13 (0.18)
Constant	5.59* (0.89)	7.02* (1.21)	14.44* (2.71)	14.41* (2.62)	13.17* (1.21)	-	15.52* (2.20)	17.50* (2.11)
Observations	888	888	645	645	778	-	537	537
Groups	13	13	10	10	13	-	11	11

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. Estimation the impact of foreign entry-bank technology interaction on adoption of internet banking innovation not possible as numerical derivatives are approximate flat*

5.3.6. Summary

In summary, we note as follows:

Firstly, we fail to find statistically significant evidence of a short run impact of foreign ownership on bank adoption of BBI, either directly or indirectly. Given that the majority of these foreign banks in Malawi are the product of takeovers rather than greenfield investment, the results are unsurprising. Our argument is supported by the literature, which shows that the management of local banks taken over generally continue to make their own independent decisions for some time, given that they are frequently retained for a length of time before risk management procedures can be fully harmonised with those of the parent bank (De Haas and Naaborg, 2005; De Haas and Van Lelyveld, 2006; Wu et al., 2017). However, for greenfield foreign banks according to the above literature, the benefit of parent company business strategies is immediate, because home country management are usually transferred to establish the new institution and thereby execute home country strategies straight away.

In the long run, we find evidence of the direct impact of foreign entry as being positive for ATM banking innovation and negative for mobile phone banking innovation. However, increasing bank size diminishes the direct impact of foreign entry on adoption of ATM banking innovation, so that the positive impact of foreign ownership is prominent mostly for small banks. Apart from that, the study fails to find evidence of an indirect impact of foreign entry on adoption of BBI, through bank technology.

Firstly, the SSA region leads the world in mobile financial accounts, with nearly 25 thousand per 100,000 adults owning mobile banking accounts, compared to the global average of nearly 4000 (Burns, 2018). Given that mobile phone banking innovation has resulted in a significant increase in the overall share of adults in SSA with formal financial accounts, according to the World Bank (2014), it is arguably an innovative strategy primarily best suited for retail consumers including in the typical SSA remote areas. We therefore interpret the findings of the long run inverse relationship between foreign ownership and bank adoption of mobile phone banking innovation as reflecting skim-creaming tendencies among foreign banks to target large corporates, with little focus on the low-end consumers for whom mobile banking innovation is best suited (Mian, 2006; Sengupta, 2007; Gormley, 2010; Giannetti and Ongena, 2012). This should not be confounding considering previous studies that failed to establish a statistically significant relationship between foreign ownership of banks and adoption of innovation (see Hue, 2019); and also foreign ownership of banks and pursuit of financial inclusion (see, Sarma and Pais, 2011).

Secondly, the findings that rapid adoption of ATM banking innovation is directly associated with foreign entry should not be surprising, considering that ATMs are imported, rather than developed domestically. However, the evidence that interacting foreign entry with bank technology does not yield any significant impact on adoption of any form of innovation makes it clear that foreign ownership does not provide any advantage to a bank in terms of skills or technological transfer with respect to ATM banking adoption. After all, ATM banking innovation, being one of the earliest forms of BBI, has been shown in Chapter 2 to have been widely adopted by all banks in Malawi, regardless of being foreign or domestically owned.

An important factor underpinning the positive impact of foreign ownership on bank adoption of ATM banking innovation hinges on its effect on bank size. As Malawi's banking system has become more open to foreign entrants, there has been an increase in the number of small banks in the sector (Nkowani, 2008; Kaluwa and Chirwa, 2017). In this regard, the positive impact of foreign ownership on bank adoption of ATM banking innovations corroborates the findings in Chapter 4 that small banks are rapid adopters of BBI, in this case leveraging ATM innovation to service retail consumer niches that major banks generally overlook. This argument is strengthened by our finding of an inverse relationship between the *foreign ownership-bank size* interaction term and bank adoption of ATM banking. In this regard, we conclude that foreign entry’s beneficial effect on financial inclusion can be routed through its effect on the proliferation of small banks that, in turn, adopt ATM banking innovation – and do so more rapidly than large banks.

5.4 Bank Holding Company (BHC) Membership

5.4.1. Model Specification

We test the hypotheses that adoption of BBI is a direct function of BHC membership. This is against the background of widespread evidence supporting the view that a bank that is a member of a BHC is more likely to adopt BBI than independent banks, because of synergies prevalent within the group which make adoption of innovation perceived as being less risky

(Hannan and McDowell, 1984; Hannan and McDowell, 1987; Courchane et al., 2002; Nickerson and Sullivan, 2003; Frame and White, 2004; De Young et al., 2007; Sullivan and Wang, 2020).

To investigate the effect of BHC membership on BBI adoption, we begin with a fixed effects (FE) model with heteroskedasticity robust standard errors (Driscoll and Kraay, 1998). Our baseline empirical model is shown in Equation 5.8.

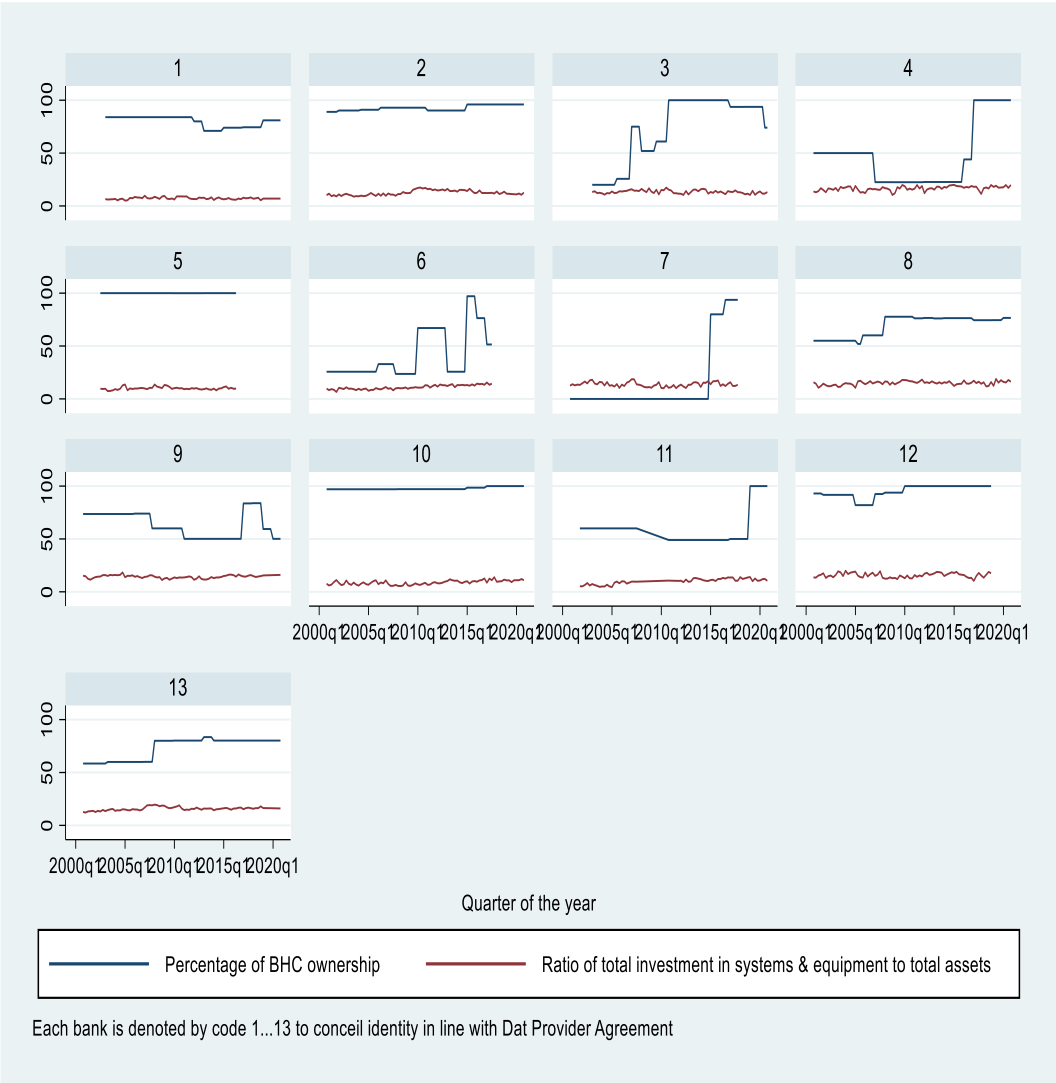
$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \beta_3 BHC_{it} + \mu_{it} \quad (5.8)$$

Where, $Y_{i,t}$ represents a vector of dimensions of BBI for bank *i* over time *t*. X is a vector of bank characteristics (bank technology, branch intensity, bank retail portfolio, bank funding and bank size) that vary cross-sectionally and over time *t*. Z is a set of macro-level factors: (market concentration, regulation and macro technology), that vary overtime but are constant cross-sectionally. μ_{it} is the error term. We also include a variable BHC_{it} to represent holding company shareholding in bank *i* over time *t*.

Furthermore, we test whether the impact of BHC ownership on adoption of BBI is felt indirectly via firm specific characteristics. In that regard, we create two interaction terms.

First, we interact BHC membership with bank technology. This derives from the technology synergies narrative, which states that if a BHC has a subsidiary ICT company, a bank can benefit from lower costs as a result of shared technological platforms used to provide innovative services (Hannan and McDowell, 1984; Sinha and Chandrashekaran, 1992; Furst et al., 2002; Courchane et al., 2002; Frame and White, 2004; Sullivan and Wang, 2020). Furthermore, if the BHC has bank subsidiaries in different countries, or subsidiaries that offer a variety of financial services, it is plausible that one of the group's banks will benefit from the experiences of other subsidiaries. However, as argued by Hannan and McDowell (1987), banks that are members of holding companies may have organisational differences that can alter the extent to which BHC membership can impact the adoption of innovations. Fig 5.4 is a diagrammatic representation of the interaction between BHC ownership and bank technology. From the plot, we see that the BHC membership and bank technology lines are near parallel only in 4 banks. Of the 13 banks, 9 banks exhibit interaction with the two variables relating differently both cross sectionally and intertemporally.

Figure 5. 4 BHC ownership & bank technology interaction term

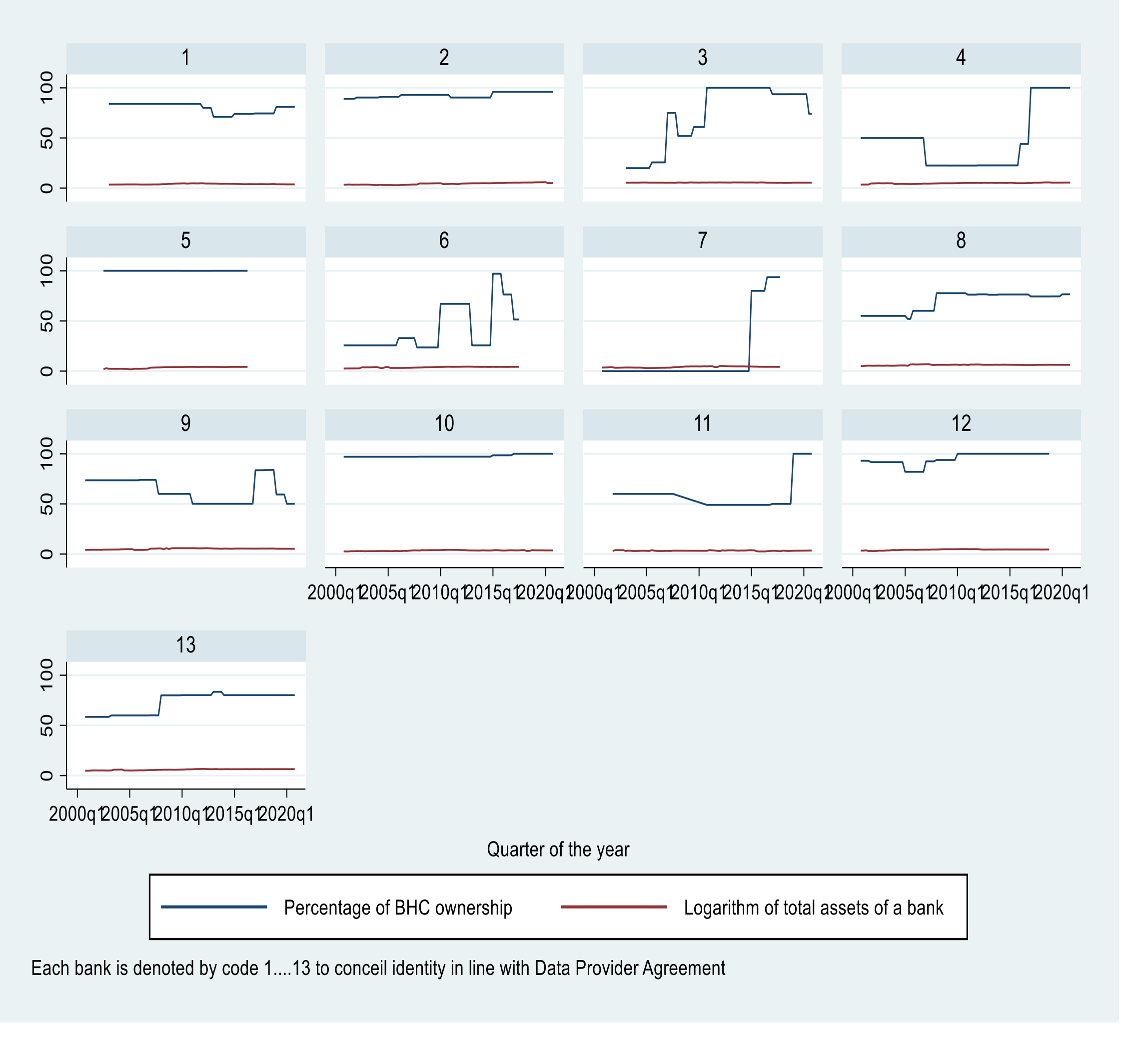


This transforms Equation 5.7 by incorporating the BHC-bank technology interaction term (BHCXtech). This transformation leads us to Equation 5.9 as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \beta_3 BHC_{it} + \beta_4 BHCXtech_{it} + \mu_{it} \qquad (5.9)$$

For our sample of Malawi's banks, firm size is an important difference among the banking institutions that are subsidiaries of BHC. Thus, our second interaction term involves BHC membership and firm size. This interaction term is important in so far as it enables us to test if BHC membership can account for the findings of the counterintuitive inverse effect of bank size on adoption of BBI, as seen in Chapter 4. Fig 5.5 is a diagrammatic representation of the interaction between BHC ownership and bank size. From the plot, we see that the BHC membership and bank size lines are near parallel in only 4 banks. In this sense, 9 out of the 13 banks exhibit interaction between the two variables with these variations relating differently across the banks.

Figure 5. 5 BHC ownership & bank size interaction term



In this regard, we transform Equation 5.7 by incorporating the BHC-bank size interaction term (BHCXSize). This transformation leads us to Equation 5.10 as follows:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \beta_2 Z_t + \beta_3 BHC_{it} + \beta_4 BHCXSize_{it} + \mu_{it} \qquad (5.10)$$

Building on the FE model, we extend the analysis to cover the panel ARDL models proposed by Pesaran et al. (1999), leveraging the discussion from the preceding chapter. As in the preceding section, the ARDL models form the framework for our analysis. In this regard, the Pesaran et al. (1999) dynamic heterogeneous panel regression can be expressed as follows:

$$\Delta BBI_{i,t} = \lambda_i\left[BBI_{i,t-1} - \left\{\beta_{i,0} + \beta_{i,1}X_{i,t-1}\right\}\right] + \sum_{j=1}^{p-1}\theta_{i,j}\,\Delta BBI_{i,t-j} + \sum_{j=0}^{p-1}\eta_{i,j}\,\Delta X_{i,t-j} + \epsilon_{i,t} \qquad (5.11)$$

where, BBI is dimension of branchless banking innovation (in logs) for bank *i* at quarter *t*. X is a vector of potential determinants of adoption of BBI (in logs) including BHC ownership as our key variable of interest. θ is the short run coefficient of the lagged dependent variable while η refers to short run coefficients of the other regressors. β represents the long-run coefficients. λ is the coefficient of speed of adjustment to the long-run equilibrium. The first term on the right-hand side of Equation 5.10 will capture any long-run relationship between foreign ownership and adoption of BBI. As the system is expected to return to the long-run equilibrium, we expect $\lambda<0$. Within the ARDL framework, we employ the Pool Mean Group (PMG) estimation for its efficiency gains under the assumption of long run homogeneity, as discussed in the preceding section.

5.4.2. Empirical Findings

FE Estimations

Summary findings from the FE Model estimation of the impact of BHC membership on bank adoption of physical BBI and remote BBI are presented in Table 5.13 and Table 5.14, respectively.

a) Physical BBI

Firstly, the results in Table 5.13 show that bank adoption of ATM banking innovation is a negative function of bank technology and a positive function of retail portfolio. These are the only control variables that are found to be statistically significant. Specifically, at 5 percent significance level, a one percent decrease in bank technology increases adoption of ATM banking innovation by 0.12 percent. At one percent significance level, a one percent increase in retail portfolio increases adoption of ATM banking innovation by 0.10 percent.

For our key variable of interest, the coefficient of BHC membership is insignificant. We note however that after interacting BHC membership with bank size, the coefficient of BHC membership becomes positive and statistically significant. At one percent significance level, a one percent increase in BHC membership leads to an increase in adoption of ATM banking innovation by 0.12 percent. However, the coefficient of the interaction term is -0.03, statistically significant at one percent. The results suggest that the positive impact of BHC membership on adoption of ATM banking innovation is stronger among small banks.

Also noteworthy is the positive and statistically significant coefficient of BHC membership when BHC membership is interacted with bank technology. Here, at 5 percent significance level, a one percent increase in BHC membership leads to a 0.12 percent increase in the adoption of ATM banking innovation. However, the interaction term in this case is not statistically significant, suggesting that there is no evidence of the impact of BHC membership on adoption of ATM banking innovation as being via BHC membership influence on bank technology.

Secondly, as shown in Table 5.13, bank adoption of agent banking innovation is a negative function of bank technology and market concentration, but a positive function of bank size, regulation, and macro technology. These are the only control variables that are found to be statistically significant. Specifically, at 10 percent significance level, a one percent decrease in bank technology increases adoption of agent banking innovation by 0.13 percent. At one percent significance level, a one percent decrease in market concentration increases adoption of agent banking innovation by 0.08 percent, *ceteris paribus*. Furthermore, at 10 percent significance level, a one percent increase in bank size increases adoption of agent banking innovation by 0.46 percent, *ceteris paribus*. At one percent significance level, a one percent increase in the index for regulation increases adoption of agent banking innovation by 0.70 percent, while a one percent increase in macro technology increases adoption of agent banking innovation by 0.15 percent, at 5 percent significance level.

For our key variable of interest, we note that the coefficient of BHC membership variable is negative and statistically insignificant. This coefficient remains statistically insignificant even after interacting BHC membership with bank size. However, the coefficient of the interaction term is negative and statistically significant at 10 percent significance level. This suggests that there is an indirect impact of BHC membership on adoption of agent banking innovation. This impact is via the BHC membership to small banks. However, when we interact BHC membership with bank technology, we observe that the coefficient of BHC membership becomes negative and statistically significant at 5 percent significance level. A one percent increase in BHC membership results in a 0.08 drop in adoption of agent banking innovation. We note also that the coefficient of the interaction term is positive and statistically significant, suggesting that the negative impact of BHC membership on adoption of agent banking innovation is prominent among the technological intensive banks.

In summary, the findings indicate that using the FE methods BHC membership impacts positively the adoption of ATM banking innovation. However, for adoption of agent banking innovation, the impact is indirect, via the proliferation of small banks. Also, we find evidence of negative impact of BHC membership, prominent among the technological intense banks.

Table 5. 13 FE results of BHC membership & adoption of physical BBI

	ATM Banking			Agent Banking		
BHC ownership *bank size	-	-0.03*** (0.01)	-	-	-0.01* (0.01)	-
BHC ownership * bank technology	-	-	0.00 (0.00)	-	-	0.01** (0.00)
BHC ownership	0.00 (0.01)	0.12*** (0.02)	0.05** (0.02)	-0.01 (0.01)	0.05 (0.03)	-0.08** (0.02)
Bank size	-0.16 (0.17)	1.61*** (0.45)	-0.19 (0.17)	0.46* (0.22)	1.01** (0.35)	0.47* (0.22)
Bank technology	-0.12** (0.05)	-0.12** (0.05)	0.09 (0.13)	-0.13* (0.06)	-0.12* (0.05)	-0.41*** (0.08)
Branch intensity	0.12 (0.07)	0.09 (0.07)	0.10 (0.07)	0.02 (0.09)	-0.01 (0.09)	0.05 (0.08)
Retail portfolio	0.10*** (0.02)	0.08*** (0.02)	0.10*** (0.02)	0.03 (0.03)	0.01 (0.03)	0.03 (0.03)
Bank funding	0.00 (0.02)	-0.04 (0.02)	-0.01 (0.02)	0.00 (0.03)	-0.02 (0.03)	0.01 (0.03)
Market concentration	0.01 (0.03)	0.00 (0.03)	0.01 (0.03)	-0.08*** (0.02)	-0.08*** (0.02)	-0.08*** (0.02)
Regulation	0.21 (0.21)	0.27 (0.20)	0.22 (0.22)	0.70*** (0.15)	0.73*** (0.15)	0.70*** (0.15)
Macro technology	0.04 (0.08)	0.05 (0.09)	0.05 (0.08)	0.15** (0.05)	0.16** (0.05)	0.14** (0.06)
Constant	14.80*** (2.98)	9.18** (3.22)	12.14*** (3.28)	18.89*** (1.82)	18.02*** (1.91)	22.10*** (2.05)
Observations	902	902	902	655	655	655
Groups	13	13	13	10	10	10

Driscoll-Kraay Standard errors in parentheses are heteroskedasticity- consistent and robust to general forms of cross-sectional and temporal dependence; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

b) Remote BBI

Firstly, the results in Table 5.14 show that bank adoption of internet banking innovation is a negative function of market concentration and a positive function of regulation. At one percent significance level, a one percent decrease in market concentration increases adoption of internet banking innovation by 0.09 percent, *ceteris paribus*. At one percent significance level, a one percent increase in the index of regulation increases adoption of internet banking innovation by 0.77 percent, *ceteris paribus*.

For our key variable of interest, the coefficient of BHC membership variable positive but statistically insignificant. However, after interacting BHC membership with bank size, the coefficient of BHC membership becomes negative and statistically significant. At one percent significance level, a one percent increase in BHC membership leads to a reduction in adoption of internet banking innovation by 0.12 percent, all other factors being equal. However, the coefficient of the interaction term is 0.03, statistically significant at one percent. This suggests that the negative impact of BHC membership on adoption of internet banking innovation is stronger among large banks.

When BHC membership is interacted with bank technology, the coefficient of BHC membership becomes statistically insignificant. Same is true for the interaction term. Thus, under FE estimation, we find no evidence that BHC membership impacts adoption of internet banking innovation through the bank technology channel. Secondly, as shown in Table 5.14, FE estimation reveals regulation as the only control variable with statistically significant impact of adoption of mobile phone banking innovation. At one percent significance level, a one percent increases in the index of regulation results in a 1.84 percent rise in adoption of mobile phone banking innovation, *ceteris paribus*.

For our key variable of interest, the coefficient of BHC membership is negative and statistically insignificant. The coefficient of BHC membership remains negative and statistically insignificant when we interact BHC membership with bank size. The coefficient of the interaction term is positive, but statistically insignificant. In this regard, the research finds no evidence of the impact of BHC membership on mobile phone banking innovation adoption, either directly or through BHC effect on the proliferation of small banks.

Regardless, when we interact BHC membership with bank technology, the coefficient of BHC membership becomes positive and statistically significant, whereas the coefficient of the interaction term becomes negative and statistically significant. The findings indicate that BHC membership has a positive impact on mobile phone banking adoption, with the impact being strongest among less technologically superior banks.

In conclusion, using FE methods, we find evidence pointing to a negative impact of BHC membership on internet banking innovation adoption, with the impact being most pronounced among large banks. However, there is no evidence to support the hypothesis that BHC membership influences adoption of internet banking innovation through the bank technology channel. The findings for mobile phone banking adoption do not support the hypothesis of the impact of BHC membership via the bank size channel. However, we find evidence that BHC membership has a positive impact on mobile phone banking adoption via the bank technology channel.

Table 5. 14 FE results of BHC membership & bank adoption of remote BBI

	Internet Banking			Mobile phone Banking		
BHC ownership *bank size	-	0.03*** (0.01)	-	-	0.01 (0.01)	-
BHC ownership * bank technology	-	-	0.00 (0.00)	-	-	-0.01*** (0.00)
BHC ownership	0.01 (0.01)	-0.12*** (0.02)	-0.02 (0.01)	-0.01 (0.01)	-0.05 (0.05)	0.076*** (0.02)
Bank size	0.03 (0.22)	-1.51*** (0.32)	0.06 (0.22)	-0.29 (0.53)	-0.90 (0.92)	-0.51 (0.50)
Bank technology	0.06 (0.06)	0.05 (0.05)	-0.06 (0.06)	0.06 (0.10)	0.07 (0.10)	0.49*** (0.12)
Branch intensity	-0.11 (0.06)	-0.05 (0.06)	-0.09 (0.06)	-0.16 (0.14)	-0.14 (0.14)	-0.21 (0.14)
Retail portfolio	0.02 (0.03)	0.05** (0.02)	0.02 (0.03)	0.04 (0.04)	0.05 (0.04)	0.04 (0.04)
Bank funding	-0.01 (0.02)	0.03 (0.02)	-0.01 (0.02)	-0.04 (0.03)	-0.04 (0.03)	-0.06 (0.03)
Market concentration	-0.09*** (0.02)	-0.09*** (0.02)	-0.09*** (0.02)	-0.05 (0.05)	-0.05 (0.05)	-0.04 (0.05)
Regulation	0.77*** (0.21)	0.71*** (0.18)	0.77*** (0.22)	1.84*** (0.37)	1.82*** (0.38)	1.83*** (0.37)
Macro technology	-0.07 (0.05)	-0.07 (0.06)	-0.07 (0.05)	0.02 (0.10)	0.02 (0.10)	0.04 (0.10)
Constant	18.69*** (2.78)	22.36*** (2.54)	20.07*** (3.04)	10.27 (6.04)	12.50 (7.32)	5.67 (5.94)
Observations	792	792	792	548	548	548
Groups	13	13	13	11	11	11

Driscoll-Kraay Standard errors in parentheses are heteroskedasticity- consistent and robust to general forms of cross-sectional and temporal dependence; * *$p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

PMG Estimations

Moving on to PMG estimates, we begin by examining the direct impact of BHC membership before moving on to the indirect impact.

a) Direct impacts

Table 5.15a shows the results from the PMG estimation of the direct impact of BHC membership on the adoption of different forms of BBI. The results of each form of BBI are presented under the respective column headings. The top part of the table displays the long-run coefficients while the bottom part presents the coefficients of the short run. In all the models estimated, the estimated error-correlation coefficients are negative and highly significant. The null hypothesis of no long run relationship is therefore rejected.

For the control variables, regulation is, as expected, positively related with bank adoption of ATM banking, agent banking and mobile phone banking innovations, in the long run. However, in the short run, we fail to find statistically significant evidence of the impact of regulation on bank adoption of BBI. Secondly, market concentration is positively associated with bank adoption of ATM banking innovation and negatively with bank adoption of internet banking innovation in the short run. In the long run, the impact of market concentration is negative and only for bank adoption of agent banking innovation. Thirdly, the impact of bank funding is as expected found to be negative and statistically significant for the adoption of mobile phone banking innovations in the long run. In the short run, a similar negative impact is found for bank adoption of internet banking innovation. Fourthly, there is statistically significant evidence of the negative impact of branch intensity on adoption of mobile phone banking innovation in the long run.

We also find a statistically significant short run impact of retail portfolio on adoption of mobile phone banking innovation as being negative. Bank technology impacts positively the adoption of agent banking innovation in the short run. However, in the long run the statistically significant impact of bank technology is negative for bank adoption of ATM and agent banking innovations. Further, we find the statistically significant evidence of a negative impact of bank size on adoption of ATM banking, agent banking and mobile banking innovations in the long run, and internet banking innovation, in the short run.

Lastly, for our main variable of interest, the study does not find evidence of the direct impact of BHC ownership on adoption of BBI, either in the short run or the long run, with the exception of mobile phone banking innovation. At the 1 percent significance level, a one percent increase in bank holding company shareholding leads to a 0.02 percent increase in bank adoption of mobile phone banking innovation in the long run. This remains statistically significant even after adjusting for FWER in Table 5.15b.

Table 5. 15a PMG results of direct impact of BHC membership & adoption of BBI

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
BHC ownership	0.00 (0.01)	-0.01 (0.01)	0.00 (0.00)	0.02*** (0.01)
Bank size	-0.33** (0.16)	-0.63 (0.40)	0.05 (0.16)	-1.11 (0.47)
Bank technology	-0.92** (0.04)	-0.20** (0.10)	-0.02 (0.03)	-0.01 (0.06)
Branch intensity	0.06 (0.05)	0.10 (0.11)	0.00 (0.03)	-0.54*** (0.07)
Retail portfolio	0.01 (0.01)	0.01 (0.04)	-0.02 (0.02)	0.03 (0.04)
Bank funding	0.00 (0.02)	-0.05 (0.03)	0.00 (0.01)	-0.06** (0.03)
Market concentration	-0.04 (0.04)	-0.22*** (0.07)	-0.01 (0.02)	-0.04 (0.05)
Regulation	0.44*** (0.15)	0.69** (0.35)	-0.06 (0.12)	0.81*** (0.26)
Macro technology	0.10 (0.08)	0.13 (0.15)	-0.13 (0.05)	-0.13 (0.09)

Table 5.15a PMG results of direct impact of BHC membership & adoption of BBI (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49*** (0.10)	-0.39*** (0.08)	-0.71*** (0.10)	-0.63*** (0.09)
Δ BHC ownership	-0.31 (0.35)	0.00 (0.01)	2.54 (2.65)	2.67 (2.90)
Δ Bank size	-0.18 (0.29)	0.63 (0.46)	-1.26* (0.71)	-2.34 (1.47)
Δ Bank technology	0.00 (0.04)	0.05** (0.02)	0.04 (0.04)	0.03 (0.12)
Δ Branch intensity	-0.13 (0.08)	-0.06 (0.09)	0.07 (0.10)	0.18 (0.11)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.02)	-0.09*** (0.05)
Δ Bank funding	0.00 (0.02)	-0.02 (0.02)	-0.06** (0.03)	0.02 (0.04)
Δ Market concentration	0.05*** (0.02)	0.03 (0.02)	-0.03* (0.02)	0.02 (0.04)
Δ Regulation	-0.39 (0.39)	-0.17 (0.18)	-0.07 (0.37)	0.03 (0.47)
Δ Macro technology	0.04 (0.06)	0.04 (0.11)	-0.12 (0.13)	0.12 (0.17)
Constant	6.99*** (1.13)	14.26*** (2.74)	13.73*** (1.35)	16.05*** (2.68)
Observations	888	645	778	537

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Table 5. 15b PMG results of direct impact after Holm-Bonferroni correction

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
BHC ownership	0.00 (0.01)	-0.01 (0.01)	0.00 (0.00)	0.02* (0.01)
Bank size	-0.33** (0.16)	-0.63 (0.40)	0.05 (0.16)	-1.11* (0.47)
Bank technology	-0.92** (0.04)	-0.20** (0.10)	-0.02 (0.03)	-0.01 (0.06)
Branch intensity	0.06 (0.05)	0.10 (0.11)	0.00 (0.03)	-0.54* (0.07)
Retail portfolio	0.01 (0.01)	0.01 (0.04)	-0.02 (0.02)	0.03 (0.04)
Bank funding	0.00 (0.02)	-0.05 (0.03)	0.00 (0.01)	-0.06* (0.03)
Market concentration	-0.04 (0.04)	-0.22* (0.07)	-0.01 (0.02)	-0.04 (0.05)
Regulation	0.44* (0.15)	0.69* (0.35)	-0.06 (0.12)	0.81* (0.26)
Macro technology	0.10 (0.08)	0.13 (0.15)	-0.13* (0.05)	-0.13 (0.09)

Table 5.15b PMG results of direct impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49* (0.10)	-0.39* (0.08)	-0.71* (0.10)	-0.63* (0.09)
Δ BHC ownership	-0.31 (0.35)	0.00 (0.01)	2.54 (2.65)	2.67 (2.90)
Δ Bank size	-0.18 (0.29)	0.63 (0.46)	-1.26 (0.71)	-2.34 (1.47)
Δ Bank technology	0.00 (0.04)	0.05 (0.02)	0.04 (0.04)	0.03 (0.12)
Δ Branch intensity	-0.13 (0.08)	-0.06 (0.09)	0.07 (0.10)	0.18 (0.11)
Δ Retail portfolio	-0.02 (0.03)	-0.04 (0.04)	0.01 (0.02)	-0.09 (0.05)
Δ Bank funding	0.00 (0.02)	-0.02 (0.02)	-0.06** (0.03)	0.02 (0.04)
Δ Market concentration	0.05* (0.02)	0.03 (0.02)	-0.03 (0.02)	0.02 (0.04)
Δ Regulation	-0.39 (0.39)	-0.17 (0.18)	-0.07 (0.37)	0.03 (0.47)
Δ Macro technology	0.04 (0.06)	0.04 (0.11)	-0.12 (0.13)	0.12 (0.17)
Constant	6.99* (1.13)	14.26* (2.74)	13.73* (1.35)	16.05* (2.68)
Observations	888	645	778	537

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

b). Indirect impacts

We next present the results of the impact of the two interaction terms in Table 5.16a.

Firstly, we note that after controlling for the interaction term between BHC membership and bank size, the direct long run impact of BHC membership becomes statistically significant for ATM banking innovation. At the 5 percent significance level, a one percent increase in BHC ownership leads to a 0.05 percent increase from the mean in bank adoption of ATM banking innovation. This remains statistically significant even after adjusting for FWER in Table 5.16b. However, the impact on mobile phone banking innovation is statistically insignificant. In the short run, the direct impact of BHC ownership remains statistically insignificant for all the forms of BBI.

Importantly, we find no evidence of a statistically significant impact between the interaction terms and the adoption of all forms of BBI in the short run. However, in the long run, there is a negative impact of this interaction term on bank adoption of ATM and agent banking innovations, -0.01 and -0.03 respectively, both statistically significant at the one percent significance level. This is robust even after adjusting for FWER in Table 5.16b. This is interpreted to mean that the positive impact of BHC shareholding on bank adoption of ATM and agent banking innovations is more prominent among small banks than large banks. These new findings about the role of BHC membership provide additional perspective, validating our earlier conclusion about the need to open further the financial sector to other forms of shareholding, as that leads to the proliferation of small banks that have been found to be rapid adopters of BBI, in the long run.

Secondly, when we control for the interaction between BHC membership and bank technology, we find no statistically significant evidence of direct impact of BHC membership on the adoption of any form of BBI, either in in the long run or the short run. However, we note mixed results regarding the indirect impact of BHC membership via bank technology. Specifically, the indirect impact of BHC membership is negative for ATM innovation in the short run. At the one percent significance level, a one percent increase in the interaction term leads to 0.01 percent decrease in adoption of ATM banking innovation in the short run. In the long run however, the indirect impact of BHC membership (via bank technology) is positive for agent banking innovation in the long run and negative for mobile banking innovation in the long run. At the one percent confidence level, a one percent increase in the interaction term leads to a 0.01 percent increase in the adoption of agent banking innovation, and a 0.01 percent drop in the adoption of mobile phone banking innovation.

The long run positive impact on the adoption of agent banking innovation attests to how other subsidiaries within the holding group, such as foreign exchange bureaux, micro finance institutions and retail chain stores, can provide a large network of entities that can serve as bank agents. In this regard, agent banking innovation stands to benefit in the long run from the technological synergies of being connected through shared intra conglomerate technological platforms, as noted in the literature (Hannan and McDowell, 1984, Hannan and McDowell, 1987; Sinha and Chandrashekaran, 1992; Furst et al., 2002; Courchane et al., 2002; Frame and White, 2004; Sullivan and Wang, 2020).

Nonetheless, the counterintuitive finding of a negative impact of BHC membership on the adoption of mobile banking innovation in the short run can be explained by the fact that only two BHCs in our sample have mobile telecommunications companies that run mobile money operator businesses as their subsidiary. In the long run, however, the direct relationship between BHC membership and the adoption of mobile phone banking innovation is positive. This suggests that despite the lack of technological benefits from a shared platform, the synergies for mobile banking innovation can arise from an increase in mobile phone payment transactions as the economic activities in the various subsidiaries of conglomerates become automated.

Table 5. 16a PMG results of the indirect impact of BHC membership on adoption of BBI

Long-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
BHC Ownership	0.05*** (0.02)	-0.02 (0.02)	0.14 (0.05)	-0.12** (0.03)	0.00 (0.01)	0.00 (0.01)	-0.08 (0.07)	0.13*** (0.03)
BHC ownership *bank size	-0.01*** (0.00)	-	-0.03*** (0.01)	-	0.00 (0.00)	-	0.02 (0.01)	-
BHC ownership *bank technology	-	0.00 (0.00)	-	0.01** (0.00)	-	0.00 (0.00)	-	-0.01*** (0.00)
Bank size	0.82** (0.39)	-0.30** (0.17)	1.49** (0.64)	-0.41 (0.39)	0.11 (0.20)	0.04 (0.16)	-1.23*** (1.16)	0.03 (0.47)
Bank Technology	-0.12*** (0.04)	-0.27* (0.14)	-0.22** (0.10)	-0.65*** (0.16)	-0.01 (0.03)	0.01 (0.05)	-0.64*** (0.06)	0.06* (0.19)
Branch Intensity	0.06 (0.04)	0.06 (0.05)	0.09 (0.11)	0.02 (0.11)	0.00 (0.03)	0.00 (0.03)	-0.55*** (0.08)	0.05 (0.08)
Retail Portfolio	0.02 (0.01)	0.01 (0.01)	0.03 (0.05)	0.03 (0.04)	-0.01 (0.02)	-0.02 (0.02)	0.04 (0.04)	-0.02 (0.04)
Bank Funding	-0.01 (0.02)	0.01 (0.02)	-0.01 (0.04)	0.01 (0.04)	0.00 (0.01)	0.00 (0.01)	-0.07** (0.03)	-0.07** (0.03)
Market concentration	-0.04 (0.04)	-0.04 (0.04)	-0.19*** (0.07)	-0.21*** (0.07)	-0.01 (0.02)	-0.02 (0.02)	-0.04 (0.05)	-0.04 (0.05)
Regulation	0.50*** (0.15)	0.41** (0.16)	1.01** (0.37)	0.70** (0.34)	-0.06 (0.12)	-0.05 (0.12)	0.80*** (0.26)	0.84*** (0.25)
Macro Technology	0.11 (0.07)	0.09 (0.08)	0.06 (0.16)	0.08 (0.15)	-0.13** (0.05)	-0.13* (0.05)	-0.15 (0.09)	-0.11 (0.09)

Table 5.16a PMG results of the indirect impact of BHC membership on adoption of BBI (cont'd)

Short-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Error-correction coefficient	-0.51*** (0.10)	-0.48*** (0.10)	-0.38** (0.08)	-0.40*** (0.08)	-0.70*** (0.09)	-0.71*** (0.10)	-0.62*** (0.09)	-0.64*** (0.08)
Δ BHC Ownership	-0.84 (0.86)	0.11 (0.14)	0.88 (0.66)	0.07 (0.07)	-7.10 (7.09)	2.50 (2.62)	51.95 (53.44)	1.74 (2.45)
Δ BHC ownership *bank size	0.02 (0.04)	-	-0.24 (0.19)	-	1.74 (1.74)	-	-12.12 (12.37)	-
Δ BHC ownership *bank Technology	-	-0.01** (0.01)	-	0.00 (0.00)	-	0.00 (0.01)	-	0.3 (0.02)
Δ Bank size	-1.46 (3.53)	-0.14 (0.29)	17.07* (10.20)	0.57 (0.43)	-17.47 (17.40)	-1.25** (0.69)	12.16 (12.34)	-1.85 (1.39)
Δ Bank technology	0.01 (0.04)	1.32* (0.72)	0.06** (0.03)	-0.32 (0.29)	0.03 (0.04)	0.11 (0.48)	0.02 (0.13)	-2.23 (1.47)
Δ Branch intensity	-0.13 (0.08)	-0.12 (0.07)	-0.09 (0.09)	-0.08 (0.09)	0.07 (0.11)	0.07 (0.10)	0.16 (0.12)	0.20** (0.12)
Δ Retail Portfolio	-0.02 (0.03)	-0.01 (0.03)	-0.04 (0.03)	-0.04 (0.03)	0.01 (0.02)	0.01 (0.02)	-0.10** (0.05)	-0.11** (0.05)
Δ Bank Funding	0.01 (0.02)	0.01 (0.02)	-0.03* (0.02)	-0.04** (0.01)	-0.06** (0.03)	-0.06** (0.3)	0.02 (0.05)	0.02 (0.04)
Δ Market concentration	0.06*** (0.02)	0.06*** (0.02)	0.02 (0.03)	0.03 (0.02)	-0.03** (0.02)	-0.03* (0.02)	0.03 (0.04)	0.02 (0.04)
Δ Regulation	-0.43 (0.38)	-0.48 (0.39)	-0.04 (0.15)	0.06 (0.13)	-0.03 (0.37)	-0.16 (0.38)	-0.06 (0.55)	-0.10 (0.54)
Δ Macro technology	0.05 (0.06)	0.07 (0.07)	0.04 (0.12)	0.09 (0.11)	-0.12 (0.12)	-0.14 (0.13)	0.14 (0.17)	0.09 (0.19)
Constant	5.16*** (0.81)	7.67*** (1.28)	7.75*** (1.79)	14.92*** (2.85)	13.18*** (1.21)	13.45*** (1.33)	21.03*** (2.99)	10.85*** (2.69)
Observations	888	888	645	645	778	778	537	537

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. * p < 0.10, ** p < 0.05, *** p < 0.01.*

Table 5. 16b PMG results of the indirect impact after Holm-Bonferroni correction

Long-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
BHC Ownership	0.05* (0.02)	-0.02 (0.02)	0.14* (0.05)	-0.12* (0.03)	0.00 (0.01)	0.00 (0.01)	-0.08 (0.07)	0.13* (0.03)
BHC ownership *bank size	-0.01* (0.00)	-	-0.03* (0.01)	-	0.00 (0.00)	-	0.02 (0.01)	-
BHC ownership *bank technology	-	0.00 (0.00)	-	0.01** (0.00)	-	0.00 (0.00)	-	-0.01*** (0.00)
Bank size	0.82 (0.39)	-0.30 (0.17)	1.49* (0.64)	-0.41 (0.39)	0.11 (0.20)	0.04 (0.16)	-1.23* (1.16)	0.03 (0.47)
Bank Technology	-0.12* (0.04)	-0.27 (0.14)	-0.22 (0.10)	-0.65* (0.16)	-0.01 (0.03)	0.01 (0.05)	-0.64 (0.06)	0.06* (0.19)
Branch Intensity	0.06 (0.04)	0.06 (0.05)	0.09 (0.11)	0.02 (0.11)	0.00 (0.03)	0.00 (0.03)	-0.55* (0.08)	0.05* (0.08)
Retail Portfolio	0.02 (0.01)	0.01 (0.01)	0.03 (0.05)	0.03 (0.04)	-0.01 (0.02)	-0.02 (0.02)	0.04 (0.04)	-0.02 (0.04)
Bank Funding	-0.01 (0.02)	0.01 (0.02)	-0.01 (0.04)	0.01 (0.04)	0.00 (0.01)	0.00 (0.01)	-0.07* (0.03)	-0.07* (0.03)
Market concentration	-0.04 (0.04)	-0.04 (0.04)	-0.19* (0.07)	-0.21* (0.07)	-0.01 (0.02)	-0.02 (0.02)	-0.04 (0.05)	-0.04 (0.05)
Regulation	0.50* (0.15)	0.41* (0.16)	1.01* (0.37)	0.70 (0.34)	-0.06 (0.12)	-0.05 (0.12)	0.80* (0.26)	0.84* (0.25)
Macro Technology	0.11 (0.07)	0.09 (0.08)	0.06 (0.16)	0.08 (0.15)	-0.13* (0.05)	-0.13* (0.05)	-0.15 (0.09)	-0.11 (0.09)

Table 5.16b PMG results of the indirect impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Error-correction coefficient	-0.51* (0.10)	-0.48* (0.10)	-0.38* (0.08)	-0.40* (0.08)	-0.70* (0.09)	-0.71* (0.10)	-0.62* (0.09)	-0.64* (0.08)
Δ BHC Ownership	-0.84 (0.86)	0.11 (0.14)	0.88 (0.66)	0.07 (0.07)	-7.10 (7.09)	2.50 (2.62)	51.95 (53.44)	1.74 (2.45)
Δ BHC ownership *bank size	0.02 (0.04)	-	-0.24 (0.19)	-	1.74 (1.74)	-	-12.12 (12.37)	-
Δ BHC ownership *bank Technology	-	-0.01 (0.01)	-	0.00 (0.00)	-	0.00 (0.01)	-	0.3 (0.02)
Δ Bank size	-1.46 (3.53)	-0.14 (0.29)	17.07* (10.20)	0.57 (0.43)	-17.47 (17.40)	-1.25** (0.69)	12.16 (12.34)	-1.85 (1.39)
Δ Bank technology	0.01 (0.04)	1.32 (0.72)	0.06 (0.03)	-0.32 (0.29)	0.03 (0.04)	0.11 (0.48)	0.02 (0.13)	-2.23 (1.47)
Δ Branch intensity	-0.13 (0.08)	-0.12 (0.07)	-0.09 (0.09)	-0.08 (0.09)	0.07 (0.11)	0.07 (0.10)	0.16 (0.12)	0.20 (0.12)
Δ Retail Portfolio	-0.02 (0.03)	-0.01 (0.03)	-0.04 (0.03)	-0.04 (0.03)	0.01 (0.02)	0.01 (0.02)	-0.10 (0.05)	-0.11 (0.05)
Δ Bank Funding	0.01 (0.02)	0.01 (0.02)	-0.03 (0.02)	-0.04* (0.01)	-0.06 (0.03)	-0.06 (0.3)	0.02 (0.05)	0.02 (0.04)
Δ Market concentration	0.06* (0.02)	0.06* (0.02)	0.02 (0.03)	0.03 (0.02)	-0.03 (0.02)	-0.03 (0.02)	0.03 (0.04)	0.02 (0.04)
Δ Regulation	-0.43 (0.38)	-0.48 (0.39)	-0.04 (0.15)	0.06 (0.13)	-0.03 (0.37)	-0.16 (0.38)	-0.06 (0.55)	-0.10 (0.54)
Δ Macro technology	0.05 (0.06)	0.07 (0.07)	0.04 (0.12)	0.09 (0.11)	-0.12 (0.12)	-0.14 (0.13)	0.14 (0.17)	0.09 (0.19)
Constant	5.16* (0.81)	7.67* (1.28)	7.75* (1.79)	14.92* (2.85)	13.18* (1.21)	13.45* (1.33)	21.03* (2.99)	10.85* (2.69)
Observations	888	888	645	645	778	778	537	537

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

5.4.3 Robustness Check

We test the hypotheses that adoption of BBI is a direct function of BHC membership. This is against the background of widespread evidence supporting the view that a bank that is a member of a BHC is more likely. Having presented the findings from the BHC-BBI benchmark model, the next step is to present the results of the robustness check models, where dummy variables have been applied to represent BHC ownership. Under this approach, a bank is accorded a dummy value of 1 if it is a member of a holding company; or zero otherwise. This is consistent with Furst et al., (2002); Courchane et al., (2002); Nickerson and Sullivan, (2003); De Young et al., (2007); Sullivan and Wang, (2020)

a) Direct impacts

Table 5.17a shows the results from the PMG estimation of the direct impact of BHC membership on the adoption of different forms of BBI. The results of each form of BBI are presented under the respective column headings. For all the models estimated, the respective error correction terms are negative, less than 2 in absolute terms and statistically significant at 1 percent. These attributes confirm the existence of cointegration between the variables.

For the control variables, the results corroborate the earlier findings of statistically significant positive impact of regulation on the adoption of ATM banking, agent banking and mobile phone banking, in the long run. However, in the short run, we fail to find statistically significant evidence of the impact of regulation on bank adoption of BBI. Also, as has been established in the benchmark model, the robustness check estimations establish a statistically significant negative impact of market concentration on adoption of agent banking innovation in the long run. Further, consistent with the benchmark models, the results show a statistically significant positive impact of market concentration on the adoption of ATM banking innovation; and negative for the adoption of internet banking innovation, in the short run. The impact of bank funding is as expected found to be negative and statistically significant for the adoption of mobile phone banking innovations in the long run. In the short run, a similar negative impact is found for bank adoption of agent banking innovation and internet banking innovation. The robustness check estimations also corroborate benchmark model estimation results on the long run impact of branch intensity on the adoption of mobile phone banking innovation as being negative and statistically significant. However, in the short run, the results fail to establish any evidence of statistically significant impact of branch intensity on all dimensions of BBI.

We also find a statistically significant short run impact of retail portfolio on adoption of mobile phone banking innovation as being negative. However, the impact in the long run is statistically insignificant for all dimensions of BBI. Bank technology impacts positively the adoption of agent banking innovation in the short run. However, in the long run the statistically significant impact of bank technology is negative for bank adoption of ATM and agent banking innovations. Further, we find the statistically significant evidence of a negative impact of bank size on adoption of ATM banking and agent banking innovations in the long run, and internet banking innovation, in the short run.

Lastly, for our main variable of interest, the robustness check estimations do not establish evidence of the direct impact of BHC ownership on adoption of BBI, either in the short run or the long run, with the exception of mobile phone banking innovation. At the 1 percent significance level, a one percent increase in BHC membership leads to a 0.02 percent increase in bank adoption of mobile phone banking innovation in the long run. This is consistent with findings from the benchmark model. The statistically significant impact is confirmed even after adjusting for FWER in Table 5.17b.

Table 5. 17a PMG results of direct impact of BHC membership & adoption of BBI

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
BHC ownership	1.78 (1.38)	0.30 (2.36)	-0.20 (0.39)	0.02*** (02.96)
Bank size	-0.33** (0.16)	-0.74* (0.39)	0.00 (0.15)	-1.11 (0.10)
Bank technology	-0.10** (0.04)	-0.20** (0.10)	-0.01 (0.03)	-0.01 (-0.23)
Branch intensity	0.04 (0.04)	0.05 (0.10)	-0.02 (0.03)	-0.54*** (0.03)
Retail portfolio	0.01 (0.01)	0.02 (0.04)	-0.01 (0.02)	0.03 (0.15)
Bank funding	0.00 (0.02)	-0.05 (0.03)	0.00 (0.01)	-0.06** (0.02)
Market concentration	-0.04 (0.03)	-0.20*** (0.07)	0.00 (0.02)	-0.04 (0.08
Regulation	0.45*** (0.15)	0.60* (0.35)	-0.07 (0.12)	0.81*** (0.13)
Macro technology	0.08 (0.07)	0.18 (0.15)	-0.10** (0.05)	-0.13 (-0.07)

Table 5.17a PMG results of direct impact of BHC membership & adoption of BBI (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49*** (0.10)	-0.39*** (0.07)	-0.73*** (0.10)	-0.63*** (0.11)
Δ BHC ownership	0.02 (0.02)	0.12 (0.12)	-0.06 (0.06)	2.67 (0.08)
Δ Bank size	-0.15 (0.27)	0.63 (0.45)	-1.06** (0.51)	-2.34 (0.38)
Δ Bank technology	0.00 (0.04)	0.05** (0.02)	0.03 (0.04)	0.03 (0.04)
Δ Branch intensity	-0.12 (0.08)	-0.06 (0.09)	0.07 (0.10)	0.18 (0.10)
Δ Retail portfolio	-0.01 (0.03)	-0.04 (0.04)	0.01 (0.02)	-0.09*** (0.02)
Δ Bank funding	0.00 (0.02)	-0.03* (0.02)	-0.05* (0.03)	0.02 (0.08)
Δ Market concentration	0.05*** (0.01)	0.03 (0.02)	-0.04* (0.02)	0.02 (0.04)
Δ Regulation	-0.39 (0.39)	-0.16 (0.18)	-0.06 (0.37)	0.03 (0.25)
Δ Macro technology	0.04 (0.06)	0.03 (0.11)	-0.13 (0.13)	0.12 (0.11)
Constant	6.55*** (1.04)	13.74*** (2.60)	13.66*** (1.29)	16.05*** (1.07)
Observations	888	645	778	537
Groups	13	10	13	13

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Table 5. 17b PMG results of direct impact after Holm-Bonferroni correction

Long-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
BHC ownership	1.78 (1.38)	0.30 (2.36)	-0.20 (0.39)	0.02* (0.02)
Bank size	-0.33 (0.16)	-0.74 (0.39)	0.00 (0.15)	-1.11 (1.23)
Bank technology	-0.10* (0.04)	-0.20 (0.10)	-0.01 (0.03)	-0.01 (0.23)
Branch intensity	0.04 (0.04)	0.05 (0.10)	-0.02 (0.03)	-0.54* (0.30)
Retail portfolio	0.01 (0.01)	0.02 (0.04)	-0.01 (0.02)	0.03 (0.75)
Bank funding	0.00 (0.02)	-0.05 (0.03)	0.00 (0.01)	-0.06* (0.07)
Market concentration	-0.04 (0.03)	-0.20* (0.07)	0.00 (0.02)	-0.04* (0.11)
Regulation	0.45* (0.15)	0.60 (0.35)	-0.07 (0.12)	0.81* (0.13)
Macro technology	0.08 (0.07)	0.18 (0.15)	-0.10 (0.05)	-0.13 (0.48)

Table 5.17b PMG results of direct impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients				
	Physical BBI		Remote BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile-Phone Banking
Error-correction coefficient	-0.49* (0.10)	-0.39* (0.07)	-0.73* (0.10)	-0.63* (0.07)
Δ BHC ownership	0.02 (0.02)	0.12 (0.12)	-0.06 (0.06)	2.67 (2.92)
Δ Bank size	-0.15 (0.27)	0.63 (0.45)	-1.06 (0.51)	-2.34 (0.16)
Δ Bank technology	0.00 (0.04)	0.05* (0.02)	0.03 (0.04)	0.03* (0.29)
Δ Branch intensity	-0.12 (0.08)	-0.06 (0.09)	0.07 (0.10)	0.18 (1.57)
Δ Retail portfolio	-0.01 (0.03)	-0.04 (0.04)	0.01 (0.02)	-0.09 (0.10)
Δ Bank funding	0.00 (0.02)	-0.03 (0.02)	-0.05 (0.03)	0.02 (0.38)
Δ Market concentration	0.05* (0.01)	0.03 (0.02)	-0.04 (0.02)	0.02* (0.59)
Δ Regulation	-0.39 (0.39)	-0.16 (0.18)	-0.06 (0.37)	0.03 (0.05)
Δ Macro technology	0.04 (0.06)	0.03 (0.11)	-0.13 (0.13)	0.12 (0.71)
Constant	6.55* (1.04)	13.74* (2.60)	13.66* (1.29)	16.05* (6.00)
Observations	888	645	778	537
Groups	13	10	13	13

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC.*

b) Indirect impacts

A robustness check investigation on whether BHC membership has an indirect impact on bank adoption of BBI, derives from the interaction between the BHC membership dummy with the bank size variable; and BHC membership dummy with the bank technology variable. The results are presented in Table 5.18a. The results of each form of BBI are presented under the respective column headings. This is with the exception of mobile phone banking innovation whose estimations were not possible as numerical derivatives were found to be approximately flat. For all the models estimated, the respective error correction terms are negative, less than 2 in absolute terms and statistically significant at 1 percent. These attributes confirm the existence of cointegration between the variables.

Firstly, we note that after controlling for the interaction term between BHC membership and bank size, the direct long run impact of BHC membership on adoption of ATM Banking innovation and agent banking innovation become positive. At the 5 percent significance level, a one percent increase in BHC ownership leads to a 8.02 percent increase from the mean in bank adoption of ATM banking innovation. Also, at one percent confidence level, a one percent increase in BHC membership results in an increase in the adoption of agent banking innovation by 15.97 percent. The statistically significant impact is confirmed even after adjusting for FWER in Table 5.18b. However, the impact on internet banking innovation is statistically insignificant. In the short run, the direct impact of BHC ownership remains statistically insignificant for all the forms of BBI estimated.

Importantly, regarding the interaction term between BHC membership and bank size, the results show no evidence of a statistically significant impact between the interaction terms and the adoption of all forms of BBI estimated, in the short run. However, in the long run, there is a negative impact of this interaction term on bank adoption of ATM and agent banking innovations, -1.71 and -3.65 respectively, both statistically significant at the one percent significance level. This is confirmed even after adjusting for FWER in Table 5.18b. This is interpreted to mean that the positive impact of BHC shareholding on bank adoption of ATM and agent banking innovations is more prominent among small banks than large banks. These robustness check results corroborate findings from the benchmark model.

Secondly, when we control for the interaction between BHC membership and bank technology, we find no statistically significant evidence of direct impact of BHC membership on the adoption of any form of BBI, either in in the short run. In the long run however, we see BHC membership impacting positively the adoption of ATM banking innovation and negatively the adoption of agent banking innovation. At one percent confidence level, a one percent increase in BHC membership results in an increase in the adoption of ATM banking innovation by 15.18 percent; and a decrease in the adoption of agent banking innovation by 14.04 percent. This is confirmed even after adjusting for FWER in Table 5.18b.

However, the indirect impact of BHC membership (via bank technology) is positive for agent banking innovation in the long run, consistent with findings from the benchmark model. the statistically significant impact is confirmed even after adjusting for FWER in Table 5.18b. However, the findings show no evidence on a statistically significant impact of BHC membership as being indirect via bank technology, in the short run.

Table 5. 18a PMG results of the indirect impact of BHC membership on adoption of BBI

Long-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
BHC Ownership	8.02*** (2.33)	15.18*** (15.64)	15.97*** (3.18)	-14.04** (5.84)	1.29 (1.22)	0.15 (1.14)	-	-
BHC ownership *bank size	-1.71*** (0.52)	-	-3.65*** (0.72)	-	-0.25 (0.27)	-	-	-
BHC ownership *bank technology	-	-61.39 (86.73)	-	1.07** (0.41)	-	-0.03 (0.08)	-	-
Bank size	1.34** (0.53)	-0.35** (0.16)	2.85*** (0.69)	-0.70* (0.39)	0.20 (0.25)	0.01 (0.15)	-	-
Branch Technology	-0.09** (0.04)	61.31 (86.74)	-0.20** (0.09)	-1.21*** (0.40)	0.01 (0.03)	0.02 (0.07)	-	-
Branch Intensity	0.06 (0.04)	0.05 (0.05)	0.08 (0.09)	0.05 (0.10)	-0.02 (0.03)	-0.02 (0.03)	-	-
Retail Portfolio	0.01 (0.01)	0.01 (0.01)	0.02 (0.04)	0.02 (0.04)	-0.02 (0.02)	-0.01 (0.02)	-	-
Bank Funding	0.00 (0.02)	0.00 (0.02)	-0.07** (0.03)	-0.05 (0.03)	0.00 (0.01)	0.00 (0.01)	-	-
Market concentration	-0.04 (0.03)	-0.05 (0.03)	-0.18*** (0.06)	-0.18** (0.07)	-0.00 (0.02)	-0.00 (0.02)	-	-
Regulation	0.46*** (0.15)	0.41** (0.15)	0.55** (0.33)	0.60* (0.34)	-0.10 (0.12)	-0.06 (0.12)	-	-
Macro Technology	0.10 (0.07)	0.08 (0.07)	0.16 (0.14)	0.15 (0.15)	-0.11** (0.05)	-0.10** (0.05)	-	-

Table 5.18a PMG results of the indirect impact of BHC membership on adoption of BBI (cont'd)

Short-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Error-correction coefficient	-0.50*** (0.10)	-0.46*** (0.11)	-0.42** (0.07)	-0.39*** (0.07)	-0.73*** (0.11)	-0.73*** (0.10)	-	-
Δ BHC Ownership	4.50 (4.50)	-0.67 (0.67)	-6.74 (6.74)	0.90 (0.90)	-3.21 (3.21)	-0.18 (0.18)	-	-
Δ BHC ownership *bank size	-1.02 (0.97)	-	1.49 (1.52)	-	0.56 (0.69)	-	-	-
Δ BHC ownership * bank Technology	-	0.05 (0.05)	-	-0.03 (0.05)	-	0.01 (0.03)	-	-
Δ Bank size	-0.07 (0.16)	-0.10 (0.27)	0.51 (0.33)	0.60 (0.45)	-0.97** (0.52)	-1.05** (0.52)	-	-
Δ Bank technology	0.00 (0.04)	-0.02 (0.03)	0.05** (0.02)	0.03 (0.04)	0.02 (0.04)	0.03 (0.03)	-	-
Δ Branch intensity	-0.13 (0.08)	-0.12 (0.08)	-0.08 (0.09)	-0.07 (-0.09)	0.06 (0.10)	0.07 (0.10)	-	-
Δ Retail Portfolio	-0.01 (0.03)	-0.01 (0.03)	-0.04 (0.04)	-0.05 (0.03)	0.01 (0.02)	0.01 (0.02)	-	-
Δ Bank Funding	0.01 (0.02)	0.00 (0.02)	-0.02 (0.01)	-0.02* (0.01)	-0.04** (0.03)	-0.05* (0.03)	-	-
Δ Market concentration	0.05*** (0.02)	0.05*** (0.01)	0.02 (0.02)	0.02 (0.02)	-0.04* (0.02)	-0.04* (0.02)	-	-
Δ Regulation	-0.47 (0.38)	-0.48 (0.38)	-0.01 (0.12)	-0.09 (0.14)	-0.01 (0.38)	-0.07 (0.37)	-	-
Δ Macro technology	0.03 (0.06)	0.07 (0.07)	0.03 (0.11)	0.02 (0.12)	-0.13 (0.13)	-0.13 (0.13)	-	-
Constant	3.41*** (0.61)	-6.93*** (1.64)	8.72*** (1.72)	18.81*** (3.47)	13.02*** (1.21)	13.36*** (1.26)	-	-
Observations	888	888	645	645	778	778	-	-
Groups	13	13	10	10	13	13	-	-

*Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. * p < 0.10, ** p < 0.05, *** p < 0.01. Estimation the indirect impact of BHC membership on adoption of mobile phone banking innovation not possible as numerical derivatives are approximate flat.*

Table 5. 18b PMG results of the indirect impact after Holm-Bonferroni correction

Long-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
BHC Ownership	8.02* (2.33)	15.18* (15.64)	15.97* (3.18)	-14.04* (5.84)	1.29 (1.22)	0.15 (1.14)	-	-
BHC ownership *bank size	-1.71* (0.52)	-	-3.65* (0.72)	-	-0.25 (0.27)	-	-	-
BHC ownership *bank technology	-	-61.39 (86.73)	-	1.07* (0.41)	-	-0.03 (0.08)	-	-
Bank size	1.34* (0.53)	-0.35* (0.16)	2.85* (0.69)	-0.70* (0.39)	0.20 (0.25)	0.01 (0.15)	-	-
Branch Technology	-0.09 (0.04)	61.31 (86.74)	-0.20 (0.09)	-1.21* (0.40)	0.01 (0.03)	0.02 (0.07)	-	-
Branch Intensity	0.06 (0.04)	0.05 (0.05)	0.08 (0.09)	0.05 (0.10)	-0.02 (0.03)	-0.02 (0.03)	-	-
Retail Portfolio	0.01 (0.01)	0.01 (0.01)	0.02 (0.04)	0.02 (0.04)	-0.02 (0.02)	-0.01 (0.02)	-	-
Bank Funding	0.00 (0.02)	0.00 (0.02)	-0.07 (0.03)	-0.05 (0.03)	0.00 (0.01)	0.00 (0.01)	-	-
Market concentration	-0.04 (0.03)	-0.05 (0.03)	-0.18* (0.06)	-0.18* (0.07)	-0.00 (0.02)	-0.00 (0.02)	-	-
Regulation	0.46* (0.15)	0.41* (0.15)	0.55 (0.33)	0.60* (0.34)	-0.10 (0.12)	-0.06 (0.12)	-	-
Macro Technology	0.10 (0.07)	0.08 (0.07)	0.16 (0.14)	0.15 (0.15)	-0.11* (0.05)	-0.10 (0.05)	-	-

Table 5. 18b PMG results of the indirect impact after Holm-Bonferroni correction (cont'd)

Short-run coefficients								
	Physical BBI				Remote BBI			
	ATM Banking		Agent Banking		Internet Banking		Mobile-Phone Banking	
Error-correction coefficient	-0.50* (0.10)	-0.46* (0.11)	-0.42* (0.07)	-0.39* (0.07)	-0.73* (0.11)	-0.73* (0.10)	-	-
Δ BHC Ownership	4.50 (4.50)	-0.67 (0.67)	-6.74 (6.74)	0.90 (0.90)	-3.21 (3.21)	-0.18 (0.18)	-	-
Δ BHC ownership *bank size	-1.02 (0.97)	-	1.49 (1.52)	-	0.56 (0.69)	-	-	-
Δ BHC ownership * bank Technology	-	0.05 (0.05)	-	-0.03 (0.05)	-	0.01 (0.03)	-	-
Δ Bank size	-0.07 (0.16)	-0.10 (0.27)	0.51 (0.33)	0.60 (0.45)	-0.97 (0.52)	-1.05 (0.52)	-	-
Δ Bank technology	0.00 (0.04)	-0.02 (0.03)	0.05* (0.02)	0.03 (0.04)	0.02 (0.04)	0.03 (0.03)	-	-
Δ Branch intensity	-0.13 (0.08)	-0.12 (0.08)	-0.08 (0.09)	-0.07 (-0.09)	0.06 (0.10)	0.07 (0.10)	-	-
Δ Retail Portfolio	-0.01 (0.03)	-0.01 (0.03)	-0.04 (0.04)	-0.05 (0.03)	0.01 (0.02)	0.01 (0.02)	-	-
Δ Bank Funding	0.01 (0.02)	0.00 (0.02)	-0.02 (0.01)	-0.02 (0.01)	-0.04 (0.03)	-0.05 (0.03)	-	-
Δ Market concentration	0.05* (0.02)	0.05 (0.01)	0.02 (0.02)	0.02 (0.02)	-0.04 (0.02)	-0.04 (0.02)	-	-
Δ Regulation	-0.47 (0.38)	-0.48 (0.38)	-0.01 (0.12)	-0.09 (0.14)	-0.01 (0.38)	-0.07 (0.37)	-	-
Δ Macro technology	0.03 (0.06)	0.07 (0.07)	0.03 (0.11)	0.02 (0.12)	-0.13 (0.13)	-0.13 (0.13)	-	-
Constant	3.41* (0.61)	-6.93* (1.64)	8.72* (1.72)	18.81* (3.47)	13.02* (1.21)	13.36* (1.26)	-	-
Observations	888	888	645	645	778	778	-	-
Groups	13	13	10	10	13	13	-	-

*To control for FWER, the p-values have been adjusted using the Holm-Bonferroni method with alpha =0.05. * Denotes statistical significance. Robust standard errors in parentheses. The lag structure is p=1 and q=1 based on AIC. Estimation the indirect impact of BHC membership on adoption of mobile phone banking innovation not possible as numerical derivatives are approximate flat*

.

5.4.1. Summary

In summary, the study establishes that the direct impact of BHC membership is positive, but only for the adoption of mobile phone banking innovation, in the long run. Also noteworthy is the negative impact of BHC membership on the adoption of ATM and agent banking innovations, as being indirectly through bank size. However, mixed results are found with regard to the effect of the interaction between BHC ownership and bank technology on the adoption of BBI. While this impact is negative for the adoption of ATM banking innovation in the short run, for the long run we note the impact to be positive on the adoption of agent banking innovation and negative for the adoption of mobile phone banking innovation.

In the final analysis, the following key insights can be drawn from the results. Firstly, for ATM the long run negative impact of BHC membership is positive; and for the adoption of agent banking innovations is negative, and indirectly through bank size. These corroborate our earlier findings that large banks are slow adopters of those forms of BBI. As alluded to, the large banks tend to target large corporations, whom they perceive as less risky over retail consumers. In this regard, BHC establishments therefore provide large banks with a vital network from which to tap corporate business from the subsidiaries within the conglomerate, at the expense of implementing strategies like BBI that would appeal to retail consumers. Secondly and more crucially, the contribution of BHC ownership to BBI-led financial inclusion can be seen in the context that BHC have, paradoxically, introduced into the Malawi financial sector, numerous small banks whose rapid adoption of BBI has enabled the retail customer segment often neglected by the large banks to be reached. This has thus helped address market distortions arising from the market dominance of the two largest banks in Malawi. BHC membership can have important implications on adoption of BBI in the long run, especially as financial transactions undertaken by the member subsidiaries within the group become more digitised.

5.5 Conclusion

This chapter has examined a unique dataset from Malawi's banking sector in order to answer the study's third research question, namely: Does the form of bank ownership matter for the adoption of BBI? The chapter identifies three types of bank ownership: government state ownership, foreign ownership and BHC ownership. An important contribution of the findings to knowledge lies in the development of new hypotheses which suggest a difference in the short and long-run impacts. The following are the main findings from this study.

Firstly, government ownership impacts positively the adoption of ATM banking innovation, in both the short run and the long run. The positive impact of government ownership on the adoption of ATM banking innovation is prominent for those banks with a narrow network of branches. However, while the impact of government ownership on the adoption of internet banking innovation is negative under FE estimation, for PMG estimation the impact is positive in the short run.

Secondly, the study fails to find any evidence of foreign ownership impacting on bank adoption of BBI in the short run. However, in the long run, we find evidence of a direct impact of foreign entry as being negative for the adoption of mobile phone banking innovation. As mobile banking innovation is a strategy mostly suited for retail consumers (including those in rural areas) as opposed to corporate clientele, we interpret this finding as mirroring skim creaming tendencies among foreign banks, who avoid low-end retail consumers whom they deem to be risky and costly to service in the absence of hard data about them.

Further, there is a long run positive impact of foreign ownership on the adoption of ATM banking innovation. However, this positive impact is prominent primarily among small banks. This suggests that as small banks are rapid adopters of BBI, foreign ownership positively impacts their adoption of BBI only to the extent that most small banks are foreign owned. The study fails to find evidence of an indirect impact of foreign entry on adoption of BBI, through bank technology. This suggests that being a foreign bank does not provide any distinct advantage to a bank in terms of skills/technological transfer relating to adoption of BBI. In this regard, we conclude that foreign entry's beneficial effect on financial inclusion can be routed through its effect on the proliferation of small banks that adopt ATM banking innovation more rapidly to serve retail consumers, often underserved by the large banks who have higher affinity towards large corporates.

Thirdly, the study establishes that the direct impact of BHC ownership is positive only for the adoption of mobile phone banking innovation, and only in the long run. Also noteworthy is the negative impact of BHC membership on the adoption of ATM and agent banking innovations, as being indirectly through bank size. However, mixed results are found with regard to the effect of the interaction between BHC ownership and bank technology on the adoption of BBI. While this impact is negative for the adoption of ATM banking innovation in the short run, in the long run we note the impact to be positive on the adoption of agent banking innovation and negative for the adoption of mobile phone banking innovation.

A general conclusion from this enquiry therefore is that government ownership in banks leads to the rapid adoption of only some forms of BBI, with the impact on the other forms being negative or not statistically significant. In this regard, government direct participation in the financial sector through ownership in financial institutions may not be a most effective strategy through which governments can pursue the financial inclusion agenda as a social welfare maximisation objective. Furthermore, we note the bias among state owned banks to purse financial inclusion through the branch strategy, which literature has shown to be costly (Berger et al., 2001; Mas 2009; Stapleton, 2013; Buckley et al., 2015; Gosavi, 2015). In light of this and taking into account the agency and political views on state ownership in enterprises, we conclude that the central bank's implementation of capital adequacy and risk management regulations, without forbearance towards state owned financial institutions, is critical to insulate government banks from the agency and political related risks.

We further conclude from the results that foreign entry’s beneficial effect on financial inclusion can be routed through its effect on the proliferation of small banks that adopt ATM banking innovation more rapidly. This, plus the findings about the role of BHC membership, provide additional perspective validating our earlier conclusion about the need to open further the financial sector to other forms of shareholding, as that leads to the proliferation of small banks that have been found to be rapid adopters of BBI, in the long run. This has the potential to address market distortions arising from the market dominance by the two largest banks in Malawi. Also noteworthy is the important long run implication of BHC membership on adoption of BBI, especially as more financial transactions undertaken by the member subsidiaries within the group are digitised.

Chapter 6: Conclusion & Policy Recommendations

6.1 Introduction

This chapter summarises the current research by highlighting the motivation of the research, gaps in the literature, research methods used and major findings. An important aspect of the chapter relates to the policy implications that can be drawn from the research findings, the contribution of the research to knowledge and scope for future research.

6.2 Research Background

The aim of this research was to investigate the drivers of bank adoption of BBI in the developing country context of Malawi. In this regard, the study set out to meet the following specific objectives:

a) to investigate the dimensions of BBI in the nascent banking system of Malawi;
b) to investigate what drives bank adoption of BBI in Malawi;
c) to test if the drivers of adoption vary between physical and remote forms of BBI; and
d) to establish whether there are specific forms of bank ownership that are conducive for rapid adoption of BBI.

The research was conducted against the background of the significance of an inclusive financial system in economic development, poverty alleviation, and reduction of income inequality (Beck et al., 2005; Beck et al., 2007; Sarma and Pais, 2011; Bruhn and Love, 2014). It noted however, that most SSA countries' financial systems, including Malawi's, are still underdeveloped, and the brick-and-mortar bank branch model remains the primary method of delivering financial services (Mlachila and Yabara 2013; Beck et al., 2015; Chikalipah, 2017; Makina, 2017).

Given the high cost of establishing bank branches and the fact that financial transactions among the rural poor are infrequent and small, formal financial institutions have tended to limit bank branches to urban and semi-urban areas (Allen et al., 2014). This has led many of the rural poor to be underserved by or excluded totally from the formal banking system. The few that access formal financial services must travel long distances to reach a distant bank branch (World Bank, 2014; Chikalipah, 2017). The cost of accessing formal financial services is determined not only by travel expenses to and from distant bank branches, but also by the opportunity cost of time travelling to a bank branch that could have been spent on productive activities such as farming. In light of this, BBI has been identified in the literature as a potential option for overcoming the distance and cost obstacles to financial inclusion (World Bank, 2014). Understanding what drives BBI adoption is therefore important for policymakers seeking to strengthen inclusive financial systems, which is a significant challenge for most African countries.

However, there have been gaps in the extant empirical literature. Firstly, the dominant focus of the existing literature on BBI has been on the demand side (Brown and Molla, 2005; Gerrard et al., 2006; Clemes et al., 2012). There is relatively limited empirical literature on the providers' side. Understanding the consumer side of BBI is important, but it is not sufficient, given that the financial institutions that deliver BBI are not only diverse but they also have their own set of dynamics that would have implications on the propensity to deliver BBI strategies. Thus, little is yet to be known about the key characteristics of financial institutions that matter for adoption of BBI. Secondly, due to data accessibility challenges in developing countries, much of the existing empirical literature on the financial services providers' side of BBI has focused on developed and emerging economies, with conflicting evidence and inconclusive results (see, Gourlay and Pentecost, 2002, Corrocher, 2006; Malhotra and Singh, 2010). As a result, their conclusions are difficult to generalise to developing nations, where the state of financial inclusion, the depth of financial systems, and the level of technological development differ dramatically from those in industrialised countries.

Thirdly, as has been discussed in Chapter 1, the interest in BBI research resides in the potential of BBI to improve access and usage of formal finance among different categories of people in different economic contexts. However, while different studies have explored drivers of adoption of different forms of BBI, to the best of our knowledge, there has been no attempt to explore the drivers of BBI in ways that classify BBI based on how the BBI features make them suited for a particular group of consumers or particular social economic setting. Such deeper insights are critical in informing strategy and policy that seek to incentivise a particular form of BBI that is relevant to a particular category of consumers in a particular socio-economic set up.

The current study has contributed to closing the above cited gaps by examining the factors that influence adoption of BBI among banks in Malawi. The study has distinguished between physical and remote BBI, as they relate to different consumer segments. In this context, physical BBI such as ATM and agent banking innovations are the primary forms of BBI for consumers where bank branding and physical interaction are important. This is critical given the low consumer trust in e-commerce and the lack of access to crucial infrastructure for processing e-commerce among many consumers in most developing countries (Nitsure, 2003; Allen et al., 2014). Physical BBI is also important given the cash-based nature of most developing countries' agrarian economic systems, where payments entail depositing cash at one end and withdrawing the cash at the receiving end (FinMark Trust, 2012; Buckley et al., 2015). Remote BBI on the other hand are the opposite of physical BBI as they enable access to financial services from the comfort of one's home, school or place of work, without needing to travel to be in physical contact with a bank ATM or a bank agent, as is the case with physical BBI. In this regard, the ubiquity of the mobile telephone and the internet are helping transition economies towards cashless strategies, therefore making space for remote BBI (Kimenyi and Ndung'u, 2009; Suri and Jack, 2016; Edo et al., 2019; Asongu and Nwachukwu, 2019).

Testing whether the drivers differ with the different forms of BBI is therefore important in informing how financial service providers can leverage their unique characteristics to deploy the different categories of BBI depending on the type of consumers being targeted and consumer needs being served. To the best of our knowledge, no study has been conducted to analyse BBI drivers based on this distinction, arguably due to a lack of publicly available high-quality data. We have been able to conduct such detailed analysis because we have had access to a unique dataset for all banks operating in Malawi from 2001 to 2020. Malawi is an important case study because it shares characteristics with the majority of Sub-Saharan African countries, such as low economic development, significant inequality, high poverty rates, a highly concentrated banking sector, a predominantly cash economy (especially in rural areas away from most brick-and-mortar bank branches) and growing mobile phone usage.

For this study, the PMG Estimator technique within the ARDL models proposed by Pesaran et al. (1999) was adopted. While acknowledging that the relationship between variables is not always instantaneous in economics and finance literature, adopting dynamic models was also a crucial step in resolving some of the shortfalls of static models; rendering them more suited to the analysis of our dataset and empirical context. Firstly, the ARDL models are asymptotically efficient and comparatively more robust in small or finite samples (Pattichis, 1999; Sakyi, 2011). Secondly, they can be used regardless of whether the regressors are I(0), I(1) or mutually integrated (Sakyi, 2011). Thirdly, they help overcome the problems caused by autocorrelation and endogeneity (Pesaran et al., 2001; Sakyi, 2011). Fourthly, the ARDL models estimate both short and long run relationships at the same time.

6.3 Hypotheses Tested and Findings

The study tested several hypotheses, drawing on the literature discussed in Chapter 2. In summary the following are the hypotheses tested and the findings that emerge from the analyses:

H1 Bank adoption of BBI is a positive function of bank level technology from the superior technology narrative (Malhotra and Singh, 2010; Wang et al., 2010; Ammar and Ahmed, 2016; Muthinja and Chipeta, 2018).

Contrary to the hypothesis, the findings show that bank technology has a negative long-term impact on ATM and agent based BBI adoption. However, bank technology has no bearing on remote BBI. In the literature, it has been discovered that innovations are more compatible and easily integrated with superior technologies, implying a positive relationship between bank technology and innovation (Furst et al., 2002; Frame and White, 2004; Brown and Molla, 2005; Malhotra and Singh, 2010). However, it has been suggested that bank technology has generally been set for low volume/high value business transactions, rather than the large volume/low value retail transactions that the BBI focuses on (Dermish et al., 2012). Our findings therefore highlight a new perspective on innovations not being homogeneous, particularly in terms of their technological requirements. In this regard, the findings suggest that some forms of physical BBI do not necessitate sophisticated technologies beyond what is typically found in banking institutions. This should not be surprising given the fundamental nature of payment transactions conducted through agent banking platforms. In this regard, a general conclusion from this evidence is that banks with a less superior technology are better positioned to implement physical BBI. However, the results do not provide statistical evidence that can help us shed light on what technologies present in a bank can spur remote BBI.

H2 Large banks are rapid adopters of BBI on the basis of the risk management and economies of scale argument (Brown, 1981, Hannan and McDowell, 1984, Frame and White, 2004).

From the current research, we note a general inverse relationship between bank size and adoption of physical BBIs in the long run; and the adoption of remote BBIs in the short run. These findings contradict our hypothesis and the widely documented predictions of previous academic research that argue for a positive relationship between firm size and innovation adoption (Brown, 1981; Hannan and McDowell, 1984; Frame and White, 2004). Our findings of a negative impact of bank size on BBI adoption, however counterintuitive, are not uncommon in the literature. According to the literature, small banks are less bureaucratic and, as a result, can make faster decisions on implementing innovations than larger banks, which tend to have fragmented and incompatible systems. (Escuer et al., 1991; Hunter and Timme, 1991; Segers, 1993; Nooteboom, 1994; Zhu et al., 2006; Sullivan and Wang, 2020). They use this competitive advantage to adopt the type of BBI that allows them to tap into retail consumer niches that are frequently underserved by large banks that prefer to serve corporate clients.

H3 A positive relationship between bank retail portfolio and adoption of BBI on account of the demand-pull factor (Barras, 1990; Saloner and Shepard, 1995; Malhotra and Singh, 2010).

Our research yields conflicting results regarding the impact of retail portfolio on different forms of BBI. In the case of physical BBI, we find that the impact of retail portfolio on adoption of both ATM and agent banking innovations is negative in the short run, but positive in the long run. In the case of remote BBI, we find that retail portfolio has a positive impact on the adoption of internet banking innovation in the short run but negative in the long run. All of the above findings, however, are statistically insignificant.

As regards mobile phone banking innovation, we find evidence of a statistically significant negative impact of retail portfolio in the short run. However, in the long run we note that retail portfolio has no impact.

H4 The literature around innovativeness of management in spurring innovation formed the basis of our hypothesis of a negative relationship between bank funding and adoption of BBI (Sinha and Chandrashekaran, 1992; Furst et al., 2002).

From the results, we note a general decline in adoption of both physical and remote BBI as bank funding increases; implying that management innovativeness is important in spurring innovation consistent with H4. However, the results fail to show evidence of any impact of management innovativeness on the adoption of ATM banking innovation. This is not confounding considering that as one of the earliest forms of BBI, ATM banking innovation has now become a fundamental requirement to banking service delivery, with all banks in Malawi incorporating it in their retail banking strategy.

H5 The relationship between branch intensity and adoption of BBI is inverse, against the background that BBI provides low-cost delivery alternative to the costly branch model (Furst et al., 2002; Frame and White, 2004; Malhotra and Singh, 2010).

From the findings, we see that physical BBI is positively related to branch intensity. Considering that most ATMs are located in bank branches, the findings show the presence of network effects, in which the value of an innovation increases according to the number of outlets where it can be accessed (Saloner and Shepard, 1995). On the other hand, the long run impact of branch intensity on remote BBI is negative, consistent with Corrocher (2006) and Malhotra and Singh (2010). This implies that remote BBI can serve as a substitute for physical branches for banks with a limited branch network (Furst et al., 2002).

H6 Non-prudential regulation of BBI has positive impact on adoption of BBI drawing on the literature that regulation provides financial institutions with a framework to help them manage BBI related risks (Barth et al., 2008; Calomiris, 2009; Ahmed and Ammar, 2016; Triki et al., 2017).

The study finds that adoption of both physical and remote BBIs is a positive function of regulation, supporting H7. This corroborates earlier literature attesting to the beneficial effect of regulation in reducing the risks of financial innovation, both to consumers and providers alike (Boyd et al., 1998; Barth et al., 2008; Lumpkin, 2010; Lee and Chih, 2013).

H7 The *a priori* expectation on the impact of market concentration is ambiguous. On the one hand, large market share has been argued to justify investment in costly technology necessary to support BBI (Hughes and Lonie, 2007; Mas and Ng'weno, 2010; Argent et al, 2013). On the other hand, lack of competition may stifle incentive to innovate to remain in business (Hannan and McDowell, 1984; Hannan and McDowell, 1987; Frame and White, 2004; Önder and Özyıldırım, 2019).

The results show that market concentration has a heterogeneous impact among the dependent variables and between the long and short run. For instance, in the long run it is generally negative but only statistically significant for adoption of agent banking innovation. In the short run, it is negative and statistically significant for the adoption of agent and internet banking innovations. Further, it is positive and statistically significant for the adoption of ATM banking innovation and positive and statistically insignificant for the adoption of mobile phone banking innovation. The positive short run impact on the adoption of ATM banking innovation is consistent with the earlier literature on the role of market share in enabling firms to exploit the gains from the investment in innovation (Raider, 1998; Botello-Peñaloza and Guerrero-Rincón, 2019). However, the findings of a generally inverse impact of market concentration on the other forms of BBI add to the evidence on how anti-competitive market practices can distort efficiency, including by stifling innovation that resides in competition (Hannan and McDowell, 1984; Hannan and McDowell, 1987; Frame and White, 2004; Önder and Özyıldırım, 2019).

As regards bank ownership, the study tested the hypotheses that:

H8 Government ownership impacts positively the adoption of BBI in line with the social welfare maximisation view (Brownbridge and Harvey, 1998; Peachy and Roe, 2006; Demirgüç-Kunt et al., 2008; Atkinson and Stiglitz, 2015; Neuberger, 2015).

The findings show that government ownership of banks leads to rapid adoption of only ATM banking innovation, both in the short and long run. However, this impact is more pronounced when government banks have a limited network of branches. As a result, the study's conclusion is that state-owned banks' predisposition to adopt a branch intensity strategy in order to expand outreach reduces the incentive to install off-site ATMs. With government banks' capital constraints, an overreliance on the costly branch model entails a lack of funding for investment in other forms of BBI. This may explain why the study found no evidence of a positive impact of government ownership on the adoption of other types of BBI.

H9 Bank adoption of BBI was a positive function of foreign entry, BHC membership against the background of know-how, technological, strategic and business synergies resident in group operations in various jurisdictions and sectors (Courchane et al., 2002; Furst et al., 2002; Frame and White, 2004; Cull and Soledad Martinez Peria, 2010; Sullivan and Wang, 2020).

The analysis reveals that there is no evidence of a short-term impact of foreign ownership on bank adoption of BBI. However, we find evidence of a direct impact of foreign entry as being negative for the adoption of mobile phone banking innovation in the long run. Mobile phone ubiquity has resulted in mobile banking increasingly becoming an effective form of BBI suited for retail consumers (including those in rural areas) as opposed to corporate clients.

According to estimates, a mobile phone signal reaches approximately 90 percent of Malawi's population, and mobile penetration is around 33 percent, 45 percent of whom reside in rural areas. Because mobile penetration rates are far greater than the percentage of the population with access to formal financial services, mobile phone banking innovation provides an important strategy for financial institutions to reach out to the overwhelming majority of the population who are not served by traditional financial institutions (Buckley et al., 2015). Against this background, drawing from the foreign bank ownership literature, we interpret the negative impact of foreign ownership on mobile phone banking adoption as reflecting foreign banks' skim creaming tendencies (Sengupta, 2007, Gormley, 2010; and Giannetti and Ongena, 2012). This is where financial service providers prefer to deliver financial services for the large corporate clients, at the expense of the low-end retail consumers.

However, we find a long-term positive impact of foreign ownership on ATM banking adoption. This impact is more pronounced among small foreign banks. Nonetheless, considering that ATM is one of the earliest forms of BBI, we note that its adoption has been widely adopted by all banks in Malawi, regardless of whether they are foreign or locally owned. In this sense, we conclude that foreign entry's positive impact on financial inclusion may be traced back to its impact on the growth of small banks, which are more likely to use ATM banking innovation.

Also noteworthy is the research finding that the direct impact of BHC ownership is positive but only for the adoption of mobile phone banking innovation, in the long run. However, the indirect impact of BHC membership on adoption of ATM and agent banking innovations via bank size is negative.

In the final analysis, the major conclusions drawn from this research are that the main drivers of adoption of BBI are bank size and non-prudential regulation of BBI. While the impact of these drivers is consistent across both physical and remote BBI, other drivers such as bank technology, retail portfolio, bank funding and market concentration have varying effects on different forms of BBI. Lastly, foreign entry and BHC membership impact adoption of BBI primarily through their effect on increasing the number of small banks that are rapid adopters of BBI, while government ownership in financial institutions positively impacts the adoption of only some forms of BBI.

6.4 Policy Recommendations

Having discussed the key findings from the research, a crucial step in this chapter relates to weighing the implications of the findings on bank strategy and financial inclusion policy. The policy insights that emerge from this study may be relevant not only to Malawi, but also to the majority of developing countries in SSA (and beyond) that share Malawi's characteristics.

Firstly, the importance of non-prudential regulation of BBI is indisputable, given that its positive impact is consistent across both physical and remote BBI, consistent with H6. This is particularly important for the adoption of mobile phone banking innovation, where the positive impact is statistically significant even after adjusting for FWER. Mobile phone banking innovation is increasingly becoming a delivery strategy for rural retail consumers, resulting in a significant increase in the overall share of adults in SSA who have formal financial accounts (World Bank, 2014; Ondiege, 2015; Burns, 2018). Regulation setting the minimum standards to guide financial institutions in managing risks inherent in BBI strategies (particularly mobile banking innovation) must be a vital part of the regulatory authorities' armoury. As has been alluded to, non-prudential regulation of BBI in Malawi has often been a strategic adoption of the regulatory frameworks implemented in other jurisdictions where BBI have been adopted much earlier. Given the dynamic nature of innovation and risk, bolstering the relevance of the non-prudential regulation of BBI in helping institutions to manage innovation related risks therefore requires an understanding of the unique risks that are faced in the local context.

Considering that BBI transcends many sectors, the policy recommendation that emanates from the findings hinges on increased collaboration between the different sectoral regulators of BBI and the regulated institutions in the BBI ecosystem. Setting up working groups drawing representation from these numerous sectoral regulators and the regulated institutions is a step in the right direction as it will enhance a sense of ownership amongst the participating regulators and banks. Crucially, there is need to invest in systems for automated submission of performance and regulation related data by the financial institutions to the lead regulator. Rather than requiring the regulated institutions to file periodic data with each sector regulator separately and in different formats, as happens currently, the system should make it easier for multiple sector regulators to access data relevant to their respective regulatory needs from a common database with a single data format. In addition to decreasing the time and costs of regulatory compliance on the part of financial institutions, these reforms will be critical in ensuring that regulators have a better and timely grasp of emerging BBI risks in the local ecosystem. With a greater understanding of the prevailing risks, regulators can more pragmatically design policies that aid financial institutions to handle the particular risks associated with innovative delivery channels.

The study also sheds light on a broader issue that was not directly investigated but was nonetheless the distinguishing feature that provided leverage for this study to contribute to knowledge. One of the main reasons for the scarcity of research on financial inclusion and BBI in developing countries is a scarcity of sufficiently detailed data to allow for the type of analysis given here. With rapid advancements in the technologies that underpin remote BBI, as well as the widespread and growing use of mobile telephony even in remote parts of poor developing countries, this study has demonstrated the importance of collecting and making available to researchers the data needed to conduct such analyses. Only then will efforts to promote financial inclusion, even in such difficult times as those created by Covid-19, be able to effectively utilise the new technologies that can underpin new forms of BBI.

A second important policy issue raised by the findings is the impact of bank size. According to H2, the larger the bank the higher the adoption of BBI. The finding that small banks are more likely to deploy both physical and remote BBI illustrates the potential for small banks to leverage innovation to reach out to retail customers who are typically overlooked or underserved by large banks. However, as with the banking sectors of other developing nations, Malawi's banking sector has seen multiple bank mergers and acquisitions of small banks as a strategic response to Malawi's ratification of the Basel II Accord in 2008. This is in the context of improving the stability of financial systems. Considering that small banks, not big banks, are the rapid adopters of BBI according to our research findings, it can be argued that these mergers and acquisitions potentially undermine the potential for BBI and thus limit improvements to financial inclusion.

Scaling up BBI in the face of Basel II financial stability considerations therefore requires re-opening the banking sector to smaller financially sound institutions. In this regard, reforms that introduce differentiated licensing and capital adequacy standards for different classes of banks will enable more small but financially sound institutions to enter the sector, thereby accelerating BBI driven financial inclusion. The quest for regulation that strikes a delicate balance between financial stability and the creation of more inclusive financial systems has been widely acknowledged as a topic of significant interest in the recent literature (see Ahamed et al., 2021).

Our results also validate the need to adopt a new approach to regulation, where the stringency of regulatory standards applicable to a bank ought to be premised on the systemic importance of that bank. In other words, those banks seen as too big to fail need not be regulated by the same standards applicable to smaller banks, as the latter are not systemically important. This proportionate stance to regulation will create space for small banks to thrive and implement rapid adoption of BBI (especially mobile banking innovation) n. Added to that, the finding that market concentration has a detrimental influence on bank adoption of physical and remote BBI support the aforementioned policy recommendation to open up the banking sector to more new, small entrants. This is against the background that the concentrated nature of Malawi's banking sector derives from the market dominance of the two largest banks (Kaluwa and Chirwa, 2017). As large banks have been found to be slow adopters of BBI, reforms to reduce market concentration by opening up the sector further can help spur adoption of both physical and remote BBI.

Thirdly, having discussed the policy insights drawn from the bank size-BBI nexus, the next issue relates to bank technology. The finding that increased bank technology is associated with decreased adoption of physical BBI (but with no impact on remote BBI) highlights the heterogeneity among BBI, particularly in the context of the intensity of their technological requirements. H1 posited that large investment in bank technology would lead to rapid adoption of BBI. In this regard, a strategy recommendation from this evidence is that banks with less superior technology are better placed to adopt physical BBI. The basic nature of financial services delivered under the physical BBI lends credence to the low technological intensity of these physical BBI. However, this should be interpreted with caution considering that the results became statistically insignificant after adjusting for FWER.

That said, it is acknowledged that banking technologies are traditionally configured for low volume/high value transactions of corporates, rather than low value/high volume transactions of retail clientele (Dermish et al., 2012). From bank strategy, the finding that bank technology has no statistically significant impact on the adoption of remote BBI suggests that banks seeking to accelerate remote BBI adoption, beyond physical BBI, would do well not to rely solely on their own traditional technologies. Rather, they would do well to explore broader technological synergies through collaborations with third-party providers such as TELCO and fintech.

The link between TELCO/Fintechs and bank technology has not been empirically tested in this research. It would be of interest for future research to empirically test this nexus. However, TELCO have been argued in the recent literature to overcome infrastructural shortcomings and achieve scale even in the poorest and most distant rural areas of SSA through their mobile network operator (MNO) subsidiaries (Gutierrez and

Singh, 2013; Mothobi and Grzybowski, 2017). Against this background, partnerships between TELCO and Fintechs on the one hand and traditional financial institutions on the other, will help accelerate adoption of BBI given that banks will benefit from the fintechs' technological competencies and the TELCO's large customer base, while the TELCO and fintechs will benefit from the banking institutions' distinct advantages in liquidity and risk management (Philippon, 2016; Buchak et al., 2018; Bollaert et al., 2021). However, such linkages can only be harnessed if financial regulatory policy is revised to include fintechs in the definition of financial institutions. Fintechs are by their nature risky (Thakor, 2012). Designating fintechs as financial institutions would subject them to regulatory oversight of the central bank. Only when the central bank holds fintechs to particular standard of conduct and risk management commensurate to the nature of their operation, will the banks view fintechs as less risky to enter into meaningful partnerships with, to bolster remote BBI.

Fourthly, noteworthy is the inverse relationship between bank funding and the adoption of all forms of BBI. For adoption of mobile phone banking innovation, the finding is statistically significant even after adjusting for FWER. This is consistent with H4, attesting to the role of management innovativeness in steering technological innovation. This is with the exception of ATM banking innovation which, being one of the earliest forms of BBI, has arguably become a norm for every banking institution offering retail banking services. A crucial policy inference that can be drawn from this resides in shareholders of banks ensuring that personnel appointed to drive the innovative delivery strategies of the banks are only those with a high aptitude towards innovation. In this regard, ensuring a minimum level of educational and professional competence for individuals driving the bank's strategy at the management or board level would be a critical step toward the implementation of new strategies such as BBI by the bank.

Divergent findings on the impact of branch intensity on adoption of different forms of BBI are another crucial lesson for bank strategy. According to H5, an inverse relationship was posited between branch intensity and adoption of BBI. The positive association between branch intensity and physical BBI indicates that banks with extensive networks of branches can leverage their branding and physical presence to enhance financial inclusion among low-end retail consumers using ATM and agent banking innovations. Disenfranchising the bank branch model, in this regard, will impede progress toward the establishment of physical BBI, let alone financial inclusion of low-end retail customers who still prefer to deal in cash. This brings up an important point about the need to relax regulatory criteria for branch establishment. To the extent that such regulatory relaxation minimises the cost of establishing a bank branch, the benefits for financial inclusion would be enormous in the context of incentivising banks to expand their branch networks, while at the same time freeing resources for further investment in other BBI strategies. On the other hand, another strategic insight emanating from the preceding findings is that banks with a small network of branches would benefit from remote BBI strategies. This is particularly important for mobile phone banking innovation where the results are statistically significant even after adjusting for FWER. Moreover, as these transactions tend primarily to be digital, adopting remote BBI would help remedy the cash handling and social distance challenges associated with branch banking.

A further conclusion drawn from the findings is that government direct participation in the financial sector through ownership in institutions can help improve adoption of only some forms of BBI. H8 posited that Government ownership would impact positively the adoption of BBI on the basis of social maximisation narrative. The impact on the adoption of the other forms of BBI is either negative or not statistically significant. Government direct participation in the financial services through ownership in financial institutions may therefore not be the most effective strategy to pursue the BBI led financial inclusion strategy. These new findings thus do not provide strong support for the post-war era scenario in which the dominant mode of promoting social welfare maximisation was a top-down state-led approach that included nationalising banks (Brownbridge and Harvey, 1998; Demirgüç-Kunt et al., 2008). In this regard, the agency and political considerations inherent in state ownership of firms need not to be overlooked as they have been argued to suffocate state-owned banks' corporate governance and risk management ability to control risks.. Thus, in order for the government to meaningfully achieve its financial inclusion goal through state-owned banks' BBI strategies, it is critical that the central bank, as financial institution regulator, hold state-owned banks to the same standards as other banks, particularly in terms of capital adequacy and risk management. This is critical in insulating government banks from the risks of agency and political considerations that are inherent in state ownership in enterprises. Regulatory forbearance of state-owned banks generates moral hazard, as management of state-owned banks find no incentive to pursue sound business strategies, since they are aware that the bank would still be cushioned from the consequences of their reckless business decisions.

Furthermore, H9 posited a positive impact of both foreign ownership and BHC membership on adoption of BBI. The findings from this research suggest that the beneficial effect of foreign entry on financial inclusion can be traced back to the proliferation of small banks that adopt BBI more rapidly. It has been demonstrated in the literature that small banks use BBI to provide financial services to retail customer segments that are generally ignored by large banks. Paradoxically, for Malawi many of these small banks are owned by foreign investors. This, along with the findings regarding the role of BHC membership, adds to our earlier recommendation that the financial sector be further opened up to various types of shareholding, as they lead to the proliferation of small banks. This has the potential to solve market distortions arising from the market dominance by the two largest banks in Malawi. In this regard, policy recommendations should acknowledge that while foreign entry impacts the adoption of BBI through its effect on creating small banks that are more rapid adopters of BBI, the impact of foreign entry on bank adoption of mobile phone banking innovations is negative.

Nonetheless, due to the pervasiveness of mobile phones, mobile banking is increasingly becoming a delivery strategy for rural retail clients (Burns, 2018). Mobile phone banking innovation has resulted in a significant increase in the overall share of adults in SSA who have formal financial accounts (World Bank, 2014). Arguably, it is an innovative strategy best suited for SSA retail consumers, including those in remote areas (Ondiege, 2015). In light of this, foreign banks' failure to implement mobile banking innovations may be viewed as mirroring cream skimming tendencies suggested in the literature, in which foreign banks are not significantly associated with financial inclusion as they tend to target large corporates at the expense of retail consumers, whom they perceive to be costly and risky in the absence of hard data on their low value/high-volume financial and business activities (Detragiache et al., 2008; Beck et al., 2007; Sarma and Pais, 2011). To mitigate this risk and harness the potential of mobile phone banking innovation, policy should hinge on ensuring that opening up the sector to foreign entrants is balanced with the need to introduce regulation that rewards those foreign shareholders who include *fit and proper* local shareholders in their banking institutions. Local shareholders, arguably, have better understanding of the local context than their foreign counterparts (Mian, 2006; Gormley, 2010; Giannetti and Ongena, 2012). This blend in shareholding would therefore be vital in averting the risks that foreign investors fail to manage with regard to the rural retail consumers who lack credible data about the financial performance of their businesses.

Lastly, the negative impact of mobile banking innovation on adoption of ATM banking innovation is not surprising considering that the ubiquity of the mobile telephony has shifted some financial consumers from transacting on ATMs to mobile phone banking platforms. This collaborates the view that remote BBI can substitute physical BBI. Simultaneously, ATM banking innovations have been found to positively impact adoption of mobile phone banking innovation, against the background that ATMs have undergone transformation allowing transactions to be linked to mobile phones. However, the findings that mobile phone banking has a positive impact on the adoption of agent banking innovation can be explained by the fact that most agent banking innovations include mobile phone banking in their value proposition. This demonstrates the extent to which physical BBI can be used to deliver financial services to low-income rural consumers. In this regard, a bank strategy that supports the concurrent implementation of physical and remote BBI would be critical in capturing synergies that arise from the complementarity of these two types of BBI. In addition, because financial consumers are not uniform, the strategy would expand the clientele by providing different customer classes with BBI that speaks to their particular dynamics and needs.

6.5 Significance of the Research

In the end, we can see from the preceding discussion that the study's practical implications for financial inclusion policy in developing countries represent a significant contribution of this research. Previous research has been focused on industrialised or emerging economies such as the United Kingdom, the United States, and China, and hence their findings and implications are not easily transferable to developing countries with distinct characteristics.

Firstly, the findings avail private sector practitioners with an empirical assessment that should inform how they can exploit their distinctive advantages to deploy BBI as a cost-effective way of broadening their customer base and maximise shareholder value. This reaffirms the view that private sector solutions to the problem of financial exclusion can be more sustainable than donor-driven solutions, which are often abandoned after donor funding runs out.

The study also presents empirical insights to regulators and policymakers that can help them strike a balancing act between financial soundness and financial inclusion. Ultimately, the study contributes to the development of more inclusive financial systems, which is consistent with the World Bank's Universal Financial Access 2020 initiative and germane to global efforts towards the achievement of the United Nations Sustainable Development Goals, particularly Goal 1 on poverty alleviation and Goal 10 on inequality reduction.

Furthermore, the study adds to knowledge by examining BBI from the perspective of providers in developing countries where data limitations previously made it unfeasible. Using Malawi's unique dataset to extract the drivers of BBI and distinguish between physical and remote BBI is critical in this regard. The formulation of new hypotheses that show a difference in the short and long-run impacts through the use of dynamic models, while also dealing with endogeneity concerns not fully addressed in prior relevant studies, is another key contribution of this study.

6.6 Scope for Future Research

Notwithstanding the various contributions of the study in terms of practical implications and contribution to knowledge, the study has some limitations. For instance, due to data limitations, the research only focused on four forms of BBI. Increasing coverage to incorporate other emerging forms of BBI would enrich the significance of the study and policy implications. Importantly, the study acknowledges tremendous efforts that are being made with regard adoption of BBI in the other sub sectors of the financial services such as microfinance, pensions, insurance and capital markets. However, for the same reason of data limitation, the study was restricted to BBI in the banking sector as it constitutes the largest sub-sector within the financial sector not only in Malawi and but also in most developing countries. These limitations provide scope for future research.

While focus of this research has been on the financial institutions’ side of BBI given that much of the BBI studies have predominantly focused on the consumer side, it would nonetheless for future research be of interest to explore further the extent with which the unbanked, the rural poor and the other vulnerable groups are beneficiaries of BBI; and in that regard, to empirically test the extent to which BBI contributes to financial inclusion. in this way, a clear and strong connection can be made between the research on supply side of BBI and that on the demand side.

References

Aghion, P., Bloom, N., Blundell, R., Griffith, R. and Howitt, P., 2005. Competition and innovation: An inverted-U relationship. *The Quarterly Journal of Economics*, 120 (2), 701-728.

Agur, I., Peria, S. and Rochon, C., 2020. Digital financial services and the pandemic: Opportunities and risks for emerging and developing economies. *International Monetary Fund Special Series on COVID-19, Transactions*, 1, 2-1.

Ahamed, M., Ho, S., Mallick, S. and Matousek, R., 2021. Inclusive banking, financial regulation and bank performance: Cross-country evidence. *Journal of Banking & Finance*, 124(1), 1-20.

Alam, H., 2011. An econometric analysis of export-led growth hypothesis: Reflections from Pakistan. *Interdisciplinary Journal of Contemporary Research in Business*, 2(12), 329-341.

Al-Somali, S., Gholami, R. and Clegg, B., 2009. An investigation into the acceptance of online banking in Saudi Arabia. *Technovation*, 29(2), 130-141.

Alexandre, C. and Eisenhart, L., 2012. Mobile money as an engine of financial inclusion and lynchpin of financial integrity. *Washington. Journal of Law, Technology and Arts*, 8(3), 285-302.

Alexandre, C., Mas, I. and Radcliffe, D., 2011. Regulating new banking models to bring financial services to all. *Challenge*, 54(3), 116-134.

Allen, F., Carletti, E., Cull, R., Qian J., Senbet, L. and Valenzuela, P., 2014. The African financial development and financial inclusion gaps. *Journal of African Economies,* 23(5), 614–642.

Almeida, R. and Fernandes, A., 2008. Openness and technological innovations in developing countries: evidence from firm-level surveys. *The Journal of Development Studies*, 44(5), 701-727.

Altunbas, Y., Evans, L. and Molyneux, P., 2001. Bank ownership and efficiency. *Journal of Money, Credit and Banking*, 33(4), 926-954.

Ammar, A. and Ahmed, E., 2016. Factors influencing Sudanese microfinance intention to adopt mobile banking. *Journal of Internet Banking and Commerce*, 21(3), 1-26.

Anbar, A. and Alper, D., 2011. Bank specific and macroeconomic determinants of commercial bank profitability: Empirical evidence from Turkey. *Business and Economics Research Journal*, 2(2), 139-152.

Arellano, M., 2003. *Panel data econometrics*. Oxford: Oxford University Press.

Arellano, M. and Bover, O., 1995. Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, 68(1), 29-51.

Argent, J., Hanson, J. and Gomez, M., 2013. The regulation of mobile money in Rwanda. London School of Economics International Growth Centre Working Paper No F-38026-RWA-1. Available: https://www.theigc.org/wp-content/uploads/2013/08/Argent-Et-Al-2013-Working-Paper.pdf. Accessed on 16 September 2021.

Asongu, S. and Nwachukwu, J., 2018. Bank size, information sharing and financial access in Africa, *International Journal of Managerial Finance,* 14(2), 188-209.

Asongu, S. and Nwachukwu, J., 2019. ICT, Financial sector development and financial access, *Journal of the Knowledge Economy,* 10(2), 465-490.

Athanasoglou, P., Brissimis, S. and Delis, M., 2008. Bank-specific, industry-specific and macroeconomic determinants of bank profitability. *Journal of International Financial Markets, Institutions and Money*, 18(2), 121-136.

Atkinson, A. and Stiglitz, J., 2015. *Lectures on public economics- updated edition*. Princeton: Princeton University Press.

Awrey, D., 2013. Toward a supply-side theory of financial innovation, *Journal of Comparative Economics,* 41(12), 401-419.

Bachas, P., Gertler, P., Higgins, S. and Seira, E., 2021. How debit cards enable the poor to save more. *The Journal of Finance*, 76(4), 1913-1957.

Bai, J., 2009. Panel data models with interactive fixed effects. *Econometrica*, *77*(4), 1229-1279.

Baker, J., 2012. The Technology–organisation-environment framework, in Dwivedi, Y., Wade, M., Schneberger, S. eds., 2012. *Information systems theory: explaining & predicting our digital society, volume 1*, New York: Springer. 231-245. Available: https://doi.org/10.1007/978-1-4419-6108-2_12. Accessed on 12th July 2020.

Baltagi, B., 2008. Forecasting with panel data. *Journal of Forecasting,* 27(2), 153-173.

Baltagi, B., Demetriades, P. and Law, S., 2009. Financial development and openness: evidence from panel data. *Journal of Development Economics,* 89(2), 285-296.

Banerjee, A., 1997. A theory of misgovernance. *The Quarterly Journal of Economics*, 112(4), 1289-1332.

Bangake, C. and Eggoh, J., 2012. Pooled Mean Group estimation on international capital mobility in African countries. *Research in Economics*, 66(1), 7-17.

Barras, R., 1990. Interactive innovation in financial and business services: the vanguard of the service revolution. *Research Policy*, 19(3), 215-237.

Barth, J., Caprio Jr, G. and Levine, R., 2001. Banking systems around the globe: do regulation and ownership affect performance and stability? in Mishkin, F. eds., 2009. *Prudential supervision: What works and what doesn't*. Chicago: University of Chicago Press.31-96.

Barth, J., Caprio, G. and Levine, R., 2004. Bank supervision and regulation: what works best? *Journal of Financial Intermediation*, 13(2), 205-248.

Barth, J., Caprio, G. and Levine, R., 2008. *Rethinking bank regulation: till angels govern*. Cambridge: Cambridge University Press.

Bátiz-Lazo, B. and Woldesenbet, K., 2006. The dynamics of product and process innovations in UK banking. *International Journal of Financial Services Management*, *1*(4), 400-421.

Bátiz-Lazo, B. and Wood, D., 2002. An historical appraisal of information technology in commercial banking. *Electronic Markets*, *12*(3), 192-205.

Beck, T., Demirgüç-Kunt, A. and Maksimovic, V., 2004. Bank competition and access to finance: International evidence. *Journal of Money, Credit and Banking*, 36(3), 627-648.

Beck, T., Demirgüç-Kunt, A. and Martinez Peria, M., 2005. *Reaching out: access to and use of banking services across countries*. Washington DC: World Bank.

Beck, T., Demirgüç-Kunt, A. and Levine, R., 2007. Finance, inequality and the poor. *Journal of Economic Growth*, 12(1), 27-49.

Beck, T., Senbet, L. and Simbanegavi, W., 2015. Financial inclusion and innovation in Africa: An overview. *Journal of African Economies*, 24(1), 3-11.

Benni, N., 2021. *Digital finance and inclusion in the time of COVID-19: Lessons, experiences and proposals*. Rome: Food & Agriculture Organisation.

Berger, A., Hasan, I. and Klapper, L., 2004. Further evidence on the link between finance and growth: an international analysis of community banking and economic performance. *Journal of Financial Services Research*, 25(2), 169-202.

Berger, A., Klapper, L. and Udell, G., 2001. The ability of banks to lend to informationally opaque small businesses. *Journal of Banking and Finance*, 25(12), 2127-2167.

Berger, A., Miller, N., Petersen, M., Rajan, R. and Stein, J., 2005. Does function follow organizational form? Evidence from the lending practices of large and small banks. *Journal of Financial Economics*, 76(2), 237-269.

Bhattacherjee, A., 2001. Understanding information systems continuance: an expectation-confirmation model. *Management Information Systems Quarterly*, 25(3), 351-370.

Black, N., Lockett, H., Winklhofer, H. and Ennew, C., 2001. The adoption of internet financial services: a qualitative study. *International Journal of Retail & Distribution Management*, 29(8), 390-398.

Blackburne, E. and Frank, M., 2007. Estimation of nonstationary heterogeneous panels. *The Stata Journal*, 7(2), 197-208.

Bollaert, H., Lopez-de-Silanes, F. and Schwienbacher, A., 2021. Fintech and access to finance. *Journal of Corporate Finance*, 68, 1-14.

Botello-Peñaloza, H. and Guerrero-Rincón, I., 2019. Wage differences and educational mismatch in Colombia. *Economy & Region*, 13(2), 177-191.

Bottazzi, G., Cefis, E., Dosi, G. and Secchi, A., 2007. Invariances and diversities in the patterns of industrial evolution: some evidence from Italian manufacturing industries. *Small Business Economics*, 29(1), 137-159.

Boyd, J., Chang, C. and Smith, B., 1998. Moral hazard under commercial and universal banking. *Journal of Money, Credit and Banking*, 30(3), 426-468.

Brooks, C., 2019. *STATA Guide for introductory econometrics for finance*. Cambridge: Cambridge University Press.

Brown, I. and Molla, A., 2005. Determinants of internet and cell phone banking adoption in South Africa. *Journal of Internet Banking and Commerce*, 19(4), 1–9.

Brown, L., 1981. *Innovation diffusion; a new perspective*. New York: Methuen.

Brown, M., Jappelli, T. and Pagano, M., 2009. Information sharing and credit: firm-level evidence from transition countries. *Journal of Financial Intermediation*, 18(2), 151-172.

Brownbridge, M. and Gockel, A., 1998. *Banking in Africa: the impact of financial sector reform since independence*. Oxford: James Currey and Africa World Press.

Bruhn, M. and Love, I., 2014. The real impact of improved access to finance: evidence from Mexico. *The Journal of Finance*, 69(3), 1347-1376.

Buchak, G., Matvos, G., Piskorski, T. and Seru, A., 2018. Fintech, regulatory arbitrage, and the rise of shadow banks. *Journal of Financial Economics*, 130(3), 453-483.

Buckley, R., Greenacre, J. and Malady, L., 2015. The regulation of mobile money in Malawi. *Washington University Global Studies Law Review*, 14(1) 435-497.

Bughin, J. 2001. E-pull or e-push? Laggards and first-movers in European banking, *Journal of Computer Mediated Communications*, 7(1), 7-15.

Bultum, A., 2014. Factors affecting adoption of electronic banking system in Ethiopian banking industry. *Journal of Management Information Systems and E-commerce*, 1(1), 1-17.

Buri, S., Cull, R., Giné, X., Harten, S. and Heitmann, S., 2018. *Banking with agents: experimental evidence from Senegal*. Washington DC: World Bank. Available: https://thedocs.worldbank.org/en/doc/664571466184856841-0050022016/. Accessed on 5th August 2020.

Buri, S., Reitzug, F., Heitmann, S. and De Araujo Marinho Filho, E., 2019. *Do agent networks help to boost savings? Effects on institutional deposit mobilisation and customer saving behaviour*. Washington DC: World Bank.

Burns, S., 2018. M-Pesa and the 'market-led' approach to financial inclusion. *Economic Affairs*, 38(3), 406-421.

Buzzacchi, L., Colombo, M. and Mariotti, S., 1995. Technological regimes and innovation in services: the case of the Italian banking industry. *Research Policy*, 24(1), 151-168.

Calomiris, C., 2009. Financial innovation, regulation, and reform. *Cato Journal*, 29(1), 65-91.

Campion, A. and Halpern, S., 2001. Automating Microfinance: experience in Latin America, Asia, and Africa. *Microfinance Network*. Washington DC: Accion. Available: www.accion.org/micro_pubs_list.asp. Accessed on 4th January 2020.

Campos, N. and Iootty, M., 2007. Institutional barriers to firm entry and exit: Case-study evidence from the Brazilian textiles and electronics industries. *Economic Systems*, 31(4), 346-363.

Carlson, J., Furst, K., Lang, W. and Nolle, D.E., 2001. Internet banking: market developments and regulatory issues. Washington DC: The Society of Government Economists. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.182.875. Accessed on 9th April 2021.

Carow, K. and Staten, M., 1999. Debit, credit, or cash: survey evidence on gasoline purchases. *Journal of Economics and Business*, 51(5), 409-421.

Chau, P. and Tam, K., 1997. Factors affecting the adoption of open systems: an exploratory study, *Management Information Systems Quarterly*, 21(1), 1–24.

Chen, R. and Divanbeigi, R., 2019. Can regulation promote financial inclusion? World Bank Policy Research Working Paper No 8711. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/31179/WPS8711.pdf?sequence=1. Accessed on 4 December 2021.

Chikalipah, S., 2017. What determines financial inclusion in Sub-Saharan Africa? *African Journal of Economic and Management Studies*, 8(1), 8-18.

Chipeta, C. and Muthinja, M., 2018. Financial Innovation and bank performance in Kenya: Evidence from branchless banking models. *South African Journal of Economics and Management Science*, 21(1), 1-11.

Chirwa, E. and Mlachila, M., 2004. Financial reforms and interest rate spreads in the commercial banking system in Malawi. *International Monetary Fund Staff Papers*, 51(1), 96-122. Available: https://www.jstor.org/stable/30035865. Accessed on 23 May 2021.

Chong, J. and Olesen, K., 2017. A Technology-Organization-Environment perspective on eco-effectiveness: A Meta-analysis. *Australasian journal of information systems*, *21*. ISSN 1449-8618, Available: http://dx.doi.org/10.3127/ajis.v21i0.1441. Accessed on 2 December 2022.

Chudik, A. and Pesaran, M.H., 2013. Large panel data models with cross-sectional dependence: a survey. CESifo Working Paper, No 4371, Center for Economic Studies and ifo Institute (CESifo), Munich

Claessens, S., Demirgüç-Kunt, A. and Huizinga, H., 2001. How does foreign entry affect domestic banking markets? *Journal of Banking & Finance*, 25(5), 891-911.

Clarke, G., Cull, R. and Peria, M., 2001. Does foreign bank penetration reduce access to credit in developing countries? Evidence from asking borrowers. World Bank Policy Research Working Paper No 2716. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/19437/multi0page.pdf?sequence=1. Accessed on 10 October 2020.

Clarke, G., Cull, R. and Shirley, M., 2005. Bank privatization in developing countries: a summary of lessons and findings. *Journal of Banking & Finance*, 29(8-9), 1905-1930.

Clemes, M., Gan, C. and Du, J., 2012. The factors impacting on customers' decisions to adopt internet banking. *Banks and Bank Systems*, 7(3), 33-50.

Collins, P., Hage, J. and Hull. F., 1988. Organizational and technological predictors of change in automaticity. *Academy of Management Journal*, 31(3), 512-543.

Cooper, J., 1998. A multidimensional approach to the adoption of innovation. *Management decision*, 36, 493

Cooper, R. and Zmud, R., 1990. Information technology implementation research: a technological diffusion approach, *Management Science*. 36 (2) 123–139.

Cornett, M., Guo, L., Khaksari, S. and Tehranian, H., 2010. The impact of state ownership on performance differences in privately-owned versus state-owned banks: an international comparison. *Journal of Financial Intermediation*, 19(1), 74-94.

Corrocher, N., 2006. Internet adoption in Italian banks: an empirical investigation. *Research Policy*, 35(4), 533-544.

Courchane, M., Nickerson, D. and Sullivan, R., 2002. Investment in internet banking as a real option: theory and tests. *Journal of Multinational Financial Management*, 12(4-5), 347-363.

Cull, R., Giné, X., Harten, S., Heitmann, S. and Rusu, A., 2018. Agent banking in a highly under-developed financial sector: evidence from Democratic Republic of Congo, *World Development*, 107, 54-74.

Cull, R. and Peria, M., 2013. Bank ownership and lending patterns during the 2008–2009 financial crisis: evidence from Latin America and Eastern Europe. *Journal of Banking & Finance*, 37(12). 4861-4878.

Cull, R. and Soledad Martinez Peria, M., 2010. Foreign bank participation in developing countries: what do we know about the drivers and consequences of this phenomenon? World Bank Policy Research Working Paper No 5398. Available: http://openknowledge.worldbank.org/bitstream/handle/10986/3882/WPS5398. Accessed on 12 May 2021.

Dabalen, A., De La Fuente, A., Goyal, A., Karamba, W. and Tanaka, T., 2017. *Pathways to prosperity in rural Malawi*. Washington DC: World Bank.

Das, S. and Pant, M., 2006. Measuring market imperfection in the manufacturing sector: Theory and evidence from India. *Journal of International Trade & Economic Development*, 15(1), 63-79.

David, P., 1969. *A contribution to the theory of diffusion*. Stanford: Stanford University Press.

David, P. and Olsen, T., 1984. *Anticipated automation: a rational expectations model of technological diffusion.* Stanford: Stanford University Press.

Davies, S. and Davies, G., 1979. *The diffusion of process innovations*. Cambridge: Cambridge University Press.

De Haas, R. and Naaborg, I., 2005. Does foreign bank entry reduce small firms' access to credit? Evidence from European transition economies. De Nederlandsche Bank Working Paper No. 50.

De Haas, R. and Van Lelyveld, I., 2006. Foreign banks and credit stability in Central and Eastern Europe. A panel data analysis. *Journal of Banking & Finance*, 30(7), 1927-1952.

De Young, R., Lang, W. and Nolle, D., 2007. How the Internet affects output and performance at community banks. *Journal of Banking & Finance*, 31(4), 1033-1060.

Demirgüç-Kunt, A., Levine, R. and Detragiache, E., 2008. *Finance and economic development: the role of government*. Washington DC: World Bank.

Demirgüç-Kunt, A. and Klapper, L., 2013. Measuring financial inclusion: explaining variation in use of financial services across and within countries. *Brookings Papers on Economic Activity*, 2013(1), 279-340.

Demirgüç-Kunt, A., Klapper, L., Singer, D., Ansar, S. and Hess, J., 2018. *The Global Findex Database 2017: measuring financial inclusion and fintech revolution*. Washington DC: World Bank.

Dermish, A., Kneiding, C., Leishman, P. and Mas, I., 2012. Branchless and mobile banking solutions for the poor: a survey of literature. *Innovations: Technology, Governance, Globalization*, 6(4), 81-98.

Detragiache, E., Tressel, T. and Gupta, P., 2008. Foreign banks in poor countries: theory and evidence. *The Journal of Finance,* 63(5), 2123-2160.

Devlin, J., 1995. Technology and innovation in retail banking distribution. *International Journal of Bank Marketing*.13(4), 19-25.

Devlin, J., 2005. A detailed study of financial exclusion in the UK. *Journal of Consumer Policy*, 28(1), 75-108.

Di Maggio, P. and Powell, W., 1983. The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 48(2),147-160.

Di Stefano, G., Gambardella, A. and Verona, G., 2012. Technology push and demand-pull perspectives in innovation studies: current findings and future research directions. *Research Policy,* 41(8), 1283-1295.

Dinç, I., 2005. Politicians and banks: political influences on government-owned banks in emerging markets. *Journal of Financial Economics*, 77(2), 453-479.

Dorfleitner, G., Nguyen, Q. and Röhe, M., 2019. Microfinance institutions and the provision of mobile financial services: first empirical evidence. *Finance Research Letters*, 31, 357-362.

Driscoll, J. and Kraay, A., 1998. Consistent covariance matrix estimation with spatially dependent panel data. *Review of Economics and Statistics,* 80(4), 549-560.

Ediriweera, A. and Wiewiora, A., 2021. Barriers and enablers of technology adoption in the mining industry. *Resources Policy*, *73(1),* 102-188. Available: https://doi.org/10.1016/j.resourpol.2021.102188. Accessed on 3 December 2022.

Edo, S., Okodua, H. and Odebiyi, J., 2019. Internet adoption and financial development in Sub-Saharan Africa: evidence from Nigeria and Kenya. *African Development Review*, 31(1), 144-160.

Enyang Besong, S., Okanda, T., & Ndip, S., 2021. An empirical analysis of the impact of banking regulations on sustainable financial inclusion in the CEMAC region. *Economic Systems*. Early View. Available: https://doi.org/10.1016/j.ecosys.2021.100935. Accessed on 20 June 2021.

Escuer, M., Polo, Redondo, Y., Fumas Salas, V., 1991. Market structure and the adoption of innovation: the case of the Spanish banking sector. *Economics of Innovation and New Technology*, 1(4), 295-307.

Esoimeme, E., 2017. A critical analysis of the effects of the Central Bank of Nigeria foreign exchange policy on financial inclusion, anti-money laundering measures and fundamental rights. *Journal of Money Laundering Control*, 20(4), 417-427.

Ettlie, J. and Reza, E., 1992. Organizational integration and process innovation. *Academy of management journal*, *35*(4), 795-827.

Evans, O., 2016. The effectiveness of monetary policy in Africa: modelling the impact of financial inclusion. *Iranian Economic Review*, 20(3), 327-337.

Evans, O., 2018. Connecting the poor: the internet, mobile phones and financial inclusion in Africa. *Digital Policy, Regulation and Governance*, 20(6), 568-581.

Favara, G., 2003. An empirical reassessment of the relationship between finance and growth. International Monetary Fund Working Paper No 03/123. Available: https://www.elibrary.imf.org/view/journals/001/2003/123/. Accessed on 12 February 2021.

Finmark Trust, 2012, *Mapping the retail payment services landscape: Malawi*. Johannesburg: Finmark Trust.

Finmark Trust, 2014. *Finscope consumer survey: Malawi 2014*. Johannesburg: Finmark Trust.

Frame, W. and White, L., 2004. Empirical studies of financial innovation: Lots of talk, little action?' *Journal of Economic Literature*, 42(1), 116–144.

Frame, W. and White, L., 2014. Technological change, financial innovation, and diffusion in banking, in Berger, A., Molyneux, P. and Wilson, J. eds., 2014. *The Oxford handbook of banking- 2nd edition*. Oxford: Oxford University Press, 271-291.

Franses, P. and Van Oest, R., 2004. *On the econometrics of the Koyck model*. Rotterdam: Erasmus University Rotterdam.

Furst, K., Lang, W. and Nolle, D., 2002. Internet banking. *Journal of Financial Services Research*, 22(1), 95–117.

Gaibulloev, K., Sandler, T. and Sul, D., 2014. Dynamic panel analysis under cross-sectional dependence. *Political Analysis*, *22*(2), 258-273.

German-Soto, V. and Flores, L., 2015. Contribution of education and innovation to productivity among Mexican regions: a dynamic panel data analysis. *Theoretical Economics Letters*, 5(1), 44-55.

Geroski, P., 2000. Models of technology diffusion. *Research Policy*, 29(4-5), 603-625.

Gerrard, P., Cunningham, J. and Devlin, J., 2006. Why consumers are not using internet banking: a qualitative study. *Journal of Service Marketing*, 20(3), 160-168.

Giannetti, M. and Ongena, S., 2012. "Lending by example": direct and indirect effects of foreign banks in emerging markets. *Journal of International Economics*, 86(1), 167-180.

Gill, J. and Johnson, P., 2020. *Research methods for managers-4th edition*. London: Sage Publications Ltd.

Gormley, T., 2010. The impact of foreign bank entry in emerging markets: evidence from India. *Journal of Financial Intermediation*, 19(1), 26-51.

Gosavi, A., 2015. The next frontier of mobile money adoption. *The International Trade Journal*, 29(5), 427-448.

Gourlay, A. and Pentecost, E., 2002. The determinants of technology diffusion: evidence from the UK financial sector. *The Manchester School*, 70(2), 185-203.

Government of Malawi., 2017. *National financial inclusion strategy II (2016-2020)*. Lilongwe: Government of Malawi.

Government of Malawi., 2021. *Malawi's Digital Economy Strategy (2021-2026)*. Lilongwe: National Planning Commission of Malawi.

Greene, W., 2008. The econometric approach to efficiency analysis. *The Measurement of Productive Efficiency and Productivity Growth*, 1(1), 92-250.

Greenwald, B. and Stiglitz, J., 1986. Externalities in economies with imperfect information and incomplete markets. *The Quarterly Journal of Economics*, 101(2), 229-264.

Groppe, D., 2022. Bonferroni-Holm Correction for Multiple Comparisons. Available: https://www.mathworks.com/matlabcentral/fileexchange/28303, MATLAB Central File Exchange. Accessed on 13 December 2022.

Gupta, S., Ghardallou, W., Pandey, D. and Sahu, G., 2022. Artificial intelligence adoption in the insurance industry: Evidence using the technology–organization–environment framework. *Research in International Business and Finance*, *63(1)*, 1017-57. Available: https://doi.org/10.1016/j.ribaf.2022.101757. Accessed on 3 December 2022.

Gutierrez, E. and Singh, S., 2013. What regulatory frameworks are more conducive to mobile banking? Empirical evidence from findex data. World Bank Policy Research Working Paper No 6652. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/16867/WPS6652. Accessed on 7 May 2020.

Gutiérrez-Romero, R. and Ahamed, M., 2021. COVID-19 response needs to broaden financial inclusion to curb the rise in poverty. *World Development*, 138, 105-229.

Hagendorff, J., 2014. Corporate governance in banking, in Berger, A., Molyneux, P. and Wilson, J. eds., 2014. *The Oxford handbook in Banking - 2nd edition*. Oxford: Oxford University Press, 139-159.

Han, R. and Melecky, M., 2013. *Financial inclusion for financial stability: access to bank deposits and the growth of deposits in the global financial crisis*. Washington DC: World Bank.

Hannan, T. and McDowell, J., 1984. The determinants of technology adoption: the case of the banking firm. *The RAND Journal of Economics*, 15(3), 328-335.

Hannan, T. and McDowell, J., 1987. Rival precedence and the dynamics of technology adoption: an empirical analysis. *Economica*, 54(214), 155-171.

Hanouch, M., 2015. What is USSD & why does it matter for mobile financial services? Consultative Group to Assist the Poor (CGAP) blog post. Washington DC: CGAP. Available:http://www.cgap.org/blog/what-ussdwhy-does-it-matter-mobile-inancialservices. Accessed 5th April 2022.

Harridge-March, S., Zhao, A., Hanmer-Lloyd, S., Ward, P. and Goode, M., 2008. Perceived risk and Chinese consumers' internet banking services adoption. *International Journal of Bank Marketing*, 26(7), 505-525.

Hart, O., Schleifer, A. and Vishny, R., 1997. The Proper Scope of Government: theory and applications to prisons *Quarterly Journal of Economics*. 112(4), 1127-1162.

Hester, D., Calcagnini, G. and De Bonis, R., 2001. Competition through innovation: ATMs in Italian banks. *Rivista Italiana Degli Economisti*, 6(3), 359-382.

Holly, S. and Raissi, M., 2009. The macroeconomic effects of European financial development: a heterogenous panel analysis, FINESS Working Paper No.D.1.4. Available: http://hdl.handle.net/10419/119482. Accessed on 7 March 2021.

Holm, S., 1979. A simple sequentially rejective multiple test procedure. *Scandinavian journal of statistics*, 65-70.

Hommel, G., 1988. A stagewise rejective multiple test procedure based on a modified Bonferroni test. *Biometrika*, 75(2), 383-386.

Huang, Q., 2020. Ownership concentration and bank profitability in China. *Economics Letters*, 196, 1-3.

Hue, T., 2019. The determinants of innovation in Vietnamese manufacturing firms: an empirical analysis using a technology–organization–environment framework. *Eurasian Business Review*, 9(3), 247-267.

Hughes, N. and Lonie, S., 2007. M-PESA: mobile money for the "unbanked" turning cell phones into 24-hour tellers in Kenya. *Innovations: Technology, Governance, Globalization*, 2(1-2), 63-81.

Hunter, W and Timme, S., 1991. Technological change in large U.S. commercial banks. *The Journal of Business*, 64(3), 339-362.

Iannotta, G., Nocera, G. and Sironi, A., 2007. Ownership structure, risk and performance in the European banking industry. *Journal of Banking & Finance*, 31(7), 2127-2149.

Igudia, E., Ackrill, R., Coleman, S. and Dobson, C., 2016. Determinants of the informal economy of an emerging economy: a multiple indicator, multiple causes approach. *International Journal of Entrepreneurship and Small Business*, 28(2-3), 154-177. Available: https://dora.dmu.ac.uk/bitstream/handle/2086/19277/. Accessed on 5 May 2022.

Igudia, E., Ackrill, R. and Coleman, S., 2017. Entrepreneurial responses to austerity: the role of the informal sector (No. 2017/09). Nottingham Business School, Nottingham Trent University. Available: https://www.ntu.ac.uk/__data/assets/pdf_file/0033/455658/igudia-ackrill-coleman-wp-2017-9.pdf. Accessed on 5 May 2022.

Ingham, H. and Thompson, S., 1993. The adoption of new technology in financial services: the case of building societies. *Economics of Innovation and New Technology*, 2(4), 263-274.

Ivatury, G. and Mas, I., 2008. The early experience with branchless banking. Consultative Group to Assist the Poor Focus Note (46). Washington DC: CGAP. Available: https://documents1.worldbank.org/curated/en/419181468338345832/pdf/. Accessed on 6 October 2021.

Jenkins, B., 2008. *Developing mobile money ecosystems*. Washington DC: International Finance Corporation. Available: https://www.gsm.org/mobilefordevelopment/wp-content/uploads/2012/06/report_30_mobilemoney.pdf. Accessed on 7 May 2021.

Jiya, A., Opoku, M., Nketsia, W., Dogbe, J. and Adusei, J., 2021. Achieving financial inclusion for persons with disabilities: exploring preparedness and accessibility of financial services for persons with disabilities in Malawi. *Journal of Disability Policy Studies*, 2(1).1-11.

Kabango, G., 2009. *Financial liberalization and industry structure nexus: an investigation using dynamic heterogeneous panels from Malawian data* (Doctoral dissertation, University of Glasgow).

Kaluwa, B. and Chirwa, G., 2017. Competition, regulation and banking industry pricing conduct in Malawi. *African Review of Economics and Finance*, 9(2), 3-29.

Kamath, R. and Liker, J., 1994. A second look at Japanese product development. *Harvard Business Review*, 72(6), 154-165.

Kamien, M. and Schwartz, N., 1982. *Market structure and innovation*. Cambridge: Cambridge University Press.

Kane, E., 2014. Regulation and supervision: an ethical perspective, in Berger, A., Molyneux, P. and Wilson, J. eds., 2014. *The Oxford handbook of banking - 2nd edition*. Oxford: Oxford University Press.505-526.

Kanjo, C., Phiri, Y., Mtumbuka, F. and Manda, T., 2017. ICT solutions for financial inclusion: Reaching out to the unbanked in low resource settings. In *2017 IST-Africa Week Conference (IST-Africa)*. Available: doi: 10.23919/ISTAFRICA.2017.8102408. Accessed on 12 February 2022.

Karshenas, M., 1995. Technological diffusion, in Stoneman, I. ed., 1995. *Handbook of the economics of innovation and technological change*. Cambridge: Blackwell Publishers.265-297.

Karshenas, M. and Stoneman, P., 1993. Rank, stock, order, and epidemic effects in the diffusion of new process technologies: an empirical model. *The RAND Journal of Economics*, 24(4), 503-528.

Kaur, M. and Kaur, K., 2018. Diffusion and adoption of credit cards in Indian banking sector. *American Journal of Economics and Business Management*, 1(2), 1-20.

Khan, H., 2012. Financial inclusion and financial stability: are they two sides of the same coin. Reserve Bank of India Monthly Bulletin (March), 553-563. Available: https://rbidocs.rbi.org.in/rdocs/Bulletin/PDFs/06SPBUL120312.pdf. Accessed on 11 March 2019.

Khraisha, T. and Arthur, K., 2018. Can we have a general theory of financial innovation process? A conceptual review. *Financial Innovation,* 4(4), 1-27.

Kimenyi, M. and Ndung'u, N., 2009. *Expanding the financial services frontier: lessons from mobile phone banking in Kenya*. Washington DC: Brookings Institution. Available: www.gsma.com/mobilefordevelopment/wpcontent/uploads/2012/06/1016_mobile_phone_kenya_kimenyi.pdf. Accessed on 15 June 2020.

King'ang'ai, P., Kigabo, T., Kihonge, E. and Kibachia, J., 2016. Effects of agency banking on financial performance of commercial banks in Rwanda: A study of four commercial banks in Rwanda, *European Journal of Business and Social Sciences,* 5(1), 181-201.

Kochar, A., 2018. Branchless banking: Evaluating the doorstep delivery of financial services in rural India. *Journal of Development Economics*, 135, 160-175.

Kodongo, O., 2018. Financial regulation, financial literacy and financial inclusion: Insights from Kenya. *Emerging Markets Finance and Trade*, 54(12), 2851-2873.

Koellinger, P., 2008. The relationship between technology, innovation and firm performance: empirical evidence from e-business in Europe. *Research Policy*, 37(8), 1317-1328.

Koker, L., 2011. Aligning anti-money laundering, combating of financing of terror and financial inclusion: questions to consider when FATF standards are clarified. *Journal of Financial Crime*, 18(4), 361-386.

Kosmidou, K., Pasiouras, F., Doumpos, M. and Zopounidis, C., 2004. Foreign versus domestic banks' performance in the UK: a multi-criteria approach. *Computational Management Science*, 1(3), 329-343.

Kulkarni, M. and Patil, K., 2020, March. Block Chain Technology Adoption for Banking Services-Model based on Technology-Organization-Environment theory. In *Proceedings of the International Conference on Innovative Computing & Communications (ICICC)*.

Kulkarni, M and Warke, P., 2015. The framework for assessing ICT based financial inclusion management by nationalised banks with special reference to Marathwada region. *Journal of Commerce and Management Thought*, 6(4), 684-692.

Kumar, A., Nair, A., Parsons, A., Urdapilleta, E. and Nair, A., 2006. *Expanding bank outreach through retail partnerships: correspondent banking in Brazil*. Washington DC: World Bank.

Kumar, N., 2013. Financial inclusion and its determinants: Evidence from India. *Journal of Financial Economic Policy*, 5(1), 4-19.

La Porta, R., Lopez-de-Silanes, F. and Shleifer, A., 2002. Government ownership of banks. *The Journal of Finance*, 57(1), 265-301.

Lacovou, C., Benbasat, I. and Dexter, A., 1995. Electronic data interchange and small organizations: adoption and impact of technology. *Management Information Systems Quarterly*, 19(4), 465-485.

Laforet, S. and Li, X., 2005. Consumers' attitudes towards online and mobile banking in China. *International Journal of Bank Marketing*, 23(5), 362-380.

Lapukeni, A., 2015. The impact of financial inclusion on monetary policy effectiveness: the case of Malawi. *International Journal of Monetary Economics and Finance*, 8(4), 360-384.

Lauer, K. and Tarazi, M., 2012. Supervising nonbank e-money issuers. Consultative Group to Assist the Poor Brief. Washington DC: CGAP. Available: https://openknowledge.worldbank.org/bitstream/handle/10986/17100/75147020120CGA0Box0374307B00PUBLIC0.. Accessed on 10 October 2020.

Lee, T. and Chih, S., 2013. Does financial regulation affect the profit efficiency and risk of banks? Evidence from China's commercial banks. *The North American Journal of Economics and Finance*, 26, 705-724.

Lee, Y. and Wang, K., 2015. Dynamic heterogeneous panel analysis of the correlation between stock prices and exchange rates. *Economic Research*, 28(1), 749-772.

Lenka, S. and Sharma, R., 2017. Does financial inclusion spur economic growth in India? *The Journal of Developing Areas*, 51(3), 215-228.

Lerner, J., 2006. The new financial thing; the origins of financial innovations. *Journal of Financial Economics*, 79(2), 223-255.

Lerner, J., 2010. The litigation of financial innovations. *Journal of Law and Economics*, 53(4), 807-831.

Lerner, J. and Tufano, P., 2011. The consequences of financial innovation: a counterfactual research agenda. *Annual Review of Financial Economics*, 3(1), 41-85.

Levin, S., Levin, S. and Meisel, J., 1987. A dynamic analysis of the adoption of a new technology: the case of optical scanners. *The Review of Economics and Statistics,* 6(1), 12-17.

Llewellyn, D., 1992. *Financial innovation,* London: Routledge.

Loayza, N. and Ranciere, R., 2006. Financial development, financial fragility, and growth. *Journal of Money, Credit and Banking*, 96, 1051-1076.

Lumpkin, S., 2010. Regulatory issues related to financial innovation. *Financial Market Trends*, 2, 1-31.

Lyman, T., Ivatury, G. and Staschen, S., 2006. Agents in branchless banking for use of the poor: rewards, risks, and regulation. Consultative Group to Assist the Poor Focus Note 38. Washington DC: CGAP.

Madise, S., 2019. *The regulation of mobile money: law and practice in Sub-Saharan Africa*. Cham: Palgrave Macmillan.

Mah, J., 2000. An empirical examination of the disaggregated import demand of Korea—the case of information technology products. *Journal of Asian Economics*, 11(2), 237-244.

Makhlouf, Y., Kellard, N.M. and Vinogradov, D., 2020. Finance-inequality nexus: the long and the short of it. *Economic Inquiry*, 58(4), 1977-1994.

Makina, D., 2017. Introduction to the financial services in Africa: special issue. *African Journal of Economic and Management Studies*, 8(1), 2-7.

Makoza, F., 2021. Critical Analysis of Telecommunications Regulatory Governance in Malawi. *International Journal of Interdisciplinary Telecommunications and Networking*, 13(1), 49-67.

Malhotra, P. and Singh, B., 2010. An analysis of internet banking offerings and its determinants in India, *Internet Research*, 20(1), 87-106.

Mansfield, E., 1977. *The production and application of new industrial technology*. New York: Norton.

Mantel, B. and McHugh, T., 2001. Competition and innovation in the consumer e-payments market? Considering the demand, supply and public policy issues. Federal Reserve Bank of Chicago Public Policy Working Paper No. EPS-2001-4.

Marangunić, N. and Granić, A., 2015. Technology acceptance model: a literature review from 1986 to 2013. *Universal Access in the Information Society*, 14(1), 81-95.

Marcus, R., Eric, P. and Gabriel, K., 1976. On closed testing procedures with special reference to ordered analysis of variance. *Biometrika*, 63(3), 655-660.

Martínez-Zarzoso, I. and Bengochea-Morancho, A., 2004. Pooled mean group estimation of an environmental Kuznets curve for CO2. *Economics Letters*, 82(1), 121-126.

Mas, I., 2009. The economics of branchless banking. *Innovations: Technology, Governance, Globalization*, 4(2), 57-75.

Mas, I., 2016. Strains of Digital Money. *The Capco Institute Journal of Financial Transformation*, (44)1, 97-110.

Mas, I. and Ng'weno, A., 2010. Three keys to M-PESA's success: branding, channel management and pricing. *Journal of Payments Strategy & Systems*, 4(4), 352-370.

Mazer, R. and Rowan, P., 2016. Competition in mobile financial services: lessons from Kenya and Tanzania. *The African Journal of Information and Communication*, 17(1), 39-59.

Mbutor, M. and Uba, I., 2013. The impact of financial inclusion on monetary policy in Nigeria. *Journal of Economics and International Finance*, *5*(8), 318-326.

McAndrews, J., 1991. The evolution of shared ATM networks. *Business Review*, (May), 3-16. Available: https://ideas.repec.org/a/fip/fedpbr/y1991imayp3-16.html. Accessed 11th March 2020.

McAndrews, J., 2003. Automated teller machine network pricing-a review of the literature. *Review of Network Economics*, 2(2).146-158

Mehrotra, A. and Yetman, J., 2015. Financial inclusion-issues for central banks. *Bank for International Settlement Quarterly Review* (March), 83-96.

Mian, A., 2006. Distance constraints: The limits of foreign lending in poor economies. *The Journal of Finance*, 61(3), 1465-1505.

Mlachila, M., and Yabara, M., 2013. *Banking in Sub-Saharan Africa: the macroeconomic context*. Washington DC: International Monetary Fund.

Montfaucon, A., 2020. Increasing agricultural income and access to financial services through mobile technology in Africa: evidence from Malawi, in Osabuohien, E. ed., 2020. *The Palgrave handbook of agricultural and rural development in Africa*. Cham: Palgrave Macmillan, 247-262.

Mothobi, O. and Grzybowski, L., 2017. Infrastructure deficiencies and adoption of mobile money in Sub-Saharan Africa. *Information Economics and Policy*, 40, 71-79.

Musau, S., Muathe, S. and Mwangi, L., 2018. Financial inclusion, GDP and credit risk of commercial banks in Kenya. *International Journal of Economics and Finance*, 9(1), 202-218.

Mustafa, K. and Waheed, A., 2016. Impact of alternative factors on usage of telco-led branchless banking services: empirical evidence from Pakistan. *Journal of Internet Banking and Commerce*, 21(3) 1-19.

Muthinja, M. and Chipeta, C., 2018. Financial innovations, firm performance and the speeds of adjustment: new evidence from Kenya's banking sector. *Journal of Economic and Financial Sciences*, 11(1), 1-12.

Muthinja, M. and Chipeta, C., 2018. What drives financial innovations in Kenya's commercial banks? An empirical study on firm and macro-level drivers of branchless banking. *Journal of African Business*, 19(3), 385–408.

Muthiora, B., 2015. Enabling mobile money policies in Kenya: fostering a digital financial revolution. Groupe Speciale Mobile Association (GSMA) Mobile Money for the Unbanked. London: Groupe Speciale Mobile Association. Available: http://t1.daumcdn.net/brunch/service/user/P5W/file/mxAyGPsEeNdS1FAkt9vWxBJVHSg.pdf. Accessed on 14th January 2021.

Mutsonziwa, K. and Maposa, O., 2016. Mobile money-A catalyst for financial inclusion in developing economies: a case study of Zimbabwe using FinScope survey data. *International Journal of Financial Management*, 6(3), 45-56.

Mwando, S., 2013. Contribution of agency banking on financial performance of commercial banks in Kenya. *Journal of Economics and Sustainable Development*, 4(20), 26-35.

Naghavi, N., Shulist, J., Cole, S., Kendall, J. and Xiong, W., 2016. *Success factors for mobile money services: a quantitative assessment of success factors.* London: Groupe Speciale Mobile Association.

Neaime, S. and Gaysset, I., 2018. Financial inclusion and stability in MENA: evidence from poverty and inequality. *Finance Research Letters*, 24(1), 230-237.

Neuberger, D., 2015. Financial inclusion, regulation, and education in Germany. Asian Development Bank Institute Working Paper No 530. Available: http://www.adb.org/publications/financial-inclusion-regulation-and-education-germany/. Accessed on 1st April 2022.

Newson, R., 2010. Frequentist q-values for multiple-test procedures. *The Stata Journal*, *10*(4), 568-584.

Ng, P., Lit, K. and Cheung, C., 2022. Remote work as a new normal? The technology-organization-environment (TOE) context. *Technology in Society*, *70*, 102022.

Nickerson, D. and Sullivan, R., 2003. Financial innovation, strategic real options and endogenous competition: theory and an application to Internet banking. Federal Reserve Bank of Kansas City Payments System Research Working Paper No PSR WP, 3-01. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.175.7001. Accessed on 17 June 2021.

Nitsure, R., 2003. E-banking: Challenges and Opportunities. *Economic and Political Weekly*, 38 (51-52), 5377-5381.

Nkowani, Z., 2008. Supervision of banks and financial institutions in Malawi. *Malawi Law Journal*, 2(1), 67-84.

Nooteboom, B., 1994. Innovation and diffusion in small firms: Theory and evidence. *Small Business Economics*, 6(5), 327-348.

Ojede, A. and Yamarik, S., 2012. Tax policy and state economic growth: The long-run and short-run of it. *Economics Letters*, 116(2), 161-165.

Oliveira, T. and Martins, M., 2011. Literature review of information technology adoption models at firm level. *Journal of Information Systems Evaluation,* 14(1), 110-121.

Önder, Z. and Özyıldırım, S., 2019. Foreign banks and short-term macroeconomic fluctuations: Do financial development and regions matter? *Economic Systems*, 43(1), 63-76.

Ondiege, P., 2010. Mobile banking in Africa: taking the bank to the people. *Africa Economic Brief*, 1(8), 1-16.

Ondiege, P., 2015. *Regulatory impact on mobile money and financial inclusion in African countries-Kenya, Nigeria, Tanzania and Uganda*. Nairobi. Centre for Global Development. Available:https://www.cgdev.org/sites/default/files/Background-Paper-Financial-Inclusion-Ondiege.pdf. Accessed on 30th March 2022.

Orji, I., Ojadi, F. and Okwara, U., 2022. Assessing the pre-conditions for the pedagogical use of digital tools in the Nigerian higher education sector. *The International Journal of Management Education*, 20(2), 10-26. Available: https://doi.org/10.1016/j.ijme.. Accessed on 1 December 2022.

Oxford Policy Management, 2009. Supply side study of financial inclusion in Malawi. Johannesburg: FinMark Trust.

Owiti, C., and Datche, E., 2015. Strategic options adopted in agency banking and their influence on performance: a survey of commercial banks in Mombasa county -Kenya. *International Journal of Management Research and Business Strategy*, 4(3), 1-16.

Owoputi, J., Olawale, F. and Adeyefa, F., 2014. Bank specific, industry specific and macroeconomic determinants of bank profitability in Nigeria. *European Scientific Journal*, 10(25), 1-15.

Pattichis, C., 1999. Price and income elasticities of disaggregated import demand: results from UECMs and an application. *Applied Economics*, 31(9), 1061-1071.

Peachey, S. and Roe, A., 2006. *Access to finance: what does it mean and how do savings banks foster access*. Brussels: World Savings Banks Institute.

Pennings, J. and Harianto, F., 1992. The diffusion of technological innovation in the commercial banking industry. *Strategic Management Journal*, 13(1), 29-46.

Pesaran, M., 2006. Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, *74*(4), 967-1012.

Pesaran, M., Shin, Y. and Smith, R., 1996. Testing for the 'existence of a long-run relationship. Cambridge Working Papers in Economics No 9622. Faculty of Economics, University of Cambridge. Available: https://ideas.repec.org/p/cam/camdae/9622.html. Accessed on 11 March 2020.

Pesaran, M., Shin, Y. and Smith, R., 1999. Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, 94(446), 621-634.

Pesaran, M., Shin, Y. and Smith, R., 2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289-326.

Pesaran, M. and Smith, R., 1995. Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, 68(1), 79-113.

Philippon, T., 2016. The fintech opportunity. National Bureau of Economic Research Working Paper No w22476. Available: www.nber.org/system/files/working_papers/w22476/w22476. Accessed on 2 November 2021.

Phillips, P. and Sul, D., 2003. Dynamic panel estimation and homogeneity testing under cross section dependence. *The econometrics journal*, *6*(1), 217-259.

Phillips, P. and Sul, D., 2007. Bias in dynamic panel estimation with fixed effects, incidental trends and cross section dependence. *Journal of Econometrics*, *137*(1), 162-188.

Pikkarainen, K., Pikkarainen, T., Karjaluoto, H. and Pahnila, S., 2006. The measurement of end-user computing satisfaction of online banking services: empirical evidence from Finland. *International Journal of Bank Marketing*, 24(3),158-172.

Pizam, A., Ozturk, A.B., Balderas-Cejudo, A., Buhalis, D., Fuchs, G., Hara, T., Meira, J., Revilla, R.G.M., Sethi, D., Shen, Y. and State, O., 2022. Factors affecting hotel managers' intentions to adopt robotic technologies: A global study. *International Journal of Hospitality Management*, 102(1), 10-31.

Porteous, D., 2006. *The enabling environment for mobile banking in Africa*. Boston: Bankable Frontier Associates. Available: www.bankablefrontier.com. Accessed on 4th January 2021.

Raider, H., 1998. Market structure and innovation. *Social Science Research*, 27(1), 1-21.

Rees, J., Briggs, R. and Hicks, D., 1984. *New Technology in the American Machinery Industry: Trends and Implications; a Study*. US Government Printing Office.

Reinganum, J., 1981. Market structure and the diffusion of new technology. *The Bell Journal of Economics*, (Autumn), 618-624.

Reinganum, J., 1981. On the diffusion of new technology: a game theoretic approach. *The Review of Economic Studies*, 48(3), 395-405.

Reserve Bank of Malawi., 2021. *The registrar of financial institutions 2020 annual report*. Lilongwe: Reserve Bank of Malawi. Available: https://www.rbm.mw/Supervision/BankSupervision/. Accessed on 16 March 2022.

Robb, G. and Vilakazi, T., 2016. Mobile payments markets in Kenya, Tanzania and Zimbabwe: A comparative study of competitive dynamics and outcomes. *The African Journal of Information and Communication*, 17(1), 9-37.

Romer, C. and Romer, D., 1998. Monetary policy and the well-being of the poor. National Bureau of Economic Research Working Paper No 6793. Available: https://www.nber.org/system/files/working_papers/w6793/. Accessed on 1st April 2022.

Roodman, D., 2009. How to do xtabond2: an introduction to difference and system GMM in Stata. *The Stata Journal*, 9(1), 86-136.

Sahay, M., Cihak, M., N'Diaye, M., Barajas, M., Mitra, M., Kyobe, M., Mooi, M. and Yousefi, M., 2015. *Financial inclusion: can it meet multiple macroeconomic goals?* Washington DC: International Monetary Fund.

Sakariya, S., 2013. Evaluation of financial inclusion strategy components: reflections from India. *Journal of International Management Studies*, 13(1), 83-92.

Sakyi, D., 2011. Trade openness, foreign aid and economic growth in post-liberalisation Ghana: an application of ARDL bounds test. *Journal of Economics and International Finance*, 3(3), 146-156.

Saloner, G. and Shepard, A., 1995. Adoption of technologies with network effects: an empirical examination of the adoption of automated teller machines. *The RAND Journal of Economics*, 26(3). 479-501.

Salop. S., 1990. Deregulating self-regulated shared ATM networks. *Economics of Innovation and New Technology*, 1(1-2), 85-96.

Samargandi, N., Fidrmuc, J. and Ghosh, S., 2015. Is the relationship between financial development and economic growth monotonic? Evidence from a sample of middle-income countries. *World Development*, 68, 66-81.

Sapienza, P., 2004. The effects of government ownership on bank lending. *Journal of Financial Economics*, 72(2), 357-384.

Sarafidis, V. and Robertson, D., 2009. On the impact of error cross-sectional dependence in short dynamic panel estimation. *The Econometrics Journal*, *12*(1), 62-81.

Sarkar, J., 1998. Technological diffusion: alternative theories and historical evidence. *Journal of Economic Surveys*, 12(2), 131-176.

Sarma, M. and Pais, J., 2011. Financial inclusion and development. *Journal of International Development*, 23(5), 613-628.

Saunders, M., Lewis, P. and Thornhill, A., 2016. *Research methods for business students - 7th edition*. Harlow: Pearson education.

Saxena, D. and Anand, S., 2017. A study of the impact of technology based financial inclusion initiatives by Indian commercial banks to reach out to unbanked consumers of Delhi. *International Journal of Management, Banking and Finance,* 6(1), 1-13.

Scott, J., 2007. An e-transformation study using the technology-organization-environment framework. *Bled 2007 Proceedings*, 55.

Scott, W. and Christensen, S., 1995. *The institutional construction of organizations: International and longitudinal studies*. London: Sage Publications, Inc.

Segers, J., 1993. Strategic partnering between new technology-based firms and large established firms in the biotechnology and micro-electronics industries in Belgium. *Small Business Economics*, 5(4), 271-282.

Sengupta, R., 2007. Foreign entry and bank competition. *Journal of Financial Economics*, 84(2), 502-528.

Sharma, D., 2016. Nexus between financial inclusion and economic growth: evidence from the emerging Indian economy. *Journal of Financial Economic Policy*, 8(1), 13-36.

Sharma, S., 1993. Behind the diffusion curve: An analysis of ATM adoption. University of California Department of Economics Working Paper No 686, Available: http://www.econ.ucla.edu/workingpapers/wp686. Accessed on 12th August 2020.

Shehu, A., 2012. Promoting financial inclusion for effective anti-money laundering and counter financing of terrorism (AML/CFT), *Crime, Law and Social Change*, 57(3), 305-323.

Shen, C. and Lin, C., 2012. Why government banks underperform: a political interference view. *Journal of Financial Intermediation*, 21(2), 181-202.

Shleifer, A., 1998. State versus private ownership. *Journal of Economic Perspectives*, 12(4), 133-150.

Shleifer, A. and Vishny, R., 1994. Politicians and firms. *The Quarterly Journal of Economics*, 109(4), 995-1025.

Siedek, H., 2008. Extending financial services with banking agents. Consultative Group to Assist the Poor Brief. Washington DC: CGAP. Available: https://www.worldbank.org Accessed on 4th December 2018.

Sinha, R. and Chandrashekaran, M., 1992. A split hazard model for analysing the diffusion of innovations. *Journal of Marketing Research*, 29(1), 1-16.

Soederberg, S., 2013. Universalising financial inclusion and the securitisation of development. *Third World Quarterly*, 34(4), 593-612.

Srivastava, S. and Teo, T., 2006. Facilitators for e-government development: An application of the technology-organization-environment framework. *AMCIS 2006 Proceedings*. 285.

Stapleton, T., 2013. Unlocking the transformative potential of branchless banking in Indonesia. *Bulletin of Indonesian Economic Studies*, 49(3), 355–380.

Stiglitz, J., 2002. *Globalization and its discontents*. New York: Norton and Company.

Stiglitz, J., and Weiss, A., 1981. Credit rationing in markets with imperfect information. *The American Economic Review*, 71(3), 393-410.

Stock, G., Greis, N. and Fischer, W., 2002. Firm size and dynamic technological innovation. *Technovation*, 22(9), 537-549.

Stone, R., Grossman, J., Breul, P., Carpio, A. and Cabello, M., 2009. Trade in financial services: mobile banking in southern Africa. World Bank Policy Research Working Paper No 50975. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1485976. Accessed on 16 September 2021.

Stoneman, P., 1980. The rate of imitation, learning and profitability. *Economics Letters*, 6(2), 179-183.

Stoneman, P. and Ireland, N., 1983. The role of supply factors in the diffusion of new process technology. *The Economic Journal*, 93(1), 66-78.

Sullivan, R. and Wang, Z., 2020. Technology diffusion: the case of internet banking. *Economic Quarterly*, 106(1), 19-40. Available: https://www.richmondfed.org/-/media/richmondfedorg/publications/research/economic_quarterly/2020/. Accessed on 10 April 2022.

Sundararajan, V., Enoch, C., San Jose, A., Hilbers, P., Krueger, R., Moretti, M. and Slack, G., 2002. Financial soundness indicators: analytical aspects and country practices. International Monetary Fund Occasional Paper Volume 212. Washington DC: International Monetary Fund. Available: https://www.researchgate.net/profile/Charles-Enoch-2/publication/5120159_Financial_Soundness_Indicators_Analytical_Aspects_and_Country_Practices/links/. Accessed on 12 July 2021.

Suri, T. and Jack, W., 2016. The long-run poverty and gender impacts of mobile money. *Science*, 354(6317), 1288-1292.

Thakor, A., 2012. Incentives to innovate and financial crises. *Journal of Financial Economics*, 103(1), 130-148.

Thakor, A., 2020. Fintech and banking: what do we know? *Journal of Financial Intermediation*, 41, 100833. Available: https://doi.org/10.1016/j.jfi.2019.100833. Accessed on 23rd April 2022.

Thong, J., 1999. An integrated model of information systems adoption in small businesses, *Journal of Management Information Systems*, 15(4), 187–214.

Thorne, A., 1993. Eastern Europe's experience with banking reform: is there a role for banks in the transition? *Journal of Banking & Finance*, 17(5), 959-1000.

Thulani, D., Tofara, C. and Langton, R., 2009. Adoption and use of internet banking in Zimbabwe: an exploratory study. *Journal of Internet Banking and Commerce*, 14(1), 1-14.

Tirole, J., 1994. The internal organization of government. *Oxford Economic Papers*, 46(1),1-29.

Tornatzky, L., Fleischer, M. and Chakrabarti, A., 1990. *Processes of technological innovation*. Lanham: Lexington books.

Triki, T., Kouki, I., Dhaou, M. and Calice, P., 2017. Bank regulation and efficiency: what works for Africa? *Research in International Business and Finance*, 39, 183-205.

Tsionas, M. ed., 2019. *Panel data econometrics: empirical applications*. London: Academic Press.

Tsoka, M., 2006. *Competition scenario in Malawi*. Zomba: University of Malawi Centre for Social Research/Consumer Unity & Trust Society International. Available: https://cuts-ccier.org/pdf/CRR-Malawi.pdf. Accessed on 31st March 2022.

Tufano, P., 1989. Financial innovation and first-mover advantages. *Journal of Financial Economics*, 25(2). 213-240.

Tufano, P., 2003. Financial innovation, in Constantinides, G., Harris, M., and Stulz, R. eds., 2003. *Handbook of the economics of finance- Volume 1A corporate finance*. Amsterdam: Elsevier. 307-335.

Turkson, F., Amissah, E. and Gyeke-Dako, A., 2020. The role of formal and informal finance in the informal sector in Ghana. *Journal of Small Business & Entrepreneurship*, 34(3), 333-356.

Tushman, M. and Anderson, P., 2018. Technological discontinuities and organizational environments. In *Organizational Innovation* (345-372). Routledge.

Tushman, M. and Nadler, D., 1986. Organizing for innovation. *California management review*, 28(3), 74-92.

Vutsengwa, R. and Ngugi, K., 2013. An assessment of the challenges facing commercial banks in sustainability of agency banking in Kenya: a case of commercial banks. *International Journal of Economics and Finance*, 1(2), 613-620.

Wall, L., 2014. Two drivers of financial innovation. Federal Reserve Bank of Atlanta Notes from the Vault (4/6/2014). Available: www.frbatlanta.org/cenfis/pubscf/nftv_1402.cfm? Accessed on 1 September 2021.

Wang, Y., Li, H., Li, C. and Zhang, D., 2016. Factors affecting hotels' adoption of mobile reservation systems: A technology-organization-environment framework. *Tourism Management*, *53*, 163-172.

Wang, Y., Wang, Y. and Yang, Y., 2010. Understanding the determinants of RFID adoption in the manufacturing industry. *Technological Forecasting and Social Change*, 77(5), 803-815.

Wigley, S., 2017. The resource curse and child mortality, 1961–2011. *Social Science & Medicine*, 176, 142-148.

Willis, R., Marshall, J. and Richardson, R., 2001. The impact of 'Branchless banking' on building society branch networks. *Environment and Planning A: Economy and Space,* 33(8), 1371-1384.

Wooldridge, J.M., 2009. *Introductory econometrics: a modern approach- 6th edition.* Boston: Cengage Learning.

World Bank, 2008. *Global development finance 2008 Vol I Review, analysis, and outlook*. Washington DC: World Bank.

World Bank, 2014. *Global Financial Development Report: Financial Inclusion*. Washington DC: World Bank.

World Bank, 2021. *Malawi Economic Monitor, June 2021: Investing in Digital Transformation*. Washington DC: World Bank.

Wu, J., Chen, M., Jeon, B. and Wang, R., 2017. Does foreign bank penetration affect the risk of domestic banks? Evidence from emerging economies. *Journal of Financial Stability*, 31, 45-61.

Yeh, C., Lee, G. and Pai, J., 2015. Using a technology-organization-environment framework to investigate the factors influencing e-business information technology capabilities. *Information Development*, 31(5), 435-450.

Yiu, C., Grant, K. and Edgar, D., 2007. Factors affecting adoption of internet banking in Hong Kong - Implications for the banking sector. *International Journal of Information Management,* 27(5), 336-351.

Zaffar, M., Kumar, R. and Zhao, K., 2019. Using Agent-based modelling to investigate diffusion of mobile-based branchless banking services in a developing country. *Decision Support System,* 117, 1-13.

Zhu, K., Kraemer, K. and Xu, S., 2003. Electronic business adoption by European firms: A cross-country assessment of the facilitators and inhibitors. *European Journal of Information Systems*, 12(4), 251-268.

Zhu, K., Kraemer, K. and Xu, S., 2006. The process of innovation assimilation by firms in different countries: A technology diffusion perspective on e-business. *Management Science*, 52(10), 1557-1576.

Zhu, X., Zhu, W., Ding, S. and Shu, W., 2013. The impact of financial development on China's economic growth-An empirical study. *Pakistan Journal of Statistics,* 29(6), 1141-1152.

Zins, A. and Weill, L., 2016. The determinants of financial inclusion in Africa. *Review of Development Finance, University of Cairo,* 6(1), 46-57.

Appendix

Appendix 3.1: Correlation matrix for ATM banking data among banks

	ATM 1	ATM 2	ATM3	ATM4	ATM5	ATM6	ATM7	ATM8	ATM9	ATM10	ATM11	ATM12	ATM13
ATM1	1.00												
ATM2	0.10	1.00											
ATM3	0.22	-0.02	1.00										
ATM4	-0.46*	-0.06	-0.14	1.00									
ATM5	-0.34	-0.17	-0.07	-0.03	1.00								
ATM6	-0.31	0.22	-0.27	0.06	0.01	1.00							
ATM7	0.37*	-0.07	0.43*	0.42*	-0.13	-0.07	1.00						
ATM8	0.04	0.11	0.60*	-0.28*	0.05	0.30	-0.24*	1.00					
ATM9	0.19	0.03	-0.29*	-.0.53*	0.13	0.02	-0.36*	0.03	1.00				
ATM10	0.30	0.25*	0.12	-0.10	-0.11	0.12	0.14	0.17	0.03	1.00			
ATM11	0.05	0.08	0.41*	-0.74*	0.21	0.04	-0.73*	0.30	0.52*	-0.03	1.00		
ATM12	-0.01	-0.06	0.41*	0.05	0.10	-0.02	0.14	-0.05	-0.11	0.01	-0.16	1.00	
ATM13	-0.08	0.02	-0.47*	-0.64*	0.11	0.01	-0.68*	0.08	0.68*	0.03	0.72	-0.30	1.00

** Denote significance level at 0.05. In line with Data Provider Agreement, each bank has been represented by a number to conceal identity. In this sense, atm1 represents ATM data for bank 1.*

Appendix 3.2: Correlation matrix for agent banking data among banks

	Agent1	Agent2	Agent3	Agent4	Agent5	Agent6	Agent7	Agent8	Agent9	Agent10	Agent11	Agent12	Agent13
Agent 1	1.00												
Agent 2	-	-											
Agent 3	-0.64*	-	1.00										
Agent 4	-0.28	-	0.17	1.00									
Agent 5	-	-	-	-	-								
Agent 6	-0.55*	-	0.33*	0.01	-	1.00							
Agent 7	-0.21	-	0.06	-0.07	-	-0.29*	1.00						
Agent 8	-0.36*	-	0.22	0.09	-	-0.12	-0.13	1.00					
Agent 9	0.61*	-	-0.33	0.09	-	-0.25*	-0.01	-0.25*	1.00				
Agent 10	-	-	-	-	-	-	-	-	-	-			
Agent11	0.08	-	-0.07	0.05	-	-0.06	0.13	0.04	0.13	-	1.00		
Agent12	0.30	-	0.09	-0.28*	-	-0.23	0.25	-0.19	0.31*	-	-0.16	1.00	
Agent13	0.29	-	-0.36*	0.23*	-	-0.07	0.7	0.21	-0.24*	-	0.11	-0.23	1.00

** Denote significance levels at 0.05. In line with Data Provider Agreement, each bank has been represented by a number to conceal identity. In this sense, agent1 represents agent banking data for bank 1.*

Appendix 3.3: Correlation matrix between ATM and agent banking innovations by bank

	atm1	agent1
atm1	1.0000	
agent1	0.0049	1.0000

	atm3	agent3
atm3	1.0000	
agent3	0.4497*	1.0000

	atm4	agent4
atm4	1.0000	
agent4	0.1572	1.0000

	atm6	agent6
atm6	1.0000	
agent6	0.0101	1.0000

	atm7	agent7
atm7	1.0000	
agent7	0.4313*	1.0000

	atm8	agent8
atm8	1.0000	
agent8	0.3633*	1.0000

	atm9	agent9
atm9	1.0000	
agent9	-0.2530*	1.0000

	atm11	agent11
atm11	1.0000	
agent11	-0.0793	1.0000

	atm12	agent12
atm12	1.0000	
agent12	-0.1783	1.0000

	atm13	agent13
atm13	1.0000	
agent13	0.0198	1.0000

* *Denotes significance level at 0.05. In line with Data Provider Agreement, each bank has been represented by a number to conceal identity. In this sense, atm1 represents atm banking data for bank 1*

Appendix 3.4: Correlation matrix between internet and mobile phone banking innovations by bank

	ib2	mobile2
ib2	1.0000	
mobile2	0.1100	1.0000

	ib3	mobile3
ib3	1.0000	
mobile3	-0.1001	1.0000

	ib4	mobile4
ib4	1.0000	
mobile4	-0.1838	1.0000

	ib5	mobile5
ib5	1.0000	
mobile5	0.0402	1.0000

	ib6	mobile6
ib6	1.0000	
mobile6	-0.2021	1.0000

	ib8	mobile8
ib8	1.0000	
mobile8	0.5576*	1.0000

	ib9	mobile9
ib9	1.0000	
mobile9	0.3497*	1.0000

	ib10	mobile10
ib10	1.0000	
mobile10	0.1430	1.0000

	ib11	mobile11
ib11	1.0000	
mobile11	-0.1941	1.0000

	ib12	mobile12
ib12	1.0000	
mobile12	-0.0613	1.0000

	ib13	mobile13
ib13	1.0000	
mobile13	-0.0233	1.0000

** Denotes significance level at 0.05. In line with Data Provider Agreement, each bank has been represented by a number to conceal identity. In this sense, mobile1 represents mobile phone banking data for bank 1*

Appendix 3.5: Correlation matrix for internet banking data among banks

	IB1	IB2	IB3	IB4	IB5	IB6	IB7	IB8	IB9	IB10	IB11	IB12	IB13
IB1	1.00												
IB2	0.16	1.00											
IB3	-0.40*	-0.05	1.00										
IB4	-0.15	-0.03	0.24	1.00									
IB5	-0.12	-0.04	0.34	-0.01	1.00								
IB6	-0.03	-0.22	0.00	-0.04	-0.21	1.00							
IB7	0.17	0.11	0.07	-0.02	-0.01	0.02	1.00						
IB8	-0.01	0.04	-0.11	-0.27*	-0.01	0.11	-0.14	1.00					
IB9	0.26	-0.16	-0.21	0.09	-0.03	-0.15	-0.08	-0.19	1.00				
IB10	0.42*	-0.12	0.03	-0.16	0.29	-0.05	-0.24	0.34*	0.34	1.00			
IB11	0.23	-0.16	-0.28	0.04	-0.05	0.21	-0.14	-0.10	0.17	0.07	1.00		
IB12	0.16	-0.05	0.06	-0.02	0.14	-0.18	0.20	0.25	-0.39	0.10	-0.01	1.00	
IB13	-0.14	-0.05	-0.47*	-0.19	0.11	0.13	-0.06	0.49	-0.41	-0.17	0.11	0.14	1.00

** Denotes significance level at 0.05. In line with Data Provider Agreement, each bank has been represented by a number to conceal identity. In this sense, IB1 represents internet banking data for bank 1*

Appendix 3.6: Correlation matrix for mobile phone banking data among banks

	MB 1	MB 2	MB3	MB4	MB5	MB6	MB7	MB8	MB9	MB10	MB11	MB12	MB13
MB1	-												
MB2	-	1.00											
MB3	-	0.00	1.00										
MB4	-	-0.04	0.25	1.00									
MB5	-	-0.05	-0.01	0.06	1.00								
MB6	-	0.36*	0.08	0.14	-0.01	1.00							
MB7	-	-	-	-	-	-	-						
MB8	-	0.54*	0.14	0.14	-0.27	0.04	-	1.00					
MB9	-	0.15	0.40*	0.55	0.21	0.08	-	0.27	1.00				
MB10	-	0.25	0.31*	0.02	0.17	0.15	-	0.42*	0.08	1.00			
MB11	-	-0.04	-0.14	-0.03	0.31	0.20	-	-0.03	-0.04	-0.12	1.00		
MB12	-	-0.45	-0.11	0.20	-0.25	-0.01	-	-0.59*	-0.01	-0.20	-0.28	1.00	
MB13	-	0.23	-0.07	0.20	-0.07	-0.07	-	0.16	-0.01	0.20	-0.07	0.22	1.00

** Denote significance level at 0.05. In line with Data Provider Agreement, each bank has been represented by a number to conceal identity. In this sense, MB1 represents mobile banking data for bank 1*

Appendix 4.1 Pooled least square estimation results for the drivers of adoption of BBI

	PHYSICAL BBI		REMOTE BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile phone Banking
Bank size	4.64*** (0.32)	-0.72** (0.26)	9.27*** (0.42)	3.00*** (0.54)
Bank technology	0.21*** (0.06)	0.65*** (0.14)	0.29* (0.14)	-0.26 (0.21)
Branch intensity	0.64*** (0.07)	1.03*** (0.07)	0.04 (0.05)	2.64*** (0.08)
Retail portfolio	0.02 (0.03)	0.15*** (0.03)	-0.09** (0.03)	0.09 (0.08)
Bank funding	-0.21*** (0.21)	-0.7* (0.04)	0.10** (0.04)	-0.48*** (0.06)
Market concentration	0.32*** (0.10)	-0.06 (0.08)	0.44** (0.16)	-0.01 (0.06)
Regulation	-2.17*** (0.60)	0.38 (0.45)	-3.01*** (0.88)	0.50 (0.50)
Macro technology	-0.43* (0.22)	0.47* (0.23)	-0.94** (0.37)	0.20 (0.15)
Constant	8.44 (8.39)	2.29 (7.46)	-15.21 (14.34)	6.69 (7.55)
Observations	891	648	785	547
Groups	13	10	13	11

*Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Appendix 4.2 FE estimation results for the drivers of adoption of BBI

	PHYSICAL BBI		REMOTE BBI	
	ATM Banking	Agent Banking	Internet Banking	Mobile phone Banking
Bank size	-0.24 (0.18)	0.26 (0.22)	0.20 (0.22)	3.00*** (0.54)
Bank technology	-0.09* (0.05)	-0.17** (0.06)	0.06 (0.07)	-0.26 (0.21)
Branch intensity	0.12* (0.06)	-0.01 (0.08)	-0.07 (0.05)	2.64*** (0.08)
Retail portfolio	0.10*** (0.02)	0.03 (0.03)	0.02 (0.03)	0.09 (0.08)
Bank funding	-0.01 (0.02)	0.02 (0.02)	0.01 (0.02)	-0.48*** (0.06)
Market concentration	-0.01 (0.03)	-0.07** (0.02)	-0.08** (0.03)	-0.01 (0.06)
Regulation	0.27 (0.20)	0.70*** (0.16)	0.79*** (0.22)	0.50 (0.50)
Macro technology	0.02 (0.07)	0.12 (0.07)	-0.04 (0.05)	0.20 (0.15)
Constant	16.36*** (2.67)	18.92*** (2.25)	16.48*** (3.00)	6.69 (7.55)
Observations	891	655	785	547
Groups	13	10	13	11

*Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*