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Does Financial Innovation Enhance Financial Deepening and Growth in Kenya?

Roseline Misati, Jared Osoro and Maureen Odongo[1]

March 2021

Financial innovation is a double-edged sword; it can be a force for good, but it can also have negative consequences since financial innovations are often associated with financial crises and financial malpractice in which case the use of innovation is predatory rather than the innovation itself *– (Diaz-Rainey and Ibikunle, 2012)*

Abstract

This study examined the implication of financial innovation on financial depth and economic growth in Kenya using quarterly data covering the period 2009 to 2020. Based on autoregressive distributive lag models, we demonstrate a positive relationship between financial innovation and financial depth with the strongest impact emanating from internet usage and mobile financial services and the lowest impact from the number of bank branches and automated teller machines. The results also further reveal a significant positive impact of financial depth on economic growth consistent with the supply-leading finance theory. The study recommends investment in technology-enabling infrastructure for digital financial services, design strategies to ensure affordability of mobile devices and prioritisation of financial literacy to bridge the gap between people and technology.

Key Words: *Financial Innovation, Financial Depth, Growth*

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Disclaimer: The views expressed in this study are solely those of the authors and do not necessarily reflect the views of the Central Bank of Kenya.

1.0 Introduction

The global financial industry has experienced rapid technological developments that have transformed the financial system as traditionally understood. The vibrant technological innovations have facilitated the proliferation of new financial products, multiple delivery channels and adoption of new business models. Moreover, innovations in modern technology have resulted in the development of digital financial services (DFS) which has not only increased efficiency in financial service delivery but also increased speed, transparency, security, and availability of tailored financial services that serve all categories of consumers (World Bank 2020). Banks have taken advantage of technological innovations to introduce new products and expand the existing ones to remain competitive.

Notable examples of technologically enabled financial innovations include branchless banking, electronic payment systems, internet banking and mobile banking.[2] The availability of new alternative sources of financial services and products has led to a vibrantly competitive market of digital credit as banks strive to enhance access to customers as well as differentiate their products and services. (Financial Sector Deepening, (FSD), 2015; 2019). Commercial banks have leveraged on the digital financial platforms to manage micro-accounts, build up deposits, and extend financial services to the previously unbanked and underserved population (Ndung'u, 2019; 2018).

2 Financial innovation is commonly defined to constitute new developments in the markets, institutions, instruments, processes and organizational forms, interaction with customers and regulations of the financial system. This include whatever new developments that minimize costs, reduces risks or provides an improved product/service/instrument that better satisfies participants' demand within a financial system (Lambert, 2019; Tahir et al., 2018; Khraisha, 2018; Daiz-Rainey, Ajide, 2016; Ekpu, 2015; Blach, 2011; Mention, 2011; Vargas, 2009; Frame and White, 2002). Financial innovation is further categorized into four main groups, namely, product innovation; process innovation; organization innovation and market innovation, (Tahir et al., 2018). This study focuses on product and process innovation. Process innovation refers to new ways of operating business and implementing information technology, such as the Automated Teller Machine (ATM), mobile banking, online banking, etc., geared at increasing efficiency in the financial system. Product innovation refers to new financial products or modification of existing products and can further be classified under types, functions, or characteristics, (Khraisha and Arthur, 2018). These include securitized assets, derivatives, weather derivatives, foreign currency mortgages, hedge funds, exchange-traded funds, private equity, and retail structured products, (Tahir et al., 2018; Arthur, 2017; Blach, 2011).

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In Kenya, banks have introduced new products such as, M-shwari, Timiza, M-Coop cash that are pegged on digital payments. Non-bank institution such as Tala and Branch have ventured into the credit market through their respective mobile money lending apps. Digital payments are now a popular mode of payment for goods and services. For instance, in 2015, digital credit/mobile banking channel was the most used form of credit for daily needs and emergencies, accounting for 46.2 percent of such transactions compared to 3.6 percent, 8.2 percent and 5.9 percent for Microfinance institutions, SACCOs and conventional banking channels, respectively. In 2019, 54 percent of Kenyans saved funds on their digital wallets making mobile money the most widespread savings device compared to 29 percent, 11 percent, and 8 percent in informal savings groups (popularly known as Chama), SACCO and banks, respectively, (FSD, 2015; 2019). The fact that transfers are possible even for values as low as a tenth of a dollar and loans accessible on digital platforms for values as low as one dollar has made it possible for consumers of all segments, including low-income earners, to enjoy diversified financial services.

The implications of these new developments are not well understood or structurally documented in many countries, yet pertinent questions for policymakers, financial players, and consumers remain unanswered. To the extent that the developments embody financial innovation, the arguments by Laeven et al. (2015) that economic growth will stagnate unless financiers innovate motivate a number of questions, including the following: Why are countries having different experiences and outcomes of financial innovation? Which components of financial innovation are growth-enhancing, and which ones are growth-retarding? What are the regulatory challenges that stem from these developments? Should regulatory agencies impose similar rules and regulations governing commercial banks on newly innovated non-bank financial service providers? What implications do new innovations based on digital platforms have on the economy, particularly in Africa, where rapid adoption is taking place? Is the cost of investment in technological infrastructure to support financial innovation important for commercial banks and the growth of the economy?

Against the above background, this study seeks to understand the implication of financial innovation on financial depth, with the implicit presupposition that a deeper financial system has a positive causal effect on economic growth. While there have been research attempts on financial innovation with a focus on the impact of financial innovation on bank performance, the financial innovation-financial deepening-growth nexus has not been subjected to much formal assessment (Chipeta and Muthinja, 2018; Mustapha, 2018).

Studies that have focused on finance innovation-growth linkages reveal no consensus on this relationship. On the one hand, some which have entrenched the arguments that financial innovation expands economic activities through various channels such as financial inclusion, international trade, remittances channel and financial

efficiency find positive linkages between financial innovation and economic growth, (Qamruzzaman and Jianguo, 2017; Zandi et al., 2016; Laeven et al. 2015; Hao and Hunter, 1997). On the other hand, considerable literature points to possibilities of instabilities arising from financial innovation in which case, excessive or inappropriate usage of some components of financial innovation without proper regulations can lead to financial instability. Such episodes were experienced in 2007 when there was a systemic liquidity shock generated by a decrease in liquidity from global financial markets, (Camelia and Angela, 2011; Boot and Marinc, 2010). Other studies show that growth outcome of financial innovation is sensitive to the indicator used emphasising the fact that different components of financial innovation serve different purposes in the financial system and growth process, (Bara and Mudzingiri, 2016; Ajide, 2016; Chin and Chou, 2001).

While the Kenyan experience of financial innovation has been globally acknowledged, little empirical research is documented on this subject. Few attempts on this subject have mainly focused on the linkages between financial innovation and bank performance, implications of financial innovation on monetary policy transmission as well as an examination of financial innovation-growth linkage directly without considering financial depth as the primary channel through which financial innovation impact economic growth (Chipeta and Muthinja, 2018; Cherotich et al., 2015; Ndirangu and Nyamongo, 2015; Muiruri and Ngari, 2014; Mwinzi, 2013; Misati et al., 2010).

The outlined studies that explore the Kenyan case have several shortcomings. First, they ignore the possible direct link between financial innovation on financial deepening, yet several studies show that financial innovation affects growth through many channels, financial deepening being the most important. Second, they ignore the separate effects of different components of financial innovation. Third, they assume the direction of causality from financial innovation to economic growth, yet there is evidence of reverse causality between financial innovation and financial depth as well as financial depth and economic growth.

Since 2013, there have been critical policy developments that may have directly or indirectly influenced the usage of digital platforms and the uptake of alternative digital-based financial services with possible implications on financial innovation. For instance, interest rate controls that were in place between 2016 and 2019 may have changed commercial bank-customer relationships and affected the interaction between customers and alternative non-bank financial providers, including digital and mobile agents in the financial system with implications on the pace of innovations and uptake of digital financial products. Other policy initiatives such as demonetisation of the older 1000 Shillings notes that were meant to reduce risks of illicit financial flows (IFF) and the emergence of counterfeits may have indirectly encouraged digital transaction as experiences in other countries such as India have shown, (Rupa, 2017). The most recent temporary

policy on digitalisation meant to reduce the usage of physical cash, and hence minimise transmission of Covid-19 pandemic gave Kenya a fresh impetus towards digitalisation and possible acceleration towards an entirely cashless society given the chances of consumer habits becoming entrenched.

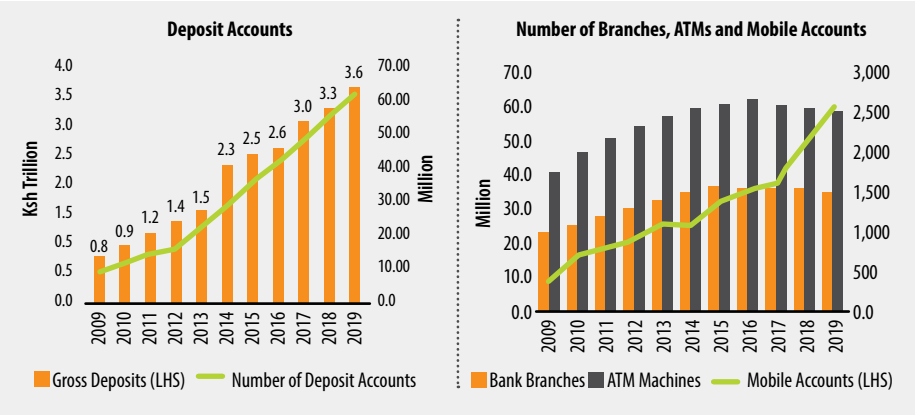
This study considers the latest developments in policy, digital uptake, and appropriate empirical methodologies. The study contributes to the literature in at least five ways.

- First, it analyses the impact of different components of financial innovation on financial depth and economic growth since the various new developments in the financial system have different effects on financial depth and economic growth.
- Second, it uses multiple indicators of financial innovation, including digitalisation variables, branchless banking variables, mobile financial services variables, online variables, and internet variables that have not been used in previous studies using Kenyan data.
- Third, it examines whether any reverse causality exists between financial innovation and financial depth, and then link that to economic growth.
- Fourth, it utilises the bound cointegration technique or the autoregressive distributive lag model (ARDL) that has not been utilised in previous studies using Kenyan data set. The ARDL is robust to small samples, is not sensitive to orders of integration of the variables of interest and is appropriate for single-equation framework.
- Fifth, it accounts for rapid policy changes in the financial landscape in the recent past by controlling for interest rate caps.

2.0 Dynamics of Financial Innovation Indicators and Enabling Infrastructure in Kenya

In this section, we analyse the evolution of financial innovation indicators as well as the enabling infrastructure, mainly access to electricity, mobile network coverage and internet connectivity, which is a prerequisite for adoption and usage of nearly all the new financial products and services. Financial innovation in the Kenyan banking industry has been associated with convenience, effectiveness, and efficiency in the provision of financial services. These attributes are deemed to have enhanced the economy's financial depth as revealed by the increased number of deposit accounts from 8.5 million in 2009 to 62.01 million in 2019, accompanied by an increase in gross deposits from Ksh 0.8 trillion to 3.6 trillion. As pointed out by Ndungu (2018), the growth in deposit accounts depicts an increase in access to financial services. In addition, Figure 1 shows that digital banking has become a gateway to financial services and has reduced the number of physical brick and mortar branch networks as well as automated teller machine (ATM) usage. Apart from the savings associated with operational and maintenance costs, these developments translate into huge travel time savings and enhanced convenience and safety for the customer.

Figure 1: Commercial Bank Deposits Account and Bank Branches in Kenya 2009-2019

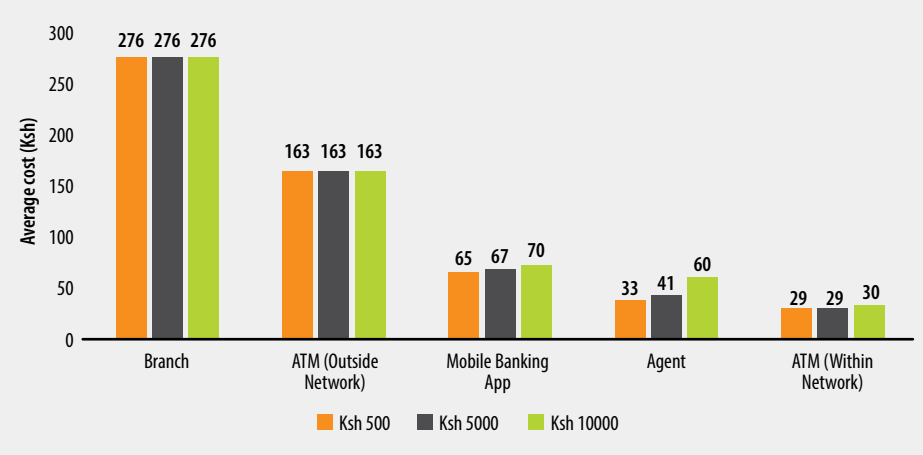


Source: Central Bank of Kenya Website Data

The changing dynamics in the Kenyan banking industry means that banks' performance is no longer solely dependent on physical branch sales but also on digital banking platforms such as internet banking, electronic banking (e-banking), mobile banking (m-banking) and agency banking. Before digitisation, direct transaction costs, such as account opening fees and minimum account balance requirements, and indirect costs such as travel time and the opportunity costs of visiting bank branches, were significant barriers to financial inclusion (FSD, 2019). However, the use of the digital financial platform has supported financial deepening by significantly reducing both the direct and indirect transaction costs of banking since services such as account balance enquiry, utility payment, money transfer, and airtime purchase, can be made conveniently without a visit to the bank, the utility service provider, or the mobile network operator (MNO) agent shop.

According to FSD (2019), withdrawals done over the counter are the most expensive, with no variations on the costs even for small transactions. A customer withdrawing Ksh 500 at a bank branch will be charged an average fee of Ksh 276 per withdrawal, similar to one withdrawing Ksh. 10,000. However, withdrawal transactions over digital channels are relatively lower. ATM withdrawals done within the issuing bank's network has the lowest charge, while withdrawals over mobile banking apps cost more than agent withdrawals. Withdrawals done from the ATM of another bank are second-most expensive with customers spending an average of KSh 163 per withdrawal (Figure 2).

Figure 2: Average Withdrawal Cost by Channel and Transaction Amount



Source: FSD-Kenya, 2019

The agency banking model adopted by commercial banks in 2010 has also enhanced financial services outreach at a lower cost and promote financial inclusion of the unbanked rural population. As at June 2020, 20 commercial banks had contracted 65,939 agents while 3 microfinance banks had 2,222 agents an improvement compared to June 2019, where 18 commercial banks and 3 microfinance banks had contracted 61,226 and 1,974 active agents, respectively, (CBK, 2020). The number of banking transactions via agents increased by Ksh. 98 million to Ksh. 815.3 million in June 2020 from Ksh. 717.3 million transactions in a similar period, 2019. Similarly, the value of banking transactions undertaken through agents increased to KSh 5.7 trillion from KSh 4.8 trillion. The increases in number and value of transactions have attributed the increase in the number of banking agents as well as increased customer awareness of agent banking. The growth in agency banking model has extended the provision of financial services such as deposits, withdrawals, payment of bills, collection of account opening application form and balance enquiries to previously unbanked segments of the Kenyan population.

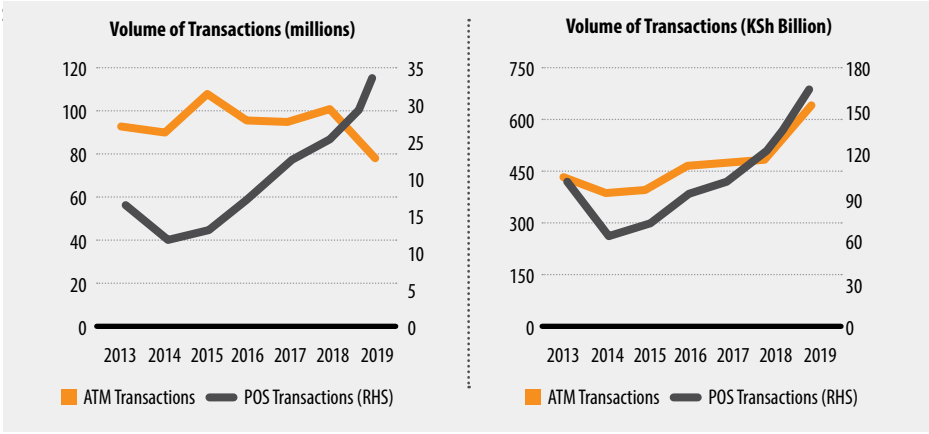
The use of ATMs and payment cards has provided an additional innovative platform for the banking sector, reducing the cost and time of seeking financial services through channels such as bank deposit, withdrawals, and transfer services. At the end of 2019, there were 2,459 ATMs, with 79 million ATM transactions. Similarly, the value of ATM transactions has increased over the years, growing by Ksh. 218 billion to 614 billion in 2019 from 423 billion in 2013 (Table 1 and Figure 3). However, the volume of ATM transactions exhibited gradual declining trends since 2016 which would be indicative of the shift towards new financial products offered by non-bank financial providers, online services, mobile and internet use services by economic agents.

Table 1: Electronic Payment Cards

		ATM Cards				Total ATM Cards	POS Machines
	ATM Machines	Prepaid Cards	Charge Cards	Credit Cards	Debit Cards		
2015	2,579	2,047,340	873	252,178	10,673,090	12,973,481	22,230
2016	2,615	1,503,715	826	233,752	12,903,875	14,642,168	30,133
2017	2,564	1,357,372	700	236,392	13,616,645	15,211,109	35,466
2018	2,529	1,261,985	695	239,484	16,167,386	17,669,550	44,874
2019	2,459	635,039	541	263,255	10,597,465	11,496,300	42,846

Source: CBK

Figure 3: Electronic Card Transaction Volume and Value

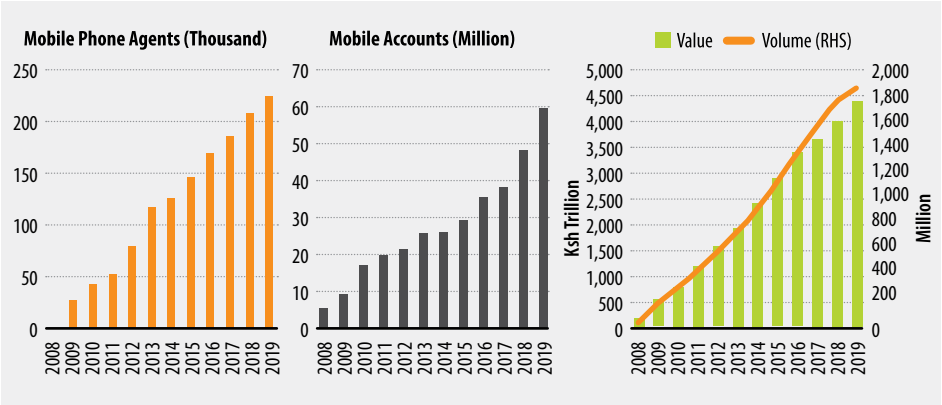


Source: CBK

Enhanced financial digitalisation saw the introduction of chip-embedded payment cards and Personal Identification Number (PIN) that have boosted the use of Point of Sale (POS) machines, which are used for the processing of transactions with the help of ATM (debit/credit/other) cards. The high adoption of POS machines has resulted in an increased in both the volume of transactions and the value of transactions (Figure 3). The demand for POS machines is expected to increase further in proportion to the implementation of advanced technologies.

The advent of mobile phones and the adoption of mobile money platform such as M-Pesa, Mobile Pay, Telkom, and Airtel, Finserve Africa among others have revolutionised the financial industry, providing access to financial services to customers that were left out in the traditional banking system. Mobile money transfer services have continued to gain popularity since its introduction in 2007. In particular, the growth in the number of mobile phone agents and mobile phone accounts from 6,104 and 5.1 million, respectively in 2008 to 224,108 and 58.4 million in 2019. The volume and value of mobile phone money transfers have also increased from 63 million transactions worth KSh 167 billion in 2008 to 1,839 million transactions worth KSh 4,346 billion in 2019 (Figure 4).

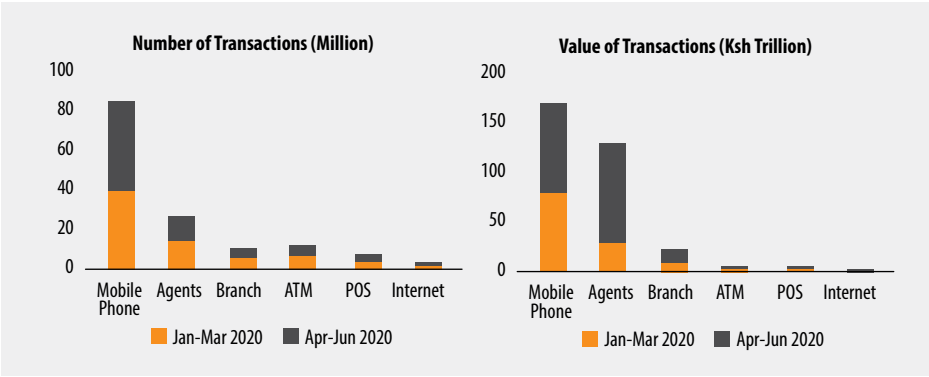
Figure 4: Mobile Money Transactions



Source: CBK

Kenya's mobile phone financial services have integrated with the banking sector to form a robust digital mobile banking ecosystem. The digital ecosystem hosts varied value-added products and services, like credit and saving platforms and e-commerce intertwined through linkages between both financial and non -financial institutions. The digital mobile phone platform uses credit rating measures by FinTechs such as airtime, mobile money transactions and savings data to provide unsecured

Figure 5: Number and Value of Bank Transaction, Pre and Post Covid-19 Pandemic



Source: CBK

loans through mobile platforms. The capacity of Fintech companies to explore massive data sets and use algorithms to identify customer patterns and generate credit scoring reports has facilitated the provision of retail loans, microloans and saving products through digital platforms. The entire process beginning from customer registration, loan application, underwriting, disbursements, and repayment is fully automated. This has provided the micro and small-scale enterprises opportunity for an online credit facility, thereby disrupting the traditional models of lending. Thus, the outreach to retail customers as well as micro and small enterprises has been extensively enlarged.

It can be inferred from the above trends that technology has provided new opportunities for the banking industry to enhance digital financial services and thereby promote financial inclusion and growth. As the world economies battled the Covid-19 pandemic, digital financial services enabled cashless transactions amid calls for social distancing and containment measures and facilitated the efficient transfer of government cash transfers to the most vulnerable members of the society. Comparison between pre-Covid Jan-March 2020 and post-Covid April-June 2020 indicated a shift in the channel used for the transaction (Figure 5). Post-Covid pandemic transaction volumes and value on physical channels (Branch, ATMs, Agents and Points of Sale) declined during the pandemic while transactions volumes and value on digital channels (mobile phone and internet) increased during the pandemic.

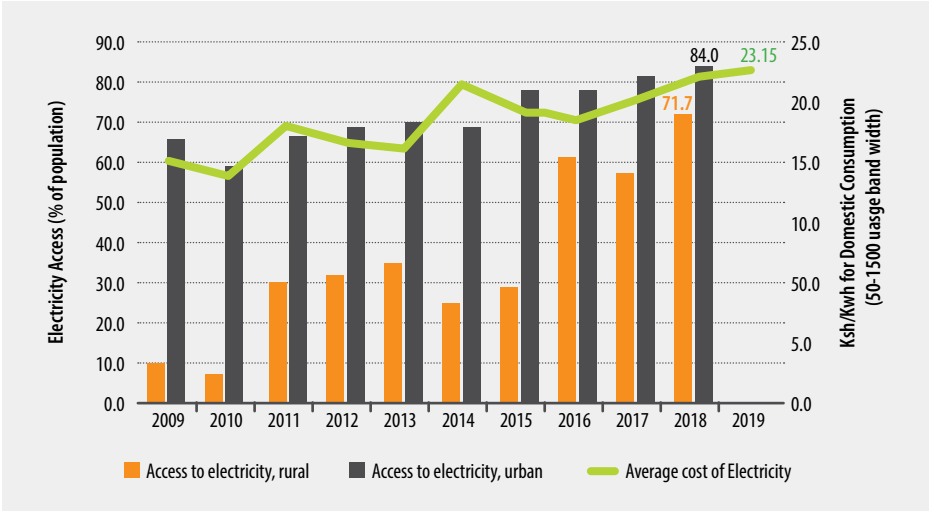
The uptake of digital financial services is dependent on reliable and quality digital infrastructure. In the developed economies, investment in digital infrastructures such as Global System for Mobile Communication (GSM) network coverage, mobile and internet platforms, smartphones, and mobile apps have enabled the rapid uptake of digital financial services. However, mobile network coverage in Kenya is still dependent on the slower narrowband second generation-2G GSM technology with penetration rate (total connections) of 50.6 percent in 2019 compared to the faster broadband fifth generation-5G technology currently used in most of the developed economies. Kenya's uptake of third generation-3G and fourth generation-4G technology remains low, at 38.0 percent and 8.7 percent, respectively in 2019, (GSMA, 2020). Because of the narrowband network coverage, the quality and reliability of the internet remain an issue more, especially when using 2G, which has less capacity band spectrum. This calls for continued significant investment in mobile networks coverage to allow for expansion on 4G network coverage and faster move to 5G technology, to improve the quality of mobile broadband services, more especially in the context of the growing demand for mobile data services.

The shift to cashless transactions in Kenya has necessitated most financial transactions to occur through electronic cards, mobile phones and other internet-enabled devices, all of which have become increasingly popular choices in the recent past. This has seen rapid adoption of smartphones and other smart devices, which use GSM network coverage and internet

connectivity as the primary communication channel for accessing information and services delivery. Despite the rapid penetration of smartphone devices in Kenya, affordability remains a key barrier, especially among the low-income earners. The cost of smartphones and internet-enabled devices has not significantly fallen and remains a key barrier to mobile ownership and mobile internet adoption. According to GSMA (2019), the cost of an entry-level internet-enabled device in more than half of low and middle-income countries (LMICs) is more than 20 percent of average monthly income. In addition, these devices are highly dependent on the availability of broadband network coverage, which remains limited in Kenya and other LMICs.

In terms of affordability of mobile data, GSMA (2020) reports that the poorest 20 percent of the population in Kenya spend approximately 8.0 percent of their monthly income on mobile ownership for low consumption basket of 500MB on data, while the medium consumption basket of 1GB of data + 250 minutes of voice + 100 SMS spend approximately 26.5 percent of their monthly earnings on data. The high cost on mobile data remains a barrier to connectivity in Kenya making the mobile internet penetration to remain relatively low at 27 percent in 2019, compared to South Africa (31.3), Nigeria (47 percent) and Cote d'Ivoire (28 percent).

Figure 6: Access to Electricity in Kenya



Source: World Bank Database and Stimatracker, Kenya

Most of the digital innovations rely on not only internet connectivity but also access to an affordable and reliable electricity supply. Power grids in Kenya have become much more widespread both in the rural and urban areas, mainly attributed to increasing supply of not only geothermal power energy but also renewable energy such as wind power and solar power energy. Despite the increase in supply of electricity, the cost remains prohibitive to the poor population. The domestic consumption of 50-1500 usage bandwidth cost Ksh 23.2 per Kwh in 2019, having increased gradually over the years (See Figure 6) This is relatively expensive compared to Ethiopia (Ksh 6.48 per Kwh), Tanzania (Ksh 9.72 per Kwh) and Uganda (Ksh 19.54 per Kwh). With the high cost of electricity, users end up spending a high proportion of their revenue, merely charging their mobile phone and or accessing the internet. This remains costly more especially to the majority of the Kenyan population where 28 percent of the rural population and 16 percent of the urban population are still not able to access electricity mainly due to the high costs involved in connecting and extending the electricity grid to remote regions. The lack of affordable electricity supply represents a significant barrier in mobile phone usage and internet connectivity for off-grid subscribers, even under the GSM broadband network coverage.

3.0 Literature Review

Earlier theoretical literature devoted to the finance-growth nexus focused on historical experiences of England and the United States of America to illustrate the role of the financial system in various channels of economic growth (Bahegot, 1873; Hicks, 1969; Schumpeter, 1912; and Robinsoe, 1952). Recent theories have based the growth finance nexus on two leading schools of thought with some authors highlighting positive outcomes (Ozurumba and Onyeiwu, 2019; Frame et al., 2018; Tahir et al., 2018; Beck et al., 2016; Boot and Marinc, 2010; Henderson and Pearson, 2011; Blach, 2011) and others pointing to complexities associated with financial innovation particularly since the global financial crisis, (Kraisha and Arthur, 2018; Beck et al. 2016; Allen, 2012; Henderson and Pearson, 2011).

Growth-enhancing financial innovation theories contend that innovation helps to correct market inefficiencies and/or imperfections and thus assists economic agents in obtaining desired outcomes, besides minimising economic volatility, (Henderson and Pearson, 2011). It, therefore, raises the efficiency of financial intermediation by increasing the variety and quality of financial products and services, including the provision of new choices of financial products, services, markets and players to households, consumers, and investors. Thus, this results in the improved matching of the needs of individual savers with those of firms raising funds. In addition, financial innovations help reduce agency costs, facilitate risk sharing, complete the market, reduce transaction costs, and ultimately improve allocative efficiency and economic growth, (Ozurumba and Onyeiwu, 2019; Beck et al., 2016; Boot and Marinc, 2010). Developments in the payment systems in the form of digital payment expedites the exchange of goods and services and expands the menu of savings and lending products with positive growth outcomes, (Frame et al., 2018; Tahir et al., 2018; Blach, 2011).

The innovation-fragility view popularised after the global financial crisis posits that financial innovation that reduces asymmetric information increases risk-taking due to agency problems between bank owners and managers, or because of lower costs of fragility, (Beck et al. 2016). Under this line of thought,

it is argued that financial innovation introduces complexity to exploit uninformed investors where structured equity products are significantly overpriced to extract money from investors who do not fully understand the alternatives to what they are buying, (Allen, 2012; Henderson and Pearson, 2011). In this case, it is assumed that issuers may have incentives to disguise the nature of products to exploit customers or to increase complexity to make it harder for buyers to make rational choices.

Diaz-Rainey and Ibikunle, (2017) further categorise the dark side of financial innovation into the abuse of financial innovation and unintended consequences of financial innovation besides, predatory schemes. In the former case, while financial innovation would be correcting some market failure, it may be misused due to unsuitable incentives, malfeasance, and financial illiteracy of the seller. In the latter case, financial innovation may be beneficial but only to some segments of the economy but generally detrimental as was demonstrated by the case of credit derivatives that hedged risk at a firm level but augmented financial contagion at the aggregate level.

Bank pricing of loan and deposit accounts are also designed to exploit behavioural biases and cognitive limitations such as rounding and truncation, (Diaz-Rainey and Ibikunle, 2017). Thus, product issuers' behaviour in the financial innovation market aggravates investor information friction contrary to the standard financial intermediation theory- implying that it is not the innovation that is predatory but the application of the innovation. Ammann et al. (2017) showed that issuers design overpriced financially engineered products due to their informational advantage over retail investors on volatility and dividends.

Another brand of literature uses economic theory, in which case, it is argued that the demand and supply of financial innovations are the results of market players trying to overcome limitations such as transaction costs, information asymmetries, and other forms of market frictions in addition to the profit motives of the shareholders. Economic theory entails four main models. The first two models are the demand model and the supply model. The idea here is to decide whether a financial innovation occurs due to market demand for new financial innovations that require institutions to innovate to satisfy this demand, or financial innovation is something that emerges independent of market factors. Demand for financial innovations can originate from the client-side in the form of household need to borrow and invest money or firm demand for innovative ways to hedge risks and reduce taxes. Demand may also originate from the innovator side, for example, financial firms facing external or internal constraints. Proponents of the supply-side theory of financial innovation maintain that regulators and conventional economic theory do not consider the incentives of the financial system to supply financial innovations, mainly financial instruments. In this case, the main incentive of financial intermediaries to innovate is to recreate the monopolistic condition that is usually lost

due to the non-patentability of financial innovations. The financial intermediaries accomplish this by accelerating the rate of financial innovation or and increasing the complexity of financial products or services, (Khraisha and Arthur, 2018).

Related economic theories are based on the arguments that financial innovation expands economic activities through promoting financial inclusion, facilitating a financial transaction in international trade, enabling remittance, and uplifting financial efficiency, which eventually play a fundamental role in economic growth. It improves the quality of financial products and services, expedites the financial development process, improves capital accumulation and allocation processes, and increases the level of efficiency in financial institutions. Innovation accelerates the procedures in the financial system with developments such as mobile, internet banking services, new financial institutions and instruments, product diversity, efficient financial intermediation, the introduction of new channels for efficient resource allocation, creation of new corporate structures and credit facilities resulting in efficiency gains that feed into improved economic growth. Financial innovations lead to a higher level of savings and capital accumulation, consequently, a higher level of economic growth, (Nazir et al., 2020; Mollaahmetoglu and Akcali, 2019; Qamruzzaman and Jianguo, 2017; Bara and Mudzingiri, 2016)

Previous empirical studies based on macro and micro models have since been done focusing on the role of financial development on growth (Muazu and Alagidede, 2018; Assefa and Mollick; 2017; Levine, 1997; Gregorio and Guidotti, 1995; McKinnon, 1973; Shaw, 1973). However, there is a paucity of similar intensity in the financial innovation-financial deepening-growth nexus despite the rapid innovation in the financial system and the different experiences and outcomes of such innovation in many economies across the globe. The few research attempts on financial innovation have concentrated on the impact of financial innovation on bank performance with minimal on finance innovation-financial deepening-growth nexus (Misati et al., 2019; Chipeta and Muthinja, 2018; Mustapha, 2018). Those that have focused on finance innovation-growth linkages reveal no consensus on this relationship. On the one hand, studies entrenched on the arguments that financial innovation expands economic activities through various channels such as financial inclusion, international trade, remittances channel and financial efficiency find positive linkages between financial innovation and economic growth, (Qamruzzaman and Jianguo, 2017; Zandi et al., 2016; Laeven et al. 2015; Hao and Hunter, 1997).

On the other hand, consistent with the dark side of financial innovation, considerable literature points out to possibilities of instabilities arising from financial innovation in which case, usage of some components of financial innovation excessively or inappropriately, without proper regulations and supervision, can lead to financial instability and the accumulation of significant systemic risks. Such

episodes were experienced in 2007 when there was a systemic liquidity shock generated by a decrease in liquidity from global financial markets, (Camelia and Angela, 2011; Boot and Marinc, 2010). Other studies show that growth outcome of financial innovation is sensitive to the indicator used emphasising the fact that different components of financial innovation serve different purposes in the financial system and growth process, (Bara and Mudzingiri, 2016; Ajide, 2016; Chin and Chou, 2001).

4.0 Data, Variables, and Methodology

This study uses quarterly data covering the period 2009-2020. Data for mobile financial services, ATM transactions, bank branch network, credit to the private sector, exchange rate, lending interest rates, remittances, public debt and trade openness is obtained from the Central Bank of Kenya while data on consumer price index, GDP, gross fixed capital formation, government expenditure on consumption is obtained from the Kenya National Bureau of Statistics. The data on internet usage was obtained from the World Development Indicators.

4.1 Model and Variable Description

The initial model that links financial innovation to financial depth is specified as follows:

$$FIND_t = \delta_0 + \gamma_1 \text{Finn}_t + \gamma_2 Xt + \varepsilon_t, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, 1$$

where FinD represents financial depth variable (credit to the private sector), Finn represents financial innovation indicators used to capture innovative financial services (Value of mobile transactions, number of mobile accounts, number of mobile agents, ATMs, individuals using the internet) and traditional financial access indicators (number of bank branches and accounts). In contrast, X represents control variables in the regression models. The indicators of financial innovation are based on the measures that have been used in previous studies, (Clavijo et al., 2019; AFI, 2019; Arif, 2018; Bara and Mudzingiri, 2016; Ekpu, 2015; Muiruri and Ngari, 2014). We then reformulate Equation 1 into a long-term relationship as represented in Equation 2, where Z is the predicted residuals from the regression of Equation 1.

$$Z = \text{LFIND}_t - \delta_0 - \gamma_1 \text{LFinn}_t - \gamma_2 \text{LX}_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots, 2$$

Following previous work, we express Equation 2 in autoregressive distributed lag (ARDL) form as represented in Equation 3 below, (Peprah et al., (2019; Jalil and Ma, 2008; Pesaran et al., 2001)

$$\Delta LFinD_t=\delta_0+\beta_1 LFinD_{t-1}+\beta_2 LFinn_{t-1}+\beta_n LX_{t-1}+\sum_{i=1}^{p}\varrho_1\Delta LFinD_{t-i}+\sum_{i=1}^{q}\delta_i\Delta LFinn_{t-i}+\sum_{i=1}^{r}\tau_n\Delta LX_{t-i}+\varepsilon_t,,,,,, 3$$

where $LFinD$ represents the log of financial depth indicator, $LFinn$ is the log of financial innovation indicators, and LX represents the log of the control variables in the model. In addition,

p, q and r are optimal lag lengths;

$\varrho i,\ \delta i$, and τi are the ARDL model's short-term dynamics;

$\beta 1, \beta 2$,..., and βn are long-run multipliers;

Δ is the first difference operator;

$\delta_{0'}$ is a constant term; and

ε_t is the white noise error term

A compact error correction model (ECM) is specified in Equation 4 below.

Where ECM_{t-1} is the error correction term representing the adjustment speed of the dependent and independent variables to their long-run equilibrium following any shock.

Consistent with previous studies, besides financial innovation and access variables, other factors represented by X in the equations above that affect financial depth include trade openness, remittances, inflation, real GDP, exchange rate and lending interest rate. Financial innovations in the form of new financial instruments, services, institutions, technologies, and markets mobilise financial surpluses from ultimate savers and channels them into most productive investment avenues, with positive implications on credit growth and financial intermediation.

The outcome of financial innovation of diversified financial products leads to the enhanced matching of savers and investors raising funds for future products, besides reducing costs and risks, and improving the menu of services available to the consumers (Mishra, 2008; Frame and White, 2004). In particular, mobile phones reduce banks costs since they can switch from large, fixed infrastructure costs in rural and more

$$\Delta LFinD_t= \delta_0+\sum_{i=1}^{p}\varrho_i\ \Delta LFinD_{t-i}+\sum_{i=1}^{q}\delta_i\Delta LFinn_{t-i}+\sum_{i=1}^{r}\tau_i\Delta LX_{t-i}+\alpha ECM_{t-1}+\varepsilon_t,\ldots\ldots, 4$$

impoverished areas to a per-transaction variable cost structure. It is cost-efficient for customers, as it reduces travel costs to and from distant branches. Besides costs reduction, mobile phones also allow customers to network with their bank and non-bank financial providers, initiate transactions, and check balances more directly from wherever they are since the device offers convenience, a level of control and immediacy to customers that cannot be provided by traditional bank models.

The interaction between financial service providers and their clients through mobile phones creates an opportunity for information capturing, which is one of the barriers to financial depth (Chinoda and Kwenda, 2019). Moreover, as pointed out by Iftekhar et al. (2013) and Berger, (2003), usage of digital methods of payments such as internet banking improves costs and lending capacity. This is as a result of the reduction in costs of "back-office" activities that represent the majority of financial institutions operational costs and improved consumer benefits from enhanced "front-office" technology. Apriori, we expect a positive relationship between financial innovation indicators and financial depth.

Remittances foster banking outreach, and depth since excess balances held by recipient households may be placed in savings and deposit accounts, thereby increasing available loanable funds. Moreover, banks can use remittance flows as collateral to extend credit to regular recipient households. However, other studies have demonstrated that remittances lead to the relaxation of borrowing constraints, which subsequently decreases the marginal utility of wealth and increases the consumption of all normal goods, including leisure. In this case, migrant remittances cause reduction of labour supply among the non-migrants who substitute income for leisure with possible adverse effects on credit growth. Moreover, this may adversely impact investments and the accumulation of capital (Misati et al., 2019; Berrak et al. 2018; Guha2013; Akkoyunlu, 2013). Apriori, an ambiguous sign is thus expected.

The relationship between trade openness and the financial sector is ambiguous as pointed out by Bayar et al. (2017). On the one hand, trade openness contributes to the development of the financial sector by increasing the necessity of insurance and risk diversification through financial institution due to increasing uncertainty, income volatility, foreign competition, and higher exposure to external shocks (more details Svaleryd and Vlachos, 2002). On the other hand, increasing openness also has the potential to affect the development of financial sectors by raising financial contagion and the frequency and severity of crises.

We include the log of consumer price index to capture inflation since previous studies show that high inflation erodes returns on savings resulting in low savings and lower number of savers which in turn reduces the available loanable funds. Consequently, the borrowing pool and credit allocation shrink with negative implications for the financial sector.

Moreover, periods of high inflation are often followed by a tight monetary policy, which implies high-interest rates with potentially inefficient financial markets (Bittencourt, 2011).

We also include lending interest rates to capture the cost of capital. McKinnon (1973) and Shaw (1973) hypothesised that restriction on financial instruments like interest rate ceiling, high reserve requirement and directed credit policies would hinder financial deepening. In this case, interest rate liberalisation asserts that repression reduces the amount of loanable funds available hence resulting in low credit supply. Mckinnon-Shaw argued that unrestricted interest rate regime motivates savers to convert some of their savings from unproductive real assets to financial assets leading to increased supply of credit. This will, in turn, enhance financial deepening and savings, increase investment, and thereby impact positively on economic growth, (Egbetunde et al., 2017). We include a dummy to capture various interest rate regimes considering that Kenya has undergone four distinct interest rate regimes since independent. Kenya liberalised interest rates in the 1990s, but interest rate controls were again re-introduced in September 2016 and subsequently repealed in November 2019. The dummy takes the value of one during interest rate controls and zero otherwise.

Real GDP is included to capture the level of economic activity consistent with the demand-following hypothesis or growth-led finance theory. According to this theory, an increase in economic activity leads to increase in demand for financial services by the real sector (Aluko and Ajayi, 2018; Bist, 2018; Banerjee and Ghosh, 1998; Patrick, 1966). As indicated by Touny and Shehab, (2015), an appreciation of the domestic currency makes goods and services produced in that economy relatively more expensive and thus weakens the competitiveness of export-oriented firms and adversely affects their ability to serve their debt with negative implications on credit growth. At the same time, a depreciation of the domestic currency implies economic agents have to pay more for their imports, causing a reduction in the capacity to repay as well increased demand for the equivalent local currency.

4.2 Estimation Method

Various methods are available for use in time series analysis with the most widely applied constituting, Engle and Granger two-step procedure (Engle and Granger, 1987), Johasen and Juselius, (1990) tests and Johansen, (1990). However, some of these methods lack power when considering finite samples and are prone to simultaneous equation bias besides failure to provide for variables integrated of different orders. In the recent past, the autoregressive distributive lag model (ARDL) has gained preference over previous time series methods due to its advantages. ARDL also referred to as bound cointegration technique is a least-squares regression using lags of the dependent and independent variables as regressors.

The ARDL has at least four advantages over the other cointegration methods; first, ARDL allows the

application of cointegration tests to time series having different integration orders. Second, the autoregressive distributed lag model is flexible to the sample size, which can either be small or finite (consisting of 30 to 80 observations). In this case, the ARDL approach gives more reliable results in small samples relative to Engel-Granger and Johansen cointegration test. Third, it also has better statistical properties relative to the Engle-Granger cointegration test because the ARDL approach uses unconstrained error, correction models. Fourth, the ARDL captures dynamic effects of both the dependent and independent variables, besides eliminating error serial correlation by including sufficient lags and allowing estimation of short-term and long-term simultaneously, (Qamruzzaman and Jianguo, 2018; Nkoro and Uko, 2016; Karamelikli and Bayar, 2015; Datta and Sarkar, 2014; Alimi, 2014; Adu et al., 2013; Jalil and Ying, 2008; Pesaran et al., 2001). To examine the existence of a long-run relationship between financial development, financial innovation, and other control variables of financial development, we employ the bounds test of cointegration within the ARDL framework.

5.0 Study Findings

In this section, we present for results for cointegration in Table 5.1. We then estimate long-run equations for the financial depth and economic growth with five different financial innovation indicators and two different indicators of financial access in seven separate models presented in Tables 5.2 and 5.4. The financial access indicators are also used to assess the extent to which shifts have occurred from traditional modes of financial intermediation to more digital channels of financial intermediation. Credit to the private sector is used as the indicator of financial depth while real GDP is used as the indicator for economic growth. In tables 5.3 and 5.5, we present short-run models with the error correction for financial depth and economic growth models, respectively. Although usage of ARDL does not require unit root tests, it is important to conduct the test since this technique collapse in the presence of integrated stochastic trend of I(2), (Nkoro and Uko, 2016). Thus, the time-series properties of the variables in equations 1 were checked using Augmented Dickey-Fuller (ADF) by Dickey and Fuller, (1981) and Phillips-Perron, (1988) and all the variables except RGDP and trade openness have a unit root in their levels but are stationary in their differences.[3]

5.1 Cointegration Tests

Cointegration tests are conducted based on equation 3 in which case; we specify the null hypothesis of no cointegration as, $H0: \beta_1 = \beta_2 = \ldots = \beta_n = 0$ against the alternative $H1: \beta_1 = \beta_2 \neq \ldots \beta_n \neq 0$ that cointegration exists. A rejection of the null hypothesis implies that cointegration exists. We test this hypothesis by comparing the F-statistics obtained from Wald's test with the critical values for small samples, or between 30 to 80 observations, as provided by Narayan (2005).

3 The results for the unit root tests are in Appendix 1. We have also reported the descriptive statistics as well as the correlation results in Appendix 4 and 5, respectively.

The cointegration test results are presented in Table 5.1, in which we estimated seven different cointegration equations corresponding to the seven financial innovation and access indicators utilised in this study. Accordingly, we used credit to the private sector as the dependent variable and same set of explanatory variables in all the estimated models but with a different financial innovation or access indicator in each case. All the results reported in Table 5.1 show existence of cointegrating relationships among the dependent and explanatory variables.

In Model 1, we used the value of mobile transactions as an indicator of financial innovation and Narayan, (2005) critical values that are designed for small observations ranging between 30-80 observations to assess the computed F-statistic. The result in the second column of Table 5.1 indicates F-statistic of 9.31 which is higher than the critical upper bound value at 1 percent significance level implying the presence of cointegration between credit to the private sector and its determinants. In Model 2 and 3, we used the number of mobile accounts and the number of bank branches, respectively, as indicators of financial innovation and access. In Model 2, the results indicate an F-statistic of 7.97 while we obtain F-statistic of 7.56 in Model 3, both of which are higher than the critical upper bound value at 1 percent significance level. Similarly, in Model 4, where we used the number of bank accounts as an indicator of access, we obtained F-statistic of 5.33 which is higher than the critical upper bound value at 5 percent significance level. In Models 5-7, we interchangeably used the number of ATMs, the individual using the internet as a percent of the population and number of mobile agents, respectively, as indicators of financial innovation. We obtained F-statistics of 11.7, 28.01 and 23.47, indicating that a long-run relationship exists between the dependent variable and the explanatory variables in all the three cases.

5.1. Table 2: Cointegration Tests: The Dependent Variable is Credit to the Private Sector

Model **	F-Statistic	Outcome-Based on Narayan, (2005)
Model 1: Cred=f(Cred, Rgdp, Topen, Er, CPI, Rem, Lend, MobV)	9.31*	Cointegrated at 1 percent
Model 2: Cred=f(Cred, Rgdp, Topen, Er, CPI, Rem, Lend, MobAcc)	7.97*	Cointegrated at 1 percent
Model 3: Cred=f(Cred, Rgdp, Topen, Er, CPI, Rem, Lend, Branch)	7.56*	Cointegrated at 1 percent
Model 4: Cred=f(Cred, Rgdp, Topen, Er, CPI, Rem, Lend, BankAcc)	5.33*	Cointegrated at 5 percent
Model 5: Cred=f(Cred, Rgdp, Topen, Er, CPI, Rem, Lend, ATMs)	11.70*	Cointegrated at 1 percent
Model 6: Cred=f(Cred, Rgdp, Topen, Er, CPI, Rem, Lend, Internet)	28.01*	Cointegrated at 1 percent
Model 7: Cred=f(Cred, Rgdp, Topen, Er, CPI, Rem, Lend, MAgent)	23.47*	Cointegrated at 1 percent

Model **	F-Statistic	Outcome-Based on Narayan, (2005)
Critical Values based on Narayan, (2005)		
Critical Values for Model 1-4	**Lower Bound**	**Upper Bound**
1 Percent	4.310	5.965
5 Percent	3.121	4.564
Critical Values for Model 5-6	**Lower Bound**	**Upper Bound**
1 Percent	4.799	6.821
Critical Values for Model 7	**Lower Bound**	**Upper Bound**
1 Percent	4.459	6.206

×× Cred= Credit to the private sector; Rgdp = Real GDP ; Topen= Trade openness; Er-Exchange rate; CPI= inflation; Rem= Remittances; Lend=Lending interest rates; MobV= Value of mobile transactions; MobAcc= Number of mobile accounts; Branch= Number of bank branches; BankAcc= Number of bank accounts; ATMs= Number of ATMs; Internet=individuals using internet; MAgent= Number of mobile agents

5.2 Estimated Long Run Coefficients

IIn Table 5.2, we report results for the long-run model with different financial innovation and access indicators in Model 1 to Model 7, from columns 2-8. Generally, the results show that both financial innovation and access indicators are positive and significant in explaining financial depth. The coefficients of the value of mobile transactions, the number of mobile agents, the number of ATMs, the number of individuals using the internet, the number of bank branches and bank accounts are all positive and significant. The results further reveal that internet use, the number of mobile agents and value of mobile transactions have the highest impact on financial depth while the number of ATMs and bank branches have the lowest impact in that order. Although the coefficient of the number of bank branches is positive and significant, the size of the coefficient is near zero showing that its contribution to financial depth is negligible with the advancement of the agency and mobile banking models. Similar results were found by Chinoda and Kwenda, (2019; Asongu et al., 2017). However, the number of mobile accounts is negative and not significant in explaining financial depth. The insignificance of the number of mobile accounts may be explained by the tendency of possession of inactive mobile accounts by economic agents.

Table 5.2: Long Run Model: The Dependent Variable is Credit to the Private Sector

	Model 1 with number of mobile accounts	Model 2 with value of mobile transactions	Model 3 with number of mobile agents	Model 4 with number of ATMs	Model 5 with bank branches	Model 6 with number of bank accounts	Model 7 with internet use
Topen	0.33(2.27)**	0.26(2.02)**	0.003(0.61)	0.28(2.45)**	0.09(1.08)	0.32(4.29)***	-0.08(-075)
ER	0.62(3.03)***	0.43(2.28)**	0.37(2.53)***	0.42(2.23)**	-0.02(-0.19)	0.19(1.48)	032(2.28)**
CPI	-0.06(-0.16)	-0.76(-2.02)	-0.86(-2.10)**	-0.12(-0.33)	-0.59(-2.20)**	-0.63(-1.62)	-0.94(2.36)**
Lend	0.18(1.64)	0.007(1.30)	-0.007(-1.70)*	-0.05(-0.61)	-0.11(-2.16)**	-0.14(-1.86)*	-0.06(-0.81)
RGDP	0.08(0.30)	-0.07(-0.34)	0.09(0.44)	-0.15(-0.69)	0.02(0.16)	0.01(0.10)	0.07(0.39)
Rem	0.32(2.61)***	0.21(2.06)**	-0.11(-1.40)	0.17(2.21)**	-0.08(-1.38)	0.21(1.98)**	0.02(0.20)
MobV		0.30(3.01)***					
MobAcc	-0.20(-1.22)						
MAgent			0.38(4.42)***				
Branch					0.004(7.41)***		
ATMs				0.19(2.74)***			
BankAcc						0.28(3.44)***	
Internet							0.53(3.92)***
Dumcap	-0.09(-2.71)***	-0.11(-3.73)***	-0.15(-3.92)***	-0.19(-5.00)***	-0.06(-2.49)***	-0.18(-5.80)***	-0.09(-2.91)***

×× Cred= Credit to the private sector; Rgdp = Real GDP ; Topen= Trade openness; Er-Exchange rate; CPI= inflation; Rem= Remittances; Lend=Lending interest rates; MobV= Value of mobile transactions; MobAcc= Number of mobile accounts; Branch= Number of bank branches; BankAcc= Number of bank accounts; ATMs= Number of ATMs; Internet=individuals using internet; MAgent= Number of mobile agents; Dum_cap= interest rate control dummy

Table 5.3: Econometric Results for the Error Correction Model (ECM)

	Model 1 with number of mobile accounts	Model 2 with value of mobile transactions	Model 3 with number of mobile agents	Model 4 with number of ATMs	Model 5 with bank branches	Model 6 with number of bank accounts	Model 7 with internet use
$\Delta Topen_{t-1}$	0.08(1.71)*	0.006(2.31)**	0.08(1.92)*	0.08(1.85)*	0.05(1.09)	0.10(2.04)**	0.10(1.86)*
$\Delta RGDP_{t-1}$	0.10(1.42)	0.80(1.25)	0.16(2.51)***	0.15(2.17)**	-0.04(-0.55)	0.79(1.34)	0.05(0.71)
ΔER_{t-1}	0.03(0.27)	0-0.02(-0.17)	0.14(1.35)	0.03(0.35)	-0.01(-1.19)	0.02(0.20)	0.19(1.47)
ΔCPI_{t-1}	0.33(1.37)	0.16(0.65)	-0.06(-0.26)	-0.25(-1.02)	0.04(0.20)	-0.17(-0.63)	0.50(0.69)
ΔRem_{t-1}	-0.05(-1.89)*	-0.07(-2.12)**	-0.05(-1.80)*	-0.05(-1.94)*	-0.07(-1.87)*	-0.05(-1.35)	-0.08(-1.69)*
$\Delta Lend_{t-1}$	-0.14(-2.24)**	-015(-1.68)*	-0.09(-1.61)	-0.09(-1.47)	-0.09(-2.65)***	-0.12(-1.87)*	-0.15(-1.72)*
$\Delta MobV_{t-1}$		0.07(1.27)					
$\Delta MobAcc_{t-1}$	0.04(0.80)						
$\Delta MAgent_{t-1}$			-0.001(-0.01)				
$\Delta Branch_{t-1}$					0.31(0.72)		
$\Delta ATMs_{t-1}$				0.06(1.95)*			
$\Delta BankAcc_{t-1}$						-2.34E-08(-2.33)**	
$\Delta internet_{t-1}$							0.26(1.95)*
Dum_cap	-0.02(-3.93)***	-0.09(-2.95)***	-0.02(-3.73)***	-0.02(-3.85)***	-0.04(-2.98)***	-0.03(-4.37)***	-0.03(-3.30)***
ECM(-1)	-0.22(-2.63)***	-0.34(-2.60)***	-0.33(-3.32)***	-0.24(-2.66)***	-0.30(2.21)**	-0.39(-2.77)***	-0.54(-2.75)***

Other important variables that bear the expected positive signs and are significant in at least four of the seven models in Table 5.2 are trade openness, remittances and the exchange rate. The relationship between remittances and financial depth is consistent with growth-enhancing theories. At the same time, the result of the coefficient of trade openness is consistent with the demand side of financial development in which trade openness triggers increased demand for financial products and services. Our results corroborate previous work (Misati et al., 2019; Ho and Lyke, 2018). The coefficient for the dummy for interest rate controls is negative and significant in all the seven models reported in Table 5.2. This result confirms that restrictions on prices, mainly, interest rates are not healthy for loan growth. This result is consistent with previous work by Alper et al. (2019) and supports the financial repression theories of McKinnon, (1973) and Shaw, (1973). Cost of credit captured by lending interest rates also negatively affects credit growth and hence financial depth in three out of the seven models in Table 5.2. The results, however, show that economic activity is not significant in explaining financial development in all the reported models.

Table 5.3 reports results for the short-term model and the error correction model. The results show that all the coefficients of financial innovation and access indicators are not significant except ATMs, internet usage and bank accounts. However, whereas the relationship between ATMs and internet usage and financial depth is positive and significant as in the case of the long-run models, the coefficient of the number of bank accounts is negative and significant in the short-run. This would be explained by the fact that banks are no longer the main channels through which economic agents hold accounts. With the increasing number of non-bank financial service providers, including telecommunication companies with options of holding cash balances, the consumers have diversified choices through which to manage the financial portfolio. The positive and significant relationship between bank accounts and financial depth, in the long run, maybe explained by the fact that over time commercial banks continue to enter into partnerships with non-bank financial providers and introduce new products including lending products. For instance, a number of commercial banks have collaborated with the main telecommunication companies to provide various mobile banking solutions, including loan products such as Mobi Bank, MobiGrow, Jaza Duka, Timiza.

The coefficient of remittances is also significant in nearly all the models, but unlike in the long-run models where the relationship is positive, in the short run models, remittances negatively affect financial depth. This would be due to the possibility of high consumption levels of remittance flows by recipients in the short run as senders settle and stabilise before they can make enough savings required for investment or that can serve as collateral for their recipients. Similar results were found by Misati et al. (2019). Lending interest rate and the interest rate control dummy have a negative effect on credit growth or financial depth as is the case for long-run models. Trade openness is also positive and significant consistent with the long-run models.

Table 5.4: Long Run Model: The Dependent Variable is Real GDP Growth

	Model 1 with number of mobile accounts	Model 2 with value of mobile transactions	Model 3 with number of mobile agents	Model 4 with number of ATM s	Model 5 with bank branches	Model 6 with number of bank accounts	Model 7 with internet use
Topen	-0.10(-1.31)	-0.08(-1.08)	-0.09(-1.20)	-0.05(-0.72)	-0.10(-1.33)	-0.09(-1.16)	-0.003(-0.04)
CPI	-0.75(-2.32)**	-0.80(-2.55)***	-0.77(-2.41)**	-0.68(-2.04)**	-0.79(-2.50)***	-0.87(-2.61)***	-0.95(-2.43)**
Rem	0.14(2.20)**	0.15(2.53)***	0.15(2.53)***	0.09(1.64)	0.12(1.89)*	0.18(2.41)**	0.20(1.96)*
Cred	0.43(2.49)***	0.46(2.69)***	0.44(2.88)***	0.51(2.41)**	0.49(2.56)***	0.44(2.80)***	0.51(2.11)**
GFCF	-0.31(-1.46)	-0.32(-1.59)	-0.30(-1.45)	-0.31(-1.39)	-0.12(-0.65)	-0.34(-1.56)	-0.31(-1.24)
Pubdebt	0.37(2.58)***	0.38(2.76)***	0.37(2.67)***	0.37(2.66)***	0.23(1.74)*	0.33(-1.93)*	0.42(2.22)**
Govcons	-0.72(-1.96)**	-0.64(-1.91)*	-0.58(-1.81)*	-0.91(-1.77)*	-0.88(-2.31)**	-0.59(-1.66)*	-0.53(-1.03)
ER	-0.35(-1.97)**	-0.26(1.71)*	-0.29(-1.83)*	-0.41(-2.27)**	-0.27(-1.78)*	-0.22(-1.47)	-0.34(-1.37)
MobV		-0.04(-0.55)					
MobAcc	-0.02(-0.52)						
MAgent			-0.03(-0.63)				
Branch					-0.31(-0.78)		
ATMs				-0.08(-1.14)			
BankAcc						0.02(0.22)	
Internet							-0.07(-0.53)
Dum_cap	-0.06(-1.48)	-0.08(-1.84)*	-0.07(-1.79)*	-0.06(-1.49)	-0.06(-1.80)*	-0.07(-1.66)*	-006(-1.31)

×× Topen = Trade openness; CPI= Inflation; Rem= Remittances; Cred= Credit to the private sector; GFCF=Gross fixed capital formation; Pubdebt= Public debt; Govcons= Government expenditure; Er = Exchange rate; MobV= Value of mobile transactions; MobAcc= Number of mobile accounts; Branch= Number of bank branches; BankAcc= Number of bank accounts; ATMs= Number of ATMs; Internet=individuals using internet; MAgent= Number of mobile agents; Dum_cap= interest rate control dummy

The coefficient of the error correction model is negative and significant in all the models as expected. The coefficient measures the proportion of the last period's equilibrium error, which is corrected in the current period. A negative and significant coefficient of ECM lagged once implies that any short-term disequilibrium between the dependent and explanatory variables converges back to the long-run equilibrium relationship. Generally, the results show a relatively low speed of adjustment to long-run equilibrium in case of a shock. In columns 2-7, the speed of adjustment to long-run equilibrium following a shock, ranges from 22 percent to 39 percent implying that it takes between 2.5 quarters to 4.5 quarters for the variable's equilibrium relationship to be restored. In model 7, however, the equilibrium relationship between variables is restored in less than two quarters.

In Table 5.4 and 5.5, we report the estimated long-run and short-run economic growth models that include an indicator of financial depth as well as financial innovation indicators in the economic growth models. The indicator of financial depth that is credit to the private sector was considered in all the reported models, but the financial innovation indicators were entered separately. The results show that whereas credit to the private sector representing financial depth is positive and significant in all the seven reported models, none of the financial innovation or access indicators directly affects economic growth. This implies that the impact of financial innovation on economic growth is indirect through the financial deepening channel. The results also imply a dominance of the supply-leading hypothesis of the finance-growth theory over the demand-pulling hypothesis, given the results in Table 5.3 that show the weak impact of GDP on financial depth. Thus, the results suggest that economic growth is reliant on how well the financial sector is deepened or developed.

The results also show that apart from financial depth, economic growth is also negatively and significantly determined by inflation and government expenditure. The significance of the coefficient of inflation in the growth equations signal that macroeconomic stability and an environment of relative certainty promotes growth. The results on the coefficient of government expenditure may be suggesting that most of the government expenditure is on recurrent expenditures as opposed to development expenditures. The coefficient of public debt is positive and significant in all the reported models implying that part of the debts in Kenya is growth-enhancing. Trade openness and gross fixed capital formation are not significant in explaining economic growth. The coefficient of remittances is positive and significant in nearly all the reported models in 5.4, implying that remittance flows deepens not only the financial system but also affects economic growth through other channels.

Table 5.5: Results for the Error Correction Model (The Dependent Variable is RGDP)

	Model 1 with number of mobile accounts	Model 2 with value of mobile transactions	Model 3 with number of mobile agents	Model 4 with number of ATMs	Model 5 with bank branches	Model 6 with number of bank accounts	Model 7 with internet use
Topen	0.14(2.03)**	0.11(1.71)*	0.15(2.12)**	0.13(2.03)**	0.14(1.85)*	0.15(2.10)**	0.12(1.71)*
ΔCPI_{t-1}	-0.61(-1.37)	-0.18(-0.36)	-0.54(-1.21)	-0.69(-1.66)*	-0.93(-1.66)*	-0.52(-1.12)	-0.87(-2.31)**
$\Delta Remit_{t-1}$	0.11(2.14)**	0.10(1.83)*	0.10(2.01)**	0.11(2.28)**	0.13(2.14)**	0.12(2.15)**	0.13(1.91)*
$\Delta CredP_{t-1}$	0.66(2.06)**	0.02(0.06)	0.71(2.18)**	0.82(2.66)***	0.93(2.39)**	0.67(1.85)*	0.76(2.27)**
$\Delta GFCF_{t-1}$	-0.36(-1.41)	0.09(0.35)	-0.35(-1.44)	-0.37(-1.60)	-0.29(-0.86)	-0.33(-1.24)	-0.40(-1.25)
$\Delta Pubdebt_{t-1}$	0.38(2.01)**	0.20(1.06)	0.42(2.18)**	0.42(2.37)**	0.39(1.71)*	0.36(1.91)	0.05(0.25)
$\Delta GovCons_{t-1}$	-0.51(-0.90)	-0.28(-0.42)	-0.21(-1.08)	-0.14(-0.26)	-0.66(-0.96)	0.23(0.34)	0.27(0.56)
ΔER_{t-1}	-0.22(-1.16)	-0.33(-1.67)*		-0.23(-1.28)	-0.22(-1.01)	-0.20(-1.20)	-0.35(-1.68)*
ΔMob_v_{t-1}		0.27(2.67)***					
ΔMob_acc_{t-1}	-0.04(-0.49)					-0.14(-0.90)	
ΔMob_age_{t-1}			-0.04(-0.47)				
$\Delta Branch_{t-1}$					-0.29(-0.26)		
ΔATM_{t-1}				0.10(1.99)**			
$\Delta internet_{t-1}$							0.07(0.26)
Dum_cap	0.009(0.57)	0.006(0.39)	0.01(0.77)	0.01(1.23)	0.01(0.62)	0.01(0.65)	0.02(1.12)
ECM(-1)	-0.87(-4.05)***	-0.71(-2.76)***	-0.89(-4.07)***	-0.87(-4.34)***	-0.74(-2.62)***	-0.87(-3.84)***	-0.95(-4.22)***
ECM(-1)	-0.87(-4.05)***	-0.71(-2.76)***	-0.89(-4.07)***	-0.87(-4.34)***	-0.74(-2.62)***	-0.87(-3.84)***	-0.95(-4.22)***

In Table 5.5, we report results for short-run analysis using real GDP as the dependent variable. The results indicate that credit to the private sector, the value of mobile transactions and number of ATMs are important in explaining economic growth in the short run. However, the number of mobile agents, bank branches and mobile accounts are not significant in economic growth in the short run. The coefficients for the ECM are all negative and significant as expected, but unlike in the case of the financial depth variables, in the models where real GDP is the dependent variable, the results show a much faster speed of adjustment to long-run equilibrium after a shock. In this case, the speed of adjustment to long-run equilibrium ranges between 71-95 percent suggesting that it takes between 1 to 1 and half quarters for long-run equilibrium relationship between the dependent and independent variables to be restored. Results from granger causality tests largely show unidirectional relationship from financial innovation indicators to financial depth regardless of the financial indicator used. The causality results further indicate that the relationship between economic growth and financial depth is also largely unidirectional but sensitive to the indicators used. In particular, financial depth, value of mobile transactions and internet usage granger causes economic growth, but the reverse is not true.[4]

4 Granger causality tests are reported in Appendix 2 and 3

6.0 Conclusion

In the recent past, financial innovation has become an integral part of the modern financial system, accounting for nearly all the changes occurring in the financial system. Financial innovation is, however, heterogeneous, and historical experiences, as well as empirical evidence, show that it can lead to ambiguous outcomes on the financial system and economic growth. On the one hand, financial innovation of various forms enhances the efficiency of financial intermediation, provides new choices of financial products and services, facilitates trade and consumption, and enhances financial inclusion with positive outcomes on growth. On the other hand, however, financial innovation that reduces asymmetric information increases risk-taking due to agency problems between bank owners and managers, or because of lower costs of fragility with negative implications on the financial system and economic growth.

In this study, we demonstrate that there is a long-run positive relationship between financial innovation and financial depth. The significant long-run relationship reflects efforts by various commercial banks to change their business models away from traditional banking strategies towards partnerships and strategic alliances with new non-bank financial players in Kenya. This finding provides a bridge for determining the causal effect of financial depth on economic growth. The results of the long-run economic growth models show that financial depth is positive and significant in explaining economic growth consistent with the finance growth theories. However, none of the financial innovation indicators is significant in explaining economic growth, implying that the impact of financial innovation on economic growth is indirect, through the financial depth channel. The results further indicate a positive relationship between remittances and economic growth both in the short run and in the long run implying that remittance affects not only economic growth through the financial deepening channel but also other channels. Results from granger causality tests largely show unidirectional relationship from financial innovation indicators to financial depth regardless of the financial indicator used and from financial depth and innovation to economic growth.

In terms of policy implications, it is evident that financial innovation largely captured by digitalised financial products and services is the new norm in the Kenyan financial system especially given the possibility of entrenchment of customer habits under the enhanced digitalisation drive following the COVID-19 pandemic. Our results show that internet and mobile usage have the greatest impact on financial depth which in turn positively affects economic growth. This implies that rising internet usage and adoption of mobile financial services is associated with increased financial depth and economic growth. A policy window exists for the government to further enhance financial intermediation efficiency by ensuring that all segments of the Kenyan population can cost-effectively and easily access internet services and mobile devices. This is particularly important for low-income earners who may not afford smartphones and internet services.

It is worth highlighting that access to internet services and usage of mobile devices largely depends on the accessibility of other infrastructural facilities, in particular, GSM network coverage, reliable electricity supply and smartphone devices. However, although most parts of Kenya can now access electricity, the cost of electricity has been increasing over time, making it difficult for low-income earners to afford, besides the inefficiencies associated with regular blackouts. Moreover, given that smartphones that are appropriate for internet use and mobile financial services are not only expensive but relatively new for most low-income earners, the government and private sector stakeholders must consider enhancing financial education on smartphone technology. In addition, there is a need to consider and develop requisite policies to ensure that all segments of the Kenyan population, especially low-income earners, are not excluded from accessing online and internet services. This calls for the need to invest in affordable infrastructure to enhance accessibility and connectivity of quality and reliable internet and electricity supply. The results further confirm that extensive physical branch network is increasingly giving way to technologically driven service delivery channels. Investment in cost-effective financial innovative products will thus be a significant determinant of the profitability of banks in future. It would also be instructive for the government and private sector, mainly commercial banks, to design new programs that embrace finance and technology as the new frontier.

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Appendix

Appendix 1: Unit Root Tests

	At level	At first difference	Order of intergration
RGDP	-6.39	-	I(0)
CRED	-1.15	-4.31	I(1)
TOPEN	-4.15	-	I(0)
ER	Variable	-5.23	I(1)
Lending	RGDP	-4.27	I(1)
INT	CRED	-7.69	I(1)
CPI	-3.10	-6.77	I(1)
REM	-2.09	-5.61	I(1)
No of Mob accounts	-0.347	-7.46	I(1)
No of Mob agents	-2.80	-6.14	I(1)
Value of transactions	-3.75	-8.02	I(1)
ATM_V	-3.22	-9.96	I(1)
Bank accounts	-2.48	-4.08	I(1)

Appendix 2: Granger Causality Tests: Financial Innovation and Financial Depth

Causality from financial innovation indicators to financial depth	F-Statistic	Probability	Causality from financial depth to financial innovation indicators	F-Statistic	Probability
BankAcc	12.17	0.001***	BankAcc	3.14	0.085*
MobV	17.43	0.001***	MobV	0.12	0.729
MobAcc	3.07	0.023**	MobAcc	1.19	0.344
MAgent	11.21	0.001***	Magent	0.50	0.483
ATMs	2.46	0.059*	ATMs	1.62	0.187
Branch	2.88	0.070*	Branch	1.06	0.357
Internet	3.04	0.064*	Internet	0.28	0756

Appendix 3: Granger Causality Tests: Financial Depth and Economic Growth

Causality from financial depth and financial innovation indicators to economic growth	F-Statistic	Probability	Causality from economic growth to financial depth to financial innovation indicators	F-Statistic	Probability
Cred	9.06	0.004***	Cred	0.82	0.370
BankAcc	2.29	0.117	BankAcc	1.09	0.348
MobV	12.80	0.001***	MobV	0.17	0.677
MobAcc	1.83	0.174	MobAcc	5.81	0.006***
MAgent	2.04	0.145	Magent	0.22	0.800
ATMs	1.67	0.202	ATMs	1.72	0.193
Branch	0.72	0.493	Branch	2.06	0.143
Internet	3.27	0.012***	Internet	0.21	0.968

Appendix 4: Descriptive Statistics

	CRED	TOPEN	ER	CPI	LEND	RGDP	REM	MobV	MobAcc	MAgent	Branch	ATMs	BankAcc
Mean	31.09	16.11	91.46	143.53	15.77	958091	1.24E+08	1.97E+11	25672322	110265.20	337.78	10698771	7484972
Median	30.69	16.36	89.06	142.85	15.60	943254	1.18E+08	1.91E+11	25508250	118488.50	355.09	10094813	6691012
Maximum	35.79	23.18	103.52	190.96	20.21	1220191	2.66E+08	3.68E+11	47694300	205745.00	383.38	17669550	14496359
Minimum	24.75	10.66	75.14	100.27	12.56	705261	52309000	4.54E+10	8016240	19803.00	243.23	3827553	2194955
Std. Dev	2.94	3.27	9.35	28.32	2.12	146980.1	52998269	9.78E+10	9741008	58589.98	45.87	4007625	4154100

Appendix 5: Correlation Results

	CRED	TOPEN	ER	CPI	LEND	RGDP	REM	MobV	MobAcc	MAgent	Branch	ATMs	BankAcc	Internet
CRED	1.00													
TOPEN	-0.97	1.00												
ER	0.93	-0.67	1.00											
CPI	0.98	-0.80	0.90	1.00										
LEND	-0.05	0.19	-0.11	-0.01	1.00									
RGDP	0.98	-0.83	0.92	0.99	-0.13	1.00								
REM	0.95	-0.73	0.87	0.98	-0.02	0.97	1.00							
MobV	0.99	-0.79	0.92	0.99	-0.08	0.99	0.97	1.00						
MobAcc	0.96	-0.71	0.90	0.97	-0.04	0.96	0.96	0.97	1.00					
MAgent	0.98	-0.81	0.87	0.98	-0.03	0.97	0.95	0.98	0.97	1.00				
Branch	0.96	-0.69	0.85	0.96	-0.12	0.92	0.93	0.95	0.94	0.96	1.00			
ATMs	0.95	-0.74	0.93	0.98	-0.03	0.97	0.96	0.98	0.97	0.96	0.95	1.00		
BankAcc	0.90	-0.83	0.90	0.96	-0.25	0.99	0.94	0.97	0.94	0.94	0.87	0.95	1.00	
Internet	0.96	-0.73	0.82	0.96	-0.01	0.93	0.94	0.95	0.94	0.97	0.98	0.94	0.90	1.00

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