
The Effect of Financial Technologies on Financial Inclusion in Kenya

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Abstract: The study sought to evaluate the effect of financial technologies (Fin-Tech) on financial inclusion in Kenya. A descriptive research design was used to collect and analyse data. The population of the study was all 25,000,000 adult population in Kenya interacting with Fin-Tech in various degrees. The study collected quarterly secondary data regarding financial inclusion and Fin-Tec from the CBK database, Communication Authority database and KNBS. The data extracted was entered on data collection sheets in the form of Excel sheets. Data on the Excel sheet were exported to STATA version 15. OLS regression model helped evaluate the effect of Fin-Tech on financial inclusion in Kenya. The study established that financial technology and other covariates have a significant effect on financial inclusion as measured by credit to the private sector. Financial technology via mobile money, Agency banking, Point of Sale and mobile phone penetration had a statistically significant effect on financial inclusion. The study thus concluded that financial technology and other covariates have a major effect on financial inclusion as measured by credit to the private sector.

Keywords: Financial Inclusion, Financial Technologies, Fin-Tech, Mobile Money, Agency Banking, Mobile Phone Penetration, Point of Sale, Diaspora Remittances, Lending Rate

1. Introduction

Financial technologies have caused disruptions in the financial industry enabling most financial institutions to pull in unbanked people into access to financial products, while still maintaining the existing conventional customer base in what is referred to as financial inclusion (Mader, 2018). Academic literature exists on the association between financial technologies (Fin-Tech) and financial inclusion (FI). Financial technologies reduce the cost of financial intermediation hence enhancing financial inclusion (Ozili, 2018). Fin-Tech can enhance the reach of financial services to as many customers as possible ranging from credit, insurance, payment and savings facilities (Gorham and Dorrance, 2017). Financial technologies (Fin-Tech) are the use of new technology and technology channels to complement the older financial service delivery systems (Bateman, Duwendack & Loubere, 2019). Fin-Tech stands for Financial Technologies, and in its broadest definition, it means technologies that are used in the financial services sector or used to help firms manage the financial aspects of their business (Mearian, 2017). "Fin-Tech business models often focus on mobile customers and services are usually accessed with a software-as-a-service (SaaS) delivery model. By digitizing traditional finance-related workflows, small Fin-Tech start-ups can compete with traditional banks for customers. According to Gomber, Koch, and Siering (2017), Fin-Tec covers an extent several new financial and banking services, financial businesses, finance-related software, and novel forms of customer communication and interaction, delivered by Fintech companies and innovative financial service providers (Ozili, 2018).

FinTech is critical in the financial sector given its ability to enhance access to and use of financial products at the lowest cost possible (Han, Park & Kim, 2016). FinTech aims to develop safer, more cost-efficient business models to support the exchange of money and other measures of value. FinTechs work in various zones going from loaning to individuals, advanced portable instalments, and virtual monetary standards (Osmani, et al., 2020). These zones can particularly affect the unbanked by bypassing conventional financial controls in the formal banking sector and advancing financial services to those who need them at the least possible cost (Kimiri, 2018). FinTech-oriented firms straightforwardly compete with banks in many areas of the financial markets. FinTechs have proved that financial products and services of all sorts need to be seamlessly integrated

with the needs of today's customers (Schmied & Marr, 2017).

Financial inclusion is the pursuit of making financial services accessible at affordable costs to all or any individuals and businesses, no matter their net worth and size, respectively (Mader, 2018). "Financial inclusion is also called inclusive financing. Financial inclusion or access is a component of financial development, alongside depth, efficiency, and stability (Fungáčová & Weill, 2015). Financial inclusion is the accessibility, ease of availability and usage of the formal financial services provided by financial institutions in an economy. Mbutor and Uba (2013) defined financial inclusion as the improvement in the number of households and individuals in an economy who hold a formal bank account with banking intuitions. The goal of Financial inclusion is to bring as many people as possible to access financial services provided by financial institutions (Adaramola & Kolapo, 2019). Financial development is vital for the economic process, and financial inclusion especially features equity also (Maina & Mungai, 2019). Other potential benefits of financial inclusion include improving efficiency and targeting of state welfare programmes; and reducing corruption and terrorism more broadly, through better monitoring and regulation of monetary transactions using digital technology (Adewoye, 2013). Financial inclusion aims at improving the use of formal modes of payments, such as Internet payments, mobile payments and others by the populace. The empirical literature has elaborated on measures of financial inclusion and has presented various proxies that can be adopted to quantify financial inclusion. Financial inclusion has three components including access, usage and barriers (Wang & Guan, 2017). Access to financial services is measured using various proxies such as the number of bank accounts, the number of bank branches (per 1000 population) and/or the number of ATMs per (1000 people). Weligama (2018) used the volume of credit and deposits to GDP as a measure of the usage of banking services. In this research, the financial inclusion proxies will be the number of bank accounts, volume of deposits and credits to GDP.

FinTech offers a great possibility to enhance the reach of financial products for the benefit of the unbanked population. "The rapid development of Fin-Tech is dramatically transforming the financial services landscape (Gomber, Koch & Siering, 2017). They are providing easy and affordable access to financial services which is a critical aspect of sustainable economic development as it can help smoothen consumption, and improve livelihoods by having better saving techniques, access to credit and be able to make cheaper payments (Gorham & Dorrance, 2017). Fin-tech solutions have the potential to promote sustainable economic development by improving wider rights to use financial services to the unbanked population in emerging markets Han, Park & Kim, 2016). In Kenya, there has been a remarkable growth of Fin-Tech with increased adoption of digital technologies by financial institutions and users that have enhanced access to financial products including account opening, savings facilities, credit facilities and payment platforms. The growth of FinTech in Kenya has seen improved financial inclusion. Major fin-tech driving financial inclusion in Kenya includes mobile money, agency banking, point of sale, and internet banking among others. However, Kimiri (2018) noted that Kenya is still grappling with a high number of unbanked populations. The majority of Kenyans are still not enjoying all possible financial services even with the explosion of financial technologies. Access to credit facilities is still a challenge with few adults being banked. Furthermore, Credit reference bureaus have listed most Kenyans for failure to pay mobile-based loans hence limiting their access to more credit facilities (Byegon, Cheboi & Bonuke, 2019).

Globally, Ozili (2018) revealed that digital finance via Fin-Tech suppliers has vital positive outcomes for financial inclusion in developing and developed nations. Therefore, Fin-tech facilitates low-income borrowers to access conventional bank services via modern technologies. Durai and Stella (2019) revealed that financial inclusion is being enhanced by Digital Finance through their convenience, accuracy, usability, convenience, and easy interbank. Demir et al., (2020) revealed that FinTech lowers income inequality indirectly through its impacts on financial inclusion. Gibson (2015) discovered that Fin-Tech had discontinued the normal money services model that has reduced the barriers to entry thus increasing money inclusion. Kim, Zoo, Lee, and Kang (2018) evaluated the nexus of mobile financial services, financial inclusion, and development. The findings revealed that mobile banking had a major impact on financial inclusion. Gorham and Dorrance (2017) established that Fin-Tech has the potential to expand access to safe and reasonable money services. Locally, Sindani, Muturi and Ngumi (2019) revealed that Internet banking improved financial inclusion by banking institutions in Kenya. ATM banking had a major direct impact on financial inclusion. Sindani, Muturi and Ngumi (2019) conducted a firm-level study at the bank level hence there is a gap for a macro-level study using macro data. Ouma, Odongo and Were (2017) revealed that accessibility and use of mobile phones in delivering financial products enhance the chances of saving at the household level. Ouma, Odongo and Were (2017) was however limited to one financial technology hence there is a gap in other financial technologies that may also have a role in financial inclusion. Byegon, Cheboi and Bonuke (2019) showed that financial innovations have an intervening effect on the link between behavioural factors and financial inclusion. Hence financial innovations like agency banking, and mobile money enhanced the relationship between behavioural factors and financial inclusion. Byegon, Cheboi and Bonuke (2019) examined the indirect effect of financial innovation on financial inclusion hence a gap remains on the direct effect of financial innovations on financial inclusion in the micro-enterprise setting in Nairobi. The study therefore sought answers to the research question: what is the effect of Fin-Tech on financial inclusion in Kenya? Even though studies exist globally and locally on the relationship between Fin-Tech and financial inclusion, there are still several gaps. First, most studies have concentrated on one or a few aspects of Fin-tech with most aspects ignored in studies. Secondly, the majority of studies in Kenya have not

introduced diaspora remittances and lending rate as control variables given that the two variables play a critical role in financial inclusion in the empirical literature. Thirdly, the majority of studies have been based on bank-level studies with few macro-level analyses in Kenya. The study thus sought answers to the research question; what is the impact of Fin-Tech on financial inclusion in Kenya?

2. Literature Review

2.1 Theoretical Review

The study was anchored on the theory of financial innovation Model and Financial intermediation theory. Silber (1983) proposed the financial innovations theory that holds that the expansion of financial services by financial institutions is the main rationale for seeking financial inclusion (Li and Zeng, 2010). The theory postulates that the reason for the innovations in finance is the barriers present in the old model of commercial banking. The old model of banking is associated with information asymmetry, the cost of running a physical bank and other operational costs (Blach, 2011). Innovations in financial technologies are a basic drive of the financial system, which promotes the transformation of the economy and associated economic advantage from the new technology that is revitalizing the financial sector (Sekhar, 2013). Financial innovations characterize financial advancements by bringing forth better approaches for financial service provision to customers and ensuring better rates of returns for financial institutions. Further, financial innovations lead to boosting the economy of a country (Raines & Leathers, 1992). Financial innovations improve the liquidity of financial markets; guarantee the distribution of financial assets to those who need them and in addition enhance the availability to rising demand for financial products hence financial inclusion (Blach, 2011). The rising inventive models of financial inclusion through mobile and other computerized financial services are helping to address the gap between financial instruments and products (Waema & Omwansa, 2014). Financial innovation theory has been criticized for assuming that financial innovations are always associated with reduced cost of financial intermediation that may not hold especially when innovation is accompanied by the growth of social evils like cybercrime that takes advantage of innovations to make users of financial information worse off through loss of money, information among other breaches (Miller, 1992; Palmer, 2015). The theory of financial innovations underpins the current study by informing the independent variable Fin-Tech. The theory explains that innovations in financial sectors lead to the emergence of financial technologies that assist in financial intermediation that ensures those who have no access to financial products can access them easily. Financial technologies that are a product of financial innovations are critical in lowering information asymmetry; the cost of running physical banks and other operational costs hence reducing the cost of financial intermediation that further leads to financial inclusion.

The financial intermediation theory as advanced by Akerlof (1970) postulates that the financial intermediation process includes economic units with surplus funds deposited with financial institutions who in turn lend the same funds to economic units with deficit funds. Generally, financial intermediaries exist in the financial markets because of the very nature of market imperfections concerning surplus units and deficit units. In a 'perfect' financial market condition where there is no information and transaction costs, financial intermediaries would not exist since they would be serving no purpose. In reality, most financial markets are characterized by information asymmetry hence there exist differences in access to market information between buyers and sellers of financial products. Financial markets have pronounced and elevated levels of information asymmetries that make it crucial that intermediaries exist to bridge the gap in information and make the flow of finances within an economic system practicable. However, the theory has some limitations regarding underpinning the current study. The traditional criticism against the financial intermediation theory is that a massive number of financial assets are required for it to hold except in special cases only (Allen & Santomero, 1997). However, with the current development of advanced methods of option pricing and pricing models and the extension of these ideas on option valuation and other derivatives have served to negate this criticism and weakness of the standard market theory of financial intermediation. The theory underpins the current study by examining the contributions of financial intermediation to financial inclusion. Financial intermediation ensures that those with excess funds are connected with those who need finances to start business ventures. The purpose of financial intermediation is to reduce the intermediation cost hence financial inclusion.

2.2 Empirical Review

Okiro and Ndungu (2013) examined the impact of mobile and internet banking in Kenya. The study established that financial institutions have been in the process of significant transformation due to innovation in information technology. The study found that the rapid development of information technology has made banking tasks more efficient and cheaper. It has changed how customers interact with their financial institutions. Okiro and Ndungu (2013) was limited to mobile banking. Gibson (2015) conducted a study on the impact that financial technology has on financial services in developing countries. The study discovered that Fin-Tech had discontinued the normal money services model that has reduced the barriers to entry thus increasing money inclusion. It had modified the approach money services are delivered to the shoppers.

Ouma, Odongo and Were (2017) examined the connection between the use of mobile phones in providing financial services on the mobilization of savings in selected countries in sub-Saharan Africa. The study adopted logistic regression where results revealed that accessibility and use of mobile phones in delivering financial products enhance the chances of saving at the household level. Additionally, the study revealed that mobile financial services have a major effect on the amount saved. Ouma, Odongo and Were (2017) was however limited to one financial technology hence there is a gap in other financial technologies that may also have a role in financial inclusion. Kithinji (2017) evaluated the causal effect link between digital banking strategy and financial inclusion among commercial banks in Kenya. The study adopted multivariate regression analysis based on panel data for commercial banks running from 2012-2016. The findings based on ANOVA revealed that digital banking strategies had a significant direct causal effect relationship with financial inclusion among commercial banks in Kenya. Financial inclusion was measured by the number of accounts, number of branches, deposit value and customer base. Mobile banking, ATM banking, agency banking and online had a major effect on financial inclusion. Kithinji (2017) was based on bank-level data and another study based on macro-level data is necessary. Mulwa (2017) investigated the effect of Internet banking on the financial performance of commercial banks in Kenya. The study acknowledged that Internet banking has the potential to transform financial services and the banking industry. The study adopted a descriptive research design and descriptive statistics for analysis. The findings revealed that ROA in commercial banks in Kenya was on an upward trajectory due to an increase in online customer deposits through Internet banking. In addition, internet expenses fees and commissions increased to total asset ratio increased. Mulwa (2017) was limited to Internet banking and another study examining other aspects of Fin-tech besides Internet banking would be more informative.

Gorham and Dorrance (2017) explored the potential for technological innovation within the money services sector, with a spotlight on Fin-Tech. The study established that Fin-Tech has the potential to expand access to safe and reasonable money services to additional customers. The benefits of those innovations embody lower prices for services driven by larger efficiencies and targeted promoting, improved transparency regarding product and repair terms and prices, larger money management, quicker and/or period deposits and expenses mirrored in account balances, new merchandise and services specifically geared toward the underserved and improved safety and security of funds. Ozili (2018) evaluated the influence of digital finance on stability and financial inclusion. The analysis revealed that digital finance via Fin-Tech suppliers has vital positive outcomes for financial inclusion in developing and developed nations, and therefore the digital finances convenience facilitates borrowers with incomes that are low and ranging is often additional vital to them compared to the larger expense they will pay to amass the precise services from standard banks. Nevertheless, the analysis explains that despite the benefits of digital finances, it faces some difficulties in money inclusion and stability. Kim, Zoo, Lee, and Kang (2018) evaluated the nexus of mobile financial services, financial inclusion, and development. This research was a critical analysis of 54 academic research papers. The findings revealed that mobile banking had a major impact on financial inclusion. Byegon, Cheboi and Bonuke (2019) examined the intervening role of financial innovations on the link between behavioural factors and the utilization of formal financial services among Micro enterprises in Kenya. The study adopted a descriptive survey where a sample of four hundred and eighty-six managers of micro-enterprises in Nairobi was studied. The study was based on regression analysis where results showed that financial innovations have an intervening effect on the link between behavioural factors and financial inclusion. Hence financial innovations like agency banking, and mobile money enhanced the relationship between behavioural factors and financial inclusion. Byegon, Cheboi and Bonuke (2019) examined the indirect effect of financial innovation on financial inclusion hence a gap remains on the direct effect of financial innovations on financial inclusion in the micro-enterprise setting in Nairobi.

Durai and Stella (2019) evaluated the contribution of Digital finance to financial inclusion. The study used primary data where multivariate regression was adopted. Research showed that financial inclusion was affected by Digital Finance through its convenience, accuracy, usability, convenience, and easy interbank. Hence, digital finance in the form of mobile banking, credit cards, Internet banking, and mobile wallets (apps) have a major influence on financial inclusion. Durai and Stella (2019) was not carried out in Kenya hence may not be wholesomely adopted in Kenya. Sindani, Muturi and Ngumi (2019) examined the causal effect link between financial inclusion and financial distribution channels in Kenya. Financial distribution channels included Internet banking and ATM banking. Annual Secondary data was collected for a period of six years from 2012 to 2017. The study population was all the forty-four silenced commercial banks in Kenya. The study adopted regression analysis where Internet banking enhanced financial inclusion by banking institutions in Kenya. ATM banking had a major direct impact on financial inclusion. Sindani, Muturi and Ngumi (2019) was a firm-level study at the bank level hence there is a gap for a macro-level study using macro data. Demir, Pesqué-Cela, Altunbas and Murinde (2020) evaluated the link between FinTech, financial inclusion, and income inequality in a panel of one hundred and forty countries. The study examined the effect of FinTech on inequality directly and indirectly via financial inclusion. The study adopted OLS, 2SLS and IV models. The study revealed that FinTech lowers income inequality indirectly through its impacts on financial inclusion. Demir, Pesqué-Cela, Altunbas and Murinde (2020) examined the mediating effect of financial inclusion on the relationship between fin-tech and income inequality. Another study needs to be carried out that adopts Fin-Tech as the independent variable affecting financial inclusion

Arthur, Musau and Wanjohi (2020) evaluated how financial inclusion in Kenya was impacted by diaspora remittances. The

study was based on quarterly data for the period 2008 to 2018. A descriptive research design where employed in the research. The study adopted a multivariate time series regression model. The research revealed that remittances from the diaspora had a direct and major effect on financial inclusion. Arthur, Musau and Wanjohi (2020) was limited to the role of diaspora remittances in financial inclusion leaving a gap that examines other factors affecting financial inclusion in addition to diaspora remittances. In a study in Ghana, kumbo, Nyaaba, and Akologo (2018) evaluated the effect of diaspora remittances on financial inclusion. The study adopted a survey design where a sample of 16772 households was adopted into the study out of the total population. The research adopted logistic regression analysis where results showed that remittances increased the chance of opening bank accounts, however, it had no predictive power over loan application and qualification. Akumbo, Nyaaba, and Akologo (2018) was limited to diaspora remittances and did not examine other factors affecting financial inclusion including financial technology. Oyelami, Saibu and Adekunle (2017) revealed that low financial inclusion among the poor masses is a hindrance to inclusive development in developing countries. The study therefore examined the determinants of financial inclusion in countries in Sub-Saharan Africa. The study used ARDL to capture the long-run time series data that is non-stationary. The study revealed that financial inclusion is explained by interest rate, ATM usage, level of income and literacy. The breadth of the study by Oyelami, Saibu and Adekunle (2017) can be expanded to include more variables of in line with financial technology.

Boro (2017) evaluated how financial inclusion was affected by mobile banking in Kenya. The study was based on an analytical model with quarterly data collected from 2007 to 2016. The study adopted trend analysis and OLS regression analysis with the results revealing that financial inclusion was affected by mobile banking transactions and mobile money subscriptions through deposits. Boro (2017) was limited to mobile banking as one aspect of financial technology and another study with more financial technology variables would expand the breadth of the current study. Kithinji (2017) evaluated how financial inclusion in Kenya was affected by digital banking. The study was based on secondary data sourced between 2012 and 2016 from CBK and was a descriptive survey of all banks licensed by CBK. The digital finance tools examined included mobile banking, ATM banking, Agency banking and online. Proxies including the number of bank accounts, number of outlets, deposits and customer base, measured financial inclusion. The study adopted OLS regression with the study establishing that digital banking had a major impact on financial inclusion. Kithinji (2017) did not introduce control variables to capture extraneous variables that also influence financial inclusion. Senou, Ouattara and Houensou (2019) examine the effect of digital technology on financial inclusion in West Africa. Data was sourced from the central bank of West African states. Digital technology was captured by mobile phone penetration and internet usage. Financial inclusion was measured by the number of bank accounts per 1000 adults, credit to the private sector as a ratio of gross domestic product and the ratio of deposits to gross domestic product. The study adopted the Random effect and GMM model with the findings showing that mobile phone penetration and internet usage had a major direct effect on financial inclusion in West African states both in isolation and jointly. Senou, Ouattara and Houensou (2019) was based in West Africa and their domestication in the Kenyan context is welcomed.

3. Methodology

3.1 Research Design and Sampling

Descriptive research design was adopted given that the researcher intended to establish causal effect relationships between variables especially where the researcher has no control over the environment in which the variables are interacting (Saunders, Lewis and Thornhill, 2019). The design enabled the researcher to evaluate the contribution of FinTech to financial inclusion in Kenya. The population of the study was all population in Kenya interacting with Fin-Tech the study will target data collected on Fin-Tech and Financial inclusion proxies. About 47.5 million Kenyans were interacting with FinTech in various degrees (KNBS, 2019). The study adopted secondary macro data regarding study variables in Kenya hence no sampling was carried out. The data targeted was country-level macro data hence data was not collected from individual Kenyans. The study targeted quarterly data from the 1st Quarter 2011 to the 4th Quarter 2020. (To assess the reception of fin-tech in the last 10 years). The data will Yield 40 observations for each variable. The study was a census regarding all Kenyans interacting with Fin-Tech and how that has affected financial inclusion among Kenyans. There was thus no need for sampling with the study collecting secondary data regarding all Kenyans.

3.2 Data Collection

The study collected quarterly secondary data regarding financial inclusion and Fin-Tec. Data regarding Fin-Tech (Mobile money, POS, Agency banking) data was extracted from the CBK database. Regarding Control variables (Diaspora remittance and lending Rate) data was extracted from the CBK database. Data regarding mobile phone penetration was extracted from the Communication Authority of Kenya database. Regarding financial inclusion (credit to the private sector) data was extracted

from economic surveys by the Kenya National Bureau of Statistics. The data extracted was entered on data collection sheets in the form of Excel sheets.

3.3 Data Analysis

The collected was entered on an Excel sheet and evaluated for completeness and absence of errors. Data on the Excel sheet will be exported to STATA version 15. Descriptive statistics was utilized to determine outliers and elaborate on study variables. The measures of dispersal and central tendency adopted included the maximum, minimum, mean and standard deviation. The study then adopted inferential statistics where a multivariate time series regression model was adopted to evaluate the effect of Fin-Tech on financial inclusion in Kenya. The study adopted the models presented in equations [1].

$$CPS_t = \beta_0 + \beta_1 \ln MM_t + \beta_2 \ln POS_t + \beta_3 \ln AB_t + \beta_4 \ln DR_t + \beta_5 LR_t + \beta_6 MPP_t + \epsilon_t \dots \dots \dots (1)$$

Where

- CPS= Credit to private sector to Gross domestic product ratio
- MM= Mobile Money
- POS= Point of Sale
- AB= Agency Banking
- DR= Diaspora remittances
- LR= Lending Rate of commercial banks
- MPP = Mobile Phone Penetration
- Ln= Natural Logarithm
- β_0 = Intercept term
- β_i = parameter estimates
- ϵ = Error term
- t = unlagged time

The variables in the models were operationalized as shown in Table 1

Table 1: Operationalization of Study Variables

Variable	Notation	Measurement	Expected sign of relationship
Dependent variable			
Financial Inclusion	CPS	Credit to the private sector as a ratio of Gross Domestic Product	CPS
Independent Variables			
Mobile Money	MM	Value of mobile money transactions in Kenyan Shillings	[+]
Point of Sale	POS	Number of POS machines	[+]
Agency Banking	AB	The volume of agency banking transactions	[+]
Control Variables			
Diaspora Remittances	DR	Value of remittances in United States Dollar	[+]
Lending Rate	LR	Average lending rate of commercial banks as a %	[+]
Mobile Phone Penetration	MPP	Number of active SIM cards	[+]

3.4 Diagnostic Tests

The study performed various diagnostic tests to ensure that the regression model is robust for parameter estimates. The study evaluated Ordinary least squares (OLS) regression assumptions including Normality, linearity, No multicollinearity, homoscedasticity, No serial correlation, and No unit roots (Pagan, 1996). Normality is the assumption that data depicts normal distribution such that the mean and median are equal. Normality was tested using skewness and Kurtosis where skewness value equal to zero and Kurtosis equaling to three implies normality (Campbell, Lo, & MacKinlay, 2012). No multicollinearity is the assumption that the data regarding explanatory variables used in the study are not highly correlated (Hautsch, 2011). The study determined multicollinearity using Variance inflation factor (VIF) such that VIF lower than 10 signify low multicollinearity. Homoscedasticity is the assumption that the data used in the study have constant and finite variances. The study used residual plots to establish the absence or presence of heteroscedasticity. No serial correlation is the assumption that data about study variables at the current time are not highly correlated with previous successive data about the same variables. The absence or presence of serial correlation was established using Durbin Durbin-Watson alternative test where a significance higher than 0.05 implies no serial correlation. The study examined whether or not the explanatory has a significant effect on the dependent variable by comparing the p-value associated with the parameters with a 0.05 level of significance. P-values less than 0.05 levels of significance imply a significant effect of the explanatory variable on the dependent variable.

4. Results

4.1 Descriptive Analysis

The preliminary analysis involves the adoption of descriptive statistics and graphs to represent the data about variables. The descriptive analysis was important in the identification of the general nature of the variables and any outliers in the study. This was critical to identify problems that might interfere with inferential analysis. The descriptive analysis is presented in Table 2.

Table 2: Summary Descriptive Statistics

	CPS	MM	POS	AB	DR	LR	MPP	GDP
Mean	1,997.50	758.52	1,684.72	85.75	464.72	15.24	39.39	1,672.52
SD	583.21	325.01	877.18	54.15	184.48	2.50	10.10	676.50
Min	939.98	240.77	518.49	2.19	196.46	11.88	24.97	379.07
Max	2,883.61	1,661.40	3,502.10	162.97	820.37	20.21	61.41	2,834.25
Count	40	40	40	40	40	40	40	40

In Table 2, the deposits include savings and deposits made by the population in the banking sector including commercial banks and deposits taking Sacco's. Deposits had a mean of Ksh.931.24 billion for 40 observations. The standard deviation showed that deposits in each quarter were spread around the mean with about sh.329.75 billion. The minimum deposit was sh. 482.37 billion while the highest deposit was Ksh. 1,486.45 billion. Credit to the private sector (CPS) includes loans extended to the general population in Kenya apart from loans extended to the government. The mean credit to the private sector for the ten years was Ksh. 1,997.50 billion. The standard deviation showed that credit to the private sector in each quarter was spread around the mean with Ksh. 583.21 billion. The minimum credit to the private sector was Ksh. 939.98 billion and the maximum credit to the private sector was Ksh.2,883.61 billion. The mobile money (MM) was the value of mobile money transactions carried out through the economy through the mobile money agents. The mean mobile money was Ksh. 758.52 billion and the standard deviation showed that mobile money in each quarter of the year was spread around the mean with Ksh.325.01 billion. The lowest mobile money was Ksh. 240.77 billion while the highest mobile money was Ksh.1,661.40 billion. Point of sale (POS) machines had a mean of 1,684,720 machines with a standard deviation of 877,180 machines around the mean. The minimum number of machines was 518, 490 machines and the maximum number of machines was 3,502,100 machines. Agency banking (AB) was the volume of transactions carried through the commercial banks and MFI bank agents. The mean agency banking transactions was 85.75 million with a standard deviation of 54.15 million transactions around the mean. The minimum agency banking volume of transactions was 2.19 million and the maximum volume of agency banking transactions was 162.97 million.

Diaspora remittances (DR) were the money sent back home by Kenyans working or doing business abroad. The mean diaspora remittances was USD. 464.72 million with a standard deviation of USD. 184.48 million around the mean. The minimum diaspora remittances was USD.196.46 million while the maximum diaspora remittances was USD. 820.37 million. The lending rate (LR) was the average lending rate per year across the 44 licensed commercial banks in Kenya. The mean lending rate is 15.24% with a standard deviation of 2.50% around the mean. The minimum lending rate was 11.88% and the maximum lending rate was 20.21%. Mobile phone penetration (MPP) was the number of registered mobile phone sim cards within Kenya. The mean Mobile phone penetration was 39.39 million subscribers and the standard deviation showed that the number of subscriptions per quarter was spread around the mean with 10.10 million sim card subscriptions. The minimum number of subscribed SIM cards was 24.97 million while the maximum was 61.41 million subscriptions. The gross domestic product (GDP) was the monetary value of all finished goods and services produced or offered within the Kenyan boundary. The mean GDP was Ksh. 1,672.52 billion with a standard deviation of Ksh.676.50 around the mean. The minimum GDP was Ksh.379.07 billion and the maximum GDP was Ksh.2,834.25 billion. The number of bank accounts (NBA) was the accounts opened with commercial banks and deposit-taking MFIs in Kenya. The mean number of accounts was 39.01 million with a standard deviation of 18.38 million bank accounts. The minimum bank accounts were 14.24 million and the maximum bank accounts were 72.59 million.

4.2 Diagnostic Tests

The study performed various diagnostic tests to ensure that the regression model is robust for parameter estimates. The study evaluated Ordinary least squares (OLS) regression assumptions including Normality, multicollinearity, homoscedasticity and serial correlation (Pagan, 1996). Homoscedasticity is the assumption that the data used in the study have constant and finite variances. The study used residual plots to establish the absence or presence of heteroscedasticity. The results showed that most of the residuals fall along and around the normal line hence there was minimal problem of heteroscedasticity in the three models used in the study. The absence or presence of serial correlation will established using the Durbin alternative test where a p-value greater than 0.05 level of significance implies no serial correlation. The p-values (0.315, 0.129 and 0.4) were all

greater than 0.05 level of significance implying that there was no problem of autocorrelation as shown in Table 3.

Table 3: Durbin's alternative test for autocorrelation

Models	Durbin's alternative test for autocorrelation chi2	df	Prob>Chi2
Model 1	7.133	4	0.129

H0: no serial correlation

The study determined multicollinearity using VIF such that VIF lower than 10 signify low multicollinearity. The results presented in Table 4.3 show that there was no major problem of multicollinearity given that all the VIF values were less than 10.

Table 4: Variance Inflation Factor Test for Multicollinearity

Variables	VIF	1/VIF
MPP	5.830	0.171
MM	4.410	0.226
DR	3.950	0.253
AB	2.440	0.409
POS	1.310	0.763
LR	1.089	0.918
Mean VIF	3.171	

Normality is the assumption that data depicts normal distribution such that the mean and median are equal. Normality was tested using skewness and Kurtosis where skewness value equal to zero and Kurtosis equaling three implies normality (Campbell, Lo, & MacKinlay, 2012).

Table 5: Skewness and Kurtosis

Variable	Skewness	Kurtosis
CPS	-.1291889	2.928088
POS	-.1535099	2.930881
DR	.0403526	3.015086
LR	.2329092	2.938423
MM	-.4538719	3.316663
MPP	.2501538	3.023432
AB	-.339452	4.258323

Skewness between -0.5 and 0.5 if fairly symmetrical data, skewness between -1 and -0.5 or and 0.5 and 1, data moderately skewed, skewness less than -1 and greater than 1, the data is highly skewed. Skewedness of 0 is perfectly symmetrical data. All the values of skewness were between -0.5 and 0.5 hence the data was fairly symmetrical and normal. A standard normal distribution has a kurtosis of 3 in what is referred to as mesokurtic. Values of kurtosis greater than 3 are referred to as leptokurtic and values less than 3 are referred to as platykurtic. All values of kurtosis were near three hence, the data is said to be normal. The study thus concluded that the data collected was normal.

4.3 Regression Analysis

The study carried out OLS regression to establish the contribution of financial technology to financial inclusion in Kenya. The study adopted ordinary least squares regression given that the assumptions of OLS were not breached (Table 6).

Table 6: Effect of Financial Technology on Credit to Private Sector

CPS	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
MM	0.390	0.077	5.09	0.000	0.234	0.546	**
POS	0.184	0.034	5.46	0.000	0.253	0.116	**
AB	0.154	0.025	6.07	0.000	0.103	0.206	**
DR	0.290	0.085	3.43	0.002	0.462	0.118	**
LR	-0.013	0.004	-3.34	0.002	-0.021	-0.005	**
MPP	0.683	0.167	4.08	0.000	0.342	1.023	**
Constant	7.850	1.429	5.50	0.000	4.943	10.756	**
Mean dependent var		14.459	SD dependent var		0.327		
R-squared		0.920	Number of obs		40.000		
F-test		542.940	Prob > F		0.000		
Akaike crit. (AIC)		-147.096	Bayesian crit. (BIC)		-135.274		

** $p < 0.05$

Table 6 presents the effect of financial technology on credit to the private sector. The coefficient of determination ($R^2 = 0.920$) implies that model 3 explains 92% of the variation in financial inclusion (credit to private sector) hence financial technology (MM, POS and AB) and other covariates (DR, LR and MPP) explains 92% of the total variation in financial inclusion with the remaining 8% being explained by unobserved variables that were not part of the study. The analysis of variances (ANOVA) showed that financial technology (MM, POS and AB) and other covariates (DR, LR and MPP) have a significant effect on financial inclusion as measured by credit to the private sector ($F=542.940$, $p=0.000 < 0.05$). The value ($\beta_0 = 7.850$) is the level of financial inclusion, measured credit to the private sector to GDP ratio when fin-tech and other covariates are held constant at zero. Further, the effect of mobile money (MM) as an indicator of financial technology on financial inclusion measured by credit to the private sector was positive and significant ($\beta_1 = 0.390$, $t= 5.09$ and $p=0.000 < 0.05$). The effect of Point of Sale (POS) on financial inclusion (credit to the private sector) was negative and statistically significant ($\beta_2 = 0.184$, $t= 5.46$ and $p=0.000 < 0.05$). The effect of agency banking (AB) on financial inclusion (credit to the private sector) was positive and statistically significant ($\beta_3 = 0.154$, $t= 6.07$ and $p=0.000 < 0.05$). The effect of diaspora remittances (DR) on financial inclusion (credit to the private sector) was inverse and statistically significant ($\beta_4 = 0.290$, $t= 3.43$ and $p= 0.002$). The effect of commercial banks' lending rate (LR) on financial inclusion (credit to the private sector) was inverse and statistically significant ($\beta_5 = -0.013$, $t= -3.34$ and $p= 0.002$). Finally, the effect of mobile phone penetration (MPP) on financial inclusion (credit to the private sector) was positive and statistically significant ($\beta_6 = 0.683$, $t= 4.08$ and $p=0.000$). The model [1] is thus estimated as shown in the equation.

$$CPS_t = 7.858 + 0.390 \ln MM_t + 0.184 \ln POS_t + 0.154 \ln AB_t + 0.290 \ln DR_t - 0.013 LR_t + 0.683 MPP_t \dots\dots\dots(1)$$

5. Discussion

The study also sought to establish the effect of financial technology on credit to the private sector. The coefficient of determination ($R^2 = 0.920$) implied that financial technology (MM, POS and AB) and other covariates (DR, LR and MPP) explain 92% of the total variation in financial inclusion with the remaining 8% being explained by unobserved variables that were not part of the study. The analysis of variances (ANOVA) showed that financial technology (MM, POS and AB) and other covariates (DR, LR and MPP) have a significant effect on financial inclusion as measured by credit to the private sector ($F=542.940$, $p=0.000 < 0.05$). Further, the study revealed that the effect of mobile money (MM) on financial inclusion credit to the private sector was direct and significant ($\beta_1 = 0.390$, $t= 5.09$ and $p=0.000 < 0.05$). The positive relationship means that increased access to mobile banking was associated with increased financial inclusion through credit to the private sector. Further, increasing access to mobile money implies that the population can easily access mobile phone-based credit facilities. Moreover, the value and volume of mobile money transactions improve the creditworthiness of would-be borrowers hence increasing access to credit facilities from banking institutions. The improvement in access to mobile money by one unit is associated with improving financial inclusion through access to credit facilities in Kenya by 0.390 units. The research also revealed that the effect of Point of Sale (POS) on financial inclusion through credit to the private sector was positive and statistically significant ($\beta_2 = 0.184$, $t= 5.46$ and $p=0.000 < 0.05$). The positive relationship between POS and financial inclusion through credit to the private sector implies increasing access to POS machines leads to increasing financial inclusion through credit to the private sector. Increased access to POS machines encourages more lending through credit cards. When the population has access to POS machines, more people are likely to take credit cards which leads to increased credit to the private sector. Increased access to POS machines by one unit implies increasing financial inclusion through credit to the private sector by 0.184 units. The study also showed that the effect of agency banking (AB) on financial inclusion through credit to the private sector was positive and statistically significant ($\beta_3 = 0.154$, $t= 6.07$ and $p=0.000 < 0.05$). The positive relationship between agency banking and financial inclusion through credit to the private sector implies that increased access to agency banking enhances transactions through the bank account that qualifies individuals for credit from financial institutions. Access and usage of agency banking thus lead to improved creditworthiness of would-be borrowers in Kenya and ease of access to credit facilities. Further, increasing access and use of agency banking by one unit leads to increased financial inclusion through access to credit facilities by 0.154 units.

The study also showed that the effect of diaspora remittances (DR) on financial inclusion through credit to the private sector was positive and statistically significant ($\beta_4 = 0.290$, $t= 3.43$ and $p= 0.002$). The positive association between diaspora remittances and financial inclusion through credit to the private sector means that increasing diaspora remittances in Kenya is associated with increasing credit to the private sector. Diaspora remittances are associated with increased deposits in local bank accounts. The increased deposits in bank accounts imply more funds available for lending purposes especially the time deposits that are not needed for immediate use by depositors. Further, increasing diaspora remittances by one unit leads to increasing credit to the private sector by 0.290 units. The effect of commercial banks' lending rate (LR) on financial inclusion through credit to the private sector was inverse and statistically significant ($\beta_5 = -0.013$, $t= -3.34$ and $p= 0.002$). The relationship between lending rate and financial inclusion through credit to the private sector was inverse given that increasing lending rate

discourages borrowing hence reducing credit to the private sector. Increasing lending rates means increased cost of borrowing funds from financial institutions hence borrowers shy away from expensive loans. Increasing the lending rate by one unit is associated with reducing credit to the private sector by 0.013 units.

Finally, the study established that mobile phone penetration (MPP) had a significant effect on financial inclusion through credit to the private sector was positive and statistically significant ($\beta_6 = 0.683$, $t = 4.08$ and $p = 0.000$). The positive relationship between mobile phone penetration and financial inclusion through credit to the private sector implies that increasing the number of mobile phone sim card subscriptions leads to increasing access to financial inclusion through credit to the private sector. The increased access to mobile phones leads to increased access to qualification for loans. Access to mobile phones thus enhances access to credit facilities especially those accessed via mobile phones. Increasing adoption of mobile phones by one unit leads to increased financial inclusion via credit to the private sector by 0.683 units. The study findings on the effect of financial technology on financial inclusion via credit to the private sector have a basis in the literature. The study findings agree with Demir, Pesqué-Cela, Altunbas and Murinde (2020) who revealed that FinTech lowers income inequality indirectly through its enhancing impacts on financial inclusion. Further, Okiro and Ndungu (2013) supported the study findings on the effect of mobile money on financial inclusion via credit to the private sector when they revealed that the rapid development of mobile money had made banking tasks more efficient and cheaper. Regarding the effect of agency banking on financial inclusion via credit to the private sector, Byegon, Cheboi and Bonuke (2019) showed that financial innovations like agency banking enhanced financial inclusion making it easy for clients to get access to loans. Further, Ocharo (2014) and El Qorchi, Maimbo and Wilson (2003), regarding the effect of diaspora remittances on financial inclusion via credit to the private sector, noted that that remittance was positive and statistically significant and it enhanced financial inclusion through improved access to loanable funds in the domestic economy. However, Akumbo, Nyaaba, and Akologo (2018) had a contrary finding with their study showing that diaspora remittances had no predictive power over loan application and qualification. Uddin and Islam (2017) supported the study findings on the effect of lending rates on financial inclusion via credit to the private sector when they established that lower loan interest rates could encourage the population to access financial services like loans. However, Wokabi (2018) established that Interest rates had a direct and insignificant effect on financial inclusion measured by credit to the private sector. Further regarding the effect of mobile phone penetration on financial inclusion through credit to private sectors, the findings agree with Senou, Ouattara, and Houensou (2019), and Boro (2017) showed that mobile phone penetration and internet usage is critical to financial inclusion through encouraging lending.

6. Conclusions

6.1 Conclusion

The positive and major effect of mobile money on financial inclusion implies that money mobile money accessed through mobile phone sim cards improves financial inclusion by enabling users to easily open bank accounts via their phones, transfer money into mobile accounts and improve access to loans, especially mobile phone-based loans. The positive effect of Point of Sale (POS) on financial inclusion through credit to the private sector means that increased access to POS machines encourages more lending through credit cards. The positive and major effect of agency banking on financial inclusion through credit to the private sector implies that agency banking enhances transactions through the bank's account hence improving the creditworthiness of would-be borrowers in Kenya and ease of access to credit facilities. The positive relationship between diaspora remittance and financial inclusion implies more funds available for lending purposes especially the time deposits that are not needed for immediate use by depositors. The inverse relationship between lending rate and financial inclusion through credit to the private sector implies that increasing the lending rate discourages borrowing hence reducing credit to the private sector given that increasing lending rate means increased cost of borrowing funds from financial institutions hence borrowers shy away from expensive loans. The positive relationship between mobile phone penetration and financial inclusion implies that increased access to mobile phones leads to increased access to credit facilities especially those accessed via mobile phones like mobile phone-based loans.

6.2 Recommendations

The study recommends to the Central Bank, Communication Authority of Kenya, communication firms and banking institutions to strengthen and deepen mobile money. The regulators should put in place policies that make it possible for mobile money to be accessed at the lowest possible transaction fees. The communication and banking firms should continue innovating in the area of mobile money with a focus on security, transactions cost and ease of use of mobile money. Increased access to mobile money improves financial inclusion through improved access to bank accounts, eased transfer of money into bank accounts and increased access to mobile-based loans. The study also recommends that CBK and financial institutions institute policies that are aimed at strengthening agency banking. The financial regulator and financial institutions should aim at the increase in number of bank agents, increase the security of transactions carried out via bank agents and enhance technology for carrying out agency banking. Improved uptake of agency banking results in increased financial inclusion

through creditworthiness for access to credit facilities. Regarding point-of-sale, the study suggests that the regulator and financial institutions continue deepening the use of point-of-sale machines. The CBK should put policies in place for securing transactions carried over the point of sale as well as improved POS technology. The financial institutions issuing cards for use with POS machines should enhance their security features to protect transactions carried over the point-of-sale machines. Access to POS machines improves financial inclusion through credit facilities through credit cards. The study also recommends that the government put in place policies and strategies for ease of the remittance of money by Kenyans working and doing business abroad. The government should also put in place a favourable investment climate both at national and county governments to encourage Kenyans working abroad to remit their earnings back to Kenya to improve available investable funds. Further investment firms including banks should come up with innovative investment facilities targeting Kenyans living and working abroad. Diaspora remittances improve financial inclusion by enhancing loanable funds for the benefit of borrowers. The study also suggests that the Central Bank of Kenya, Sacco Regulatory Authority (SASRA), commercial banks, and deposit-taking MFIs continue lowering the cost of borrowing. The regulators should continue encouraging and persuading banking institutions to offer loans at favourable interest rates to borrowers. The CBK does this by lowering central bank rates further enabling commercial banks to offer loans at lower rates. Reduced lending rate leads to improved financial inclusion through access to loans at lower costs. Finally, the study recommends to the Communications Authority of Kenya and communication firms to continue improving mobile phone penetration rate. The communication Authority should continue putting in place policies aimed at encouraging uptake mobile phones as well as subscription to sim cards. The policies should also include improved security for Kenyans using mobile phones for communication and transfer of money. Mobile phone penetration improves financial inclusion through increased access to mobile-based loans.

6.3 Limitations of the Study

The study has a few limitations regarding its application for decision-making. First, the study was limited to three aspects of financial technology including agency banking, mobile money and point of sale hence the parameter estimates should be used with caution. The inclusion of more financial technologies would lead to a change in the size of parameter estimates. Other financial technologies that were not within the breadth of the study include Internet banking and ATM banking. Further, the meaning of financial technology was limited to end-user financial technologies whereas other financial technologies are targeting the internal use of financial institutions and Fin-tech companies. Secondly, the study concentrated on one proxy of financial inclusion (credit to GDP ratio). Other proxies of financial inclusion exist which might mean differing results and conclusions thereof. Financial inclusion has other dimensions that were not within the scope of the current study including usage and barriers to financial inclusion. This implies that the study findings should be used in policy decisions targeting the access dimension of financial inclusion. Thirdly, the study was based on quarterly secondary data covering ten years, the period is not long enough to examine aspects of financial technology and financial inclusion that need long-range data covering twenty years and above. Further, the secondary data alone cannot capture all aspects of financial technology and inclusion. There are qualitative aspects of financial technology and financial inclusion that cannot be adequately measured using secondary data only. Quality decision-making should be driven by both qualitative and quantitative empirical findings. Fourthly, the study was also analyzed based OLS model which is a fixed model and does not capture the dynamic nature of most financial data. The study was thus based on stock measures of financial technology and financial inclusion. The stock data was captured at the end of each quarter in March, June, September and December of each financial year. The flow aspect of financial data was not considered. Flow data is captured based on dynamic models that introduce the aspect of change in each variable. Financial data have both flow and stock aspects hence needs both static and dynamic models.

6.4 Areas for Further Research

The study suggests that future studies should include more financial technology variables to enhance the usefulness of the results for decision and policy purposes. Future studies should include other financial technologies that were not within the breadth of the study including internet banking and ATM banking. Further, future studies should have an expanded meaning of financial technology including technologies targeting the internal use of financial institutions and Fin-tech companies. Further, future studies should investigate the effect of financial technology on financial inclusion based on other aspects of financial inclusion beyond what is covered in the current study. Other proxies of financial inclusion should be considered. The proxies should include three dimensions of financial inclusion including access, usage and barriers to financial inclusion. Further, future studies can adopt a financial inclusion index that captures all three dimensions of financial inclusion. The study also suggests that future studies can be carried out using both secondary and primary data to capture both qualitative and quantitative aspects of financial inclusion. Future studies should also adopt long-range data of twenty years and above a period that is long enough to examine aspects of financial technology and financial inclusion that need long-range data. The primary data should be collected based on semi-structured questionnaires collecting both qualitative and quantitative data. Future studies should also be based on both static and dynamic models. The static models like OLS that were adopted in this study

would enable in capturing the stock measures of financial technology and financial inclusion that was measured at the end of each quarter in March, June, September and December of each financial year. The dynamic model would capture the flow aspect of financial data. Flow data is captured based on dynamic models that introduce the aspect of change in each variable. Models such as Vector Autoregressive (VAR) model, Error Correction Model (ECM), and Generalized Linear Model (GLM) among others.

Conflicts of Interest

“The authors declare no conflicts of interest.”

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