Journal of Economic and Financial Sciences
ISSN: (Online) 2312-2803, (Print) 1995-7076

Financial innovation, firm performance and the speeds of adjustment: New evidence from Kenya's banking sector

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Dates:
Received: 01 May 2017
Accepted: 09 Nov. 2017
Published: 28 June 2018

How to cite this article:
Muthinja, M.M. & Chipeta, C., 2018, 'Financial innovation, firm performance and the speeds of adjustment: New evidence from Kenya's banking sector', *Journal of Economic and Financial Sciences* 11(1), a158. http://dx.doi.org/10.4102/jef.v11i1.158

This article examines the speed of adjustment of firm performance to financial innovations usage and the speed of adjustment of financial innovation to financial innovation drivers for banks in Kenya. We used the Koyck distributed lag model, which is estimated using dynamic panel estimation with System Generalised Method of Moments. We find that it takes on average 1.179 years for bank financial performance to adjust to the four financial innovations studied. Secondly, it takes less than a year (0.368 years) to accomplish 50% of the total change in firm performance following a unit-sustained change in the financial innovations. Moreover, mobile banking has the shortest mean lag (2.849), while Automated Teller Machines (ATMs) have the longest mean lag (4.926). Notably, it takes approximately three years for mobile banking to adjust to financial innovation drivers at firm level and on average five years for ATMs to adjust to the financial innovation drivers.

Introduction

The last decade has witnessed growing interest in innovation studies in general and financial innovations in particular. Financial innovation is the act of creating and popularising new financial instruments and new financial technologies, institutions and markets (Tufano 2003). Financial innovations have been placed in two categories, namely product innovations such as new financial instruments and process innovations such as new ways of dispensing financial products, executing transactions or transaction pricing (Frame & White 2004; Lerner 2006; Tufano 2003).

The origin of economic thought which sees innovation as a determinant of economic performance is credited to Schumpeter (1934), whose study of innovation is a 'landmark initial contribution to economic literature. Schumpeter argues that the successful introduction of products, processes as well as organisational innovations enables firms to supersede the existing industries as well as markets. These companies finally grow to attain significant market share at the expense of the less innovative firms. Innovation may be carried out by existing or new firms. However, new innovators are likely to penetrate a sector at the same time, a situation that would cause them to either grow or exit over time (Malerba & Orsenigo 1997). This exit over time is explained in the later work of Schumpeter (1942:83) as 'creative destruction', defined as the process of industrial mutation that continually revolutionises the economic structure from within, constantly destroying the old one and continuously creating a new one. In the context of innovations, Schumpeter argues that creative destruction refers to the incessant product and process innovation mechanism by which new production units replace outdated ones. Schumpeter contends that innovation enables a firm to build monopolistic rent, which tends to decline as new products and processes imitate the innovation.

Historically, financial innovations have been described as '… one of the bedrocks of our financial system and the life blood of efficient and responsive capital markets…' (Horne 1985:621). The truth of this statement is underlined in Kenya's financial markets, where innovations in mobile money have propelled the country to fifth position globally and the highest ranking in Africa (EIU 2012). The ranking by the Economist Intelligence Unit Global microfinance survey attributes Kenya's ranking to her global leadership and pioneering in mobile banking services. In addition to mobile banking innovations, Kenya has a robust network of agency banking agents contracted by a number of leading commercial banks. Moreover, many banks have adopted Internet banking and installed a number of Automated Teller Machines (ATMs) across the country. In general, these innovations amount to a departure from the traditional branch-based banking commonly referred to as 'brick and mortar' banking. The country's leadership in mobile money innovations has stimulated research curiosity in the field of financial innovations. However, the research efforts appear fragmented in the sense that most studies focus on individual types of branchless banking such as mobile money, agency banking, Internet banking and ATM banking.

Although it is broadly acknowledged that innovation and technological change are major drivers of economic growth, which give competitive edge to firms, most of the literature has focused on innovation in the manufacturing sector (Cainelli, Evangelista & Savona 2006; Djellal, Gallouj & Miles 2013). Consequently, innovation in services remains under-researched by innovation analysts (Hipp & Grupp 2005; Tether 2003). However, a number of studies have focused on the role of services innovation in general and financial services innovation in particular (Miles 1993; Miles et al. 1995; Rybinski 2016). These studies find considerable contribution of innovation in services to modern economies in relation to their employment output and input to other sectors of the economy. For example, Frame and White (2004) conclude that the adoption and spread of an innovation or its diffusion across an industry is important and that faster innovation diffusion leads to higher returns to the society associated with investments in innovations. It would be expected, therefore, that firms which adopt and use financial innovations would have better financial results or generally outperform the non-innovating firms as well as firms which do not adopt financial innovations.

Generally, financial innovation generates value to firms. However, most studies have not empirically established what exactly drives financial innovation at both firm and macro levels. This is documented in Frame and White's (2004; 2014) extensive review of literature spanning a number of years, which paints a grim picture with regard to the paucity of empirical studies on financial innovation. Importantly, Jiménez-Jiménez and Sanz-Valle (2011) find a positive connection between innovation and firm performance whereby bigger and older firms in the manufacturing sector display a higher strength of the link between innovation and firm performance than other firms. Innovation in services therefore has a major role to play in financial performance of firms. For instance, an empirical study of Norwegian manufacturing firms observes significant contribution of service innovation to higher operating results of manufacturing firms than their peers (Aas & Pedersen 2011).

There is notable dearth of studies on the speed of adjustment of financial innovation to financial innovation drivers. The implication of this finding is that if the speed of adjustment is unknown, the management and the research community lack empirical evidence on which of the financial innovation drivers (firm or macro level drivers) are more important in spurring financial innovations. Moreover, there is lack of empirical evidence on the speed at which firm financial performance adjusts to financial innovation usage. In the absence of the knowledge on the speed of adjustment, it is difficult or impossible to know the time lag between the adoption and usage of financial innovation and the resultant effect on firm financial performance. In this article, we test the speed of adjustment of firm performance to financial innovation as well as the speed of adjustment of financial innovation to financial innovation drivers at both firm and macro levels.

The rest of the article is organised as follows: literature review, data and methodology, results and discussion, conclusion and directions for further research and lastly the references.

Literature review

The speed of innovation, magnitude of innovation and the speed of adjustment

Innovation studies have in the past focused on the speed and magnitude of innovation. Conversely, it appears there is no consensus in the research community with regard to the computation of the speed of innovation as well as the magnitude of innovation. Innovation speed shows how fast a firm, relative to other firms in the industry, adopts either process or product innovation (Gopalakrishnan 2000). Innovation speed can also be defined as the time taken between initial product development and introduction of the product to the market (Kessler & Chakrabarti 1996; Vesey 1991). Innovation speed may explain variations in the magnitude of innovation usage across firms. For instance, Rogers (1983) argues that innovation speed is an indicator of a firm's quickness in adopting a product or process innovation relative to its competitors in the industry. Although the speed of innovation has a positive link to firm financial performance, studies have shown that the link is bidirectional. For example, Gopalakrishnan's (2000) study of innovation speed relative to other firms operating in the industry observes reverse causality between the speed of innovation and financial performance as measured by return on assets (ROA). In addition, the study finds that higher profitability in an earlier time period facilitates speedy innovation, while speedy innovation leads to higher financial performance in the current time period.

In order to increase innovation speed, firms need to make proper use of market intelligence and assign the responsibility of promoting the innovation to an influential person in the company. This is because fast response to market intelligence achieves the greatest impact with regard to innovation speed and new product performance (Carbonell & Rodríguez-Escudero 2010). In addition, the influential champion should promote the usage of the innovations as the champion is seen as the only significant positive factor necessary for faster innovation speed (Allocca & Kessler 2006). Nevertheless, such a champion would only optimise performance where there is top management support, clarity of goals and speed-based rewards (Carbonell & Rodríguez-Escudero 2009). Carbonell & Rodríguez-Escudero see these as central in building conditions that increase innovation speed, especially in an environment of high technological instability.

A number of empirical studies have focused on the speed of innovation and its impact on firm financial performance.

For instance, Allocca and Kessler's (2006) study of 158 projects in a number of technology-related industries apply a conceptual model of innovation speed for small and medium-sized enterprises (SMEs). The study finds that with respect to organisational capability and staffing-related factors, the only statistically significant positive factor for innovation speed is an influential champion of the innovation. Allocca and Kessler's (2006) findings are supported by Carbonell and Rodríguez-Escudero's (2009) work on 183 new product projects, which shows that the support of the top management coupled with the clarity of goals are critical for innovation speed. Innovation speed has been operationalised using five variables: a firm's quickness in generating novel ideas, launch of new products, new processes, new product development and new ways of solving problems relative to competition (Liao, Wang, Chuang, Shih & Liu 2010; Wang & Wang 2012). Using these five variables, Wang and Wang (2012) examined the effects of innovation speed on both operational performance and financial performance. Their empirical hypotheses tests confirm that innovation speed is positively linked to both firm operational performance and firm financial performance.

The magnitude of innovation refers to the quantity of innovations of any type adopted by a firm within a period of time (Gopalakrishnan 2000). It is represented by the number of new products or newly developed processes by a firm. According to Gopalakrishnan (2000), to determine the magnitude of innovation, one needs to aggregate the total number of new products, processes and practices adopted by a firm as a proportion of total innovations. Gopalakrishnan finds that increased firm performance in the form of profitability is associated with a high magnitude of innovation score and that the scores increase with increased focus on innovation magnitude. The implication of these studies is that although innovation generally leads to firm financial performance, the speed and magnitude of innovation is also critical and that the role of management is seen as crucial in determining the speed and magnitude of innovation.

Although the speed and magnitude of innovation is important, studies using a positivist approach would find it challenging getting data which can be used in running regression models. Consequently, recent innovation studies have focused more on the speed with which the dependent variable (innovation) adjusts to changes in independent variables (German-Soto & Flores 2015). The speed at which firm performance (dependent variable) adjusts to financial innovations (independent variable) can therefore be determined using Koyck's (1954) mean and median lags. In addition, the speed at which financial innovation (dependent variable) adjusts to financial innovation drivers (independent variables) can also be computed using the mean and median lags. The mean and median lags are discussed in more detail in the 'Data and methodology' section.

Theoretical framework

There is need to identify an appropriate framework to be able to study the drivers of financial innovation and the contribution of financial innovation to firm performance. The appropriate framework should be able to explain the relationships between variables which affect financial innovation and the variables which affect firm performance. We argue that the technology-organisation-environment (TOE) framework is appropriate for this study.

Technology-organisation-environment framework

The study of the adoption and usage of technological innovations can be performed using the TOE framework (Tornatzky & Fleischer 1990). According to these authors, factors in the environmental and organisational context coupled with the technology itself fundamentally affect technological innovation adoption decisions. The TOE framework shows how the adoption and implementation of innovations is affected by the firm context (Baker 2011). The TOE framework entails a threefold context for adopting and implementing technological innovations: technological, organisational and environmental contexts (Wang, Wang & Yang 2010).

Technological context

Technological context refers to technologies relevant to the firm, including technologies already being used by the firm and the ones not in current use but available in the market (Baker 2011). Advancement in electronic payments has led to the emergence of electronic money (e-money), which can be transferred through cell phones. For instance, Hughes and Lonie (2007) link the M-Pesa money transfer in Kenya to e-money technology. For a firm to be able to adopt and use new technologies, its current information and communication technology (ICT) infrastructure must have the ability and capacity to adopt and use the new innovations. A firm which possesses superior technologies will have an advantage over the firm that uses outdated hardware and software. The speed of adoption between two firms may vary depending on the quality and quantity of the ICT infrastructure they use. According to Collins, Hage and Hull (1988), technologies currently used by the firms are important in the adoption process as they define the limit on the scope and pace of a firm's technological change adopted. Technologies currently being used by the firm should be compatible with the new innovations for the firm to be able to fully exploit the potential of the new innovations. More importantly, technological context refers to not only the internal but also the applicable firm's external technologies (Oliveira & Martins 2011).

Technological innovations are prone to network externalities, where the value of the product to one user is largely dependent on how many others are using similar products. The implication of network effects or externalities is that the firm should consider owning or using technologies that are widely used in the market. This is important because of service costs and replacement of parts. A firm needs to have not only hardware and software but also a high-speed and reliable Internet connection to be able to connect to other firms. This is critical especially for a provider of financial innovation products such as online banking. Koellinger's (2008) analysis of the link between the use of Internet-based technologies, innovation types and firm-level performance finds that Internet-based technologies are critical in enabling the adoption of innovation. Technological context should be considered at both firm and macro levels. At macro level the role of the state in providing telecommunications infrastructure such as fibre-optic cable networks and licensing of 4G networks is critical in adoption of technological innovations in general and financial innovations in particular. The state also plays a critical role in providing a regulatory and legal framework that guides the usage and adoption of the innovations as well as the enforcement of (digital) contracts. Technologies available at macro level enable firms to create linkages which broaden the network adopting the innovations. As the network attains a critical mass, the value of the financial innovation to each individual firm increases with positive implications on the firm's financial performance.

Organisational context

The context of an organisation or a firm to a large extent determines the adoption and usage of innovations by that firm. Firms are generally heterogeneous in many respects. For example, firms have different resource endowment in terms of assets, human capital, networks and surplus resources available for adoption of innovations. Organisational context relates to measures that describe a firm, including the scope, firm size and the structure of management (Oliveira & Martins 2011). Additionally, organisational context includes characteristics and the resources a firm controls, such as the linkages between employees, communications within the firm and the level or degree of a firm's slack resources (Baker 2011). A number of studies have attempted to link firm size to innovation, but the literature on innovation is divided on the role of firm size to innovation adoption and usage. For instance, Rogers (1995) opines that firm size is a 'surrogate' measure of a number of dimensions which collectively lead to innovations, namely aggregate resources, technical expertise of employees and slack resources.

Large firm size may not necessarily imply higher innovation adoption or usage. Larger firms are likely to have fragmented and incompatible systems which could increase complexity and cost of adoption (Zhu, Kraemer & Xu 2006). As firms expand their customer bases, increase the number of personnel, open new branches and enter into new mergers and partnerships, the linkages become more and more complex. Nevertheless, Tushman and Nadler (1986) observe that innovation is promoted by mechanisms that connect organisations' internal subunits or go beyond internal boundaries. Complex business processes, deep-rooted organisational structure and the hierarchy of decision-making could further complicate the changes in structures and processes in large firms (Zhu 2004). The end result of this complexity is slow decision-making or suboptimal decisions regarding investment in innovations. Notwithstanding the fact that the debate on the role of organisational context in the adoption and usage of innovations appears inconclusive, a significant number of studies have found a link between firm context and innovations (Frame & White 2004; Lerner & Tufano 2011; Tufano 2003). We strongly suggest that in view of the reviewed literature, firm context has a relationship with the adoption and usage of financial innovations.

Environmental context

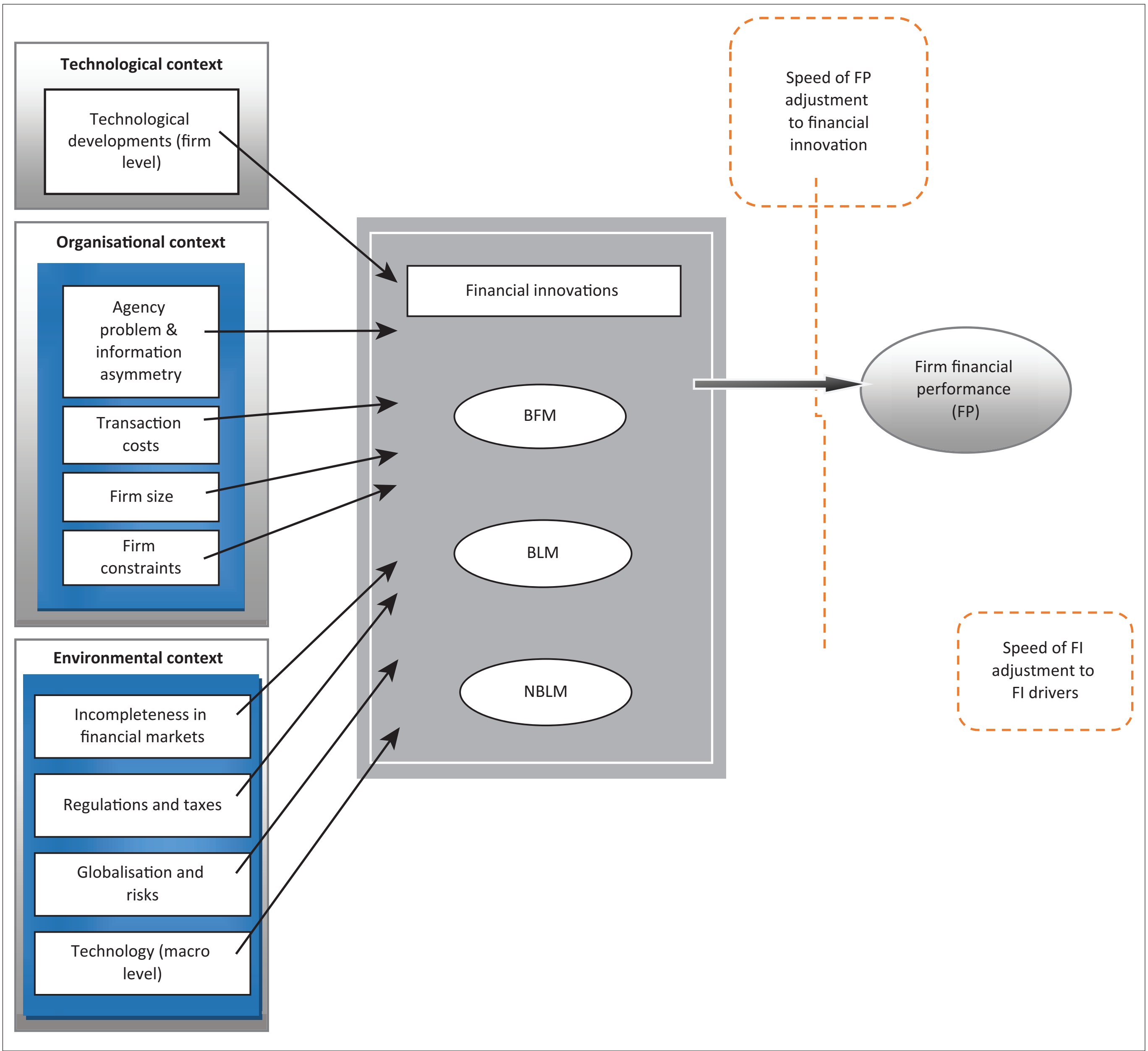
This is the stage where a firm does business, comprising its industry, competition and government dealings (Oliveira & Martins 2011). In addition, environmental context encompasses industry structure, availability or non-availability of technology service providers and the environment of government regulation (Baker 2011). According to Baker, privacy laws requiring banks not to disclose their customer data could hinder banks from developing technologies which could enable customers access their accounts easily. Baker argues that government regulation could either increase or reduce the cost of innovations. The environment within which firms operate creates opportunities and threats to their innovation adoption and usage efforts. For example, regulation and taxes deemed supportive of financial innovations at firm level are likely to spur innovation adoption and usage. The type of innovations a firm adopts must be compatible with the innovations or technologies in use by the industry. This is necessary because in the case of a bank which wants to adopt technologies for enabling funds transfer, it must consider the compatibility of the system to the systems in use by the other banks; otherwise transfer transactions will not be executed. Financial innovations literature has identified three main environmental factors encouraging the development of financial innovations: regulation and taxes, globalisation, and risks and incompleteness in financial markets (Boyer 2000; Calomiris 2009; Tufano 2003). In addition, regulations and taxes have led to the development of financial innovations designed to sidestep regulatory restrictions on individuals' financial activities (Calomiris 2009). Globalisation environment exposes firms to foreign exchange risks, interest rate risks, political risks and transaction exposure risks (Boyer 2000). According to Lütz (1998), governments in the 1970s allowed financial innovations to increase through the elimination of foreign exchange controls.

Financial innovation value model

Using the TOE framework, Zhu and Kraemer (2005:66) developed '… an integrated model of E-business use and value …' to study post-adoption variations in usage and value of e-business by organisations. Although Zhu and Kraemer's work represents a major step in the study of e-business innovations, the weaknesses of the model are identified and corrected by Salwani et al. (2009). Salwani et al. integrated the TOE framework with e-commerce usage and linked them to business performance. The study graphically demonstrates how TOE affects e-commerce usage and how e-commerce usage leads to business performance. Salwani et al. referred to their framework as *E-Value model*, highlighting the value a business generates from the use of e-commerce. According to the model, the business performance arising from e-commerce usage is moderated by e-commerce experience.

Building on Tornatzky and Fleischer's (1990) TOE model, Zhu and Kraemer's (2005) 'integrated model of E-business use and value' and Salwani et al.'s (2009) 'E-Value model', we developed a 'Financial innovation value model' (see Figure 1). This model shows the value a firm generates from the continued use of financial innovations. The value is in the form of increased financial performance represented by adjusted return on equity (ROE) and return on assets (ROA). Based on the reviewed literature, financial innovation is driven by factors at both firm and environmental (macro) levels. It is, therefore, plausible to study financial innovation drivers using the TOE framework. The financial innovation value model links financial innovation drivers at firm and macro levels to financial innovation and financial innovation is linked to firm financial performance. The model demonstrates that financial innovation leads to firm financial performance, but the extent of the financial performance is moderated by the speed at which financial performance adjusts to financial innovation usage.

The financial innovation value model in Figure 1 maps out the variables used in this article and their relationship to each other. The conceptual model is developed with reference to the TOE framework. In the technological and organisational context, the literature has identified nine drivers of financial innovation. These include: technological developments at firm level, agency problems and information asymmetry; transaction costs, firm size and firm constraints; incomplete financial markets, regulation and taxes; globalisation and risk and technological developments at macro level. We argue that TOE provides the theoretical framework for explaining the value of financial innovation adoption and usage by firms. A



BFM, Bank focused model; BLM, Bank led model; NBLM, Non-bank led model; FI, Financial innovation; FP, Financial performance.
FIGURE 1: Financial innovation value model.

combination of technological, environmental and organisational factors significantly affects technological innovation adoption and usage decisions at firm level. The financial innovation value model in Figure 1 encapsulates the drivers of the three financial innovations in the form of branchless banking models. The branchless banking models include: bank-focused model, bank-led model and non-bank-led model. The models enable customers to enjoy banking services from remote locations without having to visit physical bank branches. Bank-focused model entails the use of ATMs and Internet banking for cash deposits, cash withdrawals and bank statements, among other services. Secondly, bank-led models use third parties or licensed bank agents to serve customers with the help of point-of-sale terminals. Bank agents are paid commissions for services offered to the bank customers but are not employees of the bank. Lastly, non-bank-led models use mobile phone technologies and electronic money (e-money) to carry out an array of banking services without requiring a customer to have a bank account with a commercial bank.

The adoption and usage of financial innovation generates value to the firm in the form of an increase in firm financial performance. We argue that, firstly, the value generated from the usage of financial innovations depends on the speed at which firm financial performance adjusts to financial innovations. Secondly, the value generated is dependent on the speed at which financial innovation responds to financial innovation drivers. For instance, some firms are early adopters while others are laggards or late adopters. The speed of adjustment or adoption shows how fast a firm relative to other firms in the industry adopts either process or product innovations. Although the adoption of innovation is critical in generating value to a firm, it is the usage of the financial innovations that ultimately pays off. The development of financial innovation value model therefore represents key original extension of methodologies used in the study of financial innovations. Although the model has been contextualised to Kenya, it can be used in the study of different financial innovations in other countries, especially with regard to financial innovations which are technology driven and technology dependent.

Data and methodology

Data sources and variables

We used secondary data extracted from financial statements of the commercial banks under study and largely downloaded from Bankscope. We collected other secondary data from individual bank's websites, Kenya's Capital Markets Authority, bank supervision reports of the Central Bank of Kenya (CBK) as well as the CBK annual reports, The World Bank, Communication Authority of Kenya (CAK), Kenya National Bureau of Statistics, International Telecommunications Union (ITU) and the World Bank Development Indicators. The study encompassed all of Kenya's locally and foreign-owned commercial banks except one of the banks under statutory management. The population size comprised 42 out of the 43 commercial banks. The definitions of the variables used in this article are summarised in Table 1.

Model specification

We test the speeds of adjustment on the three econometric models. The first model examines the speed of adjustment of bank performance with respect to the financial innovation variables discussed in Table 1. We argue that the effect of financial innovation on firm performance is lagged for a number of reasons. Firstly, it takes time before financial innovation capital outlay can have a significant effect on firm financial performance, meaning the effect is time lagged. Secondly, financial innovation capital outlay can be quite substantial, effectively prolonging the payback period. Thirdly, the time lag can be explained by the network effect or externality which arises where the number of other users of the same product determines the value of the product to one user (Katz & Shapiro 1986). Organisations have a tendency to wait until a new innovation attains a critical mass of users before they can adopt and use the innovation. Model 1 is expressed as:

$$Y_{i,t} = \alpha_i(1-\lambda) + \lambda Y_{i,t-1} + \beta_0 X_{i,t-1} + \theta Z_{i,t} + \mu_{i,t} \quad \text{[Eqn 1]}$$

where $Y_{i,t}$ is the measure of bank performance defined in panel A of Table 1. (1–λ) is the measure of adjustment costs, $Y_{i,t-1}$ represents lagged values of the dependent variable, $X_{i,t-1}$ represents the lagged values of the financial innovation variables defined in panel B of Table 1, $Z_{i,t}$ is the vector for control variables for defined in Panel D of Table 1 and $\mu_{i,t}$ is the error term. $\mu_{i,t}$ is equal to (u_t–λu_{t-1}) which is a moving average of u_t and u_{t-1}. u_t is the time t error term while u_{t-1} is the time t–1 error term. The independent variables have been scaled down using industry usage of the financial innovations. The independent variables deal with financial innovation usage.

In the second model, we establish the firm-level drivers of financial innovation. The financial innovations described in model 1 are the dependent variables in model 2. The model tests the drivers of financial innovation at the firm level. For models 2 and 3, we argue that the effect of financial innovation drivers (both firm and macro level) on financial innovations is also time lagged and therefore the lagged values of the dependent variable (financial innovation) are incorporated among the independent (financial innovation drivers) variables. The impact of the drivers of financial innovation on financial innovation is time lagged as a bank needs time to grow to be able to afford investments such as technological infrastructure in financial innovations. Therefore, we use a general distributed lag model expressed as:

$$Y_{i,t} = \alpha_i(1-\lambda) + \lambda Y_{i,t-1} + \beta_0 X_{i,t-1} + \theta Z_{i,t} + \mu_{i,t} \quad \text{[Eqn 2]}$$

where $Y_{i,t}$ represents the financial innovation variables defined in panel C of Table 1, (1 – λ) is the measure of adjustment costs and $Y_{i,t-1}$ is the lagged value of the dependent variable. The dependent variable is defined in panel B of Table 1. $X_{i,t-1}$ represents the lagged values of the firm-level drivers of financial innovation drivers defined in panel C of Table 1. $Z_{i,t}$ is the vector of control variables defined in panel D of Table 1. $\mu_{i,t}$ = (u_t–λu_{t-1}), a moving average of u_t and u_{t-1} the error terms. u_t is equal to time t error term while u_{t-1} is equal

TABLE 1: Definition of variables.

Variable	Definition
Panel A **Bank performance variables**	
iROA	The industry-adjusted return on total assets for bank *i* at time *t*, and is computed by deducting the average industry ROA from the ROA of the bank, and dividing the result by the standard deviation of the banking industry ROA
iROE	The banking industry-adjusted return on equity for bank *i* at time *t*, and is computed by subtracting the average industry ROE from the ROE of the bank, and dividing the result by the standard deviation of the industry ROE
Panel B **Financial innovation variables**	
ATM	Is automated teller machines, computed as the number of ATMs for bank *i* at time *t*, divided by the total number of ATMs in the banking industry at time *t*
IB	Is Internet banking, represented by the number of internet accounts for bank *i* at time *t*, divided by the number of banking industry Internet accounts at time *t*. The number of deposit accounts is used as the proxy for Internet accounts.
AB	Agency banking, represented by the number of agency banking agents for bank *i* at time *t*, divided by the number of agency banking agents in the banking industry, at time *t*.
MB	Mobile banking, computed as the logarithm of the number of mobile banking transactions for bank *i* at time *t*.
Panel C **Firm-level drivers of financial innovation**	
LMB	The lag of the MB variable defined in Panel A.
AUR	Asset Utilisation Ratio, computed as annual sales divided by total assets for bank *i* at time *t*.
ER	The expense ratio, computed as the annual operating expenses divided by annual sales for bank *i* at time *t*.
CAR	The capital adequacy ratio, computed as the sum of bank *i* tier one and two capital divided by bank *i* risk weighted assets over time *t*.
TDF	Technological developments at firm level (TDF). TDF is calculated as the sum of the value of bank *i*'s ICT infrastructure and personnel salaries over time *t*, scaled by the bank's total assets over time *t*.
TC	The transaction cost stated as bank *i*'s net fees and commissions over time *t*, divided by the total income for bank *i* over time *t*.
TA	Firm size, computed as the logarithm of total assets for bank *i* over time *t*.
LTA	The lag of the TA variable
LIB	The lag of the IB defined in Panel A.
Panel D **Control variables**	
inROA	The average value of the banking industry return on total assets at time *t*
inROE	The average value of the banking industry return on equity at time *t*
FS	Bank size represented by the logarithm of total assets for bank *i* at time *t*,
LST	A dummy variable capturing the effect of listing on the Nairobi Securities Exchange (NSE). We assign a value of 1 to banks listed on the NSE and 0 to unlisted banks.
OSP	A dummy variable which captures the effect of ownership of sampled banks. A value of 1 is assigned to locally owned banks, and 0 otherwise.
GDP	The annual growth rate in Kenya's gross domestic product (GDP)
LAB	Past bank *i* agency banking represented by the lag of AB
LATM	Past bank *i* ATM represented by the lag of ATM
LTA	Past bank *i* size represented by the lag of TA
iROE	The Industry-Adjusted Return on Equity defined in panel A
iROA	The Industry-Adjusted Return on Total Assets defined in panel A
Dummy Medium	As at 31 December 2013, 15 banks are classified as medium whereby the medium banks account for 37.95% of the (weighted) market size.
Dummy Large	Six banks are classified as large as at December 2013. The six large banks account for 52.39% of the (weighted) market size.
Panel E **Macro level drivers of financial innovation**	
GI	The globalisation index, and is proxied by the globalisation index (Dreher 2006)
IDI	The Technological developments at the macro level, and is proxied by ICT development index (IDI). The index is sourced from the International Telecommunications Union
RT	Regulation and taxes proxied by a dummy variable which assumes 1 for regulation and 0 for the inexistence of regulation
SMINDEX	The incompleteness in financial markets represented by stock market development index (Mahonye 2014)

ROA, return on asset; iROA, industry adjusted return on assets; iROE, industry adjusted return on equity; ATM, automated teller machines; IB, internet banking; AB, agency banking; MB, mobile banking; LMB, lag of mobile banking; AUR, asset utilization ratio; ER, expense ratio; CAR, capital adequacy ratio; TDF, technological developments at firm level; TC, transaction cost; TA, total assets; LTA, lag of total assets; LIB, lag of internet banking; FS, bank size; LST, listing on the NSE; NSE, Nairobi Securities Exchange; OSP, Ownership; GDP, gross domestic product; LAB, lag of agency banking LATM, lag of ATM; LTA, lag of total assets; GI, globalisation index; IDI, ICT development index; RT, regulation and taxes; SMINDEX, stock market development index.

to time $t-1$ error term. We run separate regressions with ATMs, internet banking, mobile banking and agency banking as the dependent variables in the respective models.

The third model identifies the macro-level drivers of financial innovation: the model tests financial innovation drivers at the macro level using the financial innovations discussed in model 1 as the dependent variable. The model is expressed as:

$$Y_{i,t} = \alpha_i(1-\lambda) + \lambda Y_{i,t-1} + \beta_0 X_{i,t} + \theta Z_{i,t} + \mu_{i,t} \quad \text{[Eqn 3]}$$

where $Y_{i,t}$ represents the financial innovation variables defined in panel B of Table 1, $(1-\lambda)$ is the measure of adjustment costs, $Y_{i,t-1}$ is the lagged value of the dependent variable, $X_{i,t-1}$ represents the lagged values of the macro-level drivers of financial innovation drivers defined in panel E of Table 1 and $Z_{i,t}$ is the vector of control variables defined in panel D of Table 1.

As financial innovation is driven by firm-level and macro-level drivers, the speed with which financial innovation adjusts to the drivers is expected to affect financial innovation usage. Consequently, the speed with which firm performance adjusts to financial innovation usage will affect the value a firm gets from financial innovation usage. The relationship between financial innovation drivers, financial innovation and firm financial performance is illustrated in the financial innovation value model in Figure 1. According to Koyck's (1954) model, the mean and the median lags serve as a measure of the speed with which Y responds to X.

Therefore, the mean and median lags would represent the speed with which $Y_{i,t}$ (Financial innovation) responds to $X_{i,t}$ (financial innovation drivers). Secondly, the mean and the median lags can show the speed with which bank financial performance responds to financial innovations usage:

The Koyck (1954) model mean lag $= \frac{\lambda}{1-\lambda}$ [Eqn 4]

Thus, according to Koyck (1954), if $= \frac{1}{2}$, the mean lag is 1.The median lag is the time required to accomplish 50% of the total change in Y following a unit sustained change in X:

The Koyck (year) model median lag $= -\frac{log 2}{log \lambda}$ [Eqn 5]

If the median lag is 0.4, the implication is that it takes less than half the period to accomplish 50% of the total change in Y. If the median is 3.3, it implies that it takes more than three periods to accomplish 50% change in Y. Koyck (1954) argues that the higher the value of λ, the lower the speed of adjustment of $Y_{i,t}$ and the lower the value of λ, the higher the speed of adjustment of $Y_{i,t}$. Therefore, the mean and median lag can be used to measure the speed of financial innovations adjustment with regard to financial innovation drivers as well as the speed of adjustment of firm financial performance to financial innovation.

Results and discussion

The speed of adjustment in models 1–3

As discussed in the 'Literature review' section, according to Koyck's (1954) model, the mean and the median lags measure the speed at which Y responds to X. For instance, the mean and median lags would represent the speed at which $Y_{i,t}$ (firm financial performance) responds to $X_{i,t}$ (financial innovation). It is argued that '… the median lag is the time required for the first or 50% of the total change in Y following a unit sustained change in X …' (Gujarati 2003:668).

Firm financial performance: Speed of adjustment to financial innovations

This section reports on the tests on the speed of adjustments of the dependent variables to independent variables in models 1–3, which are summarised in Table 2 and Figure 2. Firm financial performance has been measured by the industry-adjusted ROE and industry-adjusted ROA. The industry-adjusted ROE has a mean lag of 1.179 and a median lag of 0.368. This means that it takes on average 1.179 years for firm performance as measured by industry-adjusted ROE to adjust to the four financial innovations studied. Secondly, it takes less than a year (0.368 year) to accomplish 50% of the total change in firm performance following a unit-sustained change in the financial innovations. The industry-adjusted ROA has a mean lag of 1.340 and a median lag of 0.506. This means that it takes on average 1.34 years for financial performance as measured by industry-adjusted ROA to adjust to financial innovations. When firm financial performance is measured by industry-adjusted ROA, it takes more than a half year (0.506 year) to accomplish 50% of the total change in firm performance following a unit-sustained change in financial innovations. The speed of adjustment is illustrated in Figure 2.

The speed of financial innovation adjustment to financial innovation drivers at firm level

This section discusses the speed of adjustment of financial innovations to firm-level financial innovation drivers. Firm-level financial innovation drivers are summarised in model 2 results presented in Table 2 and Figure 3. The results show that mobile banking has the shortest mean lag (2.849) while ATMs are associated with the longest mean lag (4.926). These results, therefore, show that it takes on average about three years for mobile banking to adjust to firm-level financial innovation drivers and about five years for ATMs to adjust to the financial innovation drivers. Consequently, mobile banking has the shortest median lag (1.603) while ATMs have the longest median lag (3.055). It therefore takes more than a year, that is, 1.6 and 3.055 years to achieve 50% of the total change in mobile banking and ATMs, respectively. The speed of adjustment is illustrated in Figure 3. These findings provide evidence that the effect of firm-level financial

TABLE 2: Speeds of adjustment in models 1, 2 and 3.

Model	$Y_{i,t}$	Dependent variable[1]	λ	log λ	log 2	Mean lag	Median lag
Model 1							
	Lag iROE	Firm performance	0.152	-0.818	0.301	1.179	0.368
	Lag iROA	Firm performance	0.254	-0.595	0.301	1.340	0.506
Model 2							
	Lag LMB	Mobile banking	0.649	-0.188	0.301	2.849	1.603
	Lag MB	Agency banking	0.753	-0.123	0.301	4.049	2.443
	Lag ATM	ATMs	0.797	-0.099	0.301	4.926	3.055
	lag IB	Internet banking	0.779	-0.108	0.301	4.525	2.775
Model 3							
	Lag LMB	Mobile banking	0.121	-0.917	0.301	1.138	0.328
	Lag AB	Agency banking	0.639	-0.194	0.301	2.770	1.548
	Lag ATM	ATMs	0.579	-0.237	0.301	2.375	1.268
	Lag IB	Internet banking	0.87	-0.060	0.301	7.692	4.977

iROA, Industry return on assets; iROE, Industry return on equity; ATM, automated teller machines; IB, internet banking; AB, agency banking; MB, mobile banking; LMB, Lag of mobile banking.

1.Refer to Table 1.

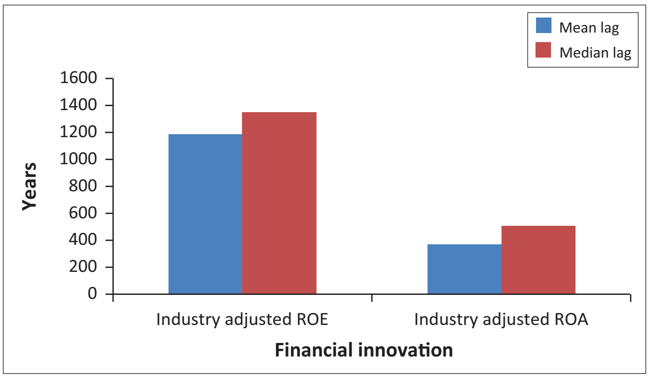


FIGURE 2: Firm financial performance speed of adjustment to financial innovation.

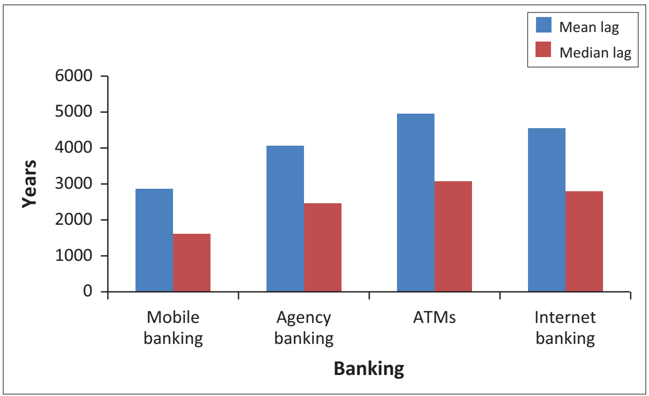


FIGURE 3: Financial innovation speed of adjustment to firm-level drivers.

innovation drivers on different financial innovations is time lagged, with the length of the lags ranging on average between 1.6 and 3.055 years for the four financial innovations.

The speed of financial innovation adjustment to financial innovation drivers at the macro level

This section discusses the speed of adjustment of financial innovations to macro level drivers of financial innovation. The results are presented in Table 2 and Figure 4. The results show that mobile banking has the shortest mean lag (1.138 years) and the shortest median lag (0.328 year) while Internet banking has the longest mean lag (7.692 years) and the longest median lag (4.977 years). However, the speed of adjustment of Internet banking to macro-level drivers is very low as it takes on average 7.7 years for Internet banking to respond to macro-level drivers.

We have established the speed of adjustment of firm financial performance to financial innovations and the speed of adjustment of financial innovation to various financial innovation drivers. We suggest that management should ensure fast response to market intelligence to achieve the greatest impact with regard to innovation speed and new product performance (Carbonell & Rodríguez-Escudero 2010). This is because it is possible that the speed of adjustment may be linked to the speed of innovation. In addition, it is critical that management identifies an influential champion to promote the usage of the innovations as the champion is the only significant positive factor needed for faster innovation

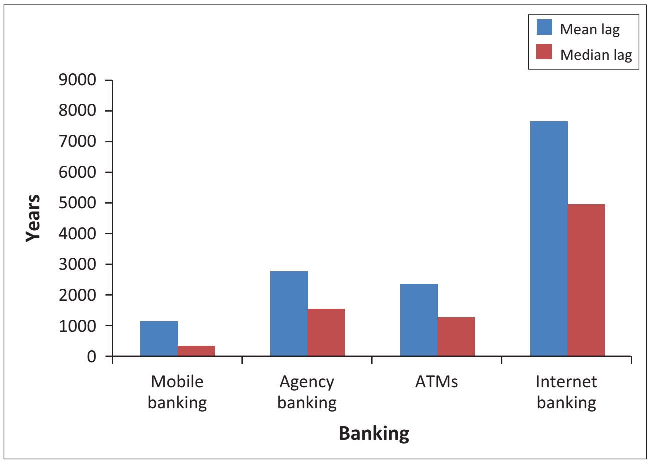


FIGURE 4: Financial innovation speed of adjustment to macro-level drivers.

speed (Allocca & Kessler 2006). Nevertheless, although an influential innovation champion is critical for innovation speed, such a champion can only succeed where the management is supportive of the innovation and rewards innovative activities. For instance, Carbonell and Rodríguez-Escudero's (2009) study of 183 new product innovations confirms that top management support, clarity of goals and speed-based rewards are crucial in building conditions which hasten innovation speed, especially in an environment of high technological turbulence.

We postulate that, generally, the speed of adjustment of financial innovation to financial innovation drivers and the speed of adjustment of firm financial performance to financial innovation may depend on the innovation speed in a given firm. Innovation speed has been operationalised in a number of studies as the firm's quickness in generating new ideas, launching new products, development of new products, new processes and new ways of solving problems relative to competitors (Chen & Hambrick 1995; Liao et al. 2010). According to Wang and Wang (2012), innovation speed is critical for attainment of superior firm performance and can enable the firm to effectively compete in the market. This is consistent with the previous studies which empirically confirm a positive link between speed-to-market and the whole success of the new product (Carbonell & Rodríguez-Escudero 2009; 2010). Moreover, rapid technological developments in the marketplace, increased competition as well as shortened product lifecycles have put pressure on companies to innovate at a faster rate (Heirman & Clarysse 2007; Lynn 2008). The implications of these studies, coupled with our findings, are that the macro-economic environment where firms operate is critical for the speedy adoption and usage of financial innovations. Secondly, although firms may have a fast response to macro-economic opportunities, bureaucracies inherent at firm level may slow the response to the usage of financial innovation.

The results encapsulated in this article indicate that the speed of adjustment of financial innovation to financial innovation drivers at firm level is lower than the speed of adjustment of financial innovation to financial innovation drivers at macro level. This could be explained by the degree of complexity characteristic of most organisations.

According to Rogers (2003), complexity refers to the extent to which the adopting unit perceives an innovation as relatively hard to understand and use. For example, the need for new knowledge to make use of the newly introduced innovation may disrupt the existing knowledge, leading to resistance to change (Armstrong & Hardgrave 2007). In addition, as the adopting units may have insufficient information about the new innovation, the risk of error in decision-making increases, compounding the degree of complexity (Liu et al. 2012).

Conclusion and directions for future research

This article examined the speed of adjustment of firm performance to financial innovations usage and the speed of adjustment of financial innovation to financial innovation drivers for Kenyan banks. A distributed lag model is estimated using dynamic panel estimation with System GMM. According to the results, it takes a shorter period for firm financial performance to adjust to financial innovations than it takes financial innovation to respond to financial innovation drivers at firm level. The implication of these findings is that although it may take longer for a firm to adopt and use financial innovations, once the innovations are adopted and used, firm value will be achieved in a shorter period. This firm value is in the form of increase in financial performance represented by the increase in industry-adjusted ROE and ROA. We suggest that future studies should empirically establish a link between the speed of adjustment of firm performance to financial innovations and the speed and magnitude of financial innovations.

Acknowledgements

Competing interests

The author declares that he has no financial or personal relationships which may have inappropriately influenced him in writing this article.

Authors' contributions

This work is a product of the PhD thesis completed by M.M.M. under the supervision of C.C. at the School of Economic and Business Sciences, University of the Witwatersrand. Both authors approved the final version of the manuscript.

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