EFFECTS OF MOBILE MONEY FINANCIAL TECHNOLOGY SERVICES ON OUTPUT GROWTH AND PRODUCTIVITY IN KENYA

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NOVEMBER, 2023

DECLARATION

This research project is my original work and has not been presented for a degree in any other university for any other award.

Signature …… Date: …….

Gladys Njeri Wachira

K102/26862/2019

I confirm that the work reported in this project was carried out by the candidate under my supervision.

Signature: ……Date: …….

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DEDICATION

This research project is dedicated to my parents, Dr. Stanley Muchori and Mrs. Eleanor Wachira for their unending love, encouragement and support.

ACKNOWLEDGEMENT

I praise and thank the Lord for His unmerited grace and also for giving me the strength to develop this project to its completion.

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ACRONYMS

ATM	-	Automated Teller Machine
B2B	-	Business to Business
B2C	-	Business to Consumer
E-money	-	Electronic Money
FinTech	-	Financial Technologies
FSP	-	Financial Service Provider
MFI	-	Micro-Finance Institutions
MNO	-	Mobile Network Operators
P2P	-	Person to Person
PIN	-	Personal Identification Number
SIM	-	Subscriber Identity Module
TFP	-	Total Factor Productivity

OPERATIONAL DEFINITION OF TERMS

Agent - An entity that facilitates mobile money transactions for the users, with the most essential transactions being cash in (depositing money into the account) and cash out as well as registering new users.

E-money - Stored value kept in accounts of users, agents and mobile money service providers.

FinTech - Organizations that utilize technology and innovation to deliver financial services more efficiently.

Formal Financial Services - Financial services that are provided by institutions that are regulated such as banks and micro-finance institutions.

Leapfrogging- The concept that areas/sectors with technology that is poorly developed can advance rapidly through adoption of newer and modern systems without undergoing the intermediary steps and economies can skip through some stages of economic growth.

Mobile Banking - This is refers to the use of mobile devices, such as phones to conduct financial transactions and access banking services remotely.

Mobile Money - A service in which financial services are provided through mobile phones.

Mobile Payment - Transfer of e-money for bill payments or for the purchase of products and services online or at remote retail establishments.

Mobile Wallet - An account that holds e-money and is primarily accessed by use of mobile phone.

M-Pesa- A mobile banking solution provided by the service provider Safaricom, that enables clients to keep and transfer money.

Output Growth - This refers to the growth in production of goods and services over a given period of time.

Structural change – This refers to a significant shift in the way an economy operates or is organized, including composition of production, employment, demand and trade, which occurs along with the development of a country.

Total Factor Productivity (TFP) – This is the measure of the rate of technical progress or change leading to increased output.

Unbanked - Clients who own neither a transaction nor bank account in any formally recognized financial institution.

Under-banked - Individuals who despite having a basic transaction account in a formally registered financial institution, still have needs that are either entirely unmet or are insufficiently fulfilled such when one cannot send money safely or it is not affordable to transact

.

ABSTRACT

The advent of mobile money services in Kenya has revolutionized the financial sector in the country. The rate of uptake for the service- specifically M-Pesa has been nothing but phenomenal. Within 4 years of introduction, the service had reached a high proportion of 80 percent of the Kenyan households. This is in stark contrast to the 60 years it took for Kenya to have electricity- an equally important infrastructure. This service continues to grow and evolve - providing new and more services as the years go by. It has led to the financial inclusion of people who were previously unbanked or under-banked. Africa has for years been leading her counterparts in the number of active accounts and transaction value carried out using mobile money and more specifically, M-Pesa has been heralded to be a global leader in terms of mobile money financial technology services. It is, therefore, not surprising that foreign leaders have traversed for long distances to learn about this Kenyan-bred financial service. This study, therefore, takes cognizance of the massive growth of M-Pesa and its uniqueness in providing solutions for financial inclusion particularly in a developing country like Kenya. The general objective of this study was to analyze the effects of mobile money financial technology services on output growth and productivity in Kenya. The specific objectives were to investigate whether there is a structural change in the output growth and productivity in Kenya due mobile money financial technology services; to quantify the effect of mobile money financial technology services on output productivity in Kenya; and to examine the presence of a leapfrog effect of mobile money financial technology services on output productivity in Kenya. Secondary data was obtained for the years 1980 to 2020 and diagnostic tests for unit root, normality, multi-collinearity, auto-correlation and model misspecification were conducted to ensure that the results obtained were not spurious. The study used the Growth Accounting Method to determine Total Factor Productivity's contribution to the economic growth in Kenya. A regression analysis was then performed to establish the contributions of different factor variables to the Total Factor Productivity. The findings of the study suggest that there is a structural change in output growth and productivity in Kenya as a result of the introduction of mobile money financial technologies. Mobile money financial technology services were also found to have a significant positive effect on output productivity while leapfrogging did not have a significant effect. Given mobile money's positive effect on productivity, constraints hindering adoption and use of digital technologies such as lack of electricity access, poor network quality, affordability and lack of digital skills should be addressed for increased productivity. Additionally, a robust cyber security system that ensures client transactions and information is secure should be developed and enforced.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Mobile money falls under an umbrella of services which have come to be referred to as financial technologies, commonly referred to as, FinTech. These are financial services and solutions that have been enabled by technology (Arner, Barberis &Buckley, 2015). Mobile money can basically and simply be defined as financial services provision through a mobile phone (United Nations Conference on Trade and Development [UNCTAD], 2012).

The three primary mobile financial services are: mobile banking, mobile payment and mobile transfers. While mobile banking at times refers to the entire entity of mobile money, it is simply a type of mobile money service which allows individuals with accounts in a traditional formal bank to access their accounts through their mobile phone devices. In contrast, mobile payment and mobile transfer services do not require one to hold an account in a formal banking institution. These two services are made available to an individual through the Subscriber Identity Module (SIM) Card in the mobile phone. The electronic account in which the funds or money is held is referred to as the mobile wallet and it has a Personal Identification Number (PIN) feature which allows for privacy and protection from fund theft (African, Pacific and Caribbean Observatory on Migration [APCOM], 2014).

Mobile payment, which is also referred to as m-commerce, allows for one to pay for goods purchased from a vendor or services rendered by transferring funds from the mobile wallet rather than using physical cash. Mobile transfer, also referred to as person to person (P2P) or mobile remittances, allows for individuals to transfer money to other users using their mobile wallets

regardless of the mobile service provider either within the country or across international borders (APCOM, 2014).

For mobile money systems to be successful there has to be a network of relevant partnerships. There are five key members of the mobile money ecosystem- the Mobile Network Operators (MNOs), Agents, Fintech companies and banking institutions, retailing outlets and the regulators. The MNOs are the telecommunication service providers, the agents are the main point of contact with the consumer of the service by providing services such as deposits and withdrawal. The banks and Fintech companies provide banking services that are available on mobile phone devices. The retailing outlets are the point of Business to Consumer (B2C) transactions such as utilities and shopping bills payments as well as Business to Business transactions (Shrier, Canale & Pentland, 2016).

Mobile money technology has been identified as a leapfrog technology since it has boosted the provision of financial services by by-passing traditional institutions of banking. Leapfrogging occurs when an economy skips a stage of economic growth rather than going through the three stages of primary, secondary and tertiary sectors. The leapfrogging theory has been proposed as a way for the developing countries to catch-up mainly by skipping the manufacturing stage to the services sector. An example of this is the Indian economy which by-passed the manufacturing sector into the services sector- more specifically, the Information Technology (IT) services sector- which is now the main growth propellant of the Indian economy (Lee, 2019).

The conventional banking institutions have for a long time been associated with high costs through their minimum balance requirement as well as the regular maintenance costs for the accounts (Aron, 2018). The costs as well as the location of these institutions (mainly in urban areas) hindered

majority of the population from getting access to financial services provided via these institutions. In turn, this resulted in a large un-banked and under-banked population. Mobile money technology addressed these challenges by giving the people a low-cost option of saving and transferring funds as well as eradicating the physical location barrier.

Globally, it is now easier for the rural areas population to obtain financial services through the mobile money since its agents have a far much greater accessibility rate than ATMs and traditional bank branches- evidence of the leapfrog by mobile money technology. The mobile money agents have 7 times the accessibility rate of ATMs and also 20 times the accessibility rate to banks and their branches. This is a density of 228 active mobile agents for every 100,000 adults this is in comparison to 11 banks per 100,000 adults and 33 ATMs per 100,000 adults (Global System for Mobile Communications Association [GSMA], 2019).

According to GSMA (2016), the growth in the worldwide adoption of mobile money has mainly been propelled by the growth experiences in Sub-Saharan Africa (SSA) and it remains to be the global epicenter for mobile money (GSMA, 2019). SSA not only has the greater proportion of registered and active mobile money accounts but also has the greatest transaction volume and transaction value in the world. In the years 2017, 2018 and 2019, SSA has had the largest contribution to the global total of registered accounts, active accounts, volume of transaction and value of transactions. SSA accounted for 63.4 percent, 65.7 percent and 66.1 percent of the total global value of transactions in the years 2017, 2018 and 2019 (GSMA, 2019).

1.1.1 Mobile Money Financial Technology Services in Kenya

The mobile money phenomenon is said to have been globally popularized by the success of the Kenyan mobile money ecosystem (APCOM, 2014). This position was secured upon the

introduction of Safaricom's M-Pesa in 2007 which took the country by storm. Mobile money has revolutionized the financial services industry by providing a means of financial inclusion for people who were previously unbanked or were under-banked. The success has gained Kenya a global audience as the mobile money system is more developed than even in developed countries with a post on The Economist stating that mobile phone payments for cab rides are easier and more convenient in the capital city of Kenya- Nairobi than it is in the most popular city of the world- New York City (Amuomo, 2017).

Prior to the introduction, the Kenyan economy was largely characterized by high financial exclusion. This has however changed over the years as there is now more financial inclusion. The evolution in access to financial services over the years can be summarized as shown in Figure 1.1:

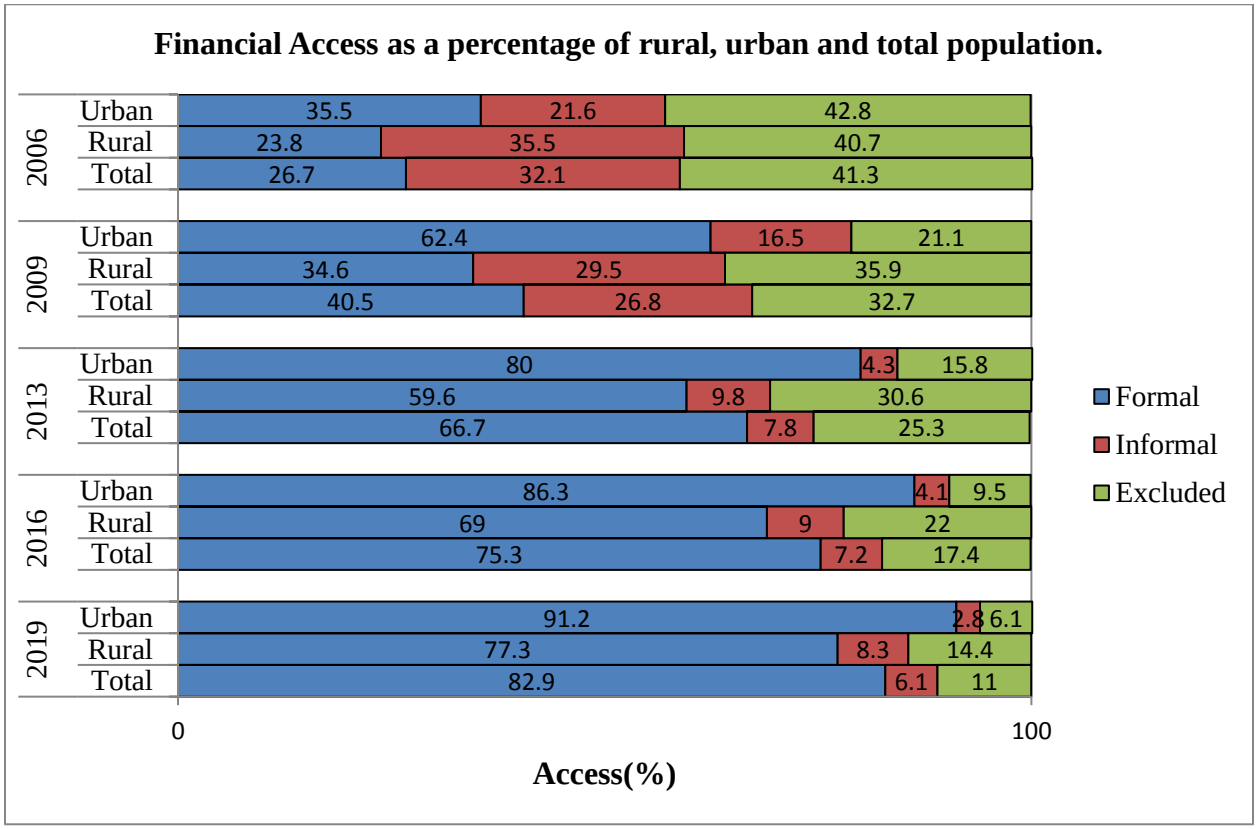

Figure 1.1: Status of Financial Access in Kenya
Source: FinAccess, 2019

It is evident that there has been growth in terms of the country's measure of financial inclusion. Of the total population, there was an increase in access to formal financial services from 26.7 percent in 2006 to 82.9 percent in 2019. The uptake of informal financial services and products reduced from 32.1 percent to 6.1 percent in 2019 and the fraction of the total population that was financially excluded declined from 41.3 percent to 11 percent. This increase in the uptake of the formal financial services is evident also among the rural population where there has been a steady growth. Only 34.6 percent of people living in the rural areas had access to formal financial services. However, in 2019, the proportion of the rural population that had access to formal financial services increased to 77.3 percent. From the graph, it is evident that financial services access among the urban population has been higher than that of the rural population- mainly because most of the institutions that provided formal financial services have historically been located in towns. The access rates have also been recorded to be increasing in the urban areas as 91.2 percent of the urban population had access in formal financial services in 2019, compared to the 35.5 percent in 2006. The decline in the informal financial access across the groups is due to the increased availability of convenient and affordable formal financial products.

The growth in Mobile Money Financial Services in Kenya can better be depicted by comparing its uptake to alternative financial service providers (FSPs) - Commercial Banks, Savings and Credit Co- Operatives (SACCOs) and Micro-Finance Institutions (MFIs). Based on the number of adults that use each financial service, the trend can be shown as in the Figure 1.2:

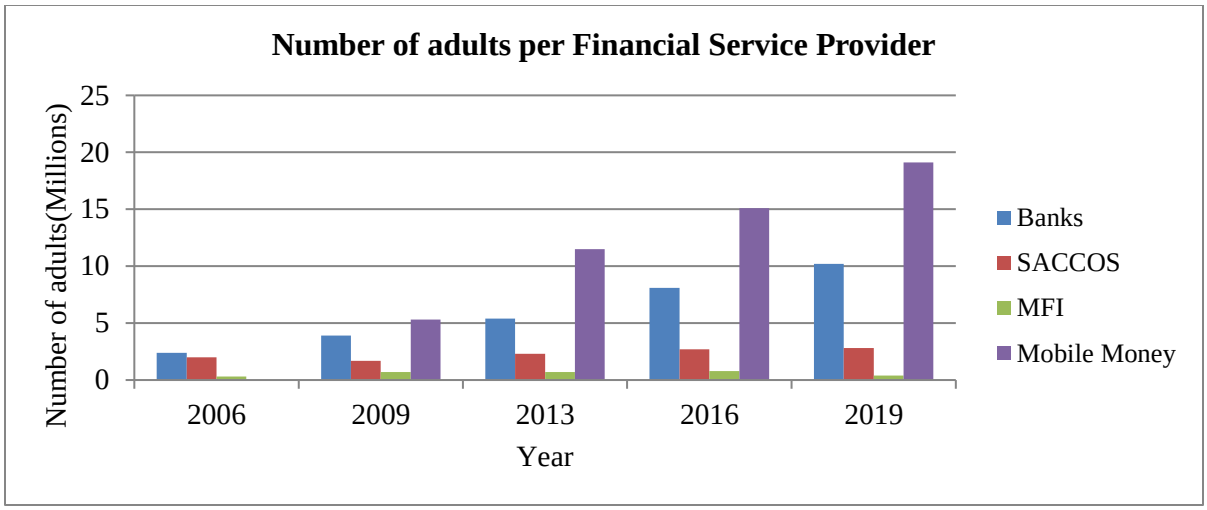

Figure 1.2: Number of Adults per Financial Service Provider
Source: FinAccess, 2019

From the graph it is evident that the number of adults with banks, SACCOs and Mobile Money access has been increasing over the years. It is also necessary to note that among the four FSPs, Mobile Money financial service has had the fastest growth, overtaking its predecessors. The dominance of the mobile money services is despite the fact that commercial banks already had 2.4 million account holders- as shown in the graph- before mobile money financial technology services were even introduced in Kenya. Only two years after its introduction, it already had amassed more account holders than banks by 1.4 million and this difference keeps growing. Banks have also been outperforming the SACCOs and MFIs as they have increased their access points significantly through the use of agency banking and linkage of M-Pesa to bank accounts. Between 2013 and 2016, banking services grew by 10 percent with 6 percent of the growth being attributed to the introduction of mobile banking services such as KCB M-Pesa (Nd'ung'u, 2021).

The evolution and growth of the mobile money in Kenya is evident in the statistics over the past decade. In 2010, the number of subscriptions, total agents and total value of deposits was 13.55 million, 35,684 and Ksh.114 billion respectively (Communication Authority of Kenya [CAK],

2011). There is a massive difference between the statistics in 2010 and the statistics in 2020 (as at September), where there were 31.79 million subscriptions, 245,124 agents and the total value of deposits was Ksh.888 billion (CAK, 2020). The statistics in 2020 are nearly 2.5 times, 6.9 times = and 7.8 times more for the number of subscriptions, total agents, and total value of deposits respectively than they were 10 years before. This is an equivalent of a 135 percent, 587 percent and 679 percent increase respectively.

There are three main mobile money services in Kenya: M-Pesa offered by Safaricom, Airtel Money by Airtel and T-Kash from Telkom- with the pioneer service being M-Pesa. The performance of the different mobile money service providers in 2020 is as summarized in the Table 1.1.

Table 1.1: Performance Indicators for Mobile Money Technology Service Providers

MNO/Indicator	**M-Pesa**	**Airtel Money**	**T-Kash**	**Total**
Agents	215,367	25,206	4,551	245,124
Subscriptions	31,417,232	341,306	32,875	31,791,413
Deposits	886,157,500,354	1,928,947,106	20,958,476	888,107,405,936

Source: CAK, 2020

In terms of the total number of agents, the highest proportion is by M-Pesa at 87.9 percent while Airtel Money and T-Kash have 10.2 and 1.9 percent respectively. A similar trend is seen in the subscriptions and the total value of deposits. In the subscriptions, the share by M-Pesa is 98.8 percent while Airtel and T-Kash follow at 1.1 and 0.1 percent respectively. The disparity across the mobile money services is even greater in terms of the deposits as M-Pesa has a contribution of a massive 99.78 percent as compared to 0.217 percent by Airtel Money and 0.003 percent by T-

Kash. M-Pesa has the greatest dominance of the mobile money technology infrastructure with greater network coverage across the country and wider range of services in comparison to the other mobile money service providers.

The term M-Pesa is a combination of two words- M is short for Mobile while Pesa is directly translated to money in the Swahili language. The service was launched in 2007 with three features only. These were withdrawal or deposit of cash at agent outlets, money transfer from person to person (P2P) and purchase of prepaid airtime. Once the service was introduced, there were over 20,000 M-Pesa clients registered in the first month alone (Hughes and Lonie, 2017). This has since expanded and evolved into a plethora of services and transactions that can be carried out through the M-Pesa service to meet different client needs. In order to access the M-Pesa services, one has to register at the nearest M-Pesa agent outlet and require only a valid identification document and a mobile phone which has a Safaricom SIM Card. Once a person is registered, he or she can access any of the M-Pesa services- deposit, withdrawal, sending money, Lipa na M-Pesa (pay with M-Pesa) and M-Shwari (savings account).

In 2020, there was the global outbreak of the novel COVID-19 - a viral disease affecting the respiratory system resulting in death at its worst. In an attempt to contain the pandemic, the Kenyan government encouraged the use of mobile money rather than physical cash. This was done through the introduction of incentives by M-Pesa. The incentives were the zero-rating of person to person transfers below Ksh.1, 000, zero-rating of M-Pesa to bank accounts and vice versa, increase of the M-Pesa transaction limit from Ksh.70, 000 daily to Ksh. 150, 000 daily for Small and Micro-Business Enterprise and the maximum amount to be held in the M-Pesa wallets being Ksh. 300, 000 (Safaricom, 2020).

1.1.2 The Kenyan Economy

Growth in the Gross Domestic Product (GDP) of an economy is often used as a measure of economic performance. GDP growth and output productivity are linked in that output productivity through Total Factor Productivity (TFP), is one of the contributing factors to growth in an economy. Kenya's GDP performance over the years can be summarized as shown in the Figure 1.3:

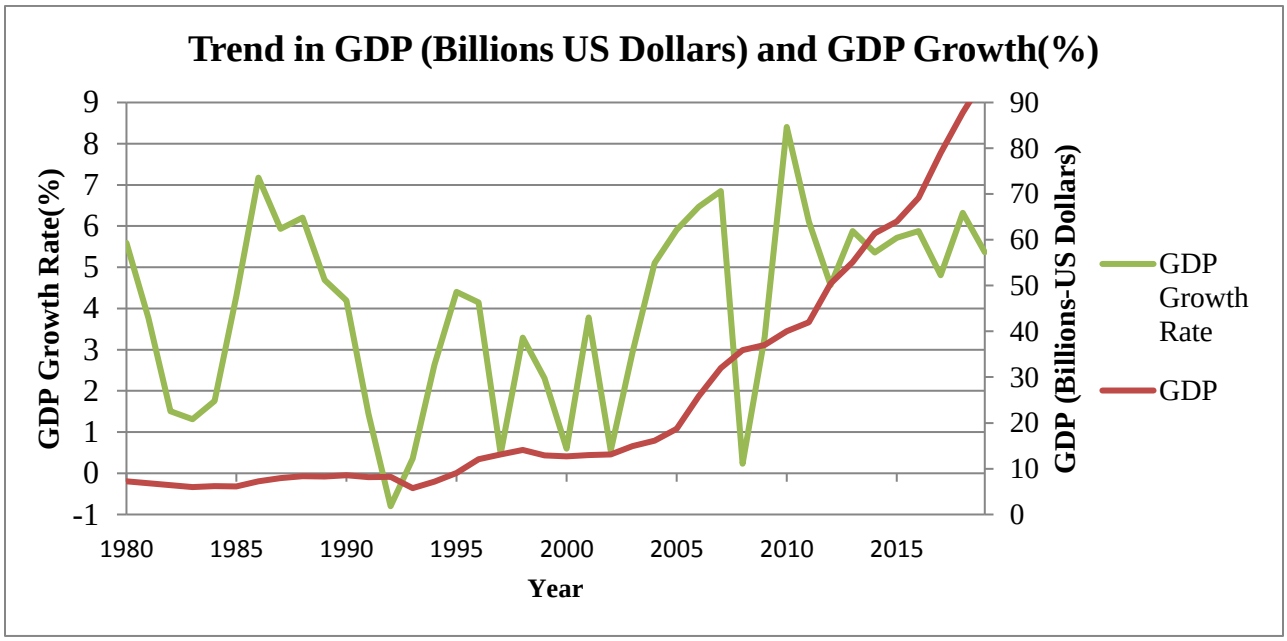

Figure 1.3: Trend in GDP Growth in Kenya, 1980-2019
Source: World Development Indicators, World Bank Online Dataset

The graph above shows the trend in the growth of GDP in Kenya between 1979 and 2019. In this period, the highest GDP growth recorded is in 2010 at 8.46 percent and the lowest is in 2008 at 0.232 percent. The noticeable lows in GDP growth were recorded in 1983, 1992, 1997, 2000 and 2008. The decline in the early 1980s was attributed to the shocks in oil prices in 1979, the attempted coup of 1982 and the drought experienced in 1983-84. In 1992, the 1992 elections and the rise in oil prices due to the Gulf War of 1992 led to the decline in GDP growth while in 1997 the performance was affected by the drought that led to the declaration of a state of national disaster

and the 1997 election (Ichwara, 2003). The 2002 decline was due to a drought that led to power rationing and the aid embargo that had been imposed in the years 1997-2000. Presence of a drought, the 2008 elections and the global financial crisis led to the decline in 2008. The years 2003-2007 recorded steady economic growth- the only time in post-independence Kenya that there was a five-year episode of growth. The steady growth is due to the sound economic and governance reforms that were undertaken in the period under the Economic Recovery Strategy such as increased infrastructure investments, reduced debt and anti-corruption efforts (Kimenyi, Mwega and Ndung'u, 2016).

The growth in the TFP can be shown by the trend in TFP Growth Index as shown in the Figure 1.4:

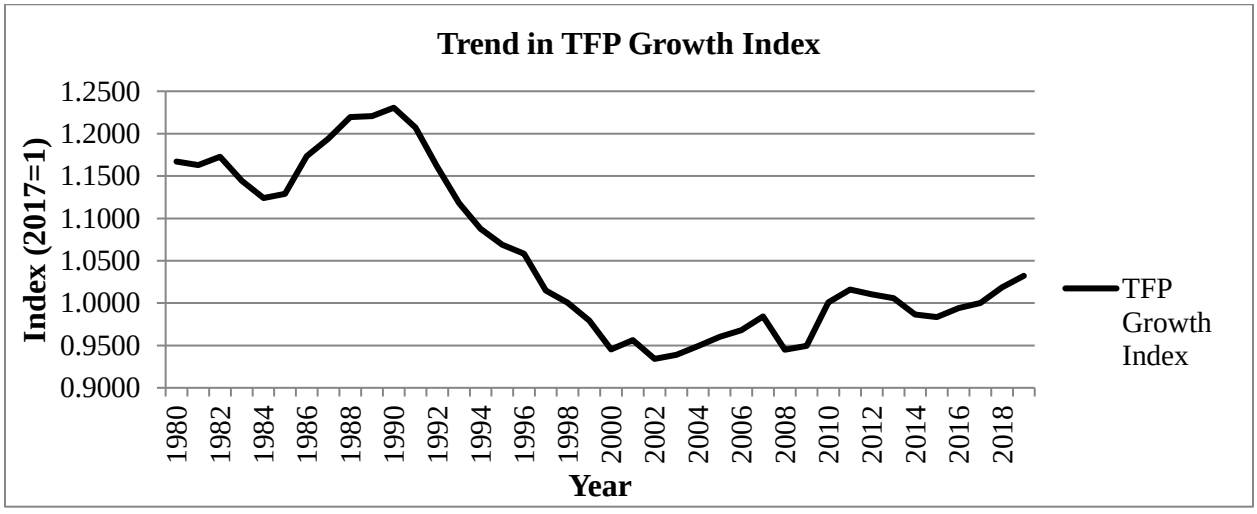

Figure 1.4: Trend in TFP Growth Index
Source: Penn World Tables 10.0

The highest TFP Growth Index recorded is 1.23 in 1990. From 1990, the TFP Growth Index steadily plummets for the next decade to 0.93 in 2002. This could be attributed to the tumultuous times experienced at that time- both in terms of governance and the macroeconomic performance. There were multiple sources of political tension as it is in this period that we have the Saba Saba

protests arising, ethnic clashes after both the 1992 and 1997 elections and the embassy bombing of 1998. The period was also characterized by high inflation and withdrawal of assistance by international donors in 1991 (Onjala, 2002). The plummet in 2008 was attributed to the 2008 post-election violence. Despite the upward trend in the TFP growth index since 2009, the growth index recorded prior to the 1990-2002 declines are yet to be re-attained.

Economic growth in African countries such as Kenya has been tempered by high unemployment and lack of structural change or transformation (Bhorat, Kanbur, Rooney & Steenkamp, 2017). The definition of structural transformation is the movement of economic activity from sectors characterized by low productivity (such as agriculture) to those that have a higher productivity level (such as manufacturing). Developed countries and developing countries have been distinguished by the speed of structural transformation where developed countries have faster structural transformation and channel economic activity away from agriculture to more productive sectors while African countries do not. A comparison of the African and Asian countries shows that the divergence in economic performance -despite having had similar economic characteristics such as GDP per capita in the 1960s- is due to the fact that Asian countries underwent structural transformation through the Industrial Revolution and the Green Revolution while African countries did not (UN-Habitat, 2016). This serves as an indicator of the significance of structural change to a nation's economy. According to United Nations Industrial Development Organization [UNIDO] (2012), not only does structural transformation lead to economic growth and development, it also reduces poverty as well as the susceptibility of an economy to external shocks since it has a diversified economy.

There are different ways in which mobile money financial technology services can impact the economic health of a country. First, there is creation of employment opportunities. This is not only

through the expanding businesses but also because the mobile money financial services ecosystem requires agents at different physical locations. Second, there is an increased accumulation in human capital through education. The savings and credit facilities offered by mobile money service providers allow for parents to save and take credit facilities in order to pay for school fees for their children and thus more children get educated. Third, there is the ease of doing business. This is because transfer of funds can be done not only quickly, but also in an affordable manner. In addition to this, physical barriers that previously hindered cross-border business are eliminated as one can now pay for their goods while miles away and still get them delivered to their doorstep. Fourth and ultimately, there is local economic expansion as businesses thrive since they can now reach more customers thus boosting their profits, ease of fund transfers encourages remittances that can be channeled to income generating ventures and the increased employment opportunities increase the labor force participation in the economy (Plyer, Haas and Nagarajan, 2010).

1.2 Statement of the Problem

In Kenya, mobile money technology has had a faster adoption rate in comparison to other technological innovations. Some of the other major technological innovations in Kenya are electricity- which took 60 years to become widespread in Kenya, computers- which took 20 years to have 50 percent penetration rate and cell-phones- which took 8 years to have almost 100 percent adoption. These adoption rates have been slower in comparison to M-Pesa which only took 4 years to reach 80 percent of the households (World Bank, 2016). This shows that mobile money has become a widely accepted and highly demanded service due to its numerous advantages such as lower transaction charges, lack of a minimum balance requirement, unnecessary delays in acquiring funds such as queuing in banks and also faster and easier access to credit services.

With mobile money having such exponential growth and reaching a great majority of the population, there is need to understand its impact on the economy. Firstly, in theory, since mobile money is a form of technology, it would have a positive impact on output productivity and growth. Secondly, the mobile money in Kenya has contributed to the growth of its services sector more so, the financial services sector- or as alternatively stated, mobile money has brought about vibrancy in the financial services sector (Ndung'u, 2021). Additionally, there is a debate on whether leapfrogging to services sector can be adopted as a strategy for economic growth in developing countries. There is therefore need to assess whether mobile financial technology has contributed to the output productivity and growth in Kenya and whether there has been a leapfrog effect of mobile money in the Kenyan economy.

The growth in the mobile money sector in Kenya is being attained against a backdrop of an elusive growth rate target as the target set in the Vision 2030 for an annual growth rate of 10 percent yearly is still yet to be achieved. Statistics by Central Bank of Kenya indicate that the highest growth rate to be attained in the past fifteen years was 8.40 percent in 2010. After 2010, the growth rates have fluctuated between 4.0 percent and 6.5 percent. Furthermore, TFP growth index has had a general downward trend and does not seem to have recovered.

With mobile money vastly impacting financial inclusion in the country and other specific aspects such as savings, there is need to understand whether this effect has been translated into the country's GDP growth. This will help draw a framework in which mobile money can be developed to impact the economic growth- if it does not have any impact or to compound and magnify its effect on the economic growth- in the event that it has impacts the GDP growth in Kenya.

1.3 Research Questions

i) What is the evidence for the presence of a structural change in the output growth and productivity due to mobile money financial technology services in Kenya?

ii) How has mobile money financial technology services affected output productivity in Kenya?

iii) What is the effect of leapfrogging by mobile money financial technology services on output productivity in Kenya?

1.4 Research Objectives

The general objective is to establish the effect of mobile money financial technology services on the output growth and productivity in Kenya.

The specific objectives are:

i) To investigate whether there has been a structural change in the output growth and productivity due to mobile money financial technology services in Kenya.

ii) To quantify the effect of mobile money financial technology services on output productivity in Kenya.

iii) To examine the presence of a leapfrog effect of mobile money financial technology services on output productivity in Kenya.

1.5 Significance of the study

Mobile Money use has steadily been increasing as the years have progressed by. The Kenyan ecosystem has gained global attention with its prolific success story of M-Pesa. Its introduction in 2007 has since paved the way for other mobile money services to crop up to satisfy the substantial

service demand. Its high adoption rate within the economy by both the rich and the poor proves that it has a place and purpose for everyone. While it has been identified as a leapfrog technology, there hasn't been an investigation on whether it has had a leapfrog effect on the country's economic growth.

1.6 Scope of the Study

The study focuses on the Kenyan economy as it has the greatest and most developed mobile money ecosystem in Africa. M-Pesa, a global success in mobile money is hosted in Kenya. There is also an elusive growth rate target which requires understanding of the key areas to invest and develop in order to attain the 10 percent per annum growth rate target.

1.7 Organization of the Study

This project is comprised of five chapters. Chapter One is the introduction which contains the background of the study, statement of the problem, research questions and objectives, significance of the study and the scope of the study. Chapter Two is the Literature Review and has the theoretical literature review, empirical literature review, overview of the literature and the research gaps. Chapter Three is on the Methodology and it contains the research design, theoretical framework, model specification, data sources and data analysis procedure. Chapter Four contains the empirical findings and Chapter Five contains the summary, conclusion and policy recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter contains a review of the existing literature and has three sections- theoretical literature, empirical literature, overview of the literature and research gaps.

2.2 Theoretical Literature

2.2.1 Neo-classical and Endogenous Growth Models

Technology's significance in economic growth has been advocated for in both the neo-classical and endogenous growth models. The importance of technology has been propagated by various economic theorists such as Paul Romer in his seminal work 'Endogenous Technological Change' published in 1990 (Endogenous Growth Model) and Robert Solow in his paper, 'A contribution to the theory of Economic Growth' of 1956 (Neo-Classical Growth Model).

Solow (1956) improved the Harrod- Domar model by introducing technology into the production function thereby making output a factor of three inputs; technology, labour and capital. In this model, the growth in per capita output is attributed to the technological changes experienced within the economy. In the absence of technology, sustained growth would only be achieved through growth in the population. The challenge posed by population-driven growth is that the per capita income would not experience any growth in the long-run as it will remain constant (Zhao, 2018). With the objective of each economy being to experience growth, there therefore has to be growth in the level of technology in order to stimulate the growth in output per capita. This model is now identified as the Solow- Swan model after a publication of a similar model by Trevor Swan later in 1956.

Romer (1990) propagated the endogenous model to explain economic growth. There are three arguments made on technological change in this model. The first is that technology is within the heart of economic growth. Second, the technological changes experienced within an economy are due to deliberate actions taken by primary economic agents acting in response to market incentives. Third, technology is a non-rival good. The economy in the model is divided into three sectors; research and development, intermediate goods sector and the final goods sector. The rate of technological change in the research and development sector is defined as a function of the current level of technology and the labour in the sector. The technological changes in this model drive the growth in the economy.

There are few differences between the model by Solow (1956) and that by Romer (1990). One of the differences is that while the rate of technology change in the neo-classical model is determined exogenously (determined by factors outside the model), Romer's growth theory has technology as endogenously determined as a result of the decision-making process of the entrepreneurs, consumers and workers within the economy. Another difference is that while population growth does not have a share in the growth of per capita income in Solow's model, the model by Romer (1990) identifies population growth as having a growth impact on the per capita income as increased population translates to a larger workforce in the research and development sector and in turn increased rate of technological change (Zhao, 2018).

Technological change can be classified into three; Hicks-Neutral, Harrod-Neutral or Solow-Neutral (Romer, 2012). If a technological change results in a similar proportional rise in the marginal productivity of both labor and capital, it is said to be Hicks-Neutral. A Harrod-Neutral technological change is one in which the ratio of capital and output remains unchanged, thus, is referred to as labor-augmenting technological change. The Solow-Neutral technological change is

the inverse of the Harrod-Neutral in that the change in technology affects the capital and leaves the labour to output ratio unaltered and is thus referred to as capital-augmenting technological change.

2.2.2 Rostow's Five Stages of Growth Theory

Rostow (1960) stated that all economies are either in one of five stages of development. These are the traditional economy, the preconditions for take-off, take off, the drive to maturity and the age of high mass consumption. Each of these stages is marked by various social, economic, political and technological changes that gear the economy towards expounded growth. In this theory there is the emphasis of technology adoption as the economy transitions through the different stages.

In the traditional society, the production function is limited and there is limited science and technology development. While agriculture takes up the bulk of the available resources in this society, the level of agricultural productivity is hindered by the lack of modern scientific knowledge and technology. The pre-conditions for take-off is the period in which the major transitory changes that accommodate modern science and technology are taken. This is either through substantially changing the social and political systems or through economic and technological changes rather than focusing on the socio-political systems. In this stage there is the development of social overhead capital which includes communication and transport systems as well as a shift from trade and agriculture to manufacturing. This is succeeded by the take off stage where there is the expansion of new industries and also spread of new technology in agriculture and industry beginning the modernization influx.

After these three stages, the economy gets into the drive to maturity stage. Rostow (1960) defined it as the period when an economy has managed to effectively apply modern technology to a great

proportion of its resources (technological maturity). In this stage, the technological progress accelerates new industries and the economy now attains a new international position with goods that were previously being imported becoming locally produced and the economy's export sector begins to grow. The economy in this stage proves its prowess to produce whatsoever it chooses to produce. If an economy in this stage fails to produce a particular output, it is merely as an economic choice or a result of a political stance but not out of a lack of the necessary technological advancements. The economy at this stage is able to reap the most of the fruits yielded by modern technology.

The final stage is the age of high mass consumption. This is the post-maturity stage in which there are three major objectives of the economy. First, the economy seeks power and influence externally through the development of foreign policy and increasing military resource allocation. Second is to achieve human and social objectives through the powers of the state- such as using progressive taxation to achieve income redistribution. Third, consumption is expanded beyond the scope of basic food, shelter and clothing a more comprehensive consumption bundle inclusive of other durable goods and services.

In summary, this Rostow (1990) acknowledges that for an economy to grow, it has to first keep up with the advancements in modern technology and apply them extensively within the economy to allow for the evolution of the old industries as well as the development of the new industries set to propel the economy into the age of mass consumption.

2.2.3 Kuznet's Three-Sector Hypothesis

Under this theory, the economy is aggregated into three sectors: the primary, secondary and tertiary sectors. The primary sector involves agricultural activities to meet the basic needs of the society

and natural resources exploitation. The secondary sector is mainly made up of manufacturing and construction while the tertiary sector is made up of service providers such as banks and insurance providers (Kruger, 2008). This transition of the economy as it experiences growth is as shown in the Figure 2.1:

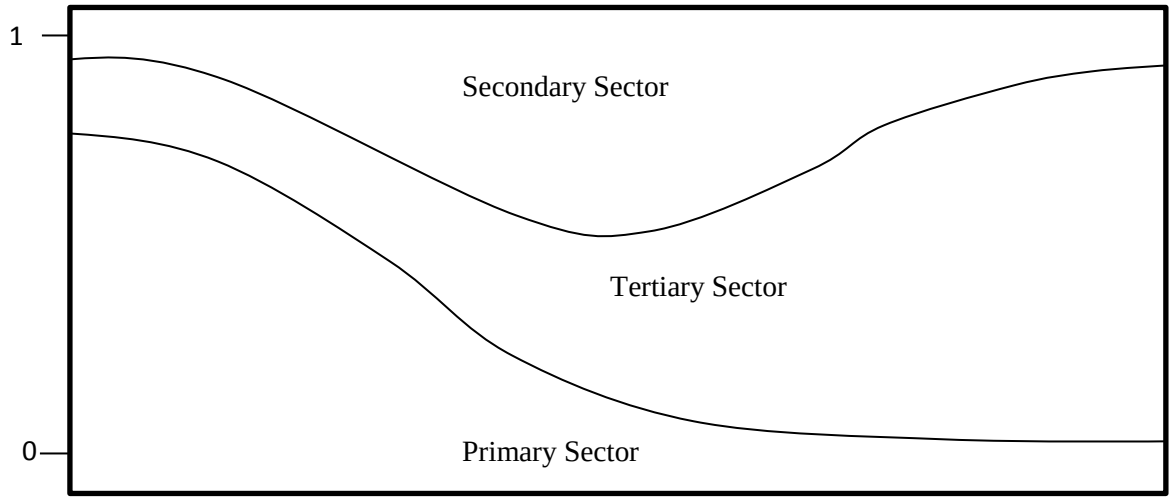

Figure 2.1: Three Sector Hypothesis
Source: Kruger (2008)

In this hypothesis, the initial dominant sector is the primary sector. This is both in terms of the number of people employed and also in terms of its contribution to the total value added in the economy. In the primary sector dominance period, the secondary and tertiary sectors have a smaller contribution. However, as the economy undergoes growth, the secondary sector grows due to industrialization and the primary sector shrinks. Further growth in the economy leads to the tertiary sector ultimately becoming the most dominant sector as it has the highest employment levels and also contributes the greatest share to the total value added (Kruger, 2008).

Kuznets (1973) identifies six distinct attributes of modern economic growth- rapid population and per capita product growth, greater productivity, high structural transformation rate with a shift from agricultural to non-agricultural activities, change in societal structures and ideologies with

an increase in urbanization and secularism, increased technological power- especially in the transport and communication sectors and the spread of economic growth. Structural changes within the economy are bound to occur due to the difference in impact of the adoption of technology across different sectors, differences in the income elasticity for some goods and acquired advantages from engaging in foreign trade. In addition to this, the scale of production in plants changes as well and a change in the character of enterprise units in the economy is experienced.

Kuznets (1973) also stated that of the features of modern growth, the most prominent aspect is the high rate of aggregate growth which is sustained by the application of technological innovations on a large scale supported by the increase in the knowledge stock on technology. An important aspect of this argument is that while technological advancement is a source of economic growth, it is merely a necessary pre-requisite that is insufficient as a sole source of growth in an economy.

2.2.4 Theories on Leapfrogging

In 1942, Schumpeter introduced the theory of 'creative destruction'. Schumpeter (2003) argued that every capitalistic economy has to undergo a phase of 'creative destruction' and that the essence of capitalism is the 'perennial gale (perpetual wind) of creative destruction'. Creative destruction refers to a period in which the structure of the economy 'mutates' due to new advancements in the markets or technology. During this process, there is a revolution that occurs within the economy where the old structure no longer suffices and is replaced by a new structure. The new structure takes time to be assessed since its inherent nature and effects take time to be established and therefore its performance has to be assessed over the course of time. The time over which it is assessed could be over decades or centuries.

Additionally, the role of the entrepreneurs in the society is to be the proponents of the revolution of the different production processes. This is mainly through the adoption of the new technologies that were previously unknown or unused in order to bring forth a new good or service - thus introducing an entirely new market- or to provide a new means through which old goods and services are produced and made available in the market. In either way, the structure of the market ultimately undergoes a 'mutation'. Firms and industries that fail to keep up with the new changes are stifled out by competition and become obsolete; either gradually or promptly Schumpeter (2003).

Lee and Malerba (2017) developed the theory of the Catch-Up Cycle of Leapfrogging. In this theory, there are two distinct entities; incumbents and latecomers. The incumbents are those who have been in the industry for a long period and therefore have the pioneer forms of knowledge and technology in their production processes. The latecomers are those who do not possess the pioneer technologies and seek to enter the market when newer technologies to be used in the production process have been invented. One of the opportunity windows for late-comers to catch up with the incumbents is the technological window. This is where there is a wave of a new technological innovation. This serves to be advantageous to the latecomers since they can immediately adopt the technology unlike the incumbents who face the 'incumbent trap' where they have to remain with their already established traditional technological forms.

Lee (2019) identifies three distinct strategies that are available to the late-comers. Assuming that in a particular production process there are three generations of technology; generation one, two and three, the Path-Following strategy is where the latecomer firm chooses to adopt the most former technology- in this case the first-generation technology. Of the three strategies, this is the cheapest route that can be adopted by the latecomers. The other two are leapfrogging strategies.

The Stage-Skipping strategy is where the firm chooses to adopt the technology that is developed later (they follow later incumbents rather than the pioneer incumbents). In this case, the second-generation technology is adopted. This is a leapfrog strategy in that the first-generation technology is skipped. The last strategy is the Path-Creating technology. This is where the latecomer chooses not to adopt any of the prior technologies- they therefore do not adopt either the first- or second-generation technologies. Instead of following the already mapped out paths, they chart new paths by adopting the emerging technology and that is why they are known as the 'disruptors'. Ultimately, the incumbents who do not adapt are kicked out of the market due to their low productivity.

2.3 Empirical Literature

Demombynes and Thegeya (2012) investigated the link between mobile money and savings in Kenya in the period October to November 2010. In a probit analysis, the probability of an individual to have savings of any kind was higher for individuals who were male, married, educated, lived in the rural areas and also had high income and wealth. Possession of an M-Pesa account was found to increase the probability of having some savings by 32 percent. In an Ordinary Least Squares analysis of the same, those registered with M-Pesa were found to have a higher savings rate by 12 percent than those who were not registered with M-Pesa. The study concluded that M-Pesa did indeed increase the level of savings among the population.

Jack, Ray and Suri (2013) investigated the transaction network system of mobile money in Kenya. The study's goal was to examine the impact that M-Pesa has on the volume of the internal remittances spanning the months of September 2008 and December 2009 and adopted the Ordinary Least Squares method of analysis. The households with M-Pesa usage had a higher level of remittance activity and higher frequency of transfers than the non-users and concluded that mobile

money has revolutionized the extent of transfer of resources among the households and individuals in Kenya.

Munyegera and Matsumoto (2014) investigated the association between mobile money and household per capita consumption in rural Uganda using data collected for the years 2009 and 2012. This was done through the Ordinary Least Squares and Fixed Effects model. The findings indicated that the use of mobile money increased household per capita expenditure. The consumption expenditure for social contributions was found to be most impacted by the adoption of mobile money followed by basic non-food expenditure, Food expenditures were not greatly impacted since most of the food consumed in the rural setting is directly sourced from their farms. Using a probit analysis, the study also found that the probability that a household will receive remittances was increased by the access to mobile money services.

Gosavi (2015) conducted a cross-country investigation on the uptake of mobile money across different firms as well as whether mobile money use leads to constraints in accessing credit. This was done across 3,000 firms in Kenya, Tanzania, Uganda and Zambia. Older and small firms were found to possess a higher propensity for use of mobile money than the younger, middle aged, medium-sized and large firms. The possession of bank accounts increased the likelihood of the using mobile money. Across the four countries, Kenya was found to have the highest mobile money adoption. Additionally, the firms that adopted mobile money services had a higher access to credit services by 24 percent in comparison to firms that did not adopt mobile money.

Nyasimi (2016) investigated the effect of mobile money transfer services on the economic growth in Kenya for the period between 2007 and 2015. The study adopted the Ordinary Least Squares regression analysis where the economic growth of the country was regressed against mobile money

agents, mobile money customer enrollments, transaction frequency, deposit value of transactions, interest rate and economic growth. The number of transfer agents was found to have a positive effect on economic growth while customer enrollment, transfer deposit value and transaction frequency had no significant relationship with economic growth. Both the exchange rate and GDP growth rate were found to have a positive relationship with the economic growth rate.

Nan (2019) conducted a cross-country investigation on the linkage between mobile money and socio-economic development by comparing 21 countries in SSA that had mobile money and those that did not for the period between 2003 and 2015 using Difference-in-Difference (DD) approach. The regression analysis results were that trade openness and mobile money had a positive impact on economic growth. Countries that had embraced mobile money were found to have a higher economic growth rate by 3.12 percent. Over time, the effect of mobile money grows, showing an increase in the impact on economic growth as the service increases in its penetration rate. The Granger causality also reveals that mobile money leads to economic growth and not vice versa.

Coulibaly (2020) sought to assess the uptake of mobile money in the West African Economic and Monetary Union (comprised of Benin, Guinea-Bissau, Cote D'Ivore, Mali, Senegal, Niger, Burkina Faso, and Togo) in comparison to the uptake of the formal traditional banking services for the period between 2014 and 2019. Using probit analysis, the probability of using a mobile money service was increased by the level of education, age, penetration of the commercial banks and microfinance institutions as well as the penetration of the mobile money outlets and usage was generally found to be higher among the social categories that are least vulnerable- men, richer and educated people. The financial inclusion through mobile money was found to be greatly influenced by the penetration rate of the mobile money outlets.

2.4 Overview of the Literature

The theoretical literature regardless of the proponent all seems to suggests that there is a role that technology plays in the development of an economy. Technology is given as an input factor in the production function in the Solow and Romer models. With a shift over to development economics, one of the theories in the area of study is the Rostow's Five Stage Theory which highlights the role of technology in an economy, more so in the drive to maturity stage. Additionally, the Theory of Creative Destruction and The Catch-Up Theory help in explaining the process of leapfrogging that can be adopted by firms and economies in order to propel their productivity and growth.

The empirical literature reviewed shows the different approaches taken in order to investigate mobile money. Majority of the research studies seek to explain the association between mobile money and specific economic aspects such as savings, remittances, household per capita and credit access. Nan (2019) and Nyasimi (2016) evaluate mobile money's impact on aggregate economic performance, but differ in the approach chosen to attain the study objectives. Nan (2019) adopts a cross-country approach that highlights the difference in economic performance between economies with mobile money and those without while Nyasimi (2016) adopts a regression analysis that is not rooted in economic theory.

The studies do not show whether there has been any structural change due to the introduction of mobile money and whether the leapfrogging strategy is a viable approach to attain economic growth in developing countries like Kenya- especially since mobile money has been identified as a leapfrog technology. The study intends on filling the research gaps by using the growth accounting approach to investigate whether there has been a structural change in output productivity and economic growth, to quantify the effect of mobile money services on output productivity and to examine for the presence of a leapfrog effect in the Kenyan economy.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The study's methodology is described in this chapter. This is the research design, theoretical framework, empirical model specification, variable definitions, data sources as well as the diagnostic tests to be undertaken.

3.2 Research Design

The study adopted a quantitative and non-experimental approach. The data used to investigate the interrelationship among the variables was time-series data collected in the time period 1980 to 2020.

3.3 Theoretical Framework

3.3.1 Production Technology

The study analyzed the relationship between economic growth, output productivity and mobile money financial technology services sing the neoclassical framework or the Solow Growth Model. This model is composed variables: output (Q), capital (K), labor (L) and total factor productivity or technological progress (A) (Romer, 2012). The production function takes the general form:

$$Q_t = F[A_t,\ K_t\ , L_t] \qquad (3.1)$$

The technology in the production function can either be labor-augmenting, capital augmenting or Hicks-Neutral (Romer, 2012). If technology and labor enter multiplicatively, the model becomes labor augmenting or Harrod-Neutral and is specified as follows:

$$Q_t = F[K_t, A_t L_t] \qquad (3.2)$$

If technology enters multiplicatively with capital, the model becomes capital augmenting and is presented in the form:

$$Q_t = F[A_t K_t,\ L_t] \qquad (3.3)$$

In the Hicks-Neutral form, technology impacts both the labor and the capital and is represented as follows:

$$Q_t = A_t\ F[K_t, L_t] \qquad (3.4)$$

The Hicks-Neutral approach allows for analysis of the inputs independently and therefore the output can fully be decomposed into three components- labor, capital and technology rather than two components – effective capital and labor or effective labor and capital- as would be the case in the capital-augmenting and labor-augmenting approach. In this study, Hicks technology appropriately describes the mobile money financial technology services as this technology is considered to be neutral since it can increase output without necessarily augmenting either labour or capital.

One of the ways to represent production technology is through the Cobb-Douglas Production function represented in the following form;

$$Y_t = A_t\ K_t^{\alpha} L_t^{\beta} \qquad (3.5)$$

Where A represents neutral technological change, K is capital, L is labor, α is the elasticity of output with respect to capital and β is the elasticity of output with respect to labor and t is the time index. In the Cobb-Douglas function, the Harrod and Hicks neutralities are the same. The model assumes constant returns to scale in production and therefore the sum of the elasticity of capital and that of labor should be equivalent to 1 ($\alpha + \beta = 1$).

In order to find the contribution of TFP, the study adopts the growth accounting approach. The equation is linearized by taking the natural logarithms yielding the following equation;

$$\ln Y_t = \ln \mathrm{A}_t + \alpha \ln K_t + \beta \ln \mathrm{L}_t \quad (3.6)$$

The growth accounting equation is then derived by differentiating equation 3.6 with respect to time as follows;

$$\frac{\partial \log Y_t}{\partial \mathrm{t}} = \frac{\partial \mathrm{Log}\, A_t}{\partial \mathrm{t}} + \alpha \frac{\partial \mathrm{Log}\, K_t}{\partial \mathrm{t}} + \beta \frac{\partial \mathrm{Log} L_t}{\partial \mathrm{t}} \quad (3.7)$$

$$\frac{\mathrm{Y}_\mathrm{t}^*}{\mathrm{Y}_\mathrm{t}} = \frac{\mathrm{A}_\mathrm{t}^*}{\mathrm{A}_\mathrm{t}} + \alpha \frac{\mathrm{K}_\mathrm{t}^*}{\mathrm{K}_\mathrm{t}} + \beta \frac{\mathrm{L}_\mathrm{t}^*}{\mathrm{L}_\mathrm{t}} \quad (3.8)$$

Where; $\frac{Y_t^*}{Y_t}$ is the output growth rate, $\frac{A_t^*}{A_t}$ is the total factor productivity growth rate, $\frac{K_t^*}{K_t}$ is the capital growth rate and $\frac{L_t^*}{L_t}$ is the growth rate of labor. α and β remain to be the elasticity of capital and labor respectively. The TFP growth is therefore given as:

$$\frac{\mathrm{A}_\mathrm{t}^*}{\mathrm{A}_\mathrm{t}} = \frac{\mathrm{Y}_\mathrm{t}^*}{\mathrm{Y}_\mathrm{t}} - \alpha \frac{\mathrm{K}_\mathrm{t}^*}{\mathrm{K}_\mathrm{t}} - \beta \frac{\mathrm{L}_\mathrm{t}^*}{\mathrm{L}_\mathrm{t}} \quad (3.9)$$

This is also referred to as the Solow Residual (Romer, 2012).

3.3.2 Leapfrogging and Increasing Total Factor Productivity

According to Romer (1990), $\mathrm{A_t}$ increases as new technologies are invented. Mobile money is a financial technology and is therefore an influencing factor on TFP.

In leapfrogging, an economy can by-pass stages of economic growth- mobile money technology is considered to be a leapfrog technology since it boosts the services sector. While there are two

measures of leapfrogging- relative and absolute measures, the relative measure will be adopted in this study. This is because the absolute measure in used in studies involving cross-country comparisons. The relative measure is a comparison of the ratios of the new technology to its predecessor over time (James, 2009). It is formulated as follows;

$$\text{LF} = \frac{X}{Y}$$

Where X represents the adoption of the modern/new technology and Y represents the adoption of the predecessor system.

3.4 Model Specifications

3.4.1 Growth Model

The following empirical model used to estimate the growth equation was based on the Cobb-Douglas production function and the residuals used to derive the TFP estimates:

$$Q = f\ (t, L, K) \tag{3.10}$$

$$Ln\ Y_t = \delta + \theta t + \alpha\ Ln\ K_t + \ \beta\ Ln\ L_t\ + \ \varepsilon_t \tag{3.11}$$

Where t=0 before 2007 and t=1 after 2007.

3.4.2 Total Factor Productivity Model

The total factor productivity is obtained from the equation:

$$LnTFP = \ Ln\ Y_t - \ \alpha * Ln\ K_t - \ \beta * Ln\ L_t \tag{3.12}$$

Based on Romer (1990) and Hammouda, Karingi, Njuguna and Jallab(2009), the TFP model was be specified as follows:

TFP = f (control variables, mobile money variable, leapfrogging) (3.13)

In order to take care of structural change, if any, dummy and interaction variables are introduced and thus the empirical model is specified as follows:

$$TFP_t = \gamma_0 + \gamma_1 HC_t + \gamma_2 OPEN_t + \gamma_3 MM_t + \gamma_4 LEAP_t + \gamma_5 CONFLICT + \gamma_6 FDEEPENING + \gamma_7 D + \varepsilon_t \quad (3.14)$$

Where HC is Human Capital, OPEN is Openness to Trade, MM is Mobile Money, LEAP is leapfrogging, FDEEPENING is financial deepening, Conflict is a dummy to indicate the presence or absence of conflict and D is a dummy for the introduction of mobile money with D=1 from 2007 and D=0 before 2007. TFP is the Total Factor Productivity which will be obtained as the anti-log of the TFP obtained in the growth model. The control variables are standard in literature as in Hammouda et al (2009).

3.5 Variable Definitions

The definition of the variables used in the study and their measurement are as shown in Table 3.5:

Table 3.5: Variable Definition and Measurement

Variable	Definition and Measurement
Gross Domestic Product	This refers to the GDP of Kenya.
Capital Stock	This is the aggregate level of capital within the economy.
Labor Force	This is the number of people who are currently employed.

Total Factor Productivity	This is the measure of the rate of technical progress or change.
Human Capital	This refers to the knowledge and skills attained by individuals that lead to increased labor efficiency. This is measured as primary school enrollment as a ratio of gross enrollment.
Openness to Trade	This is the degree of the country's participation in the global markets. It is measured as the ratio of the exports and imports to the GDP.
Mobile Money	This is the ratio of the M-Pesa value of transactions to the banks' value of customer transactions.
Financial Deepening	This is credit to the private sector expressed as a percentage of the Gross Domestic Product.
Leapfrogging	This is the ratio of the number of mobile money accounts to the number of traditional bank accounts.
Conflict	This is a dummy variable to indicate the presence or absence of conflict.

3.6 Data Types and Sources

The study used annual data for the period between 1980 to 2020. Data was collected for the following variables: Gross Domestic Product (GDP), Labor Force (LF), Gross Fixed Capital Formation (GFCF), Exports (EXP), Imports (IMP), Credit to Private Sector, Number of Mobile Money Accounts, Number of Deposit Account Holders, Value of Mobile Money Transactions, Value of Bank Transactions, Financial Deepening and Human Capital. The GDP, GFCF, Human

Capital, credit to private sector and Labor Force were obtained from the World Development Indicators. GDP and GFCF were obtained in Constant 2015 US Dollars. Exports and Imports data were obtained from KNBS (1980) to KNBS (2020). The values of the remaining variables namely, number of mobile money accounts, value of mobile money transactions, number of deposit accounts and value of bank transactions were obtained from the Central Bank of Kenya (CBK) online database.

3.7 Diagnostic Tests

To ensure that the results obtained were not spurious, the diagnostic tests were conducted. These included the Jarque-Bera test for normality, Augmented Dickey Fuller (ADF) tests for stationarity, pairwise correlation and Variance Inflation Factor (VIF) tests for multi-collinearity, Breusch Godfrey test for serial correlation and the Ramset RESET test for model misspecification.

CHAPTER FOUR

EMPIRICAL FINDINGS

4.1 Introduction

In this chapter, the results of the data analysis and model estimation are presented. The first part gives the summary statistics of the various variables and the later part provides the results from model estimation and the diagnostic tests.

4.2 Descriptive Statistics

The following basic statistics, namely: the mean, the minimum and maximum values, and the standard deviation of the variables, included in the study were calculated. The computed values are as presented in Table 4.1.

The average values for GDP in the period of interest was USD 43.3 billion with a standard deviation of USD 18.9 billion. The minimum value recorded was USD 20.4 billion in 1980 and USD 84.13 billion in 2019, showing an increase in the level of the economy's output from the 1980s. There was, however, a decline in the level of GDP in 2020 which can be attributed to the reduced economic activities during the COVID-19 pandemic. Capital and Labor had experienced steady growth, with lowest value for labor at 5.34 million in 1980 and the maximum value at 24.13 million in 2020. On the other hand, capital had the lowest value in 1985 at USD 17.03 billion and the highest value given at USD 32.2 billion in 2020. Both labor and capital averaged at 13.45 million and USD 21690.59 million respectively.

Table 4.1: Summary Statistics

Variable	Mean	Standard Deviation	Min	Max
GDP (Billions USD)	43.29	18.92	20.43	84.13
Labor (Millions)	13.45	5.53	5.34	24.13
Capital (Billions USD)	21.69	5.14	17.03	32.15
Openness (%)	35.87	8.64	13.11	61.80
Human Capital (%)	101.172	7.681	88.242	118.171
Financial Deepening (%)	24.568	5.047	18.4	36.7
Leapfrogging	0.328	0.488	0	1.384
Mobile Money	1.682	2.801	0	8.535

Source: Author's Compilation

The minimum value recorded for Openness, measured as a ratio of imports and exports to the GDP, was in 2020 at 13.11 percent while the highest was in 1980 at 61.80 percent and averaged at 35.87 percent in the period 1980-2020. The decline in the degree of openness in 2020 - which can be attributed to the border closures in an attempt to curb the spread of COVID-19- is not an isolated occurrence as a similar trend has been persistent in the country's openness performance. According to IMF (2021), the declining degree of openness within the country is contrary to the expectation given that the country's development level is not yet at the saturation point beyond which the positive correlation between trade openness and development tapers off. This decline in openness, as well as its declining global and regional market share, is due to its poor performance in exports which is driven by factors such as an export portfolio that is dominated by goods characterized by low market growth, low technology intensity and low value addition increased competition from lower price products and a struggling manufacturing sector (IMF, 2021).

Human Capital, measured as the ratio of primary enrollment to gross enrollment, ranged between 88.24 percent recorded in 2002 and 118.17 percent in 1980 and averaged at 101.17 percent. The high level of enrollment in 1980 was part of the spike in enrollments recorded between 1979 and 1980. This increase is attributed to the 1979 abolition of a building levy for the construction of classrooms that had resulted in the increase of students' fees. Once the levy was abolished and the building activities were required to be funded by Harambee (self-help activities), many of the students that had dropped out due to fees re-enrolled (Somerset, 2007). This was followed by a decline in the enrollment in the period between 1985 to 2002 due to drought, political instability and school levies. However, in 2003, the enrollment levels increased after the re-introduction of free primary school education (Amoro, 2019).

Both mobile money and leapfrogging had their lowest values as 0, which was recorded for all years before 2007. The maximum values for mobile money and leapfrogging were 8.53 in 2020 and 1.384 in the 2010 respectively. They averaged at 1.68 and 0.33 respectively. Mobile Money was computed as the proportion of mobile money transactions to banking transactions in terms of value, while leapfrogging was computed as a ratio of the number of mobile money accounts to the number of traditional bank accounts. Both mobile money and leapfrogging experienced increases in 2020 as the mobile money use, instead of cash, was encouraged by the government in order to control the transmission of COVID-19. The incentives introduced- such as the elimination of transaction charges if the value of transaction was below Ksh. 1,000- resulted in an increase in mobile money subscriptions as well as the volume and value of transactions (CBK, 2021).

The average value for financial deepening, measured as private sector credit as a proportion of GDP, in the study's time frame was 24.57 percent with the minimum and maximum values recorded being 18.4 percent in 1987 and 36.7 percent in 2015 respectively. A high level of financial

deepening in an economy indicated that there are more options of financial services available to all the different levels of society (Obonyo, 2014). A high level of access to credit by the private sector implies that there is a high access to financial capital that can be channeled towards investment thus supporting economic growth. The low credit to the private sector in 1987 can be attributed to the direct controls introduced in the 1980s on credit to the private sector due to the recorded negative interest rates (Kiriga, Chacha, & Omayo, 2020).

4.3 Diagnostic Tests

4.3.1 Stationarity Tests

Stationarity tests for all the variables were conducted using the Augmented Dickey Fuller Test and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test. The two tests were used for robustness checks. The results are presented in Table 4.2 and Table 4.3, respectively for ADF test and KPSS test.

Under the ADF tests (Intercept only), Human Capital and Mobile Money are the only stationary variables at 5 percent level of significance. As for the ADF tests (trend and intercept), Openness, Mobile Money and Financial Deepening are found to be stationary at 5 percent, 1 percent and 10 percent levels of significance, respectively. The log of GDP, log of capital, log of labor and leapfrogging are not found to be stationary in either form of the test.

Table 4.2 Augmented Dickey Fuller Test

Variable	Test Statistics (Intercept)	Conclusion	Test Statistic (Trend and Intercept)	Conclusion
Ln_GDP	1.071	Non-Stationary	-2.593	Non-Stationary
Ln_Capital	-0.466	Non-Stationary	-1.746	Non-Stationary
Ln_Labor	-1.147	Non-Stationary	-2.470	Non-Stationary
Openness	1.888	Non-Stationary	-3.608	Stationary at 5%
Human Capital	-2.904	Stationary at 5%	-2.901	Non-Stationary
Mobile Money	-2.952	Stationary at 5%	-3.952	Stationary at 1%
Leapfrogging	-0.471	Non-stationary	-1.782	Non-Stationary
Financial Deepening	0.102	Non-Stationary	-3.149	Stationary at 10%

Source: Author's Computation
Note: *Asymptotic Critical Values for Intercept only are -3.58, -2.93 and -2.60 at 1%, 5% and 10% respectively while those for Trend and Intercept are -4.15, -3.50 and -3.18 at 1%, 5% and 10% respectively.*

The results from the KPSS test for unit root for each of the variables is as shown in Table 4.3:

Table 4.3: KPSS Test Results

Variable	Test Statistic (Intercept Only)	Conclusion	Test Statistic (Trend and Intercept)	Conclusion
Ln_GDP	0.696	Stationary at 1%	0.178	Stationary at 1%
Ln_Capital	0.701	Stationary at 1%	0.199	Stationary at 1%
Ln_Labor	0.704	Stationary at 1%	0.195	Stationary at 1%
Openness	0.701	Stationary at 1%	0.172	Stationary at 1%
Human Capital	0.438	Stationary at 5%	0.175	Stationary at 1%
Mobile Money	0.663	Stationary at 1%	0.192	Stationary at 1%
Leapfrogging	0.645	Stationary at 1%	0.185	Stationary at 1%
Financial Deepening	0.645	Stationary at 1%	0.136	Stationary at 1%, 5%

Source: Author's own compilation
Note: *Asymptotic Critical Values for Intercept only are 0.739, 0.463 and 0.347 at 1%, 5% and 10% respectively while for Trend and Intercept are 0.216, 0.146 and 0.119 at 1%, 5% and 10% respectively.*

All variables are found to be stationary at 1 percent level of significance when using the KPSS test of stationarity. This conclusion is drawn from the fact that the test statistics for all variables are found to be less than the critical values at 1 percent level of significance.

ADF has been criticized for its low power of test which results in the failure to distinguish between near unit root and presence of unit root. KPSS is therefore suggested as an alternative test as it does not suffer from this problem (Enders, 2015). Since KPSS has a higher power, and thus superior, the conclusions drawn from this test informed the decision to proceed with the data analysis of the variables at level.

4.3.2 Pairwise Correlation Analysis

Pairwise correlation analysis was done in order to establish the degree of association that exists between the explanatory variables. The results of the analysis were as shown in Table 4.4:

Table 4.4: Correlation Analysis

	Openness	Financial Deepening	Mobile Money	Human capital	Leapfrogging	Conflict
Openness	1.0000					
Financial Deepening	-0.7186	1.0000				
Mobile Money	-0.7447	0.8356	1.0000			
Human capital	0.2960	-0.0355	0.2206	1.0000		
Leapfrogging	-0.6241	0.6137	0.7770	0.3221	1.0000	
Conflict	0.1149	-0.2576	-0.1801	0.1629	-0.1219	1.0000

Source: Author's computation

The highest correlation was between financial deepening and mobile money at 0.84 followed by mobile money and leapfrogging at 0.78. According to Kleinbaum, Kupper, Nizam, & Rosenberg (2014), assessment of Variance Inflation Factors (VIF) should be done after obtaining pairwise correlations in order to ascertain whether high pairwise correlations among explanatory variables indicate the presence of collinearity. The rule of thumb in the assessment is that if the VIF obtained for a variable is greater than 10, then there exists a serious collinearity problem. Mobile money had the highest VIF of 8.16. Openness, Financial Deepening, Leapfrogging, Human Capital and Conflict had VIFs of 5.91, 4.05, 3.30, 3.25 and 1.20 respectively. Given that none of the variables had VIFs greater than 10, the conclusion is that the explanatory variables do not suffer from multi-collinearity.

4.4 Model Estimation

In order to attain the study's objectives, estimation of the production model using equation (3.11) and analysis of results was first conducted. The estimated model was used to generate the Total Factor Productivity (TFP) that was used later in the productivity analysis.

4.4.1 Production Function Estimation and Analysis

The production function given in equation (3.11) in Chapter 3 was estimated to establish the proportions of labor and capital in output. Moreover, the restriction of constant return to scale was imposed, that is the sum of elasticities is equal to 1. Once the shares of labor and capital were estimated, the TFP was obtained as a residual using equation (3.12).

In order to ensure that reliable results are presented, diagnostic tests were performed for the model results. These tests were the Jarque -Berra test for normality and Breusch-Godfrey test for serial correlation. The results of the diagnostic tests were as shown in Table 4.5.

Table 4.5: Diagnostic Tests Results

Diagnostic Test	**Computed Test Statistic**	**P-Value**
Jarque-Berra test H0: Residuals are normal	0.29	0.864
Breusch- Godfrey Test H0: No Serial Correlation	22.909	0.000

Source: Author's computation

The computed p-value of the Jarque Berra test is greater than 0.05 and therefore the null hypothesis of normality is not rejected therefore implying that residuals are normally distributed at 5 percent level of significance. The computed p-value for the Breusch Godfrey test was less than 0.05 and therefore the null hypothesis of no serial correlation was rejected. In order to correct this, robust

standard errors were used. The results of the production function analysis were as shown in Table 4.6:

Table 4.6: Production Function Estimation Results

Dependent Variable: Log of GDP	**Coefficient (p-value)**
Constant	5.8620 *** (0.000)
Elasticity of Output with respect to Labor	0.7082 *** (0.000)
Elasticity of Output with respect to Capital	0.2918 *** (0.000)
D (Dummy Variable: D=1 if year ≥ 2007; 0 if year < 2007)	0.1208 *** (0.000)
Adjusted R-squared	0.99

Source: Author's own computation.
Note: *** *p-value < 0.01*

From the results above, the share of capital and labor in output is 0.29 and 0.71 respectively. Both the elasticity of capital and labor are statistically significant at 1 percent level of significance. The dummy variable D (D=1 if year ≥ 2007; 0 if year < 2007) is significant indicating that there has been structural change or shift in output due to the introduction of mobile money. This is shown in Figure 4.1.

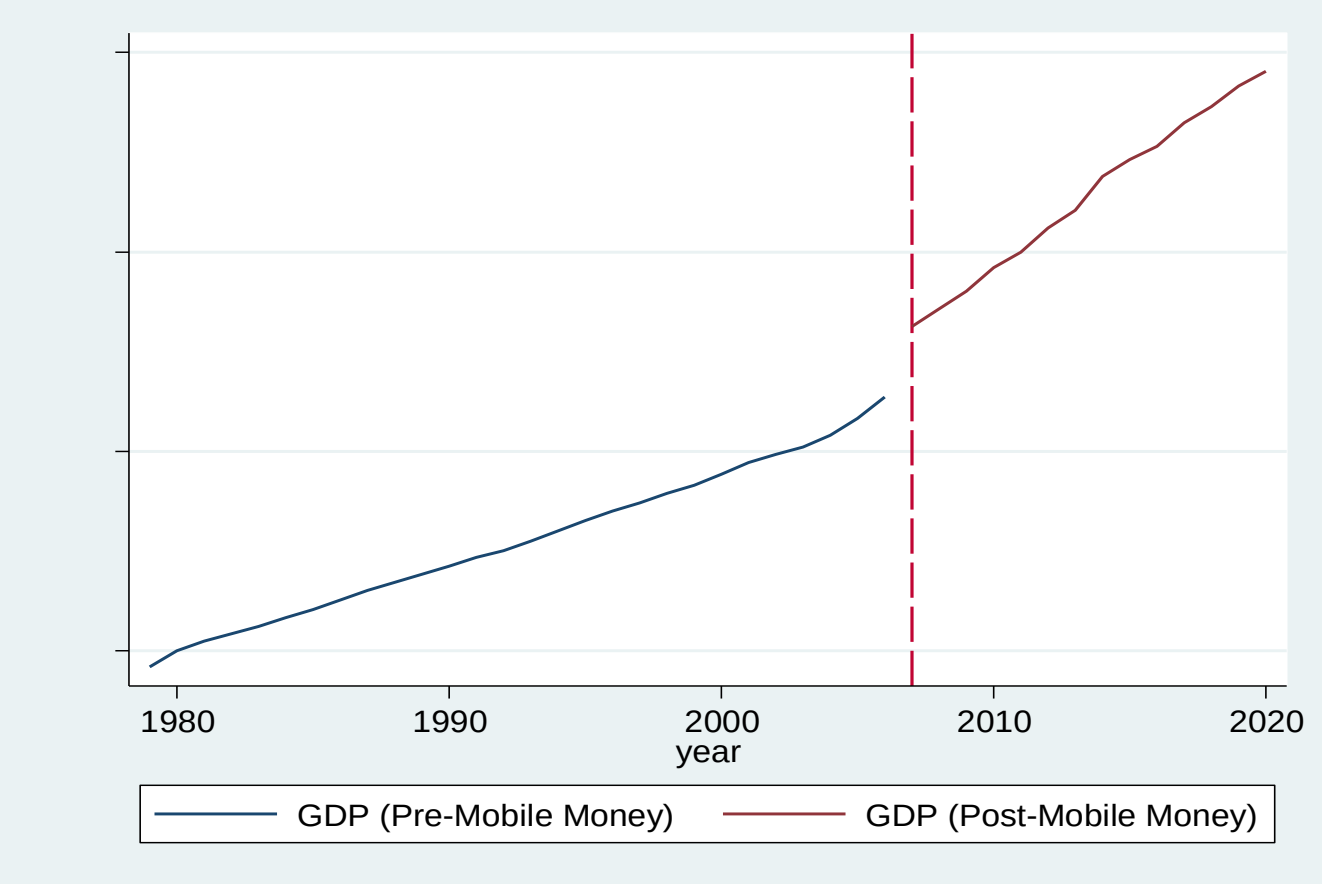

Figure 4.1: Structural Change in Output
Source: Author's computation

The results obtained in terms of labor and capital elasticities are consistent with other studies such as Hammouda *et al.* (2010) who found that African countries had capital and labor elasticities of 0.371 and 0.629. In a country-specific context, Njuguna et al. (2003) found the capital and labor elasticities to be 0.24 and 0.76 respectively. It is evident that African economies and the Kenyan economy in particular are labor-intensive.

The growth accounting is done by multiplying the elasticities with the growth rates of their respective factors of production. This gives the contributions of each factor to the overall output growth. The results obtained from the growth accounting which have been summarized in 5-year periods, were as shown in Table 4.7.

Table 4.7: Capital, Labor and TFP Contributions to GDP Growth

Years	GDP Growth	Contribution of Labor	Contribution of Capital	Contribution of TFP
1981-1985	2.53	4.13	-0.27	-1.33
1986-1990	5.64	3.19	0.21	2.23
1991-1995	1.61	2.82	0.19	-1.40
1996-2000	2.16	2.41	0.28	-0.53
2001-2005	3.65	2.40	0.43	0.83
2006-2010	4.98	2.25	1.39	1.35
2011-2015	4.70	2.49	0.97	1.23
2016-2020	3.66	2.12	0.33	1.22

Source: Author's own computation

The highest growth in GDP recorded is in the years between 1986 to 1990, where it averaged at 5.64 percent, while the lowest recorded growth was in the subsequent time period- 1991-1995. The high growth rates between 1986 to 1990 were attributed to the conscious and deliberate efforts to spur economic development. This was through the implementation and execution of the Sessional Paper No.2 of 1986- Economic Management for Renewed Growth that provided a guiding framework for re-orientation of the economy (Opondo, Etyang, Okeri, & Njuguna, 2019). The paper was developed because the country's economic growth had stalled and average incomes had not improved since the 1970s. The implementation led to structural adjustment which led to robust economy growth. The period that followed, 1991-1995 was marked by political tension resulting from election year in 1992, spike in oil prices, 1997 elections as well as the drought experienced the same year (Ichwara, 2003).

The contribution to growth by labor, capital and TFP can be respresented grapically as shown in Figure 4.2.

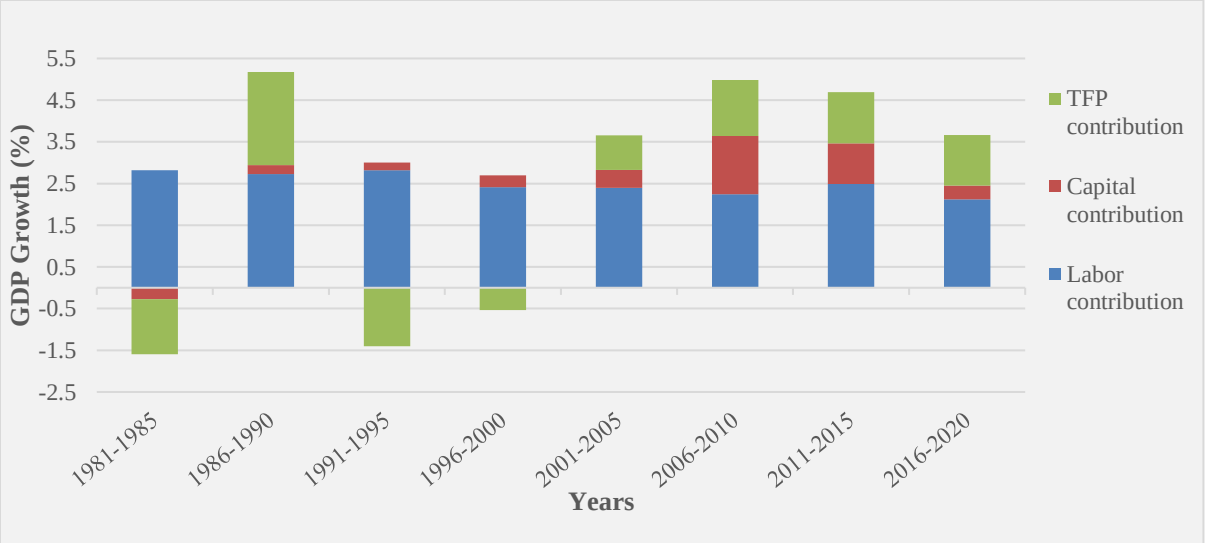

Figure 4.2: Labor, Capital and TFP Contribution to Growth
Source: Author's Computation

From the figure above, it is evident that labor has a greater contribution to growth than capital and TFP. TFP's largest economic growth contribution was observed in 1986-1990 period. The highest average growth is also recorded in this time period. As earlier stated, this could be explained by the structural adjustment that occurred after the implementation of the Sessional Paper No.2 of 1986. Negative TFP contribution was observed in the periods of 1981-1985, 1991-1995 and 1996-2000. These periods were marked by political tension due to the coup d'etat of 1982 and violence associated with the 1983, 1992 and 1997 elections. This implies that the political tension experienced in those time periods did in fact affect productivity.

As evidenced in Table 4.7 and Figure 4.1, TFP's contribution to economic growth since the introduction of mobile money in 2007 has been positive. In the subsequent years post-introduction of mobile money in Kenya, a negative contribution to growth by TFP has only been experienced in 3 years- 2008, 2014 and 2020. The negative contribution in 2008 is a result of the occurrence of the post election violence after the 2007 elections while that in 2020 could be explained by the

COVID-19 outbreak that also dampened economic growth. In 2014, the country had a weak security environment that was marked by escalated Al Shabaab terrorist acivities (World Bank, 2014). The presence of the security concerns is likely to have affected the TFP and its contribution to economic growth. Aside from this, it is also crucial to note that the Kenyan average economic growth rate has not gone beyond 6 percent in any of the periods. This is despite the fact that the country's goal as set out in the Kenya Vision 2030 is to attain a 10 percent annual growth rate.

4.4.2 Total Factor Productivity Analysis

Using the elasticities of labor and capital obtained from the estimated production function, the TFP was derived as a residual using the equation 4.1:

$$LnTFP = LnGDP - \hat{\alpha} * LnCap - \hat{\beta} * LnLab \quad (4.1)$$

Where:

$\hat{\alpha}$= 0.2918, $\hat{\beta} = 0.7082$ are the estimated shares of capital and labour, respectively.

Regression analysis was done to establish the relationship between TFP, Openness, Human Capital, Financial Deepening, Mobile Money, Leapfrogging and Conflict[1]. Two versions of regression model were estimated. Model 1 is the benchmark model that includes the variables mentioned above while model 2 includes the aforementioned variables in the benchmark model as well as a dummy variable D where D=0 if year<2007 and D=1 if year>=2007. The results of the diagnostic tests of the model are as shown in Table 4.8.

[1] TFP was calculated as the anti-log of lnTFP.

Table 4.8: Diagnostic Tests Results

Test	**Model 1**	**Model 2**
Jarque-Bera Test H0: Residuals are normal.	2.84 (0.2418)	2.45 (0.2942)
Breusch-Godfrey Test H0: No serial correlation.	8.436 (0.0037)	9.011 (0.0027)
Ramsey RESET Test H0: No model misspecification.	0.51 (0.6810)	0.52 (0.6693)

Source: Author's computation
Note: *p-values are in parenthesis.*

The results above show that the models passed the test of normality and model specification test. In both models, the Jarque Bera test for normality had p-values of greater than 0.05 and therefore the null hypothesis of normality of the residuals was not rejected at 5 percent level of significance. The Ramsey RESET test yielded similar results as the p-values were greater than 0.05 and therefore the null hypothesis of no model misspecification was not rejected at 5 percent level of significance. The models also do not suffer from multicollinearity as demonstrated above. This is evidenced by the fact that none of the variables had VIFs of greater than 10, which would indicate serious multicollinearity. However, there is evidence that the estimated models suffer from serial correlation. This was corrected by using robust standard errors in the estimation. The p-values obtained from the test in both models were less than 0.05 and therefore the null hypothesis of no

serial correlation was rejected at 5 percent level of significance. The results obtained from this analysis are as shown in Table 4.9.

Table 4.9: TFP Analysis Results

Dependent Variable : TFP	**Model 1 (p-value)**	**Model 2 (p-value)**
Constant	396.395 *** (0.000)	396.834 *** (0.000)
Financial Deepening	-1.237 * (0.056)	-1.3333 ** (0.049)
Mobile Money	9.305 *** (0.000)	8.5800 *** (0.000)
Leapfrogging	6.1139 (0.146)	-6.3951 (0.413)
Openness	-0.1821 (0.735)	-0.1644 (0.754)
Human Capital	-0.0994 (0.778)	-0.0877 (0.797)
Conflict	-2.1885 (0.661)	-5.5663 (0.336)
D (Dummy Variable: D=1 if year ≥ 2007; 0 if year ≤ 2007)	--	17.4240* (0.104)
Adjusted R-Squared	0.8478	0.8534

Source: Author's Own Computation
Note: **** p-value < 0.01; ** p-value < 0.05; * p-value<0.10*

The models are differentiated by the dummy variable D, with the variable being present in the first and absent in the second model. In both models, the results obtained were consistent with Mobile Money and financial deeping having significant effects on TFP, while openness, human capital, leapfrogging and conflict had no significant effect on TFP. To attain the first study objective, dummy variables were introduced to test for the presence of structural change in TFP due to the introduction of mobile money. In this case, the dummy variable was D which was equal to 1 if the year is post-2007 and equals to 0 if the year is pre-2007.

The significant coefficient of the dummy variable D indicates that there has been a significant change or shift in TFP since the introduction of mobile money in 2007 as shown in the Figure 4.3.

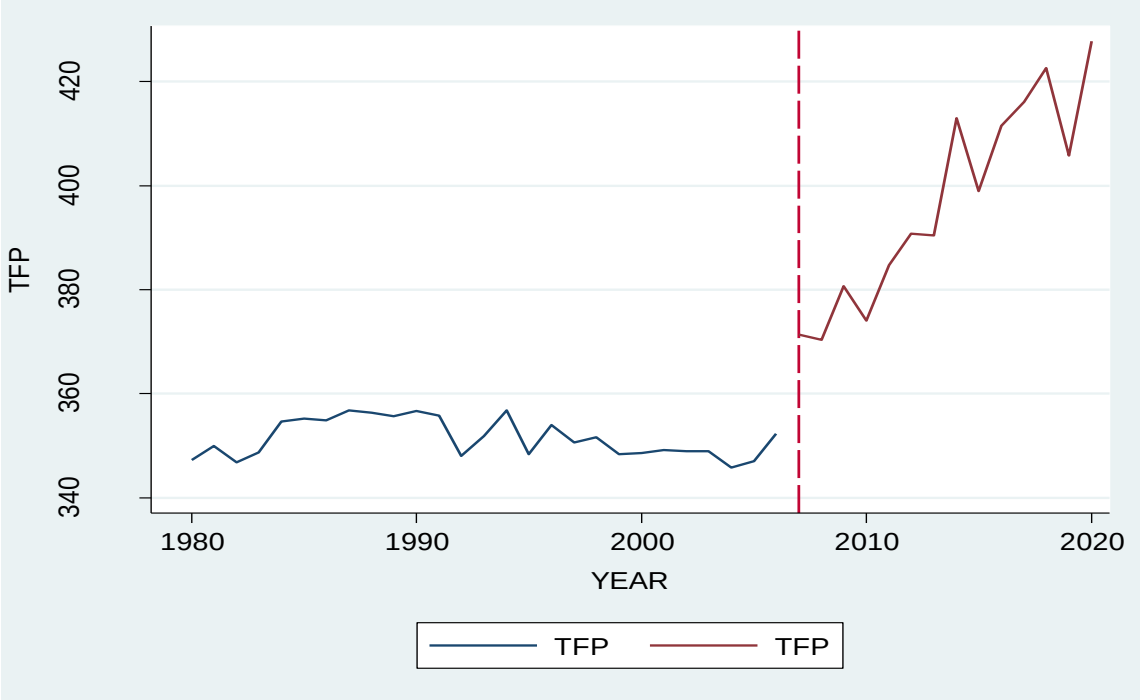

Figure 4.3: Structural Change in TFP
Source: Author's computation

In other words, there seems to have been a significant increase in the overall productivity in the economy when the financial innovation, that is mobile money; M-PESA was introduced in 2007 as a digital medium of exchange for goods and services. This is attributed to the fact that mobile money has significantly reduced the time taken for financial transactions which therefore increases the time allocation to create other products and services. In addition to this, mobile money has also increased the velocity of money in the economy, increased the purchase of goods and services since digital money is now easily available to the consumer and also increased the volume of trade as business are able to easily access credit facilities that are useful in the expansion of businesses. The significant positive effect of mobile money in both models conforms to the theoretical

expectations and is consistent with other studies such as Beck, Pamuk, Uras and Ramrattan (2015) who established that there has been a significant positive impact by mobile money on TFP in Kenya.

According to GSMA (2019), mobile money has led to increased TFP been through increased productivity in individual sectors such as agriculture and also increased productivity for the Micro, Small and Medium Enterprises (MSMEs) Agricultural producers have been found to have increased productivity as mobile money access has enabled them to purchase more equipment and inputs leading to adoption of more productive practices. MSMEs have also had increased productivity through faster payments processing (both to suppliers and from clients), reduced costs of handling cash, trade credit access and expansion of business as they can now reach clients even in different geographical regions (GSMA, 2019).

Financial deepening, which was measured as credit to private sector as a proportion of GDP, had a significant negative effect on TFP in both models. This is consistent with findings of studies such as Hammouda *et al* (2010) and Opondo *et al* (2019) that found a negative effect by financial deepening on TFP. Theoretically, deepening in the financial sector may impact growth in either of two ways. The first, is by allowing more mobilization of savings that leads to an increase in investment and the second is through increased information availability on investment projects and thus boost investment. However, this has not been achieved in the Kenyan case as financial deepening had a negative effect on TFP. According to Hammouda et al (2010), this could be as a result of weak investment by the private sector. This is by credit accessed being channeled towards personal consumption rather than towards investments in new technologies as well as research and development that are drivers of TFP. Opondo *et al* (2019) argue that while financial deepening ought to increase TFP through transmission mechanisms such as reduction of transaction cost and

time as well as improved reliability of transactions, its failure to do so can be attributed to the value of transactions. This is in light of the fact that one of the characteristics of the Kenyan mobile money system is that it depends on low-value (averaging at Ksh.2,740) but high-volume (4.8 million transactions on a daily basis) transactions (Ndung'u, 2021). The reduced value of transactions done via mobile money therefore, reduces the productivity of the system and in turn reduces its contribution to TFP.

Leapfrogging by mobile money- reflected by increase in the uptake of mobile money financial services in comparison to its predecessor, traditional bank accounts, was found to have no significant effect on TFP. While it has led to increased financial inclusion of the previously unbanked population, it had not been sufficient to increase productivity. The findings are consistent with those of Wang, Wei, & Wong (2010) who assessed whether adoption of a leapfrogging growth strategy resulted in increased growth rate. The analysis was done both across countries and across regions within China. The overall finding was that no significant evidence exists that leapfrogging could be relied upon to sustainably increase the growth rate. The conclusion was that adoption of leapfrogging as a development strategy is akin to taking a gamble and thus an unreliable approach to economic development. Additionally, leapfrogging requires a change in the labor distribution from the high labor concentration in the primary and secondary sectors to the tertiary sector. The implication is that more automation and adoption of technology is required in the production processes. However, as shown from the production function analysis, the Kenyan economy remains to be labor-intensive rather than capital intensive as would be the case in most of the developed economies.

Human capital, openness and conflict were found to have no significant effect on total productivity. According to Hammouda et al (2006), the lack of a significant effect on TFP by

openness could be explained by the fact that imports have mainly been non-technology enhancing. As opposed to capital and intermediate imports with embodied technologies that would have a significant beneficial effect on TFP, the imports are also most likely to be final consumer goods. Furthermore, as previously stated, the country's export portfolio remains dominated by goods and services that are not technologically intensive and also have low value addition thereby hindering the impact on TFP.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the findings and conclusions drawn from the study as well as the policy recommendations and areas for further research.

5.2 Summary of the Study

The mobile money financial service technology has grown exponentially within the Kenyan economy since its introduction and has led to increased financial inclusion by dealing with constraints associated with the traditional banking system. These constraints, such as affordability and access, resulted in a large financially excluded population, especially those in the rural areas. In 2006 (before the arrival of mobile money), the financial inclusion stood at a mere 26.7 percent of the total Kenyan population. However, in 2019 (13 years post-mobile money introduction), the numbers have significantly increased with the financial inclusion rate being 82.9 percent of the total population. Despite this massive effect in terms of financial inclusion, there isn't much empirical investigation into the impact of the introduction of these services on Kenya's productivity and output growth. To address this, the study aimed to evaluate the link between mobile money financial technology services and output growth and productivity.

The first study objective was to test for the presence of structural change in the output growth and productivity due to mobile money introduction in Kenya in 2007. To test for the presence of structural change in output growth, a dummy variable was introduced in the production function to capture the distinct periods; before introduction of mobile money (1980-2006) and after introduction of mobile money (2007-2020). The TFP analysis showed that there had been a

significant structural change in both output growth and output productivity due to mobile money services. Additionally, with the introduction of mobile money- a financial innovation utilized as a digital medium of exchange of goods and services- TFP has consistently been contributing positively to output growth.

The second aim was to quantify the mobile money services' effect on Kenya's output productivity. Mobile Money was measured as a ratio of the value of mobile money transactions to value of bank transactions. Mobile money was not only found to have caused a significant structural change in TFP, but also had a significant positive effect on TFP. This clearly indicates that the benefits associated with mobile money such as reduced transaction costs and time over its predecessor, traditional banking, have positively impacted the overall economy through increased productivity.

The final study objective was to examine mobile money's leapfrog effect of on output productivity. The leapfrogging of mobile money financial technology services was shown to have no significant effect on output productivity. This introduces skepticism on leapfrogging as a viable development strategy for developing countries to catch-up with their developed counterparts.

5.3 Conclusion

The study's findings indicate that like many other developing countries, the Kenyan economy is not only labor-intensive but also has low contribution by TFP to economic growth. This in contrast to developed countries which have TFP accounting for most of the economic growth. To spur economic growth, TFP's contribution to economic growth has to be increased. This is especially so since only eight years remain to 2030 and the annual economic growth rate target set in the Kenya Vision 2030 of 10 percent is yet to be attained.

From the production analysis, production output increased in the years coinciding with the introduction of financial digital technology in 2007. This is evidenced by the presence of structural change in output. Additionally, economic productivity has increased- as illustrated by the presence of structural change in TFP- due to the introduction of financial technology through digital money transactions, that is the M-Pesa payment system. In turn, TFP has contributed positively to economic growth since mobile money financial technology was introduced in the country. Leapfrogging has, however, had no significant effect on the economic productivity, thereby raising doubts on its viability as a route to economic development in Kenya.

5.4 Policy Recommendations

The financial innovation of mobile money, a digital medium for exchanging products and services has had a considerable impact on productivity and economic growth. This can be explained by the fact that the financial innovation has reduced transaction costs, transaction time, eased access to credit and has also resulted in increased volume of trade as the service eliminates previously existing geographical constraints to business. In addition to this, it has resulted in increased financial inclusion as previously unbanked populations can now access convenient and cheaper formal banking options. The massive success of mobile money implies that digitization should be encouraged across all sectors of the economy. Fostering of this financial innovation will not only result in increased productivity, but will also help the informal markets transition to formality through the use of electronic payments and access to credit and virtual saving platforms. Constraints hindering adoption and use of digital technologies such as lack of electricity access, poor network quality, affordability and lack of digital skills should be addressed for increased productivity.

The Kenyan mobile money system is currently characterized by low-value but high-volume transactions with the value of transactions averaging at Kshs. 2,740 (approximately 23 USD) and the daily transactions averaging at 4.8 million (Ndung'u, 2021). A major driver for the low-value transactions is concerns regarding the susceptibility of the mobile money platforms to cyber-crimes. Cyber security remains of great concern as Kenya is the highest-ranking country in SSA in terms of cybercrime with over 70 percent of the Kenyan population having experienced cybercrime (Didenko, 2017). An individual's sense of vulnerability when using mobile money could be heightened if the value of transactions is high and could therefore justify one's choice to use alternative means- such as the traditional banking system- to carry out such transactions. This, therefore, makes mobile money the preference if the transactions are of low-value. For increased average transaction value, these safety concerns should be addressed to reduce the skepticism held by individuals and businesses on using the mobile money services for high-value transactions. In this regard, a comprehensive legal framework should be developed for addressing cyber-crime and thresholds established for the minimum cyber security infrastructure that mobile network operators should have to ensure that the mobile money users are safeguarded from cyber threats.

As the empirical findings suggest that leapfrogging has had no impact on productivity and in turn growth, the leapfrogging development strategy is not a viable path economic development for the Kenyan economy. The traditional path of economic development – which is the gradual transition from the primary sector's dominance (mainly agriculture) to the secondary sector (manufacturing) and eventually tertiary sector (services)- is preferred to its leapfrog counterpart that transitions from primary sector dominance to tertiary sector dominance without undergoing the stage of dominance by the secondary sector. The government should therefore channel resources towards the development of a strong and resilient manufacturing sector.

As financial deepening did not lead to an increase in TFP, there is need to increase the levels of investment within the country. The negative association between financial deepening and TFP implies that while there has been growth in the private sector credit, there has been no investment towards increasing productivity by private firms. Instead of funding the renewal of technology and investing in research and development, the credit appears to be channeled towards personal spending. The government can therefore create incentives for firms to allocate a portion of their credit towards research and development. This can include providing grants or tax credits for businesses engaged in innovative projects that contribute to technological advancement. The financial sector can also introduce financial literacy programs targeted to businesses and entrepreneurs to improve their understanding of the long-term benefits of investing in productivity enhancing measures.

Human capital has had no significant effect on TFP, despite the increase in education levels among Kenyans. This points to a possible skill mismatch. Tertiary institutions should ensure that students (future workforce) are equipped with the expertise required in the labor market. A good working environment that encourages growth of professionals within their fields of expertise should also be encouraged so as to prevent brain-drain that is caused by individuals' pursuit for 'greener pastures' in other countries. Just like human capital, TFP was not significantly influenced by openness. Given that the exports have remained consistently more than imports, the government should encourage local manufacturing and export of the locally produced goods.

5.5 Areas for Further Research

The purpose of this study was to determine the association between mobile money financial technology services and output growth and productivity in Kenya. There are areas not covered by this research that merit further investigation. Further research should be done on leapfrogging as

there still exists a limited body of knowledge on the subject matter. In addition to this, an inquiry should be made on the FinTech regulatory framework in Kenya and other SSA countries so as to determine the role and impact that it has on the success of mobile money ecosystems.

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APPENDICES

Appendix A: Data Extrapolation- Perpetual Inventory Method

The values of capital stock in a country cannot be observed directly, and therefore, need to be estimated. The most commonly used method is the Perpetual Inventory Method (PIM). In this method, capital stock is regarded as inventory which grows over time. However, this inventory is subject to depreciation over time and the rate at which it falls in a period of time is regarded to as the depreciation rate. Despite decreasing over time, the capital stock never falls to zero (Berlemann & Wesselhoft, 2014).

Let *t* indicates the current period. The capital stock at period *t* is derived as sum of capital stock in the previous period (t-1), total investment in period t-1 and depreciation in period t-1. This maybe expressed as follows:

$$K_t = K_{t-1} + I_{t-1} + D_{t-1} \quad \text{(A.1)}$$

Where K_t is the capital stock at period t, K_{t-1} is the capital stock in the previous year, I_{t-1} is the gross investment in the previous period and D_{t-1} is the consumption of fixed capital.

Assuming a constant depreciation rate of δ, the formula for $K_t$can be rewritten as follows:

$$K_t = (1-\delta)K_{t-1} + I_{t-1} \quad \text{(A.2)}$$

Using recursive substitution, the capital stock series can be obtained as follows:

$$K_t = (1-\delta)^t K_0 + \Sigma_{i=0}^{t-1}(1-\delta)^i I_{t-1} \quad \text{(A.3)}$$

In order to calculate the values of capital stocks, the past values of investment series (Gross Fixed Capital Formation, GFCF), Initial Capital (K_0) and depreciation rate (δ) are necessary. The PIM

can be implemented using the Steady State approach, Disequilibrium approach, the Synthetic Time Series approach or the Unified Approach (Berlemann & Wesselhoft, 2014). The Steady State approach assumes that the economy is at a steady state and therefore the output grows at the same rate as the capital stock as follows:

$$g_{GDP} = g_K = \frac{K_t - K_{t-1}}{K_{t-1}} = \frac{I_t}{K_{t-1}} - \delta \quad \text{(A.4)}$$

The above equation is then used to solve for the capital stock at time t-1;

$$K_{t-1} = \frac{I_t}{g_{GDP} + \delta} \quad \text{(A.5)}$$

Where g_{GDP} is the growth rate of GDP and g_K is the growth rate of capital. The major drawback in this approach is the fact that the initial level of capital stock is heavily dependent on the level of investment and GDP growth of a single year. This therefore implies that any short-term shocks to investment in the first period of the level of investments series would result in biased initial capital estimates. It also may give implausible results such as a negative capital stock when the growth rate of output in a country is negative in the period for which the capital stock is being computed. (Berlemann & Wesselhoft, 2014).

The Disequilibrium Approach is similar to the Steady State Approach as the rate of output growth is taken to be equivalent to the rate of capital growth. However, unlike the steady state approach, the economy is not assumed to be at equilibrium, but rather on an adjustment path towards equilibrium.

$$K_{t-1} = \frac{I_t}{g_{GDP} + \delta} = \frac{I_t}{g_K + \delta} \quad \text{(A.6)}$$

The growth rate of capital stock in this approach can be approximated by the growth rate of investment as follows:

$$K_{t-1} = \frac{I_t}{g_I + \delta} \tag{A.7}$$

Where g_I is the growth rate of investment. The approach relies on the Hodrick- Prescott- Filter to smooth the investment data, and given that the filter displays anomalies at the end points, the first five observations of the investment series are dropped, resulting in a loss of information.

The Synthetic Time Series Approach constructs a historical time series of investments that is then used to calculate the initial capital stock. The level of investment at the chosen time period t_0 is computed which allows for the rest of the artificial time series of investments to be developed. Once the series is established, the initial capital stock for the period $t-1$ is calculated. The accumulated capital stock before the base period is therefore neglected. Given that the method heavily relies on the first observation of the investment series, the results obtained would be inaccurate should the initial value be an outlier (Berlemann & Wesselhoft, 2014).

The unified approach is adopted in the study where a linear regression of investment against time is used to obtain the initial capital stock. This approach is adopted as it seeks to address the drawbacks associated with the previously mentioned approaches. In order to avoid using the HP filter in the estimation of the investment value, as in the disequilibrium approach, the initial investment value is estimated using a regression analysis therefore making use of the whole series of investments rather than depending on a single investment observation as is the case in the Steady State and Synthetic Time Series Approaches. In this case, the log of investments, $Ln\ I_t$, is regressed on time, t as shown;

$$Ln\, I_t = \propto + \beta . t + \varepsilon_t \qquad \text{(A.8)}$$

The estimated parameters are the used to obtain the fitted value for the period t_1, which are the transformed using the exponential function in order to obtained the series of investment from time t_1 to T. The first fitted value of the series is then used to computed the initial capital stock for period t_0 as follows;

$$K_{t0} = \frac{I_{t1}}{g_I + \delta} \qquad \text{(A.9)}$$

Where K_{t0} is the initial capital stock, $I_{t1}$is the initial investment value and $g_I$is the growth of investment. In this approach, the estimated parameter $\hat{\beta}$ obtained in the regression of investment against time is used as the measure of investment growth. As standard in literature, a depreciation rate of 5.5 percent is used.

Appendix B: Growth Accounting

Year	Economic Growth (%)	Contribution of labor to growth	Contribution of capital to growth	Contribution of TFP to growth
1980	5.5920	4.9591	3.8061	-3.1733
1981	3.7735	4.6346	0.2328	-1.0939
1982	1.5065	4.3499	-1.0046	-1.8389
1983	1.3091	4.0982	-0.4083	-2.3809
1984	1.7552	3.8740	-0.0698	-2.0490
1985	4.3006	3.6731	-0.1072	0.7346
1986	7.1776	3.4920	0.5035	3.1821
1987	5.9371	3.3279	0.3848	2.2244
1988	6.2032	3.1785	-0.0500	3.0746
1989	4.6903	3.0420	0.1982	1.4501
1990	4.1921	2.9167	0.0377	1.2376
1991	1.4383	2.8013	0.1397	-1.5027
1992	-0.7995	2.8615	-0.4729	-3.1881
1993	0.3532	2.8740	0.3951	-2.9159
1994	2.6328	2.8188	0.4669	-0.6528
1995	4.4062	2.7261	0.4186	1.2615
1996	4.1468	2.5294	0.3311	1.2863
1997	0.4749	2.3710	0.1737	-2.0698
1998	3.2902	2.2908	0.4619	0.5375
1999	2.3054	2.3070	-0.0460	0.0444
2000	0.5997	2.5621	0.4988	-2.4612
2001	3.7799	2.2825	0.7957	0.7016
2002	0.5469	2.4403	-0.4303	-1.4631
2003	2.9325	2.5025	-0.5327	0.9628

2004	5.1043	2.4369	0.4607	2.2067
2005	5.9067	2.3227	1.8450	1.7389
2006	6.4725	2.3114	2.5327	1.6284
2007	6.8507	2.2030	0.2126	4.4352
2008	0.2323	2.1611	1.2612	-3.1900
2009	3.3069	2.2241	1.0581	0.0247
2010	8.0585	2.3351	1.8956	3.8277
2011	5.1211	2.3627	0.2510	2.5074
2012	4.5687	2.4832	1.5838	0.5017
2013	3.7978	2.5515	0.3219	0.9245
2014	5.0201	2.5479	2.6851	-0.2130
2015	4.9677	2.5138	0.0220	2.4319
2016	4.2135	2.5204	-0.5598	2.2529
2017	3.8155	2.2380	1.1677	0.4098
2018	5.6291	2.2088	-0.0592	3.4795
2019	4.9811	2.1992	0.5783	2.2036
2020	-0.3162	1.4257	0.5283	-2.2702

Source: Author's Computation

Appendix C: Data Used

Table C1: Production Function Analysis

Year	Capital	GDP	Labor
1980	17853622272.00	20428053820.50	5338604
1981	17996054528.00	21198915459.93	5687973
1982	17376497664.00	21518272511.52	6037342
1983	17133364224.00	21799957509.85	6386711
1984	17092360192.00	22182594065.03	6736080
1985	17029584896.00	23136570235.97	7085449
1986	17323409408.00	24797210380.20	7434818
1987	17551878144.00	26269447404.11	7784187
1988	17521825792.00	27898989515.06	8133556
1989	17640857600.00	29207549426.09	8482925
1990	17663668224.00	30431944786.35	8832294
1991	17748213760.00	30869661687.65	9181663
1992	17460590592.00	30622860607.01	9552647
1993	17697026048.00	30731019710.50	9940305
1994	17980168192.00	31540101239.84	10335948

1995	18238101504.00	32929826392.93	10733809
1996	18445027328.00	34295373364.40	11117180
1997	18554853376.00	34458242751.14	11489370
1998	18848569344.00	35591992582.88	11861012
1999	18818869248.00	36412526320.94	12247392
2000	19140546560.00	36630890563.26	12690470
2001	19662514176.00	38015503975.31	13099487
2002	19372531712.00	38223395381.67	13550867
2003	19018850304.00	39344287104.17	14029692
2004	19319140352.00	41352537462.57	14512441
2005	20540669952.00	43795093766.79	14988416
2006	22323507200.00	46629728713.92	15477612
2007	22486114304.00	49824205420.89	15959067
2008	23457994752.00	49939938453.25	16446062
2009	24308647936.00	51591422161.72	16962552
2010	25887784960.00	55748903297.99	17521856
2011	26110482432.00	58603863796.45	18106418

2012	27527657472.00	61281286575.00	18741301
2013	27831336960.00	63608656932.13	19416508
2014	30392371200.00	66801882117.21	20115070
2015	30415259648.00	70120413328.78	20829067
2016	29831788544.00	73074948912.65	21570342
2017	31025594368.00	75863128285.03	22251990
2018	30962634752.00	80133540731.91	22946017
2019	31576305664.00	84125098675.53	23658574
2020	32147994624.00	83859109642.80	24134840

Note: *GDP and Capital are in billions USD.*

Table C2: Total Factor Productivity Analysis

Year	Openness	Financial Deepening	Mobile Money	Leapfrogging	Human Capital	Conflict	t
1980	61.8023	21.8	0	0	118.171	0	0
1981	53.5916	21	0	0	114.344	0	0
1982	43.0419	20.4	0	0	115.694	1	0
1983	41.2892	19.3	0	0	114.734	1	0
1984	44.0310	19	0	0	110.051	0	0
1985	40.5695	19.3	0	0	104.926	0	0
1986	42.9421	19.3	0	0	104.372	0	0
1987	38.7248	18.4	0	0	103.658	0	0
1988	38.5922	18.9	0	0	101.677	0	0
1989	40.0335	19.2	0	0	102.208	0	0
1990	40.0259	18.7	0	0	98.776	0	0
1991	36.1817	20	0	0	96.638	0	0
1992	32.0874	22.2	0	0	95.29	1	0
1993	39.3967	18.5	0	0	94.571	1	0
1994	34.1835	19.8	0	0	91.259	0	0
1995	37.8340	25.8	0	0	89.187	0	0

1996	36.8669	21.7	0	0	89.588	0	0
1997	35.5044	24.4	0	0	89.988	0	0
1998	32.3692	24	0	0	90.389	0	0
1999	31.8274	26.6	0	0	88.977	0	0
2000	34.0775	25.8	0	0	93.187	0	0
2001	35.3824	25.2	0	0	94.381	0	0
2002	34.3389	25.9	0	0	88.242	0	0
2003	32.7434	25.2	0	0	101.822	0	0
2004	35.5224	27.3	0	0	100.444	0	0
2005	36.2985	26.3	0	0	99.346	0	0
2006	33.4766	22.9	0	0	96.348	0	0
2007	32.8361	23	1.1426	0.3263	102.365	1	1
2008	32.0844	25.4	1.7254	0.7906	102.285	1	1
2009	28.3570	21.9	1.8796	1.0473	103.914	0	1
2010	30.2103	24	1.7363	1.3842	105.749	0	1
2011	33.0995	27.4	3.5537	1.3467	107.583	0	1
2012	30.9929	26.4	4.0676	1.3278	109.418	0	1

2013	28.9281	28.3	4.1329	1.1575	107.586	0	1
2014	28.3309	34.5	7.503	0.8879	105.753	0	1
2015	25.3858	36.7	6.069	0.8139	103.662	0	1
2016	21.8388	35.6	7.3237	0.8484	103.205	0	1
2017	22.4630	33.2	7.4405	0.7836	102.748	0	1
2018	21.3832	31.2	7.9262	0.8628	102.291	0	1
2019	19.5899	30.8	5.914	0.9315	101.834	0	1
2020	13.1076	32	8.5351	0.9446	101.377	0	1

Note: *Openness, Financial Deepening and Human Capital are expressed as percentages while leapfrogging and mobile money are ratios.*