EFFECTS OF INTERNET CONNECTIVITY ON ECONOMIC GROWTH IN KENYA

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DECLARATION

This Research Project is my original work and has not been submitted for a degree in another college or university.

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This Research Project has been submitted for examination with my endorsement as a University supervisor.

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DEDICATION

I dedicate this paper to my parents and siblings for always believing in me and my colleagues at Kenya Revenue Authority for supporting my vision and encouraging me.

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I thank God for His faithfulness in this journey, my lecturers for imparting knowledge, fellow classmates for support, my parents and siblings for their prayers and encouragement. Special gratitude to my supervisor Dr Ongeri for his guidance and encouragement and my friends Doris, Vivienne and Gloria for always supporting me in this journey.

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LIST OF ABBREVIATIONS

SDG Sustainable Development Goal

ITU International Telecommunication Union

UN United Nations

GDP Gross Domestic Product

ADF Augmented Dickey Fuller

AIC Akaike information criterion

ISP Internet Service Provider

CAK Communications Authority of Kenya

CBK Central Bank of Kenya

ECM Error correction model

VECM Vector Error correction model

ECT Error correction term

GDP Gross Domestic Product

HQIC Hannan-Quinn Information Criterion

ICT Information Communication Technology

ABSTRACT

Digitalization has been increasing in Kenya and across the world with statistics showing that 4.9 billion people are now connected to the internet (ITU, 2021).Internet connectivity in Kenya has been a journey with the country now reporting 5G internet connectivity and increased access of both fixed and mobile connectivity. The rise and growth of E-commerce have contributed to economic growth. Significant investments on having Kenya connected have been made but what is not accounted for is how this investment relates to the levels of economic growth. With the objectives to analyze the effects of internet connectivity, both mobile and fixed on economic growth and draw policy implications from this, this paper addressed this problem.

Literature on both economic growth and internet connectivity was analyzed with the specific focus being on the neoclassical, endogenous and the supply leading theories. The empirical literature review indicated that financial development, internet connectivity, employment, trade, inflation and market capitalization affect economic growth. The theoretical framework used in this paper was based on the Solow model of economic growth. This paper utilized time series data from 2009 to 2020 from the KNBS, CAK and CBK. The analysis was done using the VECM and the results indicated a significant long run relationship between mobile and fixed internet connectivity and economic growth. For the mobile internet connectivity, this relationship was negative but for fixed internet connectivity the relationship was positive. For the control variables, inflation related positively but not significantly with GDP in both the short run and long run periods. In the short run, financial development and GDP related in a positive but not significant way while in the long run the relationship was positive and significant. Trade openness and GDP related positively and significantly in both the short run and long run periods. For public debt, the short run relationship was positive and not significant but this was positive and significant in the long run.

From this paper, the government should encourage policies that promote investment in fixed internet connectivity as this positively affects economic growth. The government should also encourage trade through policies upholding the ease of doing business through E-commerce platforms. Future research on this subject can incorporate labor in their analysis.

CHAPTER ONE

INTRODUCTION

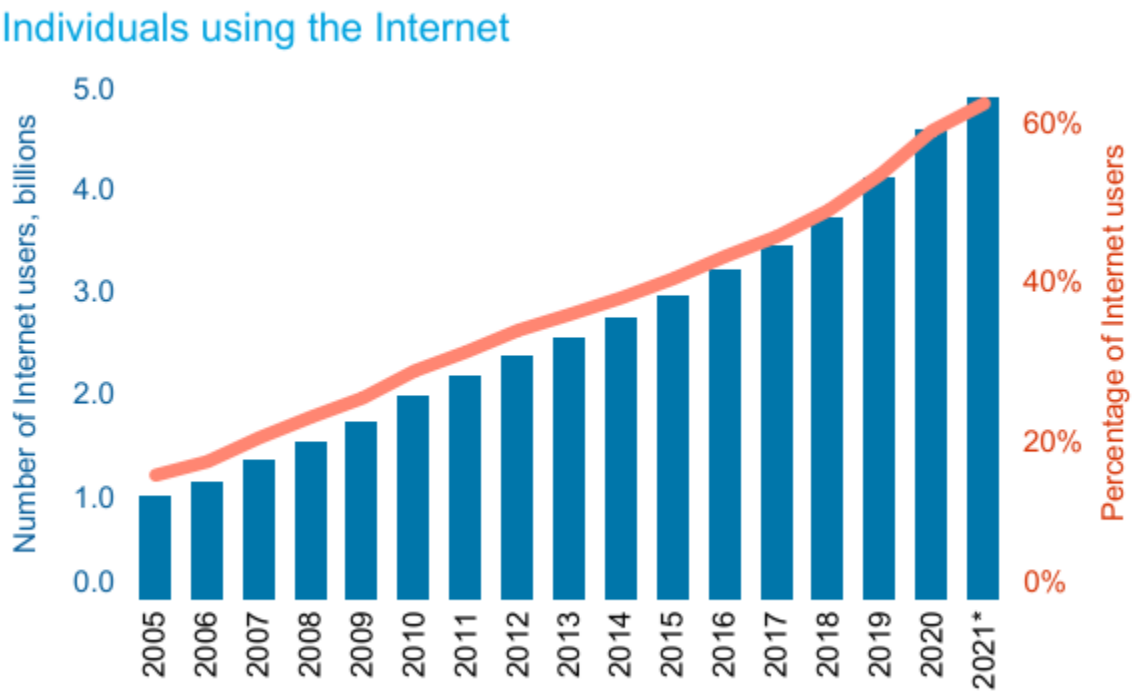
1.1 Background of the study

With an emphasis on both the global and national spheres, the uptake of digitalization has been increasing. Governments have prioritized digitalization as the key enabler in steering economic growth. Among the United Nations Sustainable Development Goals, internet connectivity is critical in attaining Sustainable Development Goal (SDG) number 9 on industry, innovation and infrastructure. Back home, digitalization is a key enabler in the Vision 2030. The universality of the internet in advanced economies is outstanding with the applications being on politics, social interactions, commerce and daily life (Poushter, 2016). Internet access affects the level of growth of per capita income (Poushter, 2016). Internet connectivity therefore contributes greatly to the growth of a country's economy, of great concern however, is the state in Less Developed Countries whereby growth and penetration of the internet is still low. Key among the drivers of the growth of an economy are internet usage and broad band subscriptions in countries within Africa's sub-Sahara, the Middle East and those in the Northern parts of Africa (Bahrini & Qafas, 2016).

1.1.1 Internet Connectivity from a Global Perspective

The history of the internet dates back to 1960s with emails being one of the first innovations to tap into this technology. Since 1960s, emails have been around, file sharing has been since 1970s and transmission protocols since 1983 (Roser, Ritchie & Ortiz-Ospina, 2015). The invention of the World Wide Web in 1989 was however the main anchor through which the spread of the internet started. People going online across the world have been increasing over time as shown by statistics. The use of internet has been growing across all countries around the world as shown in the figure below:

Figure 1.1: Individuals Using the Internet across the Globe



Source: International Telecommunications Union (2021)

Figure 1.1 shows the number of internet users in billions across the globe over time as per the International Telecommunications Union (ITU, 2021). According to the ITU (2021) the number of people using the internet was 4.9 billion across the world in 2021 which was an increase from the 4.3 billion in 2020. Figure 1.1 shows an increasing trend in the number of internet users over time. As at 2021, individuals using the internet across the globe was 60 percent. Despite, the increasing trend, there are still concerns about the number of people not being online. In fact, of the 2.9 billion people not online, 96 percent live in developing countries (ITU, 2021). The situation around connectivity to the internet is dire in these countries to the extent that almost 3/4 of the population has never had any internet connection.

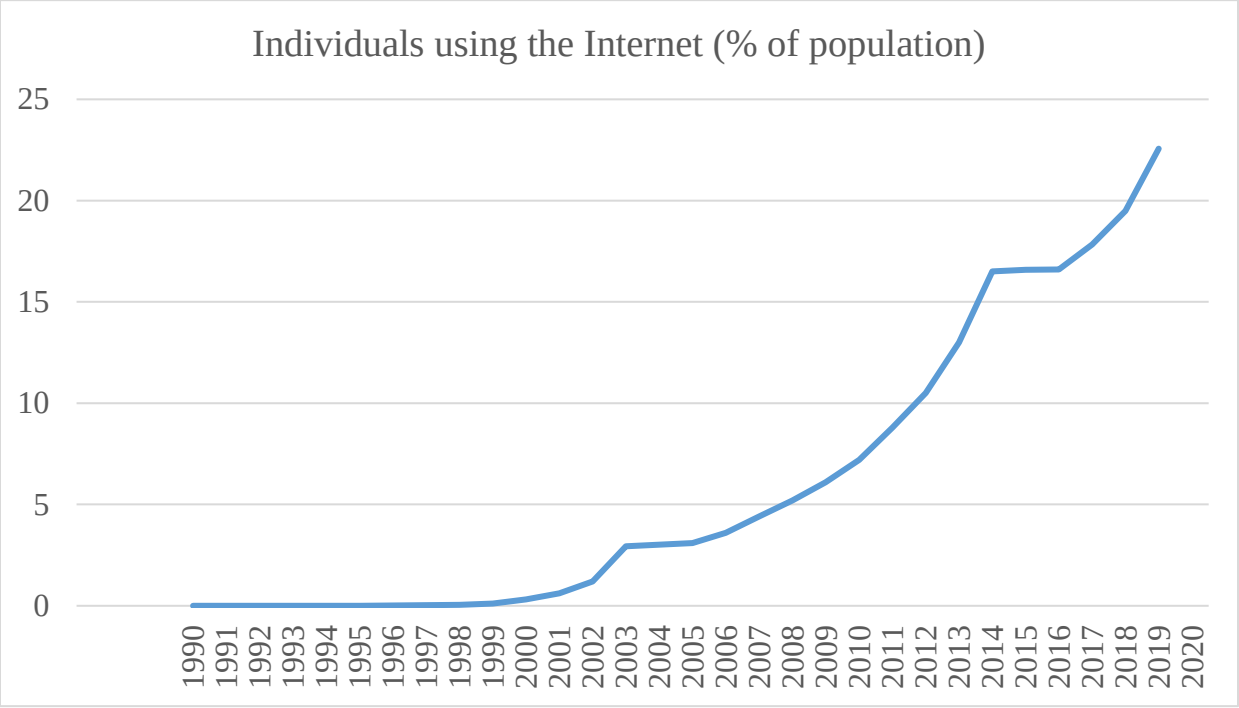
Digitalization is key in attaining the SDGs. The digital space interactions play a role in development and this should not be understated. Key in the causes of the digital divide to which poor countries are much affected is the gender gap. The report by the ITU (2021) expressed in its findings that 62 percent males use the internet compared to 57 percent females. The rural urban divide is also a key statistic to explain this discrepancy. According to the report, urban dwellers are 76 percent internet

connected while rural dwellers are 39 percent connected. Third among the concerns is generational gap. Globally, between ages 15 to 24 years, 71 percent use the internet compared to 57 percent in the other age groups. The case is worse in developing countries where 34 percent of population (young people) use the internet compared to 22 percent in other age groups (ITU, 2021). These statistics indicate that the quest towards improving internet access should take a multi-dimensional approach since factors affecting go beyond gender to generations as well the rural urban divide.

1.1.2 Internet Connectivity in Kenya

According to the World Bank (2019), Kenya's number of individuals using the internet expressed as a percentage of the population as at 2019 stood at 22.56 Million. Internet access in Kenya has been expanding over time as shown in figure 1.2 below:

Figure 1.2: Individuals using the Internet in Kenya from 1990-2020



Source: World Bank data (2021)

Figure 1.2 shows the number of individuals using the internet in Kenya over time. In percentage terms, individuals using the internet have been increasing from 1990 to 2020. Figure 1.2 shows that about 22.5 percent of the population are using internet in Kenya. Since 1990, there has been an increasing trend in the reported numbers for individuals using the internet despite challenges that

the country has been facing. One such challenge is limited integration between digitalization and SDGs pursuit in public organizations partly due to weak connectivity to the internet and low digital platforms' investment (Onyango & Ondiek, 2021). In the Kenya's vision 2030, the Information Technology service sector is an economic and macro pillar. The country aims at realizing increased economic growth from this sector. Kenya's information technology market value was 635 million dollars at December 2020 (BMI, 2021). The total sales for computer hardware was 360 million dollars and software was 174 million dollars. The Kenyan government has made progressive investment in the ICT sector with the sector contributing significantly to the economy's Gross Domestic Product (GDP). According to the World Economic Forum (2015), internet economy is growing at the rate of 15 to 25 percent annually. Kenya has seen its ICT Sector grow by a 10.8 percent average annually since 2016 (World Bank, 2019). These realized economic development, job creation and spillover effects in almost all sectors of the economy. Kenya has earned the title "Silicon Savannah" due to its comparably fast steps in ICT.

According to the Digital Economy blueprint (2019), governments should consider expanding their roles and participation in the digital economy through expansion of the national broadband coverage. This is something that the Kenyan government put in consideration in the 2021/2022 budget. The Kenyan budget for the financial year 2021/2022 includes the efforts of the government to digitize the economy (Budget Statement, 2022). According to the KPMG budget brief (2021), the budget had allocated funds for the Digital Literacy Programme establishment, the National Optic Fiber Backbone phase II Expansion cable expansion, Konza Data Centre and Smart city facilities, , commissioning of the Eldoret-Nadapal fibre optic cable and the last mile county connectivity network rehabilitation. The government is working towards better internet connectivity in order to realize the synergies that come with the digital economy. The internet penetration rate in Kenya stood at 87.2 percent in 2020 (Internet World Stats). According to the Communications Authority of Kenya, Kenya recorded 43.45 million internet/data subscriptions in the first quarter.

Internet plays a role in economic growth and this extends to trade through e-commerce. The Digital Economy Blueprint highlights developing e-commerce activity as one goal that Kenya is working towards. Kenya scored 82 out of 100 on the online payments indicator, a measure of E-commerce readiness and was ranked 88th in the B2C E-Commerce index in 2019 (UNCTAD, 2021). The role played by the internet in ensuring increased online commerce is therefore a key contributor to

economic growth. Kenya is working towards increasing the scale of available digital products so as to increase the use of digital platforms and realize the gains from trade. The growth of E-commerce will improve on efficiency and the ease of doing business and this will cut costs and barriers to operation which realizes increased economic growth (Kithinji &Onono, 2020). With a rise in the mobile payment platforms, being a key driver of E-commerce, this growth is likely to be achieved. Further to this, the government of Kenya through its budget for 2022/2023 expressed one of its objectives to be investing in ICT and digital infrastructure with an aim of supporting the use of digital platforms to facilitate e-commerce.

1.1.3 Kenyan Experience on Information Technology Issues

The turning point of the communications history in Kenya to include the internet dates back to October 1995 when a leased line connection was established. In those years, email communication was predominantly the avenue through which the internet was used and the regulatory authority was monopoly based. The inefficiencies of this monopoly saw the government banning emails and internet usage. Connectivity was by Telkom and this was handled internationally. Communications oversees were done through satellites.

The period 2000-2006 saw the introduction of the second generation (2G) connectivity. This was an alternative to easing traffic caused by the General Packet Radio Service. However, cellular operators could not easily reduce their email traffic due to difficulty in transition. In these years, they had to manage the traffic in emails through licensed Internet Service Providers (ISP). The period 2007 ushered in a new government and this spurred internet connectivity through various government interventions. The government, had its focus on addressing areas that the private sector failed. It invested in the national fiber connectivity and the international sub marine fiber optic cabling. This period that extended to 2010 saw development of data centers, developments in the domain space, and elimination of certain taxes all in the effort to cut down on costs that relate to the end-user terminals (Mureithi, 2016).

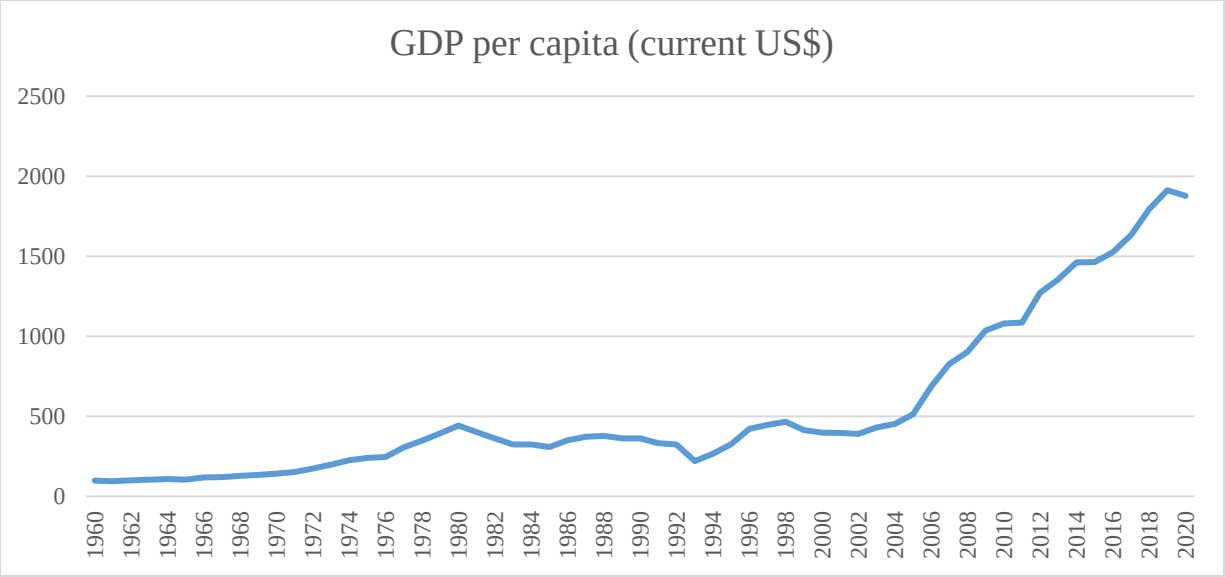
From 2010 to 2020, despite changes in government, the pace set on internet connectivity has been maintained. The government has adopted a multi-stakeholder approach in this aspect with the Ministry of ICT leading from the front. The National Optic Fiber for instance has been extended to include four undersea fiber optic cables: LION2, SEACOM, TEAMS, and EASSY that are core drivers of fixed internet penetration and this makes Kenya fastest in the region. In terms of strategy,

the government outlined its vision in ICT under the Digital Economy Blueprint, a document that was introduced in 2019. This document is implemented in partnership with other African countries. The government has been budgeting for internet connectivity initiatives and general ICT development with the current budget (Financial year 2022/2023) allocating Kshs 15.6 billion to fund initiatives in the ICT sector.

1.1.4 Economic Growth in Kenya

According to the World Bank (2021), Kenya is experiencing steady economic growth with its GDP expanding at the rate of 5.6 percent since 2014. As at 2020, Kenya's GDP per capita was 1838.21 dollars (World Bank, 2021). Diagrammatically, this is as shown below:

Figure 1.3: Economic Growth in Kenya from 1960-2020



Source: World Bank (2021)

Figure 1.3 shows the trend in economic growth since 1960 through 2020 as reported by the GDP per capita. The GDP per capita has been on an overall increase across the time period of analysis except for some periods such as 1980, 1992, 1998 and 2020 where there was a decline.

The global Covid-19 pandemic however disrupted this growth trend due to steps taken to minimize the spread of the virus. The real GDP of Kenya in the first half of the year 2020 reduced by 0.4 percent compared to the 5.4 percent achieved in the first half of 2019. During this period, policies were developed to help cushion against the effects of the pandemic. These varied from tax and

regulatory relief measures (Mogendi, Nganga, Osoro, Majune, Ongeri, Otieno & Abala, 2022). The service sector contributes the largest percentage of the GDP in Kenya. Key in the contribution to this impressive growth is reforms relating to mobile Information Technology developments in this sector.

The Kenya Investment Authority (KenInvest, 2022) points out the agricultural sector as the largest contributor to economic growth. The agricultural sector is not only the driver of this economy but also a means of livelihood for Kenyans. The sector involves crop production, horticulture, fisheries and livestock. Second among the sectors contributing is manufacturing whose contribution stands at 10 percent with the key factor for growth being processing of agricultural products. Economic growth in Kenya is also contributed to by the financial sector which includes the banking and finance categories. The finance sector recorded a 5.6 growth in 2020 (KNBS, 2021). This growth may be due to the rise in e-commerce and this called for mobile money platforms use and therefore use of the internet. Strengthening internet connectivity and widening its access is therefore very critical in this sector.

1.2 Research Problem

ICT is a key enabler of the desired economic growth stated in Vision 2030. The government looks forward to a 10 percent growth in GDP by 2030 which is yet to be achieved as at this year. Internet and mobile connections are the key drivers of ICT, how they exactly affect economic growth is a matter still under research. There is little empirical evidence on how internet connectivity relates to economic growth.

Past studies on internet connectivity and how it affected economic growth emphasized the need of ICT infrastructure in enhancing growth of the economy. Shodiey, Turayey & Shodiyey (2021) highlighted in their paper that increased broadband penetration increases the level of economic growth realized by a country. Concerted efforts ought to be directed towards realizing the inherent benefits of the usage of ICT. This includes rates of internet connectivity, costs of buying a cellular phone and subscription rates (Adeleye & Eboagu, 2019). Despite usage of the internet and the adoption realized by broadband being main drivers of growth economically in Africa's Sub Saharan countries, Middle East and the North of America, there needs to be increased investment in ICT infrastructure (Bahrini& Qaffas, 2019). The Kenyan government has taken steps in improving these infrastructure, what is not properly accounted for is how investment in this connectivity relates with

the levels of economic growth. Effectively, this paper examined this relationship with a clear policy focus on economic growth.

1.3 Research Objectives

The main objective of this study is to analyze the effects of internet connectivity on economic growth in Kenya, the specific objectives are:

1. To examine the effects of mobile and fixed internet subscriptions on economic growth in Kenya.
2. To identify the relationship between internet connectivity and economic growth in Kenya.
3. To draw implications from this.

1.4 Research Questions

1. What are the effects of mobile and fixed subscriptions on economic growth in Kenya?
2. How does internet connectivity relate to economic growth in Kenya?
3. What implications do we draw from this research?

1.5 Significance of the study

The findings of this study will be beneficial to the Ministry of Information and Communications Technology of the government of Kenya, and policy makers. This study will aid future research and contribute to literature on internet connectivity and economic growth.

1.6 Scope and Organization of the study

This study is organized in five chapters. Chapter one covers the background of the study, research problem, research objectives, research questions and the significance of the study. Chapter two covers literature review, both theoretical and empirical. Chapter three focuses on the methodology, chapter four the data analysis, results and findings and chapter five presents a summary of the study, recommendations and conclusion.

CHAPTER TWO

LITERATURE REVIEW

In this chapter, a review of literature on both the empirical and theoretical parts will be presented. The first part will be on the theories on economic growth and internet connectivity and the second part will be on the studies done on this. The third part will be an overview of the literature.

2.1 Theoretical Literature Review

2.1.1 Neoclassical Theory of Economic Growth

This theory explains how capital accumulation and changes in technology affect the economy. The Solow growth model, which captures input-output relation at the aggregate level falls under this theory. According to Solow, there is a steady state equilibrium for which economies converge with time. Economic growth in this theory comprises of accumulation of capital, growth in population and the changes in the rates of technological progress. A Cobb Douglas production function is adopted under this model as shown in equation (1):

$$Y_t = Kt^{\alpha} Lt^{1-\alpha} \quad (1)$$

Where: Yt- Is the output at time t.

Kt- Is the capital stock at time t.

α -Output elasticity of capital

Lt- Is the labor at time t.

$1 - \alpha$ Output elasticity of labor

For this production function, returns to scale are constant and there is diminishing marginal productivity of capital.

For the Solow growth model, fixed population implies that growth in output will be from additional capital stock. Economic growth, measured by output, is therefore as a result of saving or investing part of the output. The model also highlighted the sustained growth concept as being a product of growth in labour and technology. For sustained growth, the production function is:

$Y_t = A_t \ Kt^{\alpha} Lt^{1-\alpha}$

Where:

Y_t- Is the output at time t.

A_t- Is the rate of technological progress at time t.

K_t- Is the capital stock at time t.

α- Output elasticity of capital

L_t- Is the labor at time t.

$1-\alpha$-Output elasticity of labor

Labour and technology grow exogenously at the rate 'n' and 'g' respectively.

For this model, the central equation was:

$$K'_{(t)} = sK(t)^{\alpha} - (n + g + \overbrace{d)}K_{(t)} \qquad (2)$$

The equation is interpreted to capital stock's mean rate of change results from savings per effective labour and capital depreciation due to the rate of depreciation, technology growth and population growth (Zhao, 2019). The Solow growth model also discussed the balanced growth path and convergence concepts. For the former, the economy grows at a constant rate across the identified variables and in this case, sustained growth is solely due to technological change. The convergence concept as posited by Solow, states that economies eventually converge at the state where increase in capital stock does not lead to increase in output but rather accounts for depreciation.

According to Dowrick & Rodgers (2002), the Solow Swan steady state rate grows at different rates in each country. Countries have heterogeneous rates explained by international technology transfer. The technology transfer implication is that country specific rates of innovations influence productivity and the growth rate of the leader affects long run economic growth (Dowricks & Rodgers, 2002). Countries that have taken up technological innovations from a policy perspective have reaped benefits in terms of increased economic growth (Broughel & Thierer, 2019). The findings of Zhao (2019) differ from this in that, new technological innovations disrupt the economy and make the benefits of the old technologies obsolete. The neoclassical model therefore implies

that investment in technology improves the skills of the labor force and generates investment multiplier effects which lead to overall economic growth.

2.1.2 Endogenous Growth Theory

This theory was posited by David Romer, Gregory Mankiw and David Weil in 1992. In the long run, internal forces in an economy affect the growth rate (Mankiw, Romer & Weil, 1992). The theory explains that economic activities that create new knowledge contribute to long run economic growth (Mankiw, et.al, 1992). For this theory, the model is the 'AK' model and it holds that output is a function of capital:

$$Y = AK \tag{3}$$

Where Y is the output

A is a positive constant

K is capital

Assumptions on which this model was based included that the returns to capital as exhibited by the production function are constant, and the labor force grows at a constant rate which is determined exogenously. The interpretation of the 'K' has been all over in literature with views stating that it includes externalities and it incorporates both physical and human capital. Extensions to the basic model involve models with more than one sector and those incorporating microeconomic decisions behind the research process. New knowledge is developed by human capital alongside existing stock of knowledge. Growth of an economy in this case is through new forms of technology and more effective means of production, this can be enhanced through human capital. Growth of the economy and innovation relate positively and statistically significant (Apostol, Enriquez &Sumaway 2022). With time, research and development impacts economic growth in the long run and may be significant. According to this theory therefore, internet connectivity is an externality and investing in it realizes technological change which improves the capital stock leading to change in the level of economic growth.

2.1.3 Supply Leading Hypothesis

This theory posits that growth of an economy is as a result of development in the financial sector which arises from changes in the development of the real sector (Adeyeye, Fapetu, Aluko & Migiro, 2015). For this theory, growth realized by the economy may be contributed by financial deepening (Adeyeye et.al, 2015). A financial sector is considered efficient when development exists in the economy and it is this efficiency that is the driver of economic growth according to the supply leading theory (Adeyeye et.al, 2015). Internet connectivity helps in setting up and using mobile and internet banking platforms and therefore provides development in the financial sector which may lead to economic growth. Real sector development is what causes a rise in investment and therefore more money calling for mobile money developments and this realizes financial sector development (Odhiambo, 2007). From this, it may be that economic growth is the one that causes a rising need for better internet connectivity.

2.2 Empirical Literature Review

Studies by different authors have analyzed the relationship between internet and how it relates to economic growth:

Salahuddin & Gow (2016) analyzed the effects of internet usage, trade openness and financial development on South Africa's economic growth using time series data for the period 1991 through 2012. The findings were that economic growth, financial development and internet related positively is positive in the long run. Further, these variables were insignificant in the short run (Salahuddin & Gow, 2016). This implied that efforts towards boosting internet usage for example through strengthening connectivity realizes increase in economic growth.

Adeleye & Eboagu (2019) evaluated economic growth in Africa and how this is impacted by ICT development using panel data for 54 countries from 2005 through 2015. Their findings revealed that economic growth and ICT relate significantly (Adeleye &Eboagu, 2019). The authors identified the ICT indicators in their paper to be mobile phone subscribers, telephone subscribers and internet usage. The mobile phone indicator was found out to have high output elasticity and this implied that increasing mobile phones will leapfrog Africa's economic growth compared to other indicators.

Shamim (2007) using pooled cross sectional data of 61 countries divided into developing, developed and emerging economies over a period of 11 years (1990-2001), evaluated how e-finance technologies affected economic growth. This was specifically to analyze how growth in the

economy and internet connectivity related (Shamim, 2007). The findings were that better connectivity improved economic growth through enhanced financial depth. Better connectivity in this paper was as shown by the increasing internet users and subscribers through the mobile phone.

Onyango & Ondiek (2021) using panel data analyzed digitalization and how sustainable development goals have been integrated in the public organizations in Kenya. The findings were that poor network and internet connectivity affects SDGs' implementation. Further, challenges to the implementation of SDGs in these organizations included fluctuating internet connectivity, limited funding, cultural and organizational bureaucracy, inadequate technological skills, poor database management and inadequate training on the ICT skills. This shows that the challenges to internet use as an economic growth tool extend beyond connectivity to infrastructure and development of skills among the users.

Edo, Okodua & Odebiyi (2019) using time series data, analyzed adoption of internet and how it related to financial development in Kenya and Nigeria. The authors aimed at investigating the internet adoption impacted financial development (Edo, Okodua &Odebiyi,2019). The period under their analysis was 2000 to 2016 and the findings were that policies encouraging use of the internet in an inclusive way improved financial development in various countries. Further, complementing internet with financial openness positively impacted the economic growth that different countries reported.

Haini (2019) did a paper on economic growth, human capital and internet penetration with particular emphasis on the Association of South East Asian countries. The author aimed at examining how economic growth was affected by human capital formation and internet penetration. Panel data over the period 1999 to 2014 was utilized. The findings indicated that human capital and the rate of penetration of the internet related positively with economic growth. The relationship was significant. Human capital formation should therefore be encouraged and IT sector development in terms of accessibility and affordability should be upheld.

The findings of the study by Mauseth (2018) contradicted the above studies. Mauseth (2018) did a paper on economic growth and how it is affected by the internet. Mauseth (2018) aimed at assessing how internet affected economic growth. A panel data model was used utilizing data from 1990 to 2015.Analysis was done using the pooled Generalized Methods of Moments and pooled Ordinary

Least Squares (OLS). The findings of this paper were that growth as a result of the use of the internet is negative and significant.

2.3 Overview of the Literature Review

With consideration of theoretical and the empirical literature reviews, the effects of internet connectivity on economic growth in Kenya can be explored across time periods. Internet connectivity, a component of information and communications technology, has both negative and positive effects on economic growth depending with the period. Internet connectivity's effects on economic growth is on various components of growth ranging from labor productivity, human capital and technology. From the theoretical literature, internet connectivity and economic growth may have a relationship, the neoclassical model of economic growth holds that internet connectivity as an investment in the technology aspect and this improves the labor force and generates investment multiplier effects which lead to economic growth. The endogenous growth theory posits of internet connectivity being an externality whose investment leads to technology change and consequently economic growth. The supply leading hypothesis, through financial development, highlights a possible relationship of the economic growth and internet connectivity. A counter view to this theory, is the finding that it may be possible that economic growth could be the one causing financial sector development and therefore internet connectivity.

For the empirical literature, the studies by Adeleye & Eboagu (2019) and Salahuddin & Gow (2016) pointed out that connectivity of a country through mobile phones and internet relates positively to economic growth. For Salahuddin & Gow (2016) and Shamim (2007), internet connectivity is a key driver of financial development and consequently the economy grows. Edo, Okodua & Odebiyi (2019) confirmed these findings in their paper. To them, more inclusive internet usage affects economic growth positively. In the paper by Haini (2019), penetration of the internet and human capital affected economic growth positively. For Mauseth (2018), internet connectivity was a significant but negative contributor to economic growth. The literature review posits that economic growth is affected by many factors, technology being one of them. However, the issue of which particular aspect of economic growth is affected by internet connectivity is a subject that needs research. With a focus on drawing policy implications on Kenya, this paper addresses it.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The main sections in this chapter are; theoretical framework, empirical model, model specification, definition, measurement and expected signs of the variables, econometric approach, data source and type and diagnostic tests.

3.2 Theoretical Framework

Under this model, the production function is:

$$Y(t) = F\big(A(t)K(t)L(t)\big) \quad (4)$$

Where

K is the capital stock

A is the technology

L is the labour

t is the time

Labour and technological progress are exogenously determined and grow at the rates $'n'$and$'g'$.

This study will base on the augmented growth model developed by Feldstein, Heshamati & Savings (1992) where human capital was augmented in the Cobb Douglas production function and this was as shown in equation (5) below:

$$Y(t) = F(K(t), A(t)L(t), H(t) \quad (5)$$

Where:

$Y(t)$ is the output at time $'t'$

$A(t)$ is technological progress rate at time $'t'$

$K(t)$ is the capital stock at time $'t'$

$L(t)$ is the labour at time $'t'$

$H(t)$ is the human capital stock.

We base on this to give the augmented equation to include number of internet subscribers as a measure of internet connectivity.

$$Y(t) = F(K(t), A(t)L(t), Int(t)) \quad (6)$$

The production function will be:

$$Y(t) = K(t)^{\alpha} Int(t)^{\beta} A(t)L(t)^{1-\alpha-\beta} \quad (7)$$

Equation (7) is then expressed per effective worker and this becomes:

$$Y(t)/A(t)L(t) = K(t)^{\alpha} Int(t)^{\beta} A(t)L(t)^{1-\alpha-\beta}/A(t)L(t) \quad (8)$$

This becomes:

$$y_{(t)} = K(t)^{\alpha} Int(t)^{\beta} \quad (9)$$

Denoting investment in physical capital and internet connectivity by $S(t)^k$ and $S(t)^i$, and $y = \frac{Y}{AL}$

, $k = \frac{K}{AL}$ and $i = \frac{Int}{AL}$, the first differential equations will be:

$$k'(t) = S(t)^k y_{(t)} - (\tilde{d} + n + g)k_{(t)} \quad (10)$$

$$i'(t) = S(t)^i y(t) - \left(\tilde{d} + n + g\right)I(t) \quad (11)$$

In this case the evolution equations will be as shown in equations (10) and (11) below. The steady state values for capital and internet connectivity will be $\dot{K(t)} *$ and $\dot{\iota(t)} *$:

$$\dot{K(t)} *= S(t)^k y_{(t)} - (\tilde{d} + n + g)k_{(t)} \quad (12)$$

$$\dot{\iota(t)} *= S(t)^i y(t) - \left(\tilde{d} + n + g\right)I(t) \quad (13)$$

At steady state $\dot{K(t)} *$ and $\dot{\iota(t)} *$ =0, therefore equations (10) and (11) will be:

$$0 = S(t)^k K(t)^{\alpha} - (\tilde{d} + n + g)K(t)^* \quad (14)$$

$$0 = S(t)^i I(t)^{\beta} - \left(\tilde{d} + n + g\right)I(t)^* \quad (15)$$

From equations (12) and (13) we get:

$$K(t)^* = \left(\frac{S(t)^k}{(\tilde{d}+n+g)}\right)^{\frac{1}{1-\alpha}} \quad (16)$$

$$I(t)^* = \left(\frac{S(t)^i}{(\tilde{d}+n+g)}\right)^{\frac{1}{1-\beta}} \quad (17)$$

Substituting equations (16) and (17) into equation (9) gives:

$$y_{(t)} = \left(\frac{S(t)^k}{(\tilde{d}+n+g)}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{S(t)^i}{(\tilde{d}+n+g)}\right)^{\frac{\beta}{1-\beta}} \quad (18)$$

From equation (18) above, physical capital investment and output have a positive relationship. Internet connectivity and the output also relate positively. The study therefore examines the case that increased internet connectivity leads to increased economic growth.

3.3 Empirical Model

From the empirical literature: Salahuddin & Gow (2016), Shamim (2007),Mauseth(2018), and Adeleye &Eboagu (2019) the variables included in their analysis were: internet subscribers, labour, trade, investment, financial development, inflation and GDP.

Therefore:

$$GDP = F\,(Emp, FIN, Inv, TrP, SMb, TFs, Inf) \quad (19)$$

Where, GDP is the real Gross Domestic Product, Emp is the labour force, FIN is the market capitalization, Inv is the ICT contribution to GDP, TrP_t is trade openness, SMb is the number of mobile data subscribers, Inf is inflation and TFs is the number of fixed data subscribers. Equation (19) can be transformed to a log-linear function of the form:

$$\ln GDP_t = \beta_0 + \beta_1 ln\, Emp_t + \beta_2 \ln FIN_t + \beta_3 \ln Inv_t + \beta_4 \ln TrP_t + \beta_5 \ln SMb_t + \beta_6 \ln TFs_t + \beta 7 \ln Inf + \varepsilon_t \quad (20)$$

Where the subscript t implies time, β'^{s}_{i} are the respective coefficients and ε_t is an error term assumed to be Independent and Identically Distributed (IID). As the aim of the study is analyzing the effects of internet connectivity on economic growth, Nominal gross domestic product values will be the measure of economic growth in Kenya. The number of mobile data and fixed subscribers in Kenya will be a measure of internet connectivity. The other variables are summarized in table 1.

To estimate economic growth equation (18), lags of the various variables will be included and an autoregressive model of the general equation (21) will be estimated.

$$y_t = \beta_0 + \theta y_{t-1} + \sum_{i=1}^{r} \beta_i x_{t-i} \quad (21)$$

Where:

y_t is a proxy for economic growth

y_{t-1} is lag of the explanatory variable

x_{t-i} are lags of the independent variables

The study seeks to examine the effects that internet connectivity measured in terms of fixed and mobile internet subscriptions, financial development, investment, labour, trade, market capitalization and economic growth. The analysis will be done using the Vector Error Correction Model (VECM). Its general framework is as shown in equation (22) below:

$$\Delta y_t = v + \sum_{I=1}^{K-1} \Pi_i \, \Delta y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta X_{t-1} + \varepsilon_t + \rho ECT_{t-1} + u_t \quad (22)$$

Where:

Δy_t is a vector of the first difference of dependent variables, Π, Γ_i are the short run coefficients, ρ is the speed of adjustment parameter, ECT_{t-1} is the error correction term, u_t is the residual and

ΔX_t is a vector of the first difference of independent variables.

Table 1: Measurement, Definition and Expected Signs of the Variables

Variable	Notation	Description and Measure	Expected Sign
Labour Force	Emp_t	This is the proportion of population of those employed and those seeking for work. It will be measured in numbers.	Positive
Market Capitalization	FIN_t	This is a proxy for Financial Development. It will be measured in Kenya Shillings.	Positive
Information and Communication Development Contribution to GDP	Inv_t	This is a proxy for physical capital. It will be measured in Kenya shillings.	Positive
Trade openness	TrP_t	This is the sum of imports and exports. It will be measured in Kenya shillings.	Positive
Inflation	Inf_t	This is the general price level of goods and services. It will be measured in percentage terms.	Negative
Mobile Internet Connectivity	SMb_t	This is a measure of internet connectivity. It will be measured as number of mobile data subscribers.	Positive
Fixed Internet Connectivity	TFs_t	This is a measure of internet connectivity. It will be measured as number of fixed data subscribers.	Positive

Description Source: Sector Statistics Reports, Quarterly GDP reports, Central Bank of Kenya Statistical Releases for 2009-2020

3.4 Data type and Source

Secondary data was utilized in this study. Data was collected from databases of the Central Bank of Kenya, Kenya National Bureau of Statistics, and Communication Authority of Kenya. The paper covers the period 2009 to 2020 and adopts a quarterly approach. The sources for this data include Statistics releases from KNBS, sector statistics reports from CAK, KNBS Quarterly GDP Reports and CBK Statistical releases. Due to inavailability of quarterly data for labor, public debt was introduced as another variable that explains economic growth.

3.5 Diagnostic Tests

To estimate equation (22), certain conditions have to be met. The first test will be the unit root test and with this the data has to have a constant mean and variance for it to be considered stationary. Determining stationarity is critical for reliability of the results (Woolridge, 2015). The Augmented Dickey Fuller (ADF) will be used. With this test, the null hypothesis is for the presence of a unit root and the alternate is for absence of a unit root. The ADF equation to be used is equation (23) below:

$$\Delta y_t = \propto + \delta T + \rho y_{t-1} + \sum_{i=1}^{n} \beta_i \Delta y_{t-1} + \varepsilon_t \qquad (23)$$

Where: Δ is the difference operator, yt is the variables in their levels, T is a time trend, and α, δ and β are parameters and εt is a white noise error term.

Further analysis will be done considering the ADF test results. This is such that in the event the data series is stationary, then OLS as an estimation method is valid. If the variables are non-stationary, then a cointegration test will be conducted. Should the variables be found to be cointegrated, a VECM model will be estimated. If they are not cointegrated only the short run model (VAR) will be estimated.

The second test will be the autocorrelation test using the Durbin Watson statistic. This tests for the relation among different period's error terms. OLS application as an estimation technique in time series analysis requires no autocorrelation for validity. Testing for autocorrelation in time series helps in identifying seasonality and trends in time series data (Georgiou, 2022). In the presence of strong correlation, time series results, including standard errors and confidence intervals exhibit great uncertainty (Bence, 1995). Absence of autocorrelation is therefore more preferred.

CHAPTER FOUR

THE STUDY FINDINGS

4.1 Introduction

Empirical findings of this study are presented in this chapter. The chapter includes; the results of the pre-estimation analysis tests, cointegration tests, the Vector Error Correction Model (VECM) and the post-estimation analysis tests. Thereafter, there will be a discussion of the results.

4.2 Descriptive Statistics

The study aimed at analyzing the effects of internet connectivity on economic growth in Kenya for a period 2009 to 2020. Table 2 below presents summary statistics:

Table 2: Summary Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
QGDP Kshs Million	48	1562282	645498.5	700391	2821161
Mobile subscriptions	48	20900000	15500000	1981048	51600000
Fixed subscriptions	48	156293.7	155884	8154	580253
Inflation	48	7.124028	3.595706	3.33333	19.18667
Trade openness	48	496502.1	99859.46	267702.4	619308.7
NSE20 share index	48	3683.321	915.9498	1804	5349.667
QICT contribution to GDP	48	38194.81	15848.6	16403	74648
Public debt	48	9475360	5594732	2948647	21700000

Source: Author

From table 2, the average quarterly GDP was Kshs 1,562,282 million with a Kshs 645,498.5 variation. The highest quarterly GDP was Kshs 2,821,161 and the lowest was Kshs 700,391. The average mobile subscriptions were 20,900,000 with the lowest number of mobile subscriptions being 1,981,048 and the highest being 51,600,000. For the fixed subscriptions, the average was 156,293.7, the highest 580,253 and the lowest 8,154. The average inflation rate was 7.124 percent with a 3.595 percent variation. For this variable, the lowest rate was 3.333 percent and the highest rate was 19.1866 percent. For trade openness, the average was Kshs 496,502.1 with the highest being Kshs 619,308.7 and the lowest being Kshs 267,702.4. The NSE20 share index had an average

of 3683.32, the highest index was 5349.67 and the lowest was 1804. For the quarterly ICT contribution to GDP was Kshs 38,194.81 million with the highest being Kshs 74,648 and lowest being Kshs 16,403. Public debt had an average of Kshs 9,475,360,000 with the highest being Kshs 21,700,000, 000 and the lowest being Kshs 2,948,647,000.

4.3 Correlation Analysis

A correlation analysis indicated a strong positive relationship between mobile subscriptions, fixed subscriptions, trade openness, investment, public debt and GDP. The analysis indicated a negative relationship between GDP, inflation and financial development.

Table 3: Correlation Results

	lnQGDP	lnSMb	lnTFs	lninf	lnTrP	lnFIN	lnInv	lnpublicd
lnQGDP	1							
lnSMb	0.9685	1						
lnTFs	0.9143	0.8915	1					
lninf	-0.3488	-0.3877	-0.3373	1				
lnTrP	0.8141	0.7883	0.6527	-0.179	1			
lnFIN	-0.5443	-0.5469	-0.689	-0.0842	-0.1586	1		
lnInv	0.8738	0.8616	0.9033	-0.3241	0.743	-0.5351	1	
lnpublicd	0.9797	0.9673	0.9637	-0.3608	0.7599	-0.6318	0.9151	1

Source: Author

In tandem with the expectations, were the results of correlation analysis for variables except for financial development. An increase in mobile and fixed subscriptions increases the output (GDP) of a country and an increase in output increases internet connectivity in terms of more subscriptions. Similarly, an increasing trade openness implies more imports and exports and this increase the GDP. Increasing investment in ICT also increases the GDP of the country. Contrary to the expectation, correlation analysis inferred that increasing financial development had a decreasing implication on GDP.

4.4 Pre-estimation Tests

4.4.1 Unit Root Test

This tested for the stationarity presence in the data series. Before testing for the presence of a unit root, the data was visualized in the graphs shown in appendix 1. All the variables showed an upward trend and this informed the use of a trend in carrying out the Augmented Dickey Fuller test. Table 4 below shows the results:

Table 4: Unit root test Results

Variables	Test Statistic	1% critical	5% critical	10% critical
lnQGDP	-4.417	-4.187	-3.516	-3.190
1st difference lnQGDP	-10.509	-4.196	-3.520	-3.192
lnSMb	-2.559	-4.187	-3.516	-3.196
1st difference lnSMb	-4.641	-4.196	-3.520	-3.192
lnTFs	2.365	-4.187	-3.516	-3.190
1st difference lnTFs	-5.160	-4.196	-3.520	-3.192
Lninf	-4.966	-4.187	-3.516	-3.190
1st difference lninf	-3.996	-4.196	-3.520	-3.192
lnTrP	-3.002	-4.187	-3.516	-3.190
1st difference lnTrP	-7.432	-4.196	-3.520	-3.192
lnFIN	-2.220	-4.187	-3.516	-3.190
1st difference lnFIN	-3.730	-4.196	-3.52	-3.192
lnInv	-7.492	-4.187	-3.516	-3.190
Ist difference lnInv	-12.791	-4.196	-3.52	-3.192
Lnpublicd	0.139	-4.187	-3.516	-3.190
1st difference lnpublicd	-8.282	-4.196	-3.52	-3.192

Source: Author

The ADF tested the null hypothesis of no unit root meaning the data is stationary and the alternative hypothesis of the presence of a unit root. For the interpretation, in the various critical levels, when the absolute value of the test statistic is less than the calculated ADF, the data is considered non-

stationary and the we do not reject the null hypothesis (Wooldridge,2015). However, the null hypothesis is rejected if otherwise. From table 4 above, lnQGDP, lninf and lnICTcontribution were stationary while lnSMb, lnTFs, lnNSE, lnTrP and lnpublicd were non-stationary. The time series was therefore non-stationary at the data levels. In their first differences all the variables were stationary at 5 and 10 percent critical levels. This implies that the variables are integrated in order 1.This provides a basis for testing for their cointegration with an aim to test for linear combinations among variables.

4.4.2 Autocorrelation Test

The computed Durbin Watson statistic was 1.9672, rounded off to 2.0. The interpretation of this statistic is such that if the value is 2.0 this indicates absence of autocorrelation. A value less than 2.0 indicates negative autocorrelation and that greater than 2.0 indicates positive autocorrelation. This implies that this time series had no autocorrelation and therefore can be analyzed.

4.5 Lag Order Selection

For optimal lag length determination, the three commonly used methods are the AIC, HQIC and SBIC criteria. This decision criterion is based on the minimum value of the optimal selected values.

Table 5: Optimal Lag Length Selection

Selection-order Criteria								
Sample: 2010q1 - 2020q4					Number of Observations=44 44			
lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-3978.06				6.70E+68	181.185	181.305	181.509
1	-3623.94	708.24	64	0	1.30E+63	167.997	169.08	170.917
2	-3522.19	203.5	64	0	3.20E+62	166.281	168.327	171.796
3	-3407.47	229.45	64	0	7.70E+61	163.976	166.983	172.086
4	-3248.11	318.71*	64	0	1.0e+61*	159.641*	163.611*	170.347*

Source: Author

From table 5 above, the minimum value was shown by the AIC criterion and therefore the optimal lag length was 4.

4.6 Johansen Test of Cointegration

The test tests for the presence of a long run relationship in a time series (Johansen & Juselius, 1998). With the variables being non-stationary, there might be a stochastic trend and thus a long run relationship. The Johansen test of cointegration establishes cointegrating relationships (K) in a data series and therefore tests the hypotheses

H_0: K=0

H_1: K=1

The results of the Johansen test of cointegration in this study are shown in table 5 below:

Table 6: Johansen test of Cointegration Results- Trace Statistic

Maximum rank	Parms	LL	Eigen value	Trace statistic	5% Critical value
0	200	-3463.91	.	431.5888	156
1	215	-3379.38	0.97855	262.5345	124.24
2	228	-3325.47	0.91373	154.7215	94.15
3	239	-3300.43	0.6797	104.6282	68.52
4	248	-3277.3	0.6505	58.3736	47.21
5	255	-3263.65	0.46235	31.0693	29.68
6	260	-3253.12	0.3804	10.0074*	15.41
7	263	-3248.14	0.20238	0.0582	3.76
8	264	-3248.11	0.00132		

Source: Author

Table 7: Johansen test of Cointegration Results- Max Statistic

Maximum rank	Parms	LL	Eigen value	Max statistic	5% critical value
0	200	-3463.91	.	169.054	51.42
1	215	-3379.38	0.97855	107.813	45.28
2	228	-3325.47	0.91373	50.0933	39.37
3	239	-3300.43	0.6797	46.2546	33.46
4	248	-3277.3	0.6505	27.3044	27.07
5	255	-3263.65	0.46235	21.0618	20.97
6	260	-3253.12	0.3804	9.9492	14.07
7	263	-3248.14	0.20238	0.0582	3.76
8	264	-3248.11	0.00132		

Source: Author

The interpretation of the Johansen test of cointegration is such that if the max and trace statistic exceed the 5% critical value then we reject the null hypothesis of no cointegration otherwise we fail to reject the null hypothesis. From tables 5 and 6 above, there are 6 cointegrating relationships as per the trace statistic and 7 as per max statistic. This implies the presence of a long run relationship and therefore the need to run the Vector Error Correction model.

4.7 Vector Error Correction Model

The vector error correction model estimates the long run relationship whereby the speed of the adjustment of the dependent variable to the long run equilibrium due to a change in the independent variable is looked at. The general equation for this model is:

$$\Delta y_t = v + \sum_{I=1}^{K-1} \Pi_i \, \Delta y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta X_{t-1} + \varepsilon_t + \rho ECT_{t-1} + u_t \quad (23)$$

Where:

Δy_t is a vector of the first difference of dependent variables.

Π, Γ_i are the short run coefficients

ρ is the speed of adjustment parameter

ECT_{t-1} is the error correction term

u_t is the residual

ΔX_t - A vector of the first difference of independent variables.

Short run VECM Results

In the short run period, the equilibrium has not yet been reached. The short run equations (Refer to appendix 2) are as shown below:

For GDP

$$\Delta lnGDP_t = -54231.53 + \ -6.6301124\Delta lnQGDP_{t-1} - 10.27071\Delta lnInv_{t-1} + 0.053296\Delta lnpublicd_{t-1} + 50.223\Delta lnFIN_{t-1} + 0.74249\Delta lnTrP_{t-1} + 2565.571\Delta lninf_{t-1} \ - 1.435327 lnTFs_{t-1} - 0.0082\Delta lnSMb_{t-1} - 0.11993 \ + u_t \quad (24)$$

From equation 22 above, the adjustment term (-0.11993) is statistically significant with a P-value of 0.000 at 5% level of significance. This implies that at a convergence speed of 11.993 percent, deviations from the long run equilibrium are corrected for within the current quarter (. From the displayed results in appendix 2, the lags of GDP, Investment, and trade openness are significant while those of public debt, financial development, and inflation, fixed and mobile subscriptions are not significant.

For Fixed Internet Subscribers

$$\begin{aligned}\Delta lnTFs_t = 2009.15 + \ & 0.000125\Delta lnSMb_{t-1} + 1.3499\Delta lnInv + 0.0205\Delta lnpublicd_{t-1} \\ & - 10.8018\Delta lnFIN_{t-1} + 0.06134\Delta lnTrP_{t-1} + 536.1699\Delta lninf_{t-1} \\ & + 0.3135\Delta lnTFs - 0.07302\Delta lnQGDP_{t-1} - 0.00599 \\ & + u_t \end{aligned} \quad (25)$$

From equation 23 above, the adjustment term (-0.00599) is statistically significant with a P-value of 0.045. This is interpreted to mean that at a convergence speed of 0.599 percent, deviations from the long run equilibrium are corrected for within the current quarter. From appendix 2, the lag of

public debt is significant while those of mobile subscribers, fixed subscribers, investment, financial development, trade openness, inflation and GDP are not significant.

For Mobile Internet Subscribers

$$\begin{aligned}\Delta lnSMb_t = -549.69 + \ & 0.1165\Delta lnSMb_{t-1} - 37.14\Delta lnInv - 3.199\Delta lnpublicd_{t-1} \\ & + 106.979\Delta lnFIN_{t-1} + 26.2948\Delta lnTrP_{t-1} - 3742.04\Delta lninf_{t-1} \\ & + 60.22\Delta lnTFs - 6.1252\Delta lnQGDP_{t-1} - 1.615253 \\ & + u_t \end{aligned} \quad (26)$$

From equation 24 above, the adjustment term (-1.615253) is statistically significant with a P-value of 0.001. The interpretation is that at a convergence speed of 161.52 percent, deviations from the long run equilibrium are corrected for within the current quarter. The lags of public debt, investment, trade openness and fixed subscribers are significant while those of GDP, financial development, inflation and mobile subscribers are not statistically significant.

For Inflation

$$\begin{aligned}\Delta lnINF_t = -0.1308 & - 0.00000002\Delta lnSMb_{t-1} + 0.0000531\Delta lnInv \\ & + 0.000000075\Delta lnpublicd_{t-1} - 0.00112\Delta lnFIN_{t-1} + 0.00000634\Delta lnTrP_{t-1} \\ & - 3742.04\Delta lnINF_{t-1} + 0.00000456\Delta lnTFs + 0.00000218\Delta lnQGDP_{t-1} \\ & + 0.000000143 \\ & + u_t \end{aligned} \quad (27)$$

From equation 27 above, the adjustment term (0.000000143) is not statistically significant at 5% level of significance. This is interpreted to mean that at a convergence speed of 0.0000143 percent, deviations from the long run equilibrium are corrected for within the current quarter. Inflation and mobile subscribers' lags are significant while those of GDP, public debt, ICT contribution, financial development, trade openness and fixed internet subscriptions are not significant.

For Trade Openness

$$\begin{aligned}\Delta lnTrP_t = 4614.883 & - 0.00316\Delta lnSMb_{t-1} - 3.5683\Delta lnInv + 0.03526\Delta lnpublicd_{t-1} \\ & + 19.98\Delta lnFIN_{t-1} - 0.1271\Delta lnTrP_{t-1} + 1293.597\Delta lnINF_{t-1} - 0.513\Delta lnTFs \\ & + 0.1848\Delta lnQGDP_{t-1} - 0.00921 \\ & + u_t \end{aligned} \quad (28)$$

From equation 26 above, the P-value was 0.265 and this means that the adjustment term (-0.00921), is not statistically significant at 5 percent significance. At a convergence speed of 0.921 percent, the deviations from the long run equilibrium in this case are corrected for within the current quarter. Public debt, investment, financial development, trade openness, inflation and mobile internet subscribers' lags are not statistically significant. At 5 percent level of significance, the lag of GDP is significant.

For Public debt

$$\Delta lnpublicd_t = 46626.28 - 0.0141\Delta lnSMb_{t-1} - 27.58\Delta lnInv + 0.4343\Delta lnpublicd_{t-1} - 60.087\Delta lnFIN_{t-1} - 0.44127\Delta lnTrP_{t-1} - 2431.298\Delta lnINF_{t-1} + 5.1846\Delta lnTFs - 0.1033\Delta lnQGDP_{t-1} - 0.15247 + u_t \quad (29)$$

From equation 29 above, considering the 0.000 P-value, the adjustment term (-0.15247) is statistically significant at 5% level of significance. The interpretation is that at a convergence speed of 15.247 percent, deviations from the long run are corrected for in the current quarter. From appendix 2, the lags of public debt, investment, fixed subscribers are significant and those of GDP, financial development, trade openness, inflation and mobile subscribers are not significant.

For Investment

$$\Delta lnINV_t = 6956.83 - 0.000215\Delta lnSMb_{t-1} + 1.024681\Delta lnInv + 0.004557\Delta lnpublicd_{t-1} - 6.2417\Delta lnFIN_{t-1} - 0.03512\Delta lnTrP_{t-1} - 267.0998\Delta lnINF_{t-1} + 0.038\Delta lnTFs - 0.0093646\Delta lnQGDP_{t-1} + 0.0081341 + u_t \quad (30)$$

The lags of public debt, investment, financial development and trade openness are significant considering their P-values in appendix 2. Contrary to this, the lags of GDP, Inflation, fixed and mobile internet subscribers are not significant. The speed of adjustment was 0.8134 percent.

Long run VECM Results

The long run period in this case referred to the period where equilibrium has been reached. For this, the results of the analysis were as shown in the table below:

Table 7: Vector Error Correction Model

Cointegrating equations			
Equation	Parms	chi2	P>chi2
_ce1	7	362.2894	0

Johansen normalization restriction imposed						
Beta	Coefficient	Standard error	z	P>z	95% Confidence interval	
_ce1						
lnQGDP	1					
lnpublicd	0.4087982	0.093678	4.36	0.000	0.2251932	0.5924032
lnictcontr	-245.541	16.0718	-15.28	0.000	-277.0412	-214.0408
lnnse	296.4318	127.692	2.32	0.020	46.16018	546.7034
lntradeopenness	3.377972	1.41371	2.39	0.017	0.6071514	6.148792
lninf	-4692.552	21314.32	-0.22	0.826	-46467.85	37082.75
lnfixedsub	7.176723	1.458847	4.92	0.000	4.317436	10.03601
lnmobilesub	-0.054619	0.01761	-3.1	0.002	-0.089134	-0.0201054
Constant	75297.43					

Source: Author

Under the VECM, both dependent and independent variables are considered endogenous variables. Coefficients are interpreted as long run elasticities in the long run relationship of log transformed variables (Asari, Baharuddin, Jusoh, Mohamad, Shamsudin, & Jusoff, 2011). The long run relationship between GDP and fixed internet subscribers, mobile internet subscribers, inflation, trade openness, investment and financial development is therefore as shown by equation (22) below:

$$\ln GDP_t = 75297.43 - 0.054619 ln\, SMb_t + 296.4318 \ln FIN_t - 245.541 \ln Inv_t + 3.3779 \ln TrP_t + 7.1767 \ln TFs_t + 4692.552 \ln Inf + 0.408798 lnpublicd + \varepsilon_t \quad (31)$$

Equation (22) indicates that between mobile internet subscriptions and the levels of GDP the relationship is negative but significant. This is such that a percentage increase in mobile internet

subscribers lead to a decrease in the GDP by 0.0546 percent. The P-value was 0.002 and therefore significant. For fixed internet subscribers, a percentage increase in the fixed internet subscribers increases GDP by 7.1767 percent. Fixed internet subscribers and GDP therefore relate positively and significantly. For inflation, an increase in inflation by a percent leads to an increase in GDP by 4692.55 percent. With a P-value of 0.826, this relationship is not statistically significant. Increase in the trade openness by a percentage leads to a 3.3779 percent increase in the GDP. The relationship between trade openness and GDP is positive and significant. The reported P-value of 0.017 is less than 0.05. A percentage increase in financial development increases GDP by 296.43 percent holding other factors constant. With a P-value of 0.02, this positive relationship is significant. For investment, a percentage increase in investment leads to a 245.54 percentage decrease in the GDP while holding other factors constant. With a P-value of 0.000,this relationship is therefore negative but significant. Public debt and GDP have a positive and significant relationship in that an increase in public debt by one percent causes a 0.4087 percent increase in the GDP while holding other factors constant. With log of fixed internet subscribers, mobile internet subscribers, ICT contribution, NSE20 index, public debt, inflation and trade openness being equal to 1, the log of GDP equals 75297.43.

4.8 Post Estimation Tests

4.8.1 Stability Test for the VECM

This test checks whether the cointegrating ranks are correctly specified. It also checks for the stationarity of the cointegrating relationships (Alexiadis, Eleftheriou & Nijkamp, 2013).

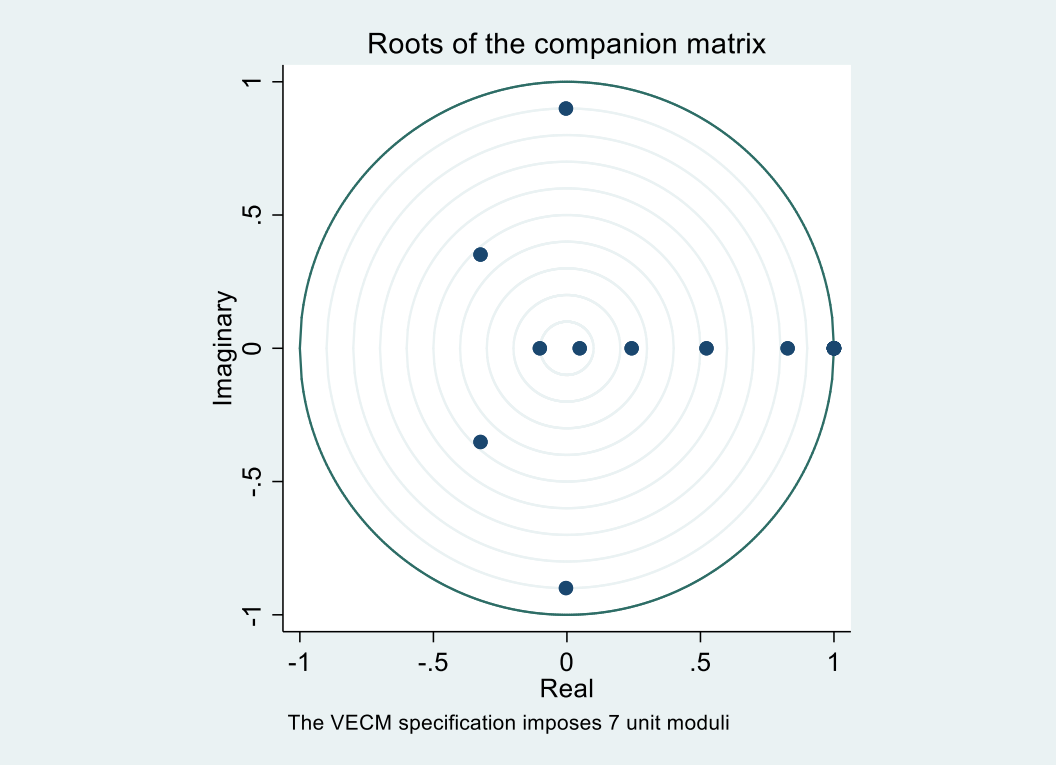
Table 8: Stability test

Eigen value	Modulus
-0.0036039-.899633i	0.899641
-0.0036039-.899633i	0.899641
0.826443	0.826443
0.522651	0.522651
0.2423439	0.242344
-.1014195	0.101419
0.04796403	0.047964

-.3235723 + .3515571i	0.477798
-.3235723 + .3515571i	0.477798

Source: Author

Figure 2: Root of the Companion Matrix



The interpretation for the stability test is that if all roots are inside the cycle, then the VECM is stable (Alexiadis et.al, 2013). This implies that with reference to figure 2,with all roots being inside the cycle, this model is stable.

4.8.2 Serial Correlation test

For this test, the relationship between the different period error terms is tested.

Table 9: Langrage Multiplier test

Lag	Chi-square	Degree of freedom	Prob > chi square
1	55.0222	64	0.78063
2	64.1008	64	0.47295
3	49.2639	64	0.91282
4	92.0702	64	0.06232

Source: Author

Using the Langrage multiplier, the P-value of the lags is interpreted against the null hypothesis of 'No serial autocorrelation'. From table 9 above, the P-values for lags 1, 2,3 and 4 indicate serial autocorrelation absence.

4.8.3 Normality test

Normality test tests for the error term's distribution that is whether it is normally distributed or not. The results of the Jarque bera test are as shown below:

Table 10: Jarque-Bera test

Equation	Chi-square	Degree of freedom	Prob>Chi square
D_lnQGDP	0.47	2	0.79058
D_lnpublicd	0.143	2	0.9311
D_lnictcontribution	0.57	2	0.75207
D_lnnse	0.626	2	0.73126
D_lntradeopenness	0.546	2	0.76119
D_lninf	0.991	2	0.60938
D_lnfixedsub	0.54	2	0.76336
D_lnmobilesub	34.488	2	0.00000
ALL	38.373	16	0.00000

Source: Author

Basing on the P-value, the interpretation of the Jarque-Bera test is done and with this the null hypothesis of not normally distributed is tested. From table 10, the logs of GDP, public debt, ICT contribution, NSE20 index, trade openness, inflation and fixed internet subscribers are normally

distributed while that of mobile internet subscribers is not normally distributed. Generally, the whole model is not normally distributed.

4.9 Summary Findings

In summary, from the correlation analysis, mobile and fixed subscriptions, ICT contribution to GDP and the trade openness relate positively with GDP. Financial development and GDP have a weak negative relationship. As per the results of the Augmented Dickey Fuller test, the variables were non-stationary at their levels and stationary at their first differences. Due to this first difference stationarity and presence of cointegration, the VECM was calculated.

In the short run, with GDP as the target variable, deviations from the long run equilibrium were at a 11.93 percent speed of adjustment. In this short run relationship, the lags of GDP, Investment, and trade openness were significant while those of public debt, financial development, and inflation, fixed and mobile subscriptions were not significant. With fixed internet subscribers as the target variable, the speed of adjustment was 0.599 percent with the lag of public debt being significant while those of mobile subscribers, fixed subscribers, investment, financial development, trade openness, inflation and GDP being not significant. With mobile internet subscribers as the target variable, the speed of adjustment was 161.52 percent with lags of public debt, investment, trade openness and fixed subscribers being significant while those of GDP, financial development, inflation and mobile subscribers not being significant.

The short run case for inflation indicated the speed of adjustment to be 0.000043 percent, the lags for inflation and mobile subscribers are significant while those of GDP, public debt, ICT contribution, financial development, trade openness and fixed internet subscriptions are not significant. With trade openness as a target variable, the speed of adjustment was 0.921 percent. The lags of public debt, investment, financial development, trade openness, inflation and mobile internet subscribers were not statistically significant. The lag of GDP was statistically significant.

For public debt, in the short run, the speed of adjustment was 15.47 percent with the lags of public debt, investment, fixed subscribers being significant and those of GDP, financial development, trade openness, inflation and mobile subscribers not being significant. The case for investment indicated significant lags of public debt, financial development ,investment and trade openness and not significant lags of GDP, Inflation, and fixed and mobile internet subscribers. The speed of adjustment was 0.8134 percent.

The results of the VECM were that in the long run, mobile subscriptions and GDP relate negatively such that a percentage increase in mobile subscriptions led to a 0.0546 percent decrease in the GDP.For the fixed subscribers, a percentage increase in the fixed subscribers led to 7.1767 percentage increase in GDP. This relationship was positive and significant. The relationship between trade openness and GDP was positive and significant with a percentage increase in trade openness leading to 3.3779 percentage increase in GDP. The relationship between the NSE20 index and GDP was also positive and significant with a percentage increase in the NSE20 index leading to a 296.43 percent increase in GDP. ICT contribution and GDP have a negative and significant relationship with a percentage increase in ICT contribution leading to a 245.54 percentage decrease in GDP. An increase in public debt by a percent leads to a 0.4087 percentage increase in GDP while holding other factors constant.

CHAPTER FIVE

CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

This chapter presents a discussion on the conclusion of the paper, policy recommendations based on the findings and the areas of further research.

5.2 Conclusion

With an aim of analyzing the effects of internet connectivity on economic growth in Kenya and a specific focus to analyze the effects of mobile and fixed internet subscriptions on Kenya's economic growth, to identify the how internet connectivity related to economic growth and draw policy implications from the findings, this paper was done. The study provided an introduction to the subject matter, discussed the literature review with a focus on the neoclassical theory, endogenous theory and the supply leading hypothesis. A review of empirical studies was also done. The framework was based on the Solow model and the paper was set to examine the case that investment in physical capital and internet connectivity affected economic growth positively. The analysis period in this paper was from 2009 to 2020 with the paper having adopted a quarterly approach.

Prior to the analysis, there were expectations that internet connectivity in both fixed and mobile parameters positively affected economic growth. This is because this connectivity increased the ease of doing business transactions and consequently increased the output of the country. There was an expectation that inflation negatively affected economic growth. This is because it lowers the purchasing power and therefore negatively affects consumption which is a constituent of GDP. The paper also had the expectation that trade openness positively affected economic growth due to the understanding that increasing exports for instance caused a balance of trade surplus and this increased output of an economy. There was an expectation that financial development related positively with economic growth due to the effects this had on businesses and consequently output. As part of the expectations was that physical capital investment in internet connectivity positively affected economic growth due to the expected synergies of increased business and production.

The findings of this paper were that in the short run, physical capital investment in internet connectivity and GDP had a negative but significant. This relationship was still negative but significant in the long run. This implies that more physical capital investment in having the internet

connected does not increase the output of a country. This contradicted the prior expectation of this study. These results were in tandem with the findings of Pami, Sarkar & Dhar (2021) where physical capital negatively impacted economic growth. The paper also found out that both fixed and mobile internet subscriptions had a negative but insignificant effect on economic growth in the short run. Further, in the long run, mobile subscriptions and economic growth had a negative but significant relationship while fixed subscriptions related positively and in a significant way with economic growth. These results indicate that the mode of internet connectivity matters. Fixed internet connectivity is more precise in terms of production and access considering it is wired. This is the form of internet connectivity used in most offices and business premises and therefore has a direct effect on production and services. This explains its positive effect on output and consequently its effect on the growth of the economy. For this paper, the findings contradicted those of Edquist, Goodridge, Haskel & Lindquist (2018) who found out that mobile internet subscriptions had a positive effect on economic growth.

For the control variables, inflation had a positive but not significant relationship with GDP in both periods. This finding contradicted prior expectation but concurs with what Majumder (2016) found in his paper. Financial development had a positive but not significant relationship with GDP in the short run while this variable related positively and significantly with GDP in the long run. This implies that financial development in terms of processes affects payments and ways in which businesses are run and consequently this increases output. In both periods, trade openness had a positive and significant relationship. Increasing trade increases output and as a result growth in the economy improves. This finding confirmed the previous expectations of this paper. The finding also agreed with the findings in the paper by Keho (2017) that trade openness has a complementary role in capital formation and as a result affects growth in a positive way in both the short run and long run periods. For public debt, the short run relationship was positive and not significant but this was positive and significant in the long run implying that more borrowing increases economic growth.

5.3 Policy Recommendations

Internet connectivity has an effect on the levels of economic growth realized by a country, in this case Kenya. However, from the findings of this paper, the mode of connectivity matters and this should be where policy focus should be. The government and policy makers should come up with policies that encourage internet connectivity through fixed subscriptions for more coverage. This

has a significant effect on output produced and consequently economy growth. The National ICT Policy guidelines (2020) outline the efforts Kenya has put into place to ensure wide access of the internet. One such initiatives is through the national fibre optic cable which will ensure all counties are connected to the internet. This is actually a fixed internet connectivity option but has not reached a bigger proportion of the population yet. This means that the Kenyan government is already underway in seeing its population connected to the internet, what is just needed is the wider access so that the benefits can be realized on GDP in a more significant way.

The other policy recommendation relates to trade; the government of Kenya should encourage growth of trade through setting policies that encourage ease of doing business through online platforms. With this, the cost of operation will go low and more output sold thereby realizing growth in the levels of GDP. This can be through encouraging setting up infrastructure to ensure online presence, an initiative the ICT policy has outlined under the Science, Technology and Innovation Act No.28 (2013). The Science, Technology and Innovation Act no. 28 highlights creation of a database of all goods and services locally produced. This is in line with the 'Buy Kenya, build Kenya' strategy. The policies to encourage trade and access on E-commerce are in place, what needs to be encouraged is implementation.

5.4 Limitation of the Study and Areas of Further Research

This study aimed at analyzing how internet connectivity affected economic growth in Kenya with a focus on the main variables being investment, GDP and internet subscriptions and the control variables being financial development, inflation and public debt. The study did not analyze labor as a factor affecting GDP due to inavailability of data on a quarterly frequency. Future researchers in this subject, can incorporate labor in their analysis.

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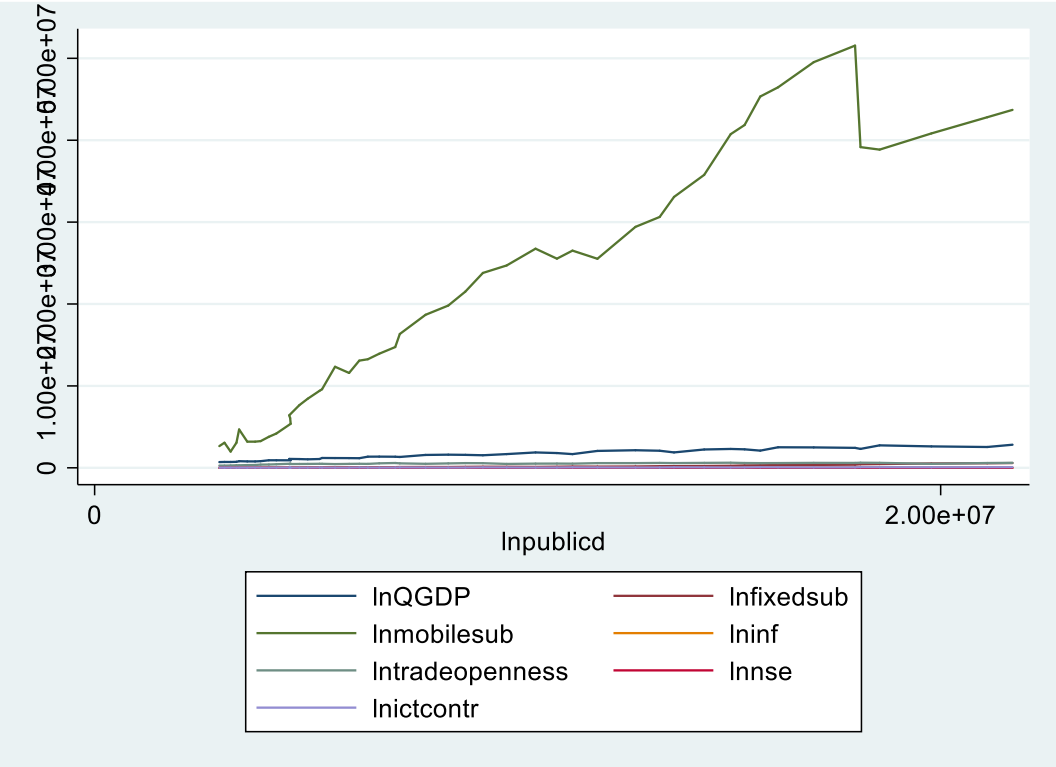
Appendices

Appendix 1



Appendix 2

```
Sample:  3 - 48                                 Number of obs      =        46
                                                AIC                =  167.5161
Log likelihood =  -3765.87                      HQIC               =  168.8117
Det(Sigma_ml)  =  1.77e+61                      SBIC               =  170.9746

Equation           Parms      RMSE     R-sq      chi2     P>chi2
------------------------------------------------------------------
D_lnQGDP              10   62417.4   0.8700   240.8418   0.0000
D_lnpublicd           10    185096   0.8937   302.5707   0.0000
D_lnictcontr          10   3224.63   0.8923   298.1245   0.0000
D_lnnse               10   276.614   0.2967   15.18473   0.1255
D_lntradeopenn~s      10   37128.3   0.2842   14.29251   0.1601
D_lninf               10   1.88212   0.3660   20.78594   0.0226
D_lnfixedsub          10   13427.5   0.6724   73.89392   0.0000
D_lnmobilesub         10   2.2e+06   0.4090   24.91503   0.0055
------------------------------------------------------------------
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_lnQGDP						
_ce1						
L1.	-.1199358	.0138854	-8.64	0.000	-.1471506	-.092721
lnQGDP						
LD.	-.6301124	.1267305	-4.97	0.000	-.8784997	-.3817251
lnpublicd						
LD.	.0532981	.0425386	1.25	0.210	-.0300761	.1366722
lnictcontr						
LD.	-10.21071	3.33726	-3.06	0.002	-16.75162	-3.669803
lnnse						
LD.	50.2231	37.95743	1.32	0.186	-24.1721	124.6183
lntradeopenness						
LD.	.7424925	.332342	2.23	0.025	.0911141	1.393871
lninf						
LD.	2565.571	4867.767	0.53	0.598	-6975.076	12106.22
lnfixedsub						
LD.	-1.435327	.8225683	-1.74	0.081	-3.047532	.1768767
lnmobilesub						
LD.	-.0081667	.0047161	-1.73	0.083	-.01741	.0010766
_cons	-54231.53	20058.39	-2.70	0.007	-93545.24	-14917.81
D_lnpublicd						
_ce1						
L1.	-.1524888	.0411763	-3.70	0.000	-.2331927	-.0717848
lnQGDP						
LD.	-.1033064	.3758124	-0.27	0.783	-.8398852	.6332724
lnpublicd						
LD.	.4342653	.1261459	3.44	0.001	.1870239	.6815068
lnictcontr						
LD.	-27.58002	9.89646	-2.79	0.005	-46.97673	-8.183313
lnnse						
LD.	-60.08697	112.5607	-0.53	0.593	-280.7019	160.5279
lntradeopenness						
LD.	-.4412798	.985542	-0.45	0.654	-2.372907	1.490347
lninf						
LD.	-2431.298	14435.1	-0.17	0.866	-30723.57	25860.97
lnfixedsub						
LD.	5.184635	2.439281	2.13	0.034	.4037315	9.965538
lnmobilesub						
LD.	-.0141044	.0139852	-1.01	0.313	-.0415149	.013306
_cons	48636.28	59482.05	0.82	0.414	-67946.39	165218.9

D_lnictcontr						
_ce1						
L1.	.0081341	.0007173	11.34	0.000	.0067281	.0095401
lnQGDP						
LD.	.0093646	.0065472	1.43	0.153	-.0034676	.0221969
lnpublicd						
LD.	.004557	.0021976	2.07	0.038	.0002497	.0088643
lnictcontr						
LD.	1.024881	.1724104	5.94	0.000	.6869629	1.362799
lnnse						
LD.	-6.241717	1.960967	-3.18	0.001	-10.08514	-2.398291
lntradeopenness						
LD.	-.0351235	.0171695	-2.05	0.041	-.0687752	-.0014718
lninf						
LD.	-267.0898	251.4799	-1.06	0.288	-759.9814	225.8018
lnfixedsub						
LD.	.0380819	.0424957	0.90	0.370	-.0452083	.121372
lnmobilesub						
LD.	-.0002155	.0002436	-0.88	0.376	-.0006931	.000262
_cons	6956.829	1036.262	6.71	0.000	4925.793	8987.865
D_lnnse						
_ce1						
L1.	-.0000211	.0000615	-0.34	0.732	-.0001417	.0000995
lnQGDP						
LD.	-.0003806	.0005616	-0.68	0.498	-.0014813	.0007202
lnpublicd						
LD.	-.0001084	.0001885	-0.57	0.565	-.0004779	.0002611
lnictcontr						
LD.	-.0039396	.0147897	-0.27	0.790	-.0329268	.0250476
lnnse						
LD.	.3907333	.1682152	2.32	0.020	.0610376	.7204289
lntradeopenness						
LD.	.0003516	.0014728	0.24	0.811	-.0025351	.0032383
lninf						
LD.	-19.04555	21.57238	-0.88	0.377	-61.32664	23.23554
lnfixedsub						
LD.	-.0015016	.0036454	-0.41	0.680	-.0086464	.0056432
lnmobilesub						
LD.	.0000132	.0000209	0.63	0.527	-.0000278	.0000542
_cons	21.19207	88.89233	0.24	0.812	-153.0337	195.4178

D_lntradeopenness						
_ce1						
L1.	-.0092066	.0082595	-1.11	0.265	-.0253951	.0069818
lnQGDP						
LD.	-.1847983	.0753842	-2.45	0.014	-.3325486	-.0370479
lnpublicd						
LD.	.0352848	.0253036	1.39	0.163	-.0143094	.0848789
lnictcontr						
LD.	-3.56838	1.985131	-1.80	0.072	-7.459166	.3224048
lnnse						
LD.	19.97975	22.57855	0.88	0.376	-24.27339	64.2329
lntradeopenness						
LD.	-.1270749	.1976899	-0.64	0.520	-.5145399	.2603901
lninf						
LD.	1293.597	2895.536	0.45	0.655	-4381.549	6968.743
lnfixedsub						
LD.	-.5129737	.4892954	-1.05	0.294	-1.471975	.4460277
lnmobilesub						
LD.	-.0031606	.0028053	-1.13	0.260	-.0086589	.0023376
_cons	4814.883	11931.5	0.40	0.687	-18570.43	28200.2
D_lninf						
_ce1						
L1.	1.43e-07	4.19e-07	0.34	0.734	-6.78e-07	9.63e-07
lnQGDP						
LD.	2.18e-06	3.82e-06	0.57	0.568	-5.31e-06	9.67e-06
lnpublicd						
LD.	7.50e-08	1.28e-06	0.06	0.953	-2.44e-06	2.59e-06
lnictcontr						
LD.	.0000531	.0001006	0.53	0.598	-.0001441	.0002503
lnnse						
LD.	-.0011212	.0011446	-0.98	0.327	-.0033645	.0011221
lntradeopenness						
LD.	6.34e-06	.00001	0.63	0.527	-.0000133	.000026
lninf						
LD.	.447244	.1467815	3.05	0.002	.1595576	.7349304
lnfixedsub						
LD.	4.56e-06	.0000248	0.18	0.854	-.0000441	.0000532
lnmobilesub						
LD.	-2.10e-08	1.42e-07	-0.15	0.882	-3.00e-07	2.58e-07
_cons	-.1310788	.6048358	-0.22	0.828	-1.316535	1.054378

D_lnfixedsub						
_ce1						
L1.	.0059943	.0029871	2.01	0.045	.0001398	.0118489
lnQGDP						
LD.	.0730244	.0272628	2.68	0.007	.0195903	.1264586
lnpublicd						
LD.	.0205447	.0091511	2.25	0.025	.0026089	.0384805
lnictcontr						
LD.	1.349985	.7179257	1.88	0.060	-.0571234	2.757094
lnnse						
LD.	-10.8018	8.165567	-1.32	0.186	-26.80601	5.202422
lntradeopenness						
LD.	.0613442	.0714948	0.86	0.391	-.0787831	.2014715
lninf						
LD.	-536.1899	1047.175	-0.51	0.609	-2588.615	1516.236
lnfixedsub						
LD.	.3134615	.1769544	1.77	0.076	-.0333628	.6602858
lnmobilesub						
LD.	.0001245	.0010145	0.12	0.902	-.0018639	.002113
_cons	2009.149	4315.047	0.47	0.641	-6448.187	10466.49

D_lnmobilesub						
_ce1						
L1.	-1.615253	.4899076	-3.30	0.001	-2.575455	-.6550522
lnQGDP						
LD.	-6.125194	4.471348	-1.37	0.171	-14.88887	2.638486
lnpublicd						
LD.	-3.19947	1.500861	-2.13	0.033	-6.141104	-.2578369
lnictcontr						
LD.	-371.137	117.7463	-3.15	0.002	-601.9155	-140.3586
lnnse						
LD.	106.9794	1339.227	0.08	0.936	-2517.856	2731.815
lntradeopenness						
LD.	26.29483	11.7258	2.24	0.025	3.312686	49.27697
lninf						
LD.	-3742.044	171746.1	-0.02	0.983	-340358.3	332874.2
lnfixedsub						
LD.	60.22143	29.02212	2.08	0.038	3.339113	117.1037
lnmobilesub						
LD.	.1165305	.1663933	0.70	0.484	-.2095944	.4426553
_cons	-549.686	707706.5	-0.00	0.999	-1387629	1386530