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ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF ECONOMICS

**The Impact of Mobile Telecom Penetration on Economic
Growth: A Case Study of Ethiopia**

By: Menber Abeje Mengesha

Advisor: Fantu Guta (PhD)

**A Thesis Submitted to Department of Economics in Partial
Fulfillment of the Requirements for the Degree of Master of
Science in Economics (Development Economics)**

June, 2020

Addis Ababa, Ethiopia

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Department of Economics**

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DECLARATION

I, Menber Abeje, declare that, this study, "The Impact of Mobile Telecom Penetration on Economic Growth: A Case Study of Ethiopia" is my own work. I have undertaken the research work independently with the guidance and support of the research advisor. This study has not been submitted for any degree or diploma program in this or any other institution. It is in partial fulfilment for the requirement of the program for the degree of Master of Science in Development Economics. All sources of material used for the research have been acknowledged.

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ENDORSEMENT

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Board of Examiners Approval Sheet

As members of board of examining of the final MSc thesis, we certify that we have read and evaluated the Thesis prepared by Menber Abeje entitled “The Impact of Mobile Telecom Penetration on Economic Growth: A Case Study of Ethiopia” and recommend that the Thesis is accepted as fulfilling the thesis requirement for the degree of Master of Science in Development Economics.

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List of Acronyms and Abbreviations

GDP.....	Gross Domestic Product
ITU.....	International Telecommunication Union
ICT.....	Information and Communication Technology
CAGR.....	Cumulative Average Growth Rate
GSMA	Global System for Mobile Association
GTP.....	Growth and Transformation Plan
4G network	Fourth Generation Network
CSA.....	Central Statistics Agency
OECD.....	Organization for Economic Co-operation and Development
PPT.....	Central office of Post, Telegraph, and Telephone
IBTE.....	Imperial Board of Telecommunications of Ethiopia
ETA.....	Ethiopian Telecommunications Authority
ETC.....	Ethiopian Telecommunication Corporation
EIR.....	Equipment Identification Register
SME.....	Small and Medium enterprise
GMM.....	Generalized Method of Moment
Q1.....	Quarter one
ARDL.....	Autoregressive Distributed Lag Model
DW.....	Durbin Watson
DF.....	Dickey Fuller
ADF.....	Augmented Dickey Fuller Test
OLS.....	Ordinary Least Square
ECM.....	Error Correction Model
AIC.....	Akaike Information Criteria
BIC.....	Bayesian Information criteria
SIC.....	Schwarz Information criteria.
VAR.....	Vector Autoregressive
AC.....	Autocorrelation
PAC.....	Partial Autocorrelation

Abstract

This paper examined the impact of mobile phone penetration rate on economic growth in Ethiopia over the period 1999Q1 to 2019Q1, with a quarterly data of 81 observations. The long-run and short-run parameters were estimated using autoregressive distributed lag (ARDL) bounds testing approach for cointegration analysis. Granger Causality Analysis was also done to determine the causality between mobile phone penetration and economic growth. Empirical finding indicate that Mobile phone penetration rate is significant in long run and insignificant in the short run and has positive impact on real GDP per capita both in the short run and long run. A 1% increase in Mobile phone penetration rate increases real GDP per capita by 0.165% and 0.013% in the long run and short run, respectively. The overall result showed that mobile phone penetration rate has a positive impact on economic growth both in the short run and long run. The magnitude of the ECT coefficient is -0.192228 implying about 19.2% of the disequilibrium quarterly converge towards long run equilibrium in the following Quarter. The Tado-Yamamoto Granger causality test result is also consistent with the co-integration result indicating bi-directional causality between mobile phone penetration rate and economic growth in Ethiopia for the period under study.

Keywords: Mobile phone penetration Rate, economic growth, ARDL bounds test, cointegration, Tado-Yamamoto Granger causality

CHAPTER ONE

1. Introduction

1.1 Background of the Study

The history of telecommunication was dated back to 1876 in which 29-year-old Alexander Graham Bell invented the first telephone and in 1903 he received a patent for his revolutionary new invention. Even though telecommunication was started after the introduction of it by Bell, it was only fixed telephone lines that were functional for hundred years until the first cellular (Mobile) phone was introduced by Martin Cooper in 1973 (M-STAT, 2015).

In Africa the standard telecommunication service was not as earlier as that of Europe and North America (more of developed countries), rather it was used during the pre-independence era by trading firms in West Africa. Like West Africans, it was also used in east Africa during the same period. It was during 1893 that the legal postal and telecommunication service was created in east Africa. But it should be pointed out that the legal development of telecommunication in Africa started after independence i.e. after the 1960s. Before the 1960s there was not any international organization that tries to initiate for the development of telecommunication in Africa. But it was ITU which takes action to initiate the first pan African telecommunication network in Africa after independence. The international telecommunication union /ITU convene for its first conference at Dakar, Senegal in 1962 regarding African postal and telecommunication administrations, and it was during this time that the development of telecommunication service in Africa was defined. This plan was later reviewed in the other meeting like the 1965/70 Addis Ababa Plan which gave a detailed assessment of the African Telecommunications Network (Aloo, 1988).

In Ethiopia, Telecommunication was introduced in 1894 by emperor Menelik II, almost eighteen year later than the bell's invention and it was the oldest public telecommunication operator in Africa. The mobile phone was also introduced in 1999 after 100 years of telephone introduction. Even if the telecommunication infrastructure development started as of 1894 it was not developed as expected. Among different challenges the one and the most

destructive challenge faced during the war with Italy which destroyed almost all network infrastructures (Worku B. , 2005).

Mobile telecom and fixed lines are substitutes in developing countries whereas in developed or rich countries they are complementary services, which imply that mobile phones have a great economic impact in developing countries like Ethiopia. However, the spread of telecommunication in general and mobile and fixed telecommunication in particular in developing countries was not that much Satisfactory. For instance, in 1995 the average fixed-line and mobile penetration per 100 inhabitants were 2 and 0 respectively and in 2003 there was little improvement which leads the averages to 5 and 8. As can be observed from this sample data it was mobile which improved well i.e. from 0 to 8 (Waverman, Meschi, and Fuss, 2005).

As Lee and Gardner (2015), discussed by Mentioning World Bank report of 2010, it was after 2000, extensive technological advances in wireless telecommunications and liberalization of telecommunications markets ushered in rapid mobile network expansions worldwide. Correspondingly, access to mobile phone services rose dramatically: in 2002 the number of mobile phones in the world exceeded the number of basic fixed-line phones, and at the end of 2008, the total number of mobile phones in the world was 4 billion. In developing countries, the spread of mobile phones was vast which substitutes inadequate, unreliable and costly infrastructures like fixed lines. For example, the number of conventional main telephone lines per 100 persons in developing countries was almost 1.15 in 1990, 2.71 in 2000, and 3.53 in 2008.

In contrast to the level of fixed-line phone penetration, the number of mobile phone subscribers per 100 persons increased from 0.04 in 1990, to 2.40 in 2000, and 38.17 in 2008, reflecting not only a wide disparity in growth between fixed-line phones and mobile phones but also unprecedented growth in mobile telephone over less than one decade from 2000 to 2008. Expanding information and communications services in Sub-Saharan Africa is connecting the region to the rest of the world and is a key factor in fostering long-term growth. Currently, many governments are beginning to give reasonable ICT services broadly than before.

Mobile phones are used almost in all activities of life (by farmers to receive crop price information and for health workers to increase the effectiveness and reach of health programs), increased almost 20-fold on a per capita subscription basis over 2000 – 08. In 2008 almost one-third of Sub - Saharan Africa's people had mobile phone subscriptions. Despite this impressive expansion, a "digital divide" remains low: Eritrea has 2 subscriptions per 100 people while South Africa has more than 90 (World Bank, 2010).

In the sub, Saharan Africa's unique mobile penetration is 44% in 2017, but in the same period, the world average mobile penetration is 66%, which shows the African low performance below the world average. When we checked the total mobile subscriber base within the region it is 444 million and accounts for 9% of the world's total subscriber base during the same period. Currently, as the industry faces difficulties due to the affordability problem and the high amount of youth population who do not use mobile service being youth, subscriber growth is low, but it remains well ahead of global Averages. It is estimated that the regional subscriber will grow at CAGR of 4.8 from 2017 to 2022, more than double the global growth rate over the same period. But it is below the average annual growth rate of the region which is recorded as a double-digit in the first half of the decade, and the CAGR for the next five years is roughly half the level recorded over the preceding five years. Thus, penetration rates will see only modest increases from current levels. The penetration rate is forecasted to reach 50% by the end of 2023, and 52% by 2025 (GSMA, 2018).

According to the global economy data of 2019, the average mobile subscriber in Ethiopia from the period 1960 to 2018 was 5.94 million and the average mobile subscriber per 100 people was 5.94. But note that mobile technology started in the country as of 1999.

When we check the penetration of fixed lines for the same period it registered a maximum of 1.11 in 2017 and a minimum value of 0.04 in 1960 with 1.04 in 2018 (ITU, 2019).

From this data, we can easily conclude that mobile phones expanded highly as compared to fixed-line in Ethiopia even if it is a recent phenomenon. There is a long literature showing that the relationship between mobile penetration and economic growth. The basis of this link

is that mobile telephone generates a positive impact on workers' productivity which in turn leads to an increase in total productivity and then economic growth prevails (Deloitte, 2012).

1.2 Statement of the Problem

Even though the introduction of mobile telecom in developing countries like Sub-Saharan Africa is a recent phenomenon, its growth is fast and even greater than that of a fixed-line within the region. Due to this recent nature of the technology, that much research was not made regarding its importance to economic growth and the development of developing countries. Most of the researches were made in developed countries as the technology was first introduced in those countries. However, some researches were also done in developing countries but not as many as those researches which were done in rich countries. To list some of them Lee and Gardner (2015), Ntoubas (2018), and Khaouani (2019) are among those researchers who studied up on this topic. For their study, the researchers used not only time series Data but they also used panel data, For example, Lee and Gardner used fixed-effect dynamic panel data to study the impact of mobile telecommunication on economic growth using 56 south Asian and Sub-Saharan countries and found a positive relationship. Ntoubas used time-series data to show the impact that mobile telecommunication plays on the Cameroon economy, and like that of Lee and Gardner, he founds a positive impact.

Such and similar researches were made in different countries like in china (R.Ward and zheng, 2014), Ghana (Peter and Emmanuel, 2017) on the role and contribution of mobile telecommunication to the business activities of small and medium-scale enterprises and in India Abraham (2007) studies the role that mobile telephone plays in the fishing industry and the result of all the above studies shows their positive relationships and advice for the development of this service in developing countries.

However, such types of researches are rare in Ethiopia especially time series papers on the impact of telecommunication in general and mobile telecom penetration in particular on the economic growth of Ethiopia has not yet studied.

Apart from time series researches, there were researches done in Ethiopia on such scenario. Among those the one which was written by (Getaw and Bahigwa, 2015), discusses the role that mobile phone plays on farmers' marketing decision and high price receiving which was done by interviewing farmers from south and central part of Ethiopia. The result of their

finding was that the introduction or use of mobile phones did not have any positive impact on their marketing decision; the reason that contributes to this weak impact of mobile phones on their marketing decision is due to the non-participation of farmers on special market arbitrage or information searching. Even though some farmers participate in information searching their number is small that is why the impact in their decision was not seen clearly.

In short, even if there is high growth of mobile telecommunication currently, its impact on the general economic growth of the country is not studied yet. Hence the main key factors that force the researcher to do this research are the following three points:

- ✓ Lack of adequate time series researches that studies the impact of mobile telecom on GDP
- ✓ To understand the role that mobile phone plays on the country's economy and finally
- ✓ To add some value upon the existing research and to show insights for further researchers.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of this study is to empirically investigate the impact of mobile telecom penetration on economic growth in Ethiopia.

1.3.2 Specific Objectives

Based on the above general objective, the research has tried to address the following specific objectives.

- ✓ To assess the performance of mobile telecommunication in Ethiopia.
- ✓ To determine the impact of mobile penetration on economic growth in Ethiopia both in the long run and short run.
- ✓ To test the direction of causality between the mobile telephone penetration and economic growth.
- ✓ To conduct the cointegration test between variables under consideration.

1.4 Research Questions

Having the above specific objectives this paper aims to answer the below questions.

- ✓ What is the performance of mobile telecom penetration in Ethiopia?
- ✓ What is the impact of mobile telecom penetration on economic growth in Ethiopia both in the short run and long run?
- ✓ What is the direction of causality between mobile telecom penetration and economic growth in Ethiopia?
- ✓ Is there any co-integration between variables within the model?

1.5 Methodology of the Study

To achieve the objective of the study and to test the proposed hypotheses descriptive research approach through the use of 20 (1999 to 2019) years of quarterly time series data is adopted. The study employed a quantitative research approach using secondary data gathered from the World Bank (WB), National bank of Ethiopia (NBE) from the Ethio Telecom web site and different documentations of the company. The relevant data is extracted from these sources and analyzed after critically evaluated it in line with their significant for the research objective.

1.6 Hypothesis of the Study

Based on the existing works done on the top of this topic the researcher hypothesizes the following three null hypothesis results:

H₀: Mobile telecom penetration has a positive impact on economic growth in Ethiopia.

H₀: There is a bidirectional causality between mobile penetration and economic growth in Ethiopia.

H₀: There is co- Integration between variables within the model.

1.7 Significance of the Study

The introduction of telecommunication in African in general and in Ethiopia in particular backs almost 130 years. Until the introduction of cellular phones in Ethiopia around 1999, it is only fixed landlines that was used for a century. Due to the high installment cost of the service, it was not expanded yet. Besides its costly nature of service, low understanding or know-how of the people including the government is also one factor for its low performance. However, after mobile service is launched the history is reversed especially

after 2000 there was rapid expansion/penetration of it. The main reason behind such rapid penetration is due to its simplicity to use as well it is the cheapest service for the government and people as compared to fixed lines.

Currently, in Ethiopia 4G mobile network launched which helps the people to have fast service. However, the national economic benefit of this mobile telephone penetration in terms of GDP has not been analyzed yet, even if some sort of figures are released by the company itself in the past 3 or 4 years.

Hence the finding of this paper will help the government to provide information on the development of this service sector.

In addition to this, it is also expected that the findings of the research will be of acute importance since it makes a contribution to both theoretical and empirical literature to researchers who would wish to carry out further research on the impact of mobile telecom on economic growth.

Theoretically, the research adds extra knowledge on the already existing literature based on the finding regarding the impact of mobile telecommunication on economic growth.

Empirically, the research delivers recommendations for the government and policymakers based on the finding.

1.8 Scope of the Study

This study is limited to the Ethiopian economy and mobile telecommunication penetration throughout the country for 20 years of quarterly data from 1999 to 2019. The reason behind using this period lies on the recent phenomenon of Mobile telecom in the country with only 20 years since its introduction.

1.9 Organization of the Study

The rest of the paper is organized as follows. Chapter two deals with the theoretical and empirical literature followed by methodology and research framework. Chapter four presents the data and estimation results and the last chapter, chapter five concludes the result with appropriate recommendations.

CHAPTER TWO

2. Literature Review

In this chapter, attempt is made to review studies on telecommunications and its relationship to development and economic growth. Parallel with this, discussion on some of the features characterizing the performance, trend and history of telecommunication sector in the country is assessed. However, discussion on the general growth theory comes first.

2.1 Economic Growth Theories

The idea for the theory of capital accumulation and economic growth has been originated from Solow-swan models of 1956 (Knežević, 2012). Solow and swan proposed an economic process model supported by a mathematical representation. They introduced economic environment with an amount of the capital stock K and labor level L and defined production function $Y = F(K, L)$ as a positive, increasing and concave function, with constant returns to capital and labor and constant total factor productivity. Cobb-Douglas production function relies on basic Solow-Swan's assumptions and introduces steady exogenous technological progress $A > 0$, which must be labor augmented to make sure the existence of steady-state, with allocated exponential rate of growth, into production function $Y = F(K, L, A)$. The important thing is that the total productivity factor isn't any longer constant and this permits the model to get positive long-run growth in GDP per person.

The standard cobb-Douglas production function is given by $Y = AK^\alpha L^{1-\alpha}$, $0 < \alpha < 1$ where Y is output, K is the stock of capital, L is labor, and A gives the starting position of a society's technology level. An implication of the model is the concept of convergence, stating that poor countries tend to grow faster than rich ones, and eventually catch up with them.

Because of the diminishing marginal return to capital, countries with low levels of capital stock will have the next marginal product of capital, and thereby grow faster than those with already high levels of per capita stock, given similar saving rates (Jacobsen, 2003). However, inquiry has given little support to the speculation of convergence. It can only be found within the OECD area.

Mankiw, Romer and Weil (1992), have introduced an extended Solow model, the augmented Solow model. They aim to clarify why convergence didn't appear and introduce

the notion of 'conditional convergence'. They argue that Solow didn't predict that each one country would reach the identical level of per capita income, but rather their respective steady state. Convergence is indeed found, as long as differences within the steady state across countries are controlled for (Jacobsen, 2003).

Neoclassical theories are challenged for failing to understand technological progress as a vital input for the economic process. They consider it as a vital element but treat technological progress as exogenous. As a result, a brand-new direction in growth theory has emerged. This new direction has been called endogenous growth or new growth theories and dismisses the concept of convergence entirely. Endogenous growth theories supported either constant or increasing returns to scale within the capital, postulating a growth within the gap between rich and poor countries. The model is based on the Cobb-Douglas production function as of Solow and swan neoclassical model, but the main aim lies on technological progress, given by the A.

According to Romer (1990), this new growth model lies its foundation supported by three premises. The primary is Technological change-this is to imply that improving instruction for the blending of raw materials lies at the guts of the economic process, which resembles the (Solow, 1956) model with technological change. So technological change ends up in continued capital accumulation, then the mixture of capital accumulation with technological change ends up in a rise in output which is growth during this scenario.

The second premise is that technological change arises in large part due to intentional actions taken by folks that answer market incentives. This suggests that the model is endogenous instead of exogenous as that of the neoclassical model of Solow-swan. However, it doesn't mean technological change comes due to market incentives only, rather it's to means that those market incentives are the important forces that push to technological change.

The third and most fundamental premise is that instructions for working with raw materials are inherently different from other economic goods. Once the price of making a brand-new

set of instructions has been incurred, the instructions are often used over and over again at no additional cost. Developing new and better instructions is such as incurring a set cost. This property is taken to be the defining characteristic of technology and telecommunication one part. Thus, endogenous growth model advocates the importance of technology as the main vehicle of economic growth, telecommunication as one part of technology, which plays a great role in it. So, the theoretical background originates from this growth theory scenario.

2.2 Trends of Ethiopian Economic Growth

The location of Ethiopia gives strategic dominance as a jumping-off point in the Horn of Africa, near to the Middle East and its market. The country is landlocked bordering of Eritrea, Sudan, South Sudan, Kenya, Somalia, and Djibouti and used the main port of Djibouti for the last two decades. It is the second-most populous country in Africa next to Nigeria with a total of 109 Million as of 2018.

Currently, the country experienced the most rapid economic growth with an average growth rate of 9.9% from 2007/8 to 2017/18. However, it is still the poorest country with a per capita income of \$790 (World Bank, 2019).

The highest contribution to the total growth rate is from service and industry mainly the construction industry. However, the contribution of agriculture is decreasing from time to time. According to (Deloitte, 2012) report, the main factors that contribute to the low share of agriculture to GDP growth are the following:

- ✓ Growth in service sector driven by an increase in financial intermediation,
- ✓ Public administration
- ✓ Retail trade and
- ✓ The expansion of mining activity.

Figure below shows the trend of GDP growth of Ethiopia from 1982 to 2018.

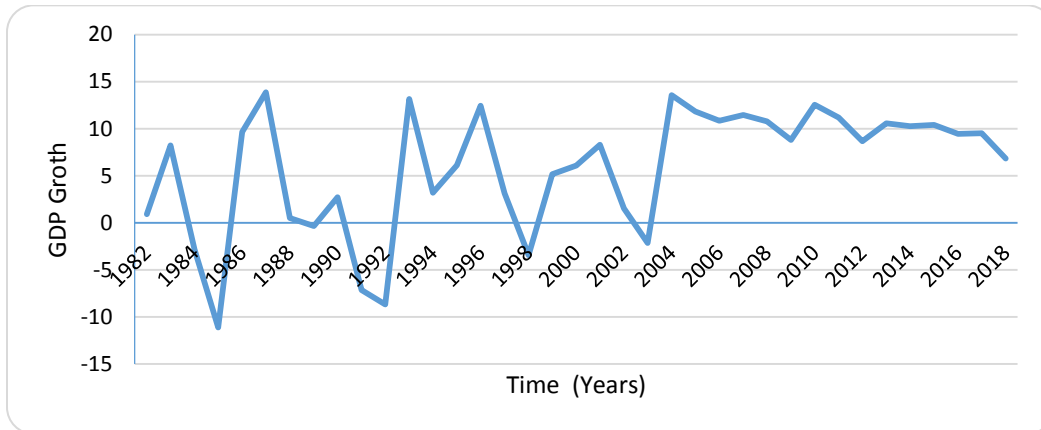


Fig 1 Trend of Ethiopian economic growth from 1982-2018: Source: World Bank Data (2019).

As can easily be seen understood from the graph, Ethiopia experienced negative Growth in 1984/85 and 1991/92 and, to some extent in 1998 and 2003.

But for the rest years it has almost a positive growth rate with a small ups and downs. This may be the direct result of a country's economic dependence on rain-fed agriculture which is vulnerable to drought and famine. The years, 1984/5 and 1991/92s is an example of this. Starting from 2004 the country has positive and relatively stable economic growth as compared to the previous years.

According to Alemayehu (2001), the economic performance of Ethiopia is highly associated with the change in the political process. For example, before 1974 the macroeconomic policy of the country is market-oriented, but later after the Derg regime came to power the policy changed to central economic system /socialism. And after the downfall of the Derg regime the federal democratic republic of Ethiopian government changes the policy to market-oriented policy of the imperial period, so such changes of macroeconomic policies aligned with change in a political process highly affects the growth of the economy, that is why the country faces inconsistent growth level through the three regimes.

2.3 Brief Historical Review of Telecom Sector in Ethiopia

The introduction of telecommunication in Ethiopia dates back to 1894 by emperor Menelik II. The company (current Ethio telecom) is one of the oldest telecommunication operators in Africa which has more than 126 years. During that period the introduction of telecommunication namely wired line telecommunication system contributed to the integration of the society by linking the capital city (Addis Ababa) to other regional cities of the country (Worku B. , 2005).

2.3.1 Telecommunication Sector in Ethiopia (1894-1941)

During this period, the telecom company has been renamed and restructured through different stages. First, the management of the service was under the Imperial Court of Menelik II in the name of the “central administration of telephone and telegraph system of Ethiopia” from 1894 up to 1907 until Mr. Stevenin, a French citizen, was appointed as the General Manager of the service. The service was renamed "The Central office of Post, Telegraph, and Telephone (PTT) System of Ethiopia" from 1908-1909. It was administered by Emperor Menelik II's Advisor, Mr. Alfer Ilg, a Swiss man. Then the service was renamed "Ministry of Post, Telegraph, and Telephone in 1910. First, it was administered by Mr. Leo shafno, a French citizen and then replaced by the first Ethiopian administrator Lij Gizaw Bezabih, Lij Beyene Yimer, and their successors consecutively (Ethiotelecom Web Page).

2.3.2 Telecommunication Sector in Ethiopia (1942-1952)

It is the period after independence from the Italian 5-year occupation of 1936 to 1941 and during this time almost all telecommunication infrastructures were destroyed. After the independence, the re-established Ministry of Post, Telegraph and Telephone took over the running of Telephone, Telegraph and Radio communications. It, therefore, rehabilitated the network of the whole country. The Imperial Board of Telecommunications of Ethiopia (IBTE) was established by proclamation No. 131 on October 15, 1952. The main purpose of the Board, as stated in its establishment charter of article 5 was “to rehabilitate, extend, repair and maintain the telecommunication facilities of Ethiopia and to engage in the business of telecommunication for profit.”

In 1960 IBTE looked after the operational matters of central Ethiopia, a Regional Office was created at Addis Ababa. And at the same time, Radio Division was created and separated

from the receding Technical Division bringing the number of Division Offices to seven during the same period (Ethiotelecom Web Page).

2.3.3 Telecommunication Sector (1974-1991) During the Derg Regime

During the Derg regime, the Ethiopian telecommunication was renamed as follows: In October 1975, the organization was renamed as "the Provisional Military Government of Socialist Ethiopia Telecommunication Services. "It was renamed again as "Ethiopian telecommunications authority (ETA) in January 1981. It retained its name as ETA up to November 1996. At this period, the telecommunication services had made a major change in technology ranging from Automatic to Digital technology (Ethiotelecom Web Page).

2.3.4 Telecommunication Sector (From 1991- Present)

The telecommunications sector was restructured and two separate independent entities namely the Ethiopian Telecommunications Authority (ETA) and the Ethiopian Telecommunications Corporation (ETC) were established by Proclamation No. 49/1996 in November 1996.

Establishment of Ethiotelecom

As a continuation of the 2005/06-2009/10 five-year plan and after concentrating its efforts on education, health, and agriculture, the Ethiopian government has decided to focus on the improvement of telecommunication services, considering them as a key lever in the development of Ethiopia, Ethio telecom is born, on Monday 29th of November 2010, from this ambition of supporting the steady growth of our country, within the Growth Transformation Plan (GTP), with ambitious objectives for 2015 (Ethiotelecom Web Page).

2.4 Reviewing the Performance of Telecommunication Sector in Ethiopia

As Lee and Gardner (2015), discussed by Mentioning World Bank report of 2010, it was after 2000, extensive technological advances in wireless telecommunications and liberalization of telecommunications markets accompanied in rapid mobile network expansions worldwide. Correspondingly, access to mobile phone services rose dramatically: in 2002 the number of mobile phones in the world exceeded the number of basic fixed-line phones, and at the end of 2008, the total number of mobile phones in the world was 4 billion. In developing countries, the spread of mobile phones was vast which substitutes

inadequate, unreliable and costly infrastructures like fixed lines. For example, the number of conventional main telephone lines per 100 persons in developing countries was almost 1.15 in 1990, 2.71 in 2000, and 3.53 in 2008. In contrast to the level of fixed-line phone penetration, the number of mobile phone subscribers per 100 persons increased from 0.04 in 1990, to 2.40 in 2000, and 38.17 in 2008, reflecting not only a wide disparity in growth between fixed-line phones and mobile phones but also unprecedented growth in mobile telephone over less than one decade from 2000 to 2008. Expanding information and communications services in Sub-Saharan Africa is connecting the region to the rest of the world and is a key factor in fostering long-term growth. Currently, many governments are beginning to give reasonable ICT services broadly than before.

According to ITU (2009) report, as prepared by Iyasu Kebede, almost all the rural population of Ethiopia lacks telecommunication infrastructure. The report has also pointed out some reasons that contribute to this low performance of ICT in general and telecommunication in particular. These are:

- ✓ Lack of skilled human resources coupled with low ICT literacy,
- ✓ Low level of Internet service and poor connectivity,
- ✓ Lack of organized data and information resources and poor accessibility to those that exist,
- ✓ Limited or no public awareness on the role and potential of ICT,
- ✓ Undeveloped private sector,
- ✓ Legal and regulatory constraints

Currently, there has been a piece of growing evidence that the spread of telecommunication has a significant benefit for economic development. The growing use of voice, internet, email, and others make easy for peoples and organizations to communicate within the country and abroad. Due to this, studies show that growth in telecommunication will generate a dividend in terms of additional overall GDP growth. However, Ethiopia's telecommunication infrastructure is lagging. This low level of telecommunication affects the people negatively by increasing communication costs, reducing market efficiency and lower productivity (Baron, 2010).

When we compare the growth of fixed lines and mobile telecommunication, it is mobile telephone that grows rapidly than that of fixed lines even though it is a recent technology. The main reason that contributes to the fast growth of mobile telecommunication is its low cost of installation as compared to a fixed line which requires huge capital for installment. The next two graphs show the trends of fixed-line and mobile telecom respectively.

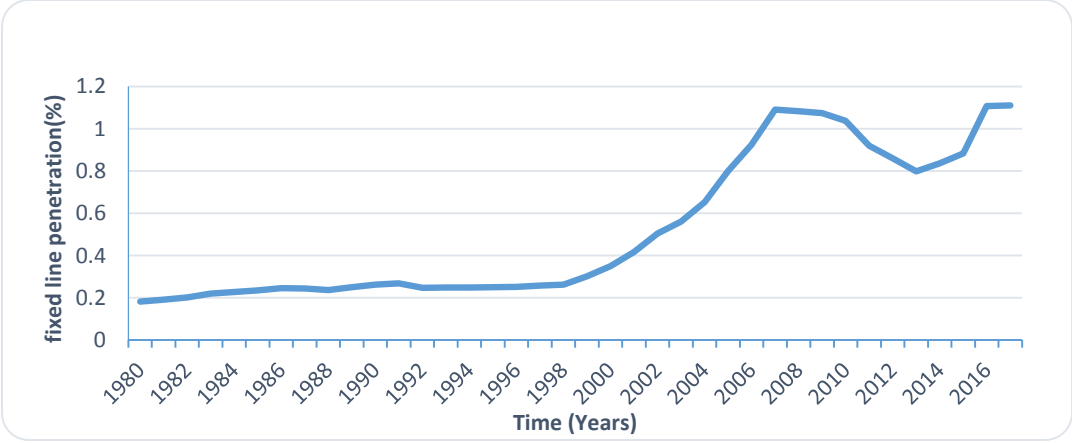


Fig 2 Trend of fixed-line penetration from 1980-2016, Source: World Bank Data (2019)

The above figure shows the trend of fixed-line penetration is slow, still; its maximum point is around 1.1. The implication of this is the shift of fixed-line customers to mobile which is cheap when compared to a fixed one and the reluctance of people to use fixed-line than that of mobile.

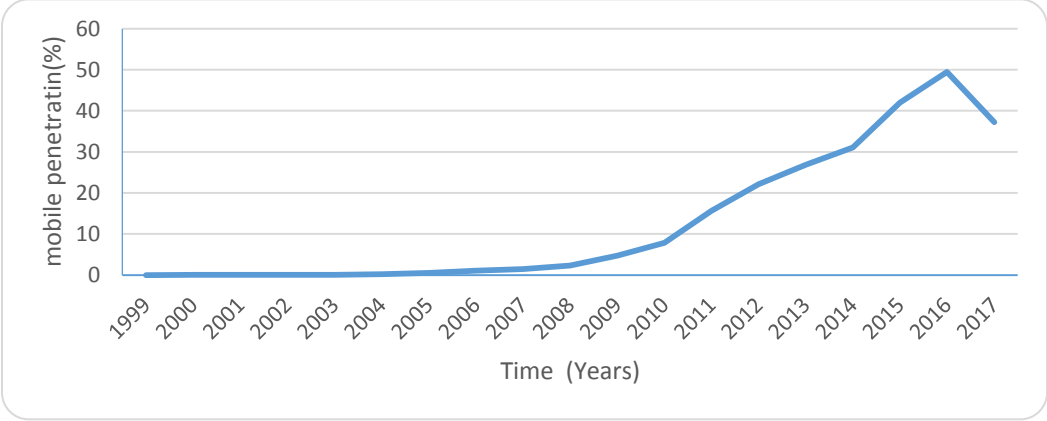


Fig 3 Trend of mobile penetration 1999-2017 Source: World Bank Data (2019)

As per the information in the above figure, the penetration of mobile telecommunication was low during its introduction, almost it is insignificant. But later especially after 2007 it increased rapidly and reached a maximum in of 49 subscription per 100 people and slightly decrease in 2017 due to the implementation of EIR system as of September 2017, which constraints some customer to use their mobile apparatus easily.

The below figure shows the combined trend of both mobile and fixed telephone penetration.

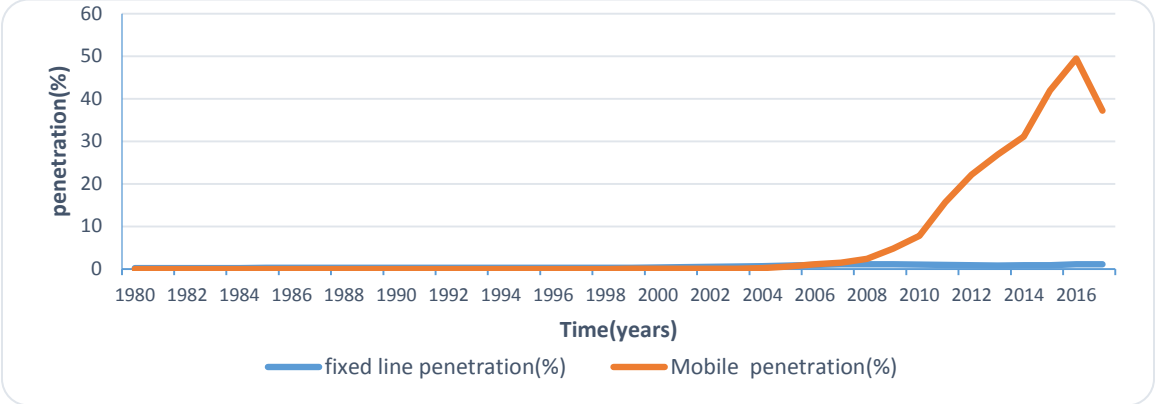


Fig 4 Trends of mobile and fixed telephone penetration 1999-2017: Source: World Bank Data (2019)

The Above figure shows the trend of mobile and fixed telephone penetration rate from 1980 to 2017. Until 2004 both have almost the same trend, but starting from 2004/05, the mobile penetration grows highly, and fixed penetration remains at previous trend with minor increment. This is because peoples use mobile phone than fixed line for their day to day activity, as mobile phone are more of cost effective than fixed line.

2.5 Empirical Literature Review

There is a long tradition of economic research on the role of social overhead capital on economic growth and the development of developing countries. Among such social overhead capital investment on telecommunication infrastructure is the one and those studies discussed the growth dividend impact of telecommunication. However, in developing countries, such types of studies were not well explored, they were few and this is due to the recent nature of telecommunication history in the region (Waverman, Meschi, and Fuss, 2005).

Although the history of telecommunication in general and mobile telecom, in particular, is a recent phenomenon in developing countries as opposed to developed countries, few studies explain the role of mobile phones on economic growth and development in developing countries.

Waverman, Meschi, and Fuss (2005), in their study of the impact of telecoms on the economic growth in developing countries, they discussed that mobile phone in developing countries have the same role that fixed lines play in developed countries during the 1970s and 1980s. In their finding, the mobile phone is a substitute for fixed lines in developing countries but not in developed countries as they complement each other. The implication of this substitute and complement behavior of mobile and fixed telecom services in poor and rich countries respectively tell the mobile phone has a greater economic impact in developing countries than developed ones. They find that mobile phones have a positive and significant impact on economic growth. Its impact in developing countries is twice as large as developed countries.

According to their finding in developing countries, an average increase of 10 more mobile phones per 100 people from 1996 to 2003 will result in a 0.59% increase in GDP than other similar countries which do not have such a mobile phone increment. Concerning demand elasticity Waverman, Mesch and Fuss found that both own price and income elasticity to be more than one. This is to mean that either reduction in the price of the service or increase in income of the people/user leads the demand for mobile phone to be more than one.

Lum(2011) investigates the effect of cell phones on economic growth and development .and discusses the various ways how mobile phones play on the efficient operation of markets and how the diffusion of information leads to the improvement of economic growth and development. Lum found that mobile phones have a positive and significant impact on the per capita GDP and growth rate of GDP. His study advises the spread of mobile technology to improve economic growth and development.

According to Bedia (1999) cited by Lum, (2011), cell phones impact economic growth and development due to their usage as a medium of communication. They can be used to improve information sharing in which can lead to the creation of ideas and this idea is an important ingredient for economic growth and development as mentioned via endogenous growth theory.

Unwin (2009), discusses that mobile phones are important in developing countries when there is a group of marginalized individuals with special needs. For example, those separated individuals may need information about the source of food and shelter, price of goods, employment opportunity education and health-related, during this time mobile phones play a great role.

Abraham (2007) , examines the use of mobile phones by fishermen in India and the effects this has had on the fishing industry market of India. From a total of 172 respondents of the survey, more than 80% of them confirm the usefulness of mobile phones in doing their business in his study 82 of the total 172 respondents responds as they could not stop using mobile phones even during their price or tariff went up. He told that all the three groups of the mobile communities (agents, merchants, and transporters) who are the actors of the fishing industry, agreed on the importance of mobile phones especially on its role in the reduction of price dispersion across merchants and locations. This means price may be unnaturally high in some markets and unnaturally low in some other markets, due to mismatch between supply and demand of fishes, so the introduction of mobile phones helps to minimize this gap via information flow. The use of mobile phones helped to increase market integration; fisher man's can participate anywhere out of their local markets after having the necessary information vial their cell phones. It also helped them to reduce wastage of time and resource by reducing searching cots and for the reduction of risks and uncertainty that would be prevailed if there is a lack of information.

Having the above all contribution of mobile phones in the fishing industry in India, Abraham concludes that the introduction of mobile phones made fishing markets to be more efficient.

Studies have also been done on the mobile revolution in China and India (Kumar and Thomas, 2005) , the number of mobile phone subscribers increased by 1.3 million each week, and the total number of subscribers had reached 350 million. They recognize the growth of mass media, including radio and television, but these types of communication did not have that much role in promoting economic development, instead, mobile communication can do in china.

While mass media certainly increases the capacity of information dispersion, it also lacks the “social and economic power structures at the grassroots level, or local cultures, local resources and indigenous knowledge” inherent to mobile phones. The grassroots power afforded by cell phones places the ability to take control of markets, improve efficiency, and effect change in the hands of farmers, fishermen, and other laborers.

Sekabira and Qaim (2017), Study’s impact of mobile phones on gender equality and nutrition by using panel data from smallholder farm households in Uganda. The regression result of their study shows that mobile phones use is positively associated with household income, women empowerment, food security, and dietary quality. Beyond this Sekabira and Qaim also tried to investigate on who uses mobile phones more within the household and found that it was males. Gender disaggregation also revealed the use of mobile phones by female households would result in a stronger association in improving gender equality, household income, and nutrition.

In 2015, lee and Gardner studied the impact of mobile phones on economic growth by estimating the fixed effect dynamic panel model for 56 countries of south Asian and Sub-Saharan using data from 1990 to 2008. From their analysis, they found that mobile phones are positively related to the economic growth of those selected sample countries. The marginal contribution of mobile phones to economic growth is even greater than fixed lines. Their study confirms that mobile phones and fixed lines are imperfect substitutes, as a result, they analysis their study by depending on the level of the fixed-line under. Their study contributes to the existing literature by incorporating the theory that fixed-line phones and

mobile phones are imperfect substitutes in the empirical model so that they can empirically examine how the marginal impact of mobile phone coverage on economic growth varies depending on the level of fixed-phone penetration study. Finally, they suggest that increasing access to mobile phones is the best way to compensate countries which have poor public infrastructure and even to boost entrepreneurship and market efficiency.

Peter and Emmanuel (2017), also investigated the role of mobile telecommunication on the business activities of small and medium scale entrepreneurs in Ghana, Akra. The research was done by selecting 40 owners of SME in Akra and asking them the role that mobile phone plays in their business activity. The respondents told that there were high business costs, poor communication, adequate marketing opportunity, and an inability to expand production at a faster rate before the expansion of mobile phones. But the spread of mobile phones makes their life easier by increasing production, profit and it helps to increase their employment opportunity as a result of an increase in production and a decrease in business costs such as information, transport and communication costs.

Ntoubu (2018), Studies the impact of mobile telephone on the economic growth of Cameroon using 10 years of data (2006-16) using GMM estimation and found a positive and bidirectional relationships between mobile telephone and economic growth in Cameroon. As per his study, a 10 % increase in mobile penetration will result in a 1.1% increase in Cameroonians GDP, and for fixed lines, a 10% increase in fixed line will generate a 0.12% increase in its GDP. In similar feedback, a 10% increase in Cameroon GDP will increase mobile penetration by 0.8% which confirms the bidirectional relationship between them.

In Ethiopia, there was not that much research done in this regard. Even some of the available researches were focused on micro-level surveys. Papers on macro-level with time series analysis are not studied.

Among the papers done in Ethiopia the one which studied by (Getaw and Bahigwa, 2015), the impact of mobile phones on farmers' marketing and price decision. The result of their finding is mixed. They suggest that mobile phones may be useful for farmers in some

circumstance, but their role is insignificant for their marketing price decision. This is because of the limited use of mobile phones for agricultural information.

2.6 Summary of Literature Review

Both the theoretical and empirical review of the paper shows the significant role of telecommunication on the economic growth of one country. Theoretically, according to the endogenous growth theory of Romer, telecommunication affects growth as being one part of technology, for him, it is technology that leads to long-run economic growth via the development of new ideas and research which helps for further new technology. Telecommunication especially mobile telecommunication plays a vital role in transferring information, ideas and to search for new knowledge via Internet access, even it helps to distribute information from abroad to the host country easily (to capture distant information).

The empirical finding of all papers mentioned in this paper shows the positive role that telecommunication plays on economic growth and development. It affects the economy positively since it helps to reduce transaction costs, communication/information cost, increase market efficiency and productivity. Ethiopia, as being one of the countries which have more than 126 years in terms of telecommunication history remains lagging in the development of the technology with little improvement after 2000 mainly on mobile telephone and broadband internet.

CHAPTER THREE

3. Research Design and Methodology

3.1 Introduction

In the preceding chapter, review of the relevant literature helped this study to understand the problem deeply and to apply appropriate research approach. So, this section deals with the research design and justifications for the selection of the methodology.

3.2 Data and Sources

The study uses descriptive statistics through the use of quarterly time series data from the period 1999Q1 to 2019Q1 with a total of 81 observations. This study adopts quantitative research approach by using secondary data which are gathered from World Bank, National Bank of Ethiopia and Ethio telecom for the sake of realizing the stated objectives.

3.3 Model Specification

One of the foremost important but least understood issues altogether of multivariate time series analysis concerns model specification. Model specification refers to the determination of which independent variables should be included in or excluded from a regression of y on x . In general, the specification of a regression model should be based totally on theoretical considerations instead of empirical or methodological ones. A multiple correlation model is, in fact, a theoretical statement about the causal relationship between one or more independent variables and dependent variable. Indeed, it is observed that multivariate analysis involves four distinct stages: the specification of a model, the estimation of the parameters of this model, evaluation of the model, and finally interpretation of estimates of the parameters. Specification is the first and most crucial of those stages. (Allen, 1997).

Our estimates of the parameters of a model and our interpretation of them rely up on the proper specification of the model. So, problems may arise when we misspecify a model. There are two basic kinds of specification errors. In the first, we may misspecify the model by including an independent variable that is theoretically irrelevant. In the second, we misspecify the model by excluding it from the regression equation that is theoretically relevant. So when we specify our model we should take care as wrong specification of the model will lead to wrong conclusion (Allen, 1997).

In this study, to investigate the impact of mobile telecom penetration on Economic Growth of Ethiopia quarterly time series data from 1999Q1 to 2019Q1 is used. Economic growth with proxy variable of Real Gross Domestic product per capita is the dependent variable while independent variables are mobile penetration rate (mobile subscriber per 100 persons), fixed line penetration rate (fixed line subscriber per 100 persons), ratio of consumption to GDP, ratio of Gross capital formation to GDP, trade openness with proxy variable of the of share of total import and export to GDP, and the share of total government expenditure to GDP, where the selection of the relevant variables is made based on economic theoretical. In order to analyze the impact of mobile telephone penetration on Economic Growth in Ethiopia, the study uses the following linear model. Here all values of the variables are in real term not nominal. By taking all the above information into consideration the model is specified as follows:

$$RGDPPC_t = \beta_0 + \beta_1 MOPR_t + \beta_2 FLPR_t + \beta_3 GEPRGDP_t + \beta_4 PCPRGDP_t + \beta_5 GCFPRGD_t + \beta_6 TOPRGDP_t + u_t \dots\dots\dots [Equation 1]$$

Where:

β_0 is an intercept term.

β_1 - β_6 are the coefficients of the explanatory variables to be estimated.

$RGDPPC_t$ is real Gross domestic product per capita.

$MOPR_t$ is mobile penetration rate at time t .

$FLPR_t$ is fixed line penetration at time t .

$GEPRGDP_t$ is government expenditure to real GDP ratio at time t .

$PCPRGDP_t$ is aggregate private consumption to real GDP ratio at time t .

$GCFPRGD_t$ is investment to real GDP ratio at time t .

$TOPRGDP_t$ is the share of trade openness to real GDP at time t .

u_t is the error term or shock in time t and t is time period from 1999Q1 to 2019Q1.

It is important to point out that all the variables under study are transformed into natural logarithm to avoid heteroskedasticity (N.Gujarati, 2004) and to ease interpretation of the parameters estimates as elasticity of the variables and the equation becomes:

$$\ln RGDPPC_t = \beta_0 + \beta_1 \ln MOPR_t + \beta_2 \ln FLPR_t + \beta_3 \ln GEPRGDP_t + \beta_4 \ln PCPRGDP_t + \beta_5 \ln GCFPRGD_t + \beta_6 \ln TOPRGDP_t + u_t \dots\dots [Equation 2]$$

3.3.1 Definitions of Variables

The variables that this study uses are described as the following:

Real Gross domestic product per capita (RGDPPC):- Real gross domestic product is an inflation adjusted measure that reflects the value of all goods and services produced by an economy in a given year, expressed in base year prices, and is often referred to as "constant-price," "inflation-corrected" GDP, or "constant dollar GDP" (Naol, 2019).

Real GDP per capita is a measurement of the total economic output of a country divided by the number of people and adjusted for inflation. It's used to compare the standard of living between countries and over time. It is also the best way to compare economic indicators like GDP for countries with very different population sizes. This is why we take it as a proxy variable for economic growth.

Ratio of Private Consumption to Real GDP (PCPRGDP): - Private consumption, also referred to as personal consumption, consumer expenditure, or personal consumption expenditures (PCE), measures consumer spending on goods and services. Private consumption includes all purchases made by consumers, such as food, housing (rents), energy, clothing, health, leisure, education, communication, transport as well as hotels and restaurant services. It also includes durable goods (such as cars), but not households' purchases of dwellings, which are counted as household investment. The share of the countries consumption to total GDP shows the statues of the country's economy (Focus economics). The higher the share the higher will be the economic growth. Due to this, this research takes into account this variable as one factor affecting economic growth with expected positive impact.

Ratio of Government expenditure to real GDP (GEPRGDP): - Government final consumption expenditure consists of expenditures incurred by the government on both individual consumption goods and services and collective consumption services. From expenditure approach of calculating national account, it is known that government final consumption expenditure is one determinant in affecting GDP and then economic growth

positively. It is also one of the determinant variables in national income account. Therefore, this research also incorporates it as one of independent variables.

Gross capital formation as a ratio of real GDP (GCFPRGDP): - Gross capital formation is measured by the total value of the gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables for a unit or sector. Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchase; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Capital formation/accumulation is an important factor for economic growth, the statement is supported by both theoretical and empirical literature. Therefore, in this study, gross capital formation has been expected to have a positive impact on economic growth.

Trade openness (TOPRGDP): -Trade openness is measured by the ratio of the sum of the values of exports and imports to GDP over the sample period. Usually, exports have the potential of impacting positively on economic growth if they increase demand for domestically produced goods in the international market, and are able to generate enough foreign exchange to finance capital imports. Besides, imports also inspire economic growth if they mainly comprise of capital goods which are inputs in the production processes of the country. Imports can also lead to decline in national income. This usually occurs when imports displace domestic production of goods and services. Total output of the country will drop as well as total employment, which negatively affects national income. Thus, the combined effect of exports and imports is ambiguous-either negative or positive. The exact effect is determined empirically.

Mobile telephone penetration rate (MOPR): - Mobile penetration is the percent of population who subscribed mobile telephone service. It is calculated as the ratio of total mobile subscriber in the country to total population in the same period. According to endogenous growth theory, technology have a great contribution for economic growth and telecommunication as one type of technology, will have impact on economy of a country.

Therefore, its real impact is analyzed in this paper. This variable is target variable that the researcher deems to investigate.

Fixed line penetration Rate (FLPR):- It is also the percent of people who subscribed fixed telephone lines. It is measured as the ratio of total fixed line subscription to total population of a country in the same year, it is incorporated in this model to make comparison with mobile telecom penetration regarding their impact on economic growth.

3.4 Estimation Procedure

To test the long run relationship between dependent variable (Real GDPPC) and independent variables (mobile penetration rate, fixed line penetration rate, gross capital formation, private final consumption, government final consumption expenditure and trade openness), this study applies Autoregressive Distributed Lag (ARDL) Model. But the study first investigates the time series properties of the Data by using Augmented Dickey Fuller (ADF) tests. The unit root test is applied in order to check the stationarity of variables under consideration, since regression using time series variables necessitates stationary variables. If the variables are non-stationary, conventional regression analysis produces spurious results. Therefore, in order to examine this property of the time-series, the unit root test need to be conducted first.

Not only this, conducting unit root test also helped to confirm the variables not to be integrated of order two (i.e. $I(2)$). This is because the variables not to be integrated of order two ($I(2)$) is a precondition to apply autoregressive distributed lag (ARDL) Model (Pesaran et al, 2001) as cited by (Tewodros, 2015).

3.5. Testing for Stationarity

If the long run relationship between different time series variables and the impact of one-time series variable on the other time series variable is to be analyzed, cointegration and causality test between variables should be conducted. But before doing of such analysis, checking stationarity of the time series variables is the priority task.

Intuitively, stationarity means that the statistical properties of the process do not change over time. It is a precondition to conduct time series analysis. If a series is non-stationary, the

result of the regression analysis will produce spurious results unless the variables are cointegrated. To check whether the time series is stationary or not, unit root test can be used. A non-stationary time series is a stochastic process with unit roots - structural breaks may mimic non-stationarity. However, unit roots are major sources of non-stationary. The presence of a unit root implies that a time series under consideration is non-stationary while the absence of it entails that a time series is stationary.

Although ARDL cointegration test does not require unit root pre-testing, to avoid ARDL model crash in the presence of integrated stochastic trend of I(2), unit root test should be carried out to know the number of unit roots in the series under consideration (Nkoro and Uko, 2016).

3.5.1 Unit Root Tests

Unit root testing is a mechanism to check whether the series under consideration is stationary (has no unit root) or non-stationary (has unit root). There are various methods of testing unit roots. They include Cointegrated Regression Durbin-Watson (CRDW) test, Dickey-Fuller test (1979) (DF), Augmented Dickey-Fuller (1981) (ADF) test, Philip-Perron (1988) (PP) test, are among others.

The choice of the right tests depends on the set up of the problem which is of interest to the practitioner (Nkoro and Uko, 2016). This study used Augmented Dickey Fuller test as it is the most popular in the past years (Naol, 2019) and (Nkoro and Uko, 2016).

The testing procedure for ADF unit root test is as follows:

$$\Delta Y_t = \alpha + \delta t + \gamma Y_{t-1} + \sum_{i=1}^p \lambda_i \Delta Y_{t-i} + \varepsilon_t \dots \dots \dots [Equation 3]$$

Where Y_t is a time series variables under consideration in this model at time t , t is a time trend variable; Δ denotes the first difference operator; ε_t is the error term; p is the optimal lag length of each variable chosen such that the residuals from the regression is a white noise process.

That is: $H_0: \gamma = 0$ (The series is non stationary); and the alternative $H_1: \gamma < 0$ (The series is stationary).

If the t value or t-statistic is more negative than the critical values, the null hypothesis (I.e. H_0) is rejected and the conclusion is that the series is stationary. Conversely, if the t-statistic is less negative than the critical values, the null hypothesis is accepted, and the conclusion is that the series is non-stationary.

3.6 The Autoregressive Distributed Lag (ARDL) Model

Many past studies have used the Johansen cointegration and Engle-Granger causality technique to determine the long-term relationships between variables of interest. In fact, this remains the technique of choice for many researchers who argue that this is the most accurate method to apply for I (1) variables. Recently, however, a series of studies by (Pesaran, 1999) and (Narayan K, 2004) have introduced an alternative cointegration technique known as the ‘Autoregressive Distributed Lag (ARDL)’ bound test. There are a number of advantages of using ARDL model also called ‘Bound Testing Approach’ instead of the conventional Engle Granger two-step procedure (1987), Maximum likelihood methods of cointegration (Johansen, 1988) and (Johansen and Juselius, 1990) as described by (Tewodros, 2015).

First, the ARDL model is more statistically significant approach to determine the Cointegration relation in small samples as the case in this study (Pesaran et al., 2001 and Narayan, 2004), while the Johansen co-integration techniques require large amount of data samples for validity.

A second advantage of the ARDL approach is that while other cointegration techniques require all of the regressors to be integrated of the same order (order one); the ARDL approach can be applied whether the regressors are purely of order one [I(1)], or mixture of order zero [I(0)] and one [I(1)]. This means that the ARDL approach avoids the pre-testing problems associated with standard cointegration, which requires that the variables be already classified into I(1) or I(0) or mixture of both (Pesaran et al, 2001) as cited by (Tewodros, 2015). Third, with the ARDL approach, it is possible that different variables have different optimal numbers of lags, while in Johansen-type models this is not permitted.

Forth, the other advantages of bound testing approach is that, the long run and short run parameters of the model in questions are determined simultaneously (Tewodros, “The determinants of economic Growth in Ethiopia”: A time series Analysis., 2015). Finally, By

Applying the ARDL technique we can obtain unbiased and efficient estimators of the parameters of the model (Narayan K, 2004) and (Harris and Sollis, 2003) as cited in (Tewodros, 2015).

According to (Pesaran et al, 2001) as cited in Tewodros 2015, the ARDL modeling of unrestricted error correction model using Ordinary Least Square (OLS) can be represent as follows.

$$\Delta Y_t = \beta_0 + \delta_1 \Delta Y_{t-1} + \delta_2 \Delta X_{t-1} + \sum_{i=1}^p \beta_i \Delta Y_{t-i} + \sum_{i=1}^q \alpha_i \Delta X_{t-i} + u_t \dots \dots \dots [Equation 4]$$

Where Δ denotes first difference operation, Y_t is a vector of dependent variables (in this case RGDPPC), X_t is a vector of determinants or regressors (mobile penetration rate, fixed line penetration rate, gross capital formation, private final consumption, government final consumption expenditure and trade openness), and u_t is the residual term which is assumed to be white noise. Basically, the ARDL approach to cointegration (See Pesaran et al. 2001) involves estimating of the error correction model (ECM) version of ARDL model for economic growth:

$$\begin{aligned} \Delta \ln RGDPPC = & \alpha_0 + \sum_{i=1}^{p_1} \beta_0 \Delta \ln RGDPPC_{t-1} + \sum_{i=0}^{p_2} \beta_1 \Delta \ln PCPGDP_{t-1} + \sum_{i=0}^{p_3} \beta_2 \Delta \ln GEPGDP_{t-1} + \\ & \sum_{i=0}^{p_4} \beta_3 \Delta \ln GCFPGDP_{t-i} + \sum_{i=0}^{p_5} \beta_4 \Delta \ln TOPGDP_{t-i} + \sum_{i=0}^{p_6} \beta_5 \Delta \ln MOPR_{t-i} + \\ & \sum_{i=0}^{p_7} \beta_6 \Delta \ln FLPR_{t-i} + \theta_0 \ln RGDPPC_{t-i} + \theta_1 \ln PCPGDP_{t-i} + \theta_2 \ln GEPGDP_{t-i} + \\ & \theta_3 \ln GCFPGDP_{t-i} + \theta_4 \ln TOPGDP_{t-i} + \theta_5 \ln MOPR_{t-i} + \theta_6 \ln FLPR_{t-i} \\ & + \mu_t \dots \dots \dots [Equation 5] \end{aligned}$$

Where RGDPPC is the real GDP per capita Birr at a time t , PCPRGDP is private consumption as a share of real GDP, GEPRGDP is government expenditure as a share of real GDP, GCFPRGDP is gross capital formation as a share of real GDP, TOPRGDP is trade openness, MOPR is mobile penetration Rate and FLPR is fixed line penetration rate, u is the residual term, which is assumed to be white noise, p 's are the optimal lag length and \ln is natural logarithm. The β s' show short run dynamics and θ s' are for long run relationships.

The bounds test is mainly based on the joint Wald test or F - test in which its asymptotic distribution is non-standard under the null hypothesis of no cointegration/long run relationship. The null hypothesis for no co-integration among the variables in equation [5] is: - $H_0: \theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = 0$ (meaning no long run relationship among the variables) against the alternative one:

H_1 : not H_0 (Meaning there is long run relationship between variables).

The F -test has no standard distribution under the null which depends on (i) whether the variables include within the model are $I(0)$, or $I(1)$, (ii) the numbers of regressors, and (iii) whether the model contains an intercept and/or a trend (Narayan K, 2004) to check the existence of long-term relationship among the variables, equation [5] is to be estimated by applying OLS. To check the importance of lagged level of the variables into account, the acceptable statistic is F or Wald test as (Pesaran et al, 2001) proposed for bound test approach is applied (Tewodros, 2015).

According to Pesaran et al (2001), there are two sets of critical bounds for all classifications of regressors' namely upper critical bound and lower critical bound. The critical values for $I(1)$ series are referred to as upper bound critical values, while the critical values for $I(0)$ series are referred to as lower bound critical values. If the calculated F statistic is greater than the upper bound critical values, we reject the null hypothesis of no long run relationship among the variables. If the calculated F statistic is less than the lower bound critical values, we can't reject the alternative hypothesis rather accept the null hypothesis of no cointegration among the variables. However, if the calculated F statistic is between the upper and lower bound critical values, inference is inconclusive and we need to have knowledge on the order of integration of underlying variables before we made conclusive inference (Pesaran et al, 2001). However, in this model we used the critical bound value developed by Narayan (2004), which is based on small sample size.

The orders of the lags in the ARDL Model is selected by either the Akaike Information Criterion (AIC) or the Schwarz Bayesian Information Criterion (SBC), before the selected model is estimated by ordinary least squares.

3.7 Cointegration Test

Cointegration is a phenomenon which occurs when two or more non-stationary variables share common trends, that is, they have long run equilibrium relationships (Naol, 2019).

When time series variables are non-stationary, using ordinary least square or other similar methods may produce spurious results unless they are cointegrated. In other words, the test results of regression may show that a significant relationship exists between two given variables, which in fact are uncorrelated. This type of regression is termed as ‘spurious regression’ which mainly occurs due to the non-stationarity of the time series variables used in the regression model. On the other hand, two or more variables may form long term equilibrium relationship even though they may deviate from the equilibrium in the short run. Due to these issues, Engle and Granger (1987) developed cointegration test method to analyze the relationships among non-stationary variables. If two or more variables are linked to form an equilibrium relationship spanning the long run, these variables are said to be cointegrated. In fact, one variable drags the other over the period and hence, both share the same movement (Sherstha and Bhatta, 2018).

3.8 Granger Causality Test

In order to investigate the causality relationship between Mobile Telecom Penetration rate and Economic Growth in Ethiopia, this study employed the Toda-Yamamoto (TY) causality approach. The TY is the modified version of the Ordinary Granger Causality test. It has been employed in this research for the following reasons:

- ✓ It is assumed to be superior to Ordinary Granger Causality as it does not require the pre-testing of variables for cointegration. This implies that researchers do not have to pre-test for cointegration of the variables. Therefore, the TY helps in overcoming the problem of asymptotic critical values when causality tests are done in the presence of nonstationarity or no cointegration.
- ✓ It is suitable for the standard VAR whereby the variables can be estimated in their levels rather than the first difference as in the case with the Ordinary Granger Causality and therefore researchers do not need to transform VAR into Vector Error Correction Mechanism (Dembure and Ziramba, 2017).

The use of TY causality approach involves the following three stages:

- I. Determination of the maximum order of cointegration.
- II. Determination of the optimal Lag length.
- III. Testing for causality

To test for TY causality between two variables, the following bivariate VAR (k) model is constructed:

$$X_t = \beta_{10} + \sum_{i=1}^{k+d} \beta_{1i} X_{t-i} + \sum_{i=1}^{k+d} \delta_{1i} Y_{t-i} + \varepsilon_{1t} \dots \dots \dots [Equation 6]$$

$$Y_t = \beta_{20} + \sum_{i=1}^{k+d} \beta_{2i} X_{t-i} + \sum_{i=1}^{k+d} \delta_{2i} Y_{t-i} + \varepsilon_{2t} \dots \dots \dots [Equation 7]$$

Where:

K is the optimal lag length of the VAR model.

ε_{1t} and ε_{2t} are the errors terms which are assumed to be white noise.

For the bivariate VAR equation in (6) above, the null (H_0) and alternative (H_1) hypotheses are specified as follows:

$$H_0 = Y_t \text{ Does not Granger cause } X_t, \text{ if } \sum_{i=1}^{k+d} \delta_{1i} = 0$$

$$H_1 = Y_t \text{ Does Granger cause } X_t, \text{ if } \sum_{i=1}^{k+d} \delta_{1i} \neq 0$$

For the bivariate VAR equation (7) above, the null (H_0) and alternative (H_1) hypotheses are specified as follows.

$$H_0 = X_t \text{ Does not granger cause } Y_t, \text{ if } \sum_{i=1}^{d+k} \delta_{2i} = 0$$

$$H_1 = X_t \text{ Does granger cause } Y_t, \text{ if } \sum_{i=1}^{k+d} \delta_{2i} \neq 0$$

The causality between two variables can be described as unidirectional, bidirectional or no causality at all.

3.9 Methodological Framework

Applying appropriate methodology to the time series data is most crucial part of the time series analysis as wrong specification of the model or using wrong method provides biased and unreliable estimates. Primarily, the method of selection of time series analysis is based on the unit root test results which determine the stationarity of the variable. Methods

commonly used to analyze the stationary time series cannot be used to analyze non-stationary series. If all the variables of interest are stationary, the methodology becomes simple. In such a case, ordinary least square (OLS) or vector autoregressive (VAR) models can provide unbiased estimates. If all the variables of interest are non-stationary, OLS or VAR models may not be appropriate to analyze the relationship. Similarly, additional problem arises when variables used in the analysis are of mixed type, i.e., some are stationary and others are non-stationary.

Following is a general methodological framework for time series analysis

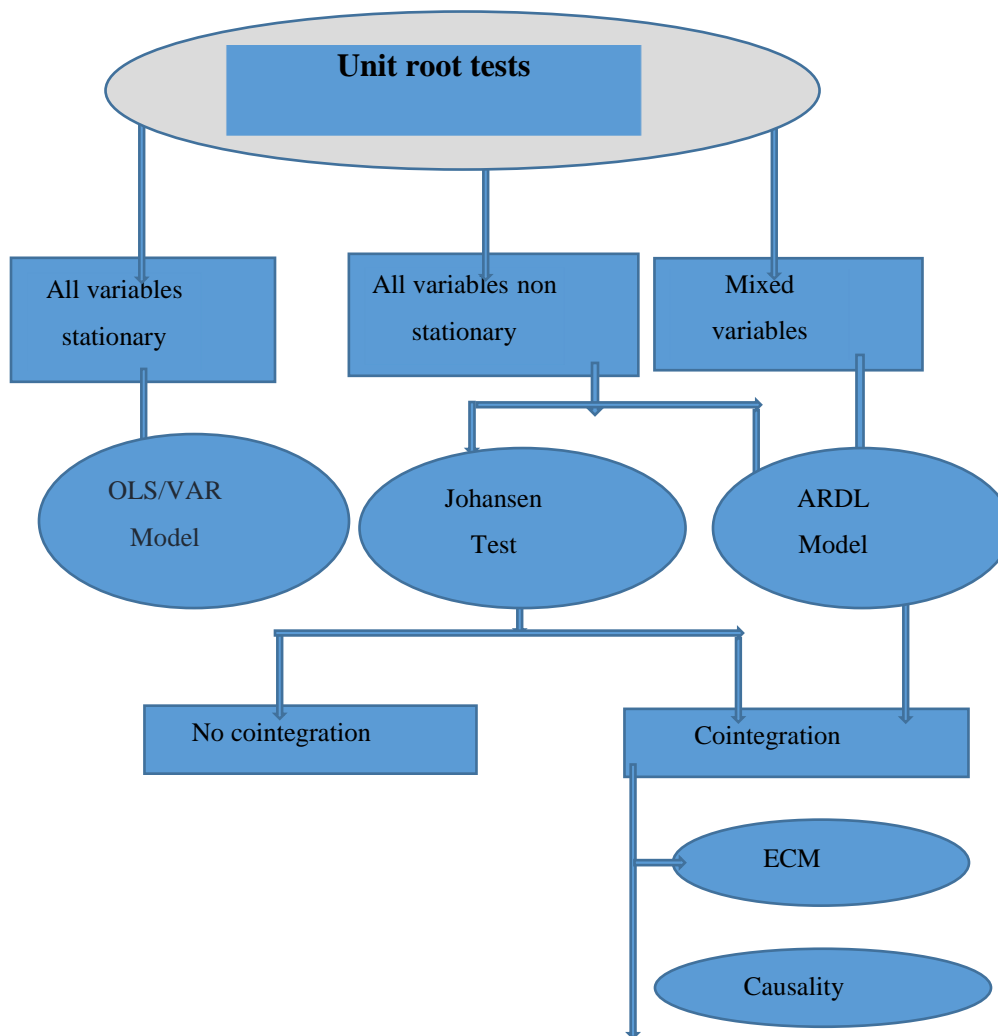


Fig.5. Method selection framework chart for time series data. Where: OLS: Ordinary least squares; VAR: Vector autoregressive; ARDL: Autoregressive distributed lags; ECM: Error correction models. Source: Sherstha and Bhatta, (2018).

CHAPTER FOUR

4. Data Analysis and Econometric Results

4.1. Introduction

The previous chapter discussed the research design employed to achieve the objectives of the study and to test the research hypothesis. In this chapter, the study analyzes the collected data using statistical software (Eviews-9) and present the result and discussions accordingly.

The main objective of this paper is to investigate the dynamic impact of Mobile telephone penetration on economic growth using time series data over the period 1999Q1 to 2019Q1 with a total of 81 observations .The data was collected from World Bank, National Bank of Ethiopia and from Ethio telecom annual and quarterly data.

4.2 Diagnostic Tests

4.2.1 Unit Root Test

The bounds test approach to cointegration does not need pre-testing for stationarity of the variables included in the model, however it is important to carry out stationarity tests of all the series. This is because the ARDL bounds test to cointegration is not applicable if the order of integration is above $I(1)$. It is, therefore, necessary to test for stationarity of the variables before regression analysis is done. It is prominent that stationarity properties of time series are investigated by testing for unit roots and there are several methods for testing for stationarity. Thus, this study used the commonly used Augmented Dickey Fuller (ADF) (1981) unit root tests and the unit root test results are presented in table 1 below.

Table 1. Unit root Test Result (ADF Test)

At Level								
		LNRGDPPC	LNPCPGDP	LNGEPGDP	LNGCFPGDP	LNTPGDP	LNMOPR	LNFLPR
With Constant	t-Statistic	0.4982	-0.6038	-1.2866	-1.1669	-0.8894	-1.7703	-2.4142
	Prob.	0.9857	0.8630	0.6322	0.6848	0.7868	0.3924	0.1413
		No	No	No	No	No	No	No
With Constant & Trend	t-Statistic	-1.9560	-2.6335	-1.8018	-2.5107	-1.1620	-0.1322	-1.9391
	Prob.	0.6157	0.2671	0.6947	0.3223	0.9110	0.9934	0.6244
		No	No	No	No	No	No	No
Without Constant & Trend	t-Statistic	2.0108	-0.8558	0.7396	0.4011	0.4244	-0.2074	-2.4794
	Prob.	0.9890	0.3421	0.8723	0.7969	0.8029	0.6083	0.0137
		No	No	No	No	No	No	**

At First Difference								
		d(LNRGDPPC)	d(LNPCPGDP)	d(LNGEPGDP)	d(LNGCFPGDP)	d(LNTPGDP)	d(LNMOPR)	d(LNFLPR)
With Constant	t-Statistic	-3.8206	-3.2412	-3.7422	-2.3987	-2.6837	-3.1428	-1.8903
	Prob.	0.0041	0.0212	0.0052	0.1456	0.0814	0.0276	0.3352
		***	**	***	No	*	**	No
With Constant & Trend	t-Statistic	-4.0377	-3.2248	-3.7659	-2.3805	-3.4975	-3.6226	-2.3670
	Prob.	0.0112	0.0871	0.0236	0.3865	0.0466	0.0344	0.3935
		**	*	**	No	**	**	No
Without Constant & Trend	t-Statistic	-3.2081	-2.8787	-3.4234	-2.1213	-2.6434	-2.4398	-1.9281
	Prob.	0.0017	0.0045	0.0008	0.0334	0.0087	0.0151	0.0519
		***	***	***	**	***	**	*

Source: Author's computation using Eviews.

Where.

- While (*), (**), and (***) indicate significance at 10 %, 5 %, and 1%, respectively, No is used to indicate insignificance (non-stationarity).
- Lag length based on Schwartz information criterion (SIC) also called BIC.
- Probability based on MacKinnon (1996) one- sided p-value.

The above table (Table 1) shows unit root results of the series at level and first differences. Based on ADF test, all the variables except one variable were found to be stationary at their first differences. The results suggest that all the variables considered in this study are integrated of order one, I (1) only with one variable stationary at level (LNFLPR). This implies that the null hypothesis of non-stationarity is rejected and rather the alternative hypothesis is accepted. Thus, we can conclude that none of the variables entered in the regression are of order two, which are not desired in applying ARDL model. So ARDL

cointegration technique proposed by Pesaran et al. (2001) is the most appropriate method for estimation or to check the long run relationship among the variables.

4.2.2 Test for Heteroskedasticity

To evaluate the estimated long run model, some diagnostic test is undertaken. Before doing any analysis, we require to check the standard property of the model. In this study we carried out a number of model stability and diagnostic checking which includes heteroskedasticity and serial correlation tests.

The presence of heteroskedasticity has been checked for the efficiency of the estimates to ensure that the standard errors are not wrong, and any inferences made could not be misleading. It is assumed that the errors are homoscedastic, or their variance is constant. The null hypothesis is the error terms are homoscedastic. The Harvey (1976) test for heteroskedasticity has been used to ensure that this assumption is no longer violated. To reject the null hypothesis that the error terms are homoscedastic, the p-value of the F Statistic, Obs*R-squared and Scaled explained SS should be less than 5%, but our result indicated that the P-value for F Statistic, Obs*R-squared and Scaled explained SS are more than 0.05, thus, the errors are not heteroskedastic so, we are going to accept the null hypothesis that the error terms are homoscedastic.

Table 2. Heteroskedasticity Test: Harvey

F-statistic	0.715407	Prob. F(33,41)	0.8378
Obs*R-squared	27.40559	Prob. Chi-Square(33)	0.7417
Scaled explained SS	34.55056	Prob. Chi-Square(33)	0.3937

Source: *Author's computation using Eviews*

4.2.3 Test for Autocorrelation

Serial correlation is usually a result of model misspecification or genuine autocorrelation of the model error term. In the presence of such a phenomenon, ordinary least squares are no longer BLUE (Best Linear Unbiased estimators). In such cases R-squared may be overestimated. In case we have lagged dependent variable to the right-hand side, OLS estimators are biased and inconsistent. There is thus a need to test for serial correlation in the residuals.

One of the methods to test for serial correlation is DW test with the following rule of thumb.

$H_0: \rho=0$, i.e. no serial correlation

$H_1: \rho>0$ i.e. presence of positive serial correlation or

$H_1: \rho<0$ i.e. presence of negative serial correlation the rule of thumb is that $DW \approx 2$, i.e. there is no serial correlation

$DW < 2$, implies a positive serial correlation and

$DW > 2$ implies presence of a negative serial correlation.

But the DW test is not applicable when there is lagged dependent variable in the right-hand side of the regression equation, due to this fact correlogram Q-statistics test is used for this study with following statistical result. The test clearly shows there is no serial correlation if the P-value exceeds the 5% critical value as indicated in table 3 there is no serial correlation.

Table 3. Autocorrelation Test (correlogram Q-statistics)

Sample: 1999Q1 2019Q1

Included observations: 75

Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation	A C	PAC	Q-Stat	Prob*	
.*.	.*.	1	-0.077	-0.077	0.4596	0.498
.*.	.*.	2	-0.189	-0.196	3.2966	0.192
.*.	.*.	3	-0.110	-0.149	4.2676	0.234
.*.	** .	4	-0.137	-0.215	5.7866	0.216
.*.	** .	5	-0.089	-0.210	6.4358	0.266
. .	.*.	6	-0.007	-0.179	6.4399	0.376
. *	. .	7	0.164	0.003	8.7358	0.272
. .	. .	8	0.050	-0.047	8.9487	0.347
. .	. .	9	0.036	0.016	9.0647	0.431
.*.	.*.	10	-0.074	-0.073	9.5490	0.481
.*.	.*.	11	-0.122	-0.118	10.882	0.453
. .	. .	12	0.000	-0.041	10.882	0.539

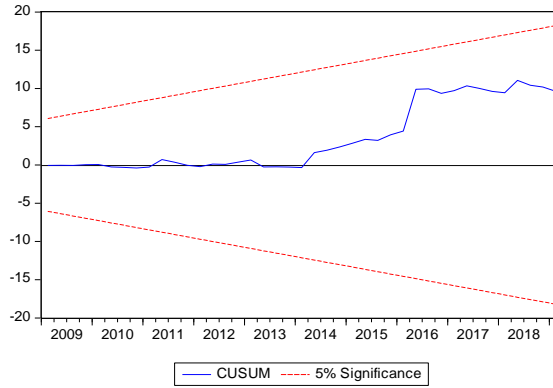
*Probabilities may not be valid for this equation specification.

Source: Author's computation using Eviews 9.

4.2.4 Test for Model Stability

This study carried a number of model stability and diagnostic checking, which includes Serial correlation test (Correlelogram Q-statistic) and Hetroskedasticity (Harvey) test. In addition to the above diagnostic tests, the stability of long run estimates has been tested by

applying the cumulative sum of recursive residuals (CUSUM) Test. The test finds serious parameter instability if the cumulative sum goes outside the area (never returns back) between the two critical lines or bounds. The below graph shows the result of CUSUM test.



Source: Author's computation using Eviews

Fig.6. Testing parameter stability using CUSUM.

- The straight lines represent critical bounds at 5% significance level.

As it can be seen from figure 6, the plot of CUSUM test did not cross the critical limits. So, we can conclude that long run estimates are stable and there is no instability of parameter estimates. Besides model stability, 99.9 percent of the variations in the dependent variable is explained by the regressors. Hence the results of the estimated model are reliable and efficient.

4.3. Key Regression Statistics: R^2

It measures goodness of fit statistics of the model. It is desirable to have some measure of how well the regression model actually fits the data.

In fact, a scaled version of the residual sum of squares is usually employed. The most common goodness of fit statistic is known as R^2 . One way to define R^2 is to say that it is the square of the correlation coefficient between the actual values of the dependent variable and the corresponding fitted values from the model, provided a constant is included in the regressions. A correlation coefficient must lie between -1 and +1 by definition. Since R^2 defined in this way is the square of a correlation coefficient, it must lie between 0 and 1. If this correlation is high, the model fits the data well, if the correlation is low (close to zero), the model is not providing a good fit to the data, while the correlation is high (close to one)

the model providing a good fit to the data. Here below are some of the key statistical results of the EViews 9 result.

Table 4. Table for key regression result.

R2	0.999672
Adjusted R2	0.999408
Durbin-Watson statistic	2.137154
F-Statistic	3785.995, Prob(F-statistic)(0.000000)

Source: Author's computation using Eviews

4.4 Bound Test for Long Run Cointegration

After confirming diagnostic tests, the next step of any time series econometric analysis is to check the long run relationship of variables under study. So to do this ARDL bound test is applied. The first step of the ARDL bounds analysis is to investigate presence of long-run relation among the variables included in model. The model was estimated by ARDL and the optimal lag was selected by VAR Lag Order Selection Criteria, as displayed in the below table.

Table 5. Table for lag order selection Criteria

Sample: 1999Q1 2019Q1

Included observations: 74

Lag	LogL	LR	FPE FDE	AIC	SC	HQ
0	72.79132	NA	0.009898	-1.778144	-1.560192	-1.691200
1	156.2068	148.7952	0.001067	-4.005589	-3.756501	-3.906225
2	170.7099	25.47844	0.000741	-4.370538	-4.090314*	-4.258753
3	170.8230	0.195620	0.000760	-4.346567	-4.035207	-4.222362
4	171.5843	1.296344	0.000765	-4.340117	-3.997621	-4.203491
5	174.4327	4.772919	0.000728	-4.390073	-4.016441	-4.241026
6	177.9944	5.872040*	0.000680*	-4.459309*	-4.054540	-4.297842*
7	178.0577	0.102562	0.000698	-4.433991	-3.998087	-4.260103

Source: Author's computation of E view result

Where:

* Indicates lag order selected by the criterion

LR: sequential modified likelihood ratio (LR) test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike Information Criterion

SC: Schwarz Information Criterion (BIC)

HQ: Hannan-Quinn Information Criterion

By using the VAR lag selection Criteria, all information criteria's showed lag length of six which is indicated by * and as highlighted in blue color with the exception of the SIC which has chosen two as the optimal lag length. Thus, the model used lag length of six to conduct the short run and long run estimation.

Table 6. Table for ARDL bound Test ARDL Bounds Test

Sample: 2000Q3 2019Q1

Included observations: 75

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k	
F-statistic	4.097573	6	

Critical Value Bounds

Significance	I(0) Bound	I(1) Bound	
10%	2.12	3.23	
5%	2.45	3.61	
2.5%	2.75	3.99	
1%	3.15	4.43	

Source: Author's computation of E view result

After estimation of the model one need to conduct an F-test on joint significance of the variables using ADRL bound Test and the result of F-statistic indicates there is a long run relationship at 5%. The rule of thumb is that by taking the lower and upper bound critical values of Narayan (2004), if the F-statistics is above the upper bound critical value then it is mean to that the variables have long run relationship, but if F-statistic is below the lower bound critical values, then the variables do not have long run relationship. Having this in mind, our statistical result lies above the upper bound critical value at 5% significance level. Thus, we have proved that the variables have long run relationship. The table also provides the upper and lower Narayan (2004) critical values. The F-statistics were compared with the upper and lower bound Narayan (2004) critical values. .

4.5 Long Run ARDL Model Estimation

After confirming the existence of long-run cointegration relationship among the variables, the next step is running the appropriate ARDL model to find out the long run and short run coefficients, which is reported in next table.

Table 7. Estimated Long Run Coefficients using the ARDL Approach ARDL (2, 2, 0, 6, 6, 5, 6) selected based on Bayesian Information Criterion BIC/SIC).

Long Run Coefficients				
Dependent variable is LNRGDPPC				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPCPGDP	-0.720217**	0.311731	-2.310380	0.0260
LNGEPGDP	-0.108833	0.393294	-0.276721	0.7834
LNGCFPGDP	1.373832***	0.369689	3.716186	0.0006
LNTOPGDP	-1.807506***	0.217442	-8.312586	0.0000
LNMOPR	0.165374**	0.069216	2.389261	0.0216
LNFLPR	0.5413548**	0.236195	2.291984	0.0271
C	7.502435***	0.731819	10.251758	0.0000

Note: *** denotes significance at 1%, ** shows significance at 5% which indicates rejection of the null hypothesis at 1% and 5% significant level.

Source: Own computation using EViews: ARDL (2, 2, 0, 6, 6, 5, 6)

As we can easily understand from the table, Except LNGEPGDP, the rest of the variables are significant at 1% and 5% significant level regardless of their signs, since some of the variables (PCPGDP and GEPGDP) sign is opposite with the researcher's expectation. The interpretation for each coefficients of the independent variable to the dependent variable is discussed as follows. Since we have specified the growth model in a log-linear form, the coefficients can be interpreted as elasticity/percentage changes with respect to real GDP per capita.

HP1: There is a negative relationship between private consumption share in GDP and economic growth (RGDPPC).

The test statistics in Table 7 how that holding other things constant a 1% increase in LNPCPGDP (private consumption share in GDP) decreases the LNRGDPPC (real gross domestic product per capita) by 0.72% and statically significant at 5 percent. This implies that share of private consumption in RGDP has negative impact on economic growth. This

result is obtained due to the fact that in the long run it is investment that will increase the per capita income of the household via saving. But if there is high consumption and low saving rate, then it will negatively affect the economic performance of the country i.e. in the long run it is saving then investment that matters instead of consumption. Here saving is a part of income after consumption.

HP2: There is a negative relationship between gross government expenditure share in GDP and real GDP per capita (economic growth).

The test statistics in Table 7 show that holding other things remain constant a 1% increase in LPCPGDP (government consumption expenditure per GDP) decreases the LRGDPPC (real gross domestic product per capita) by 0.108% and statically insignificant.

As to the impact of government spending on economic growth, there is no consistent theory developed to rely up on. Classical economists recommend little government spending, Keynesian economist on the other hand emphasized government spending as a stimulus to a stagnant economy. Others, such as (Barro, 1990) explain the role of government spending by disaggregating it into productive government spending which enhances economic growth while unproductive government spending retard it. However, there is no consensus about the classification of productive and non-productive government spending (Teshome, 2006). Thus, the negative contribution of the government spending may be due to the government expenditure on unproductive resource.

HP3: Gross capital formation share in RGDP impacts real gross domestic product per capita positively.

As per the estimation result holding other things constant 1% increase in LPGCFPGDP (Gross capital formation per GDP) increases the LRGDPPC (real gross domestic product per capita) by 1.374% and statically significant at 1%.

HP4: Trade openness (TOPPGDP) contracts real gross domestic product per capita (RGDPPC).

Holding other things constant 1% increase in trade volume share in real GDP will contract the level of real GDP per capita by 1.807% and it is statistically significant at 1%.

Usually exports have the potential to increase national income, in contrast imports may affect national income if it displaces the domestic production. Due to this nature their combined impact will depend on export and import magnitude, which affects more. Currently in Ethiopia imports are higher than exports and majority of the imported goods are consumption goods which do not further help the domestic producers rather it displaces them, as a result it affects the domestic economy negatively.

HP5: Mobile telephone penetration rate (MOPR), which is the target variable for this study, has a positive impact on real gross domestic product per capita (RGDPPC).

Table 7 shows that holding other things remain constant a 1% increase in mobile penetration rate will increase real gross domestic product per capita of Ethiopia by 0.165% and it is significant at 5%. Telecommunication in general and mobile telecom in particular has a great role on country's economy. Mobile telecommunication in Ethiopia is a recent phenomenon, however, it is spreading quickly and its role in the economy is very important.

HP6: Fixed line penetration rate has also a positive impact on real gross domestic product per capita of Ethiopia, which is a proxy variable for economic growth.

Holding other things constant a 1% increase in fixed line penetration rate will increase real GDP per capita by 0.54% and it is statistically significant at 5%. When we compare its impact with mobile telephone penetration it has stronger impact, this may be due to the recent history of mobile telecom and the long time history of fixed lines.

Finally, the long run estimated model presented as follow with figures in the parenthesis indicates calculated t-value.

$$\begin{aligned}
 LRGDPPC = & \underset{(10.25)}{7.50} - \underset{(2.31)}{0.72} LNPCPGDP - \underset{(0.27)}{0.11} LNPCPGDP + \underset{(3.71)}{1.37} LNGCFGDP \\
 & - \underset{(8.31)}{1.80} LNTOPGDP + \underset{(2.38)}{0.16} LNMOPR + \underset{(2.29)}{0.54} LNFLPR
 \end{aligned}
 \tag{Equation 8}$$

4.6 Short Run Error Correction Model

After the acceptance of long-run coefficients of the growth equation, the short-run ECM model is estimated. The coefficient of the error correction term (ECM), indicates the speed of adjustment to restore equilibrium in the dynamic model. It is a one lagged period residual obtained from the estimated dynamic long run model. The coefficient of the error correction term indicates how quickly variables converge to equilibrium. Moreover, it should have a negative sign and statistically significant at a standard significant level (i.e. p-value should be less than 0.05).

Table 8. Error Correction Representation for the Selected ARDL (2, 2, 0, 6, 6, 5, 6) selected based on Bayesian information Criterion: RGDPPC is the dependent variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (LNRGDPPC (-1))	0.516266***	0.121217	4.259035	0.0001
D(LNPCPGDP)	-0.552153***	0.109254	-5.053860	0.0000
D (LNPCPGDP (-1))	0.263212**	0.107915	2.439059	0.0191
D(LNGEPGDP)	-0.020921	0.072621	-0.288081	0.7747
D(LNGCFPGDP)	0.554400***	0.131938	4.201975	0.0001
D (LNGCFPGDP (-1))	-0.195136	0.134054	-1.455651	0.1531
D (LNGCFPGDP (-2))	0.010578	0.116634	0.090697	0.9282
D (LNGCFPGDP (-3))	-0.589537***	0.134889	-4.370539	0.0001
D (LNGCFPGDP (-4))	0.830778***	0.154738	5.368945	0.0000
D (LNGCFPGDP (-5))	-0.361665***	0.095069	-3.804246	0.0005
D (LNTOPGDP)	-0.266664	0.145820	-1.828720	0.0747
D (LNTOPGDP (-1))	0.188560	0.262530	0.718241	0.4767
D (LNTOPGDP (-2))	-0.019073	0.254762	-0.074868	0.9407
D (LNTOPGDP (-3))	1.136968***	0.263961	4.307339	0.0001
D (LNTOPGDP (-4))	-1.536140***	0.285564	-5.379322	0.0000
D (LNTOPGDP (-5))	0.612818***	0.168844	3.629490	0.0008
D (LNMOPR)	0.013028	0.014238	0.915006	0.3655
D (LNMOPR (-1))	-0.013726	0.013187	-1.040832	0.3041
D (LNMOPR (-2))	-0.003496	0.010595	-0.329981	0.7431
D (LNMOPR (-3))	0.001042	0.012695	0.082056	0.9350
D (LNMOPR (-4))	0.034287***	0.012689	2.702113	0.0100
D(LNFLPR)	0.004611	0.047833	0.096398	0.9237
D (LNFLPR (-1))	0.103841	0.065655	1.581614	0.1214
D (LNFLPR (-2))	-0.019048	0.044162	-0.431323	0.6685
D (LNFLPR (-3))	-0.013765	0.052635	-0.261512	0.7950
D (LNFLPR (-4))	0.149155**	0.059250	2.517400	0.0158
D (LNFLPR (-5))	-0.095175	0.054592	-1.743364	0.0888
ECM (-1)	-0.192228***	0.056413	-3.407541	0.0015

***, **, * indicates statistically significance at 1%, 5% and 10%, respectively.

Source: own computation using Eviews.

The estimated error correction coefficient of -0.192 is highly significant, has the correct negative sign and implies a very high speed of adjustment to equilibrium. According to (Kidanemariam, 2014) as cited by (Tewodros, 2015) the highly significant error correction term further confirms the existence of a stable long-run relationship.

Moreover, the coefficient of the error term (ECM-1) implies that the deviation from long run equilibrium level of real GDPPC in the current period is corrected by 19.22 % in the next period to bring back to equilibrium when there is a shock to a steady state relationship.

According to table 8 similar to long run result, in the short run both private and government consumption expenditure have a negative impact on economic growth and the coefficients of private consumption share in real gross domestic product is statistically significant at 1% significance level but the coefficient of gross government expenditure share in gross domestic product is insignificant. As a result, a 1% increase in private consumption share in GDP and government expenditure share in GDP will result in 0.552% and 0.021% immediate contraction in real GDP per capita in the short run, respectively. Here we have easily observe that gross government expenditure to real GDP is insignificant both in short run and long run.

Gross capital formation share in real gross domestic product has a positive impact on economic growth. Holding other things remain constant, 1% increase in gross capital formation share in GDP will immediately expands real gross domestic product per capita by 0.554% and it is significant at 1% significance level.

Trade volume share in real gross domestic product or trade openness has a negative impact on economic growth like in the long run. Holding other things remain constant, a 1% increase in trade openness will immediately contract real gross domestic product per capita by 0.27% and it is insignificant.

Mobile telecommunication penetration rate has a positive impact on economic growth. Holding other things remain constant 1% increase in mobile penetration rate will result in an immediate expansion of real gross domestic product per capita by 0.013% and it is insignificant.

Fixed line has a positive impact on economic growth. Holding other things remain constant a 1% increase in fixed line penetration rate will immediately increase real gross domestic product per capita by 0.005% and it is insignificant.

4.7 Causality Test on Mobile Telecommunication and Growth Variable

The Toda- Yamamoto Granger Causality Approach is used to determine the direction of causality between mobile penetration Rate and Economic Growth. The first Step in TY approach is determination of the order of integration in the system. The results of the unit root test in Table 1 indicates that the order of integration is one, I (1). This means the VAR Models will add one extra lag. After determining the maximum order of integration, the next step involves determining the optimal lag length as explained in the methodology section.

The optimal lag length was selected based on different lag length criterions such as Akaike’s Information Criterion (AIC), Schwarz Information Criterion (SC), Final Prediction Error (FPE) and the Hannan Quinn (HQ) Information Criterion. The results of the different lag length selection criteria are shown in the table 5 above.

The VAR result for the optimal length show 6 as per different information criteria explained there. By taking these in to consideration, the Tado-Yamamoto Granger causality result is displayed as follows. Basic idea of this approach is to increase the number of lags in the VAR model in accordance with the maximum cointegration relationship of the series will have chi-square (χ^2) distribution (Taban, 2010).

Table 9. Toda –Yamamoto Causality (modified WALD) Test Results

Null Hypothesis	χ^2	df	Prob.	Granger causality
MOPR Does not Granger Cause RGDPPC	78.4655 7	7	0.0000	Bi directional Causality. RGDPPC → MOPR ←
RGDPPC Does not Granger Cause MOPR	39.2548 3	7	0.0000	

Source: own computation using Eviews.

MWALD causality test result shows that there is a strong bi-directional causality between the proxy variable for Economic Growth (real Gross domestic Product per capita) and the rate of Mobile telecom Penetration. Thus we cannot accept both the null hypothesis that Mobile telecom penetration rate does not granger cause economic growth and the null hypothesis that economic growth does not granger Mobile telecom penetration rate.

CHAPTER FIVE

5. Conclusion and Policy Recommendation

In the first section of this Chapter, major empirical findings of the study and policy implication of those findings are discussed (conclusion part); the second section discusses future research direction (recommendations).

5.1 Conclusion

The main objective of this study is to analyze the impact of mobile telecom penetration on economic growth in Ethiopia for the specified period. To determine the long run and short run relationship among the variable Autoregressive distributed lag (ARDL) model was applied. Prior to applying the ARDL model, all the variables are tested for their time series properties (stationarity properties) using the ADF test. As a result, except FLPR which is stationary at level, all other variables are stationary at their first difference.

Next to stationarity test, diagnostic test of the model has been conducted. The major diagnostic tests applied are autocorrelation, Heteroscedasticity and model stability tests. The result showed no serial correlation and no heteroscedasticity problem faced with the model under study. Besides these two diagnostic tests, model stability test is also conducted using CUSUM test and confirmed as there is no model instability problem which means the model is stable.

As described above, this study applied the methodological approach called ARDL model also known as bound test approach. As per the result the bound test (F-statistic) value is larger than the upper bound critical value of Narayan (2004) at standard significant level of 5%, which indicates there is a long run relationship between real GDP per capita and the independent Variables (Private Consumption as a share of GDP, Gross Government Expenditure share in GDP, Gross Capital Formation as a share of GDP, Trade Openness, Mobile phone Penetration and Fixed Line Penetration Rate) in long run during the study period.

The empirical finding showed that private consumption as a share of real gross domestic product is significant and has negative impact on real GDP per capita both in the short run

and long run. A 1% increase in private consumption share in GDP will contract real GDP per capita by 0.72% and 0.552% in the long run and short run (immediate impact), respectively.

Government Expenditure as a share of real gross domestic product is insignificant and has negative impact on real GDP per capita both in the short run and long run. A 1% increase in Government Expenditure as a share of GDP will result in contraction of real GDP per capita by 0.108% and 0.021% in the long run and short run (immediate impact), respectively.

Gross capital formation share in real gross domestic product is significant and has positive impact on real GDP per capita both in the short run and long run. A 1% increase in Gross capital formation per GDP will result in expansion of real GDP per capita by 0.137% and 0.554% in the long run and short run (immediate impact), respectively.

Trade volume as a share real gross domestic product is significant in the long run and insignificant in the short run and has negative impact on real GDP per capita in both in the short run and long run. A 1% increase in trade volume as a share of GDP will contract real GDP per capita by 0.181% and 0.266% in the long run and short run (immediate impact), respectively.

Mobile penetration rate is significant in long run and insignificant in the short run and has positive impact on real GDP per capita both in the short run and long run. A 1% expansion in Mobile penetration rate will result in expansion of real GDP per capita by 0.165% and 0.013% in the long run and short run (immediate impact), respectively.

Fixed line penetration rate is significant in long run and insignificant in the short run and has Positive impact on real GDP per capita both in the short run and long run. A 1% percent increase in fixed line penetration rate will expand real GDP per capita by 0.541% and 0.0046% in the long run and short run (immediate impact), respectively.

The study also applied Tado-Yamomoto Granger causality test to check the causal relationship between economic growth approximated by real GDP per capita and mobile telephone penetration rate. The result of the granger causality test showed that there is bi-directional causality between them.

5.2 Policy Recommendations

Based on the findings of this study, the below policy recommendations are forwarded.

- In order to increase the contribution of mobile phone penetration on economic growth, the government of Ethiopia should set policies that help for higher penetration of telecommunication through the country, which supports the people to connect one to each other so as to reduce transaction costs and to enhance for the acquisition of information. Such development of information will, in turn, contribute to the creation of new ideas and researches. The policies may include the privatization of the telecom industry, reduction usage tariff, and reduction of cell phones prices.
- To enhance the contribution of the physical capital formation, the government of Ethiopia should set policies to extend domestic saving which is believed as a backbone of growth. This includes increase saving mobilization like selling of state bonds, expanding financial institutions and by strengthening existing saving tools (strengthening both private and government workers Social Security scheme, strengthening saving for housing program, saving for investment equipment scheme).
- Regarding trade openness, the government of Ethiopia should motivate imports of raw materials/inputs that will help for production of Goods and services within the domestic economy instead of importing finished products.

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Appendices

Appendix A: OLS estimation.

Test Equation:

Dependent Variable: RESID^2

Method: Least Squares

Sample: 2000Q3 2019Q1

Included observations: 75

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008947	0.004558	1.963153	0.0564
LNRGDPPC(-1)	-0.002052	0.001134	-1.809042	0.0778
LNRGDPPC(-2)	0.000902	0.001141	0.790509	0.4338
LNPCPGDP	-0.002067	0.001028	-2.009758	0.0511
LNPCPGDP(-1)	0.003257	0.001631	1.996539	0.0525
LNPCPGDP(-2)	-0.001460	0.001016	-1.437686	0.1581
LNGEPGDP	0.000137	0.000683	0.201080	0.8416
LNGCFPGDP	0.001726	0.001242	1.390220	0.1720
LNGCFPGDP(-1)	-0.002756	0.001576	-1.748318	0.0879
LNGCFPGDP(-2)	0.001574	0.001262	1.247466	0.2193
LNGCFPGDP(-3)	-0.000299	0.001098	-0.272709	0.7864
LNGCFPGDP(-4)	0.002201	0.001270	1.734031	0.0904
LNGCFPGDP(-5)	-0.003117	0.001456	-2.139980	0.0384
LNGCFPGDP(-6)	0.001762	0.000895	1.969145	0.0557
LNTOPGDP	-0.001369	0.001372	-0.997822	0.3242
LNTOPGDP(-1)	0.001526	0.002503	0.609583	0.5455
LNTOPGDP(-2)	-0.001106	0.002471	-0.447647	0.6568
LNTOPGDP(-3)	0.000817	0.002398	0.340592	0.7352
LNTOPGDP(-4)	-0.005432	0.002484	-2.186649	0.0345
LNTOPGDP(-5)	0.006373	0.002688	2.371193	0.0225
LNTOPGDP(-6)	-0.002442	0.001589	-1.536484	0.1321
LNMOPR	0.000163	0.000134	1.213424	0.2319
LNMOPR(-1)	0.000235	0.000149	1.583186	0.1211
LNMOPR(-2)	-8.53E-05	0.000124	-0.687319	0.4958
LNMOPR(-3)	5.33E-05	9.97E-05	0.534041	0.5962
LNMOPR(-4)	0.000126	0.000119	1.051826	0.2990
LNMOPR(-5)	-9.34E-05	0.000119	-0.782424	0.4385
LNFLPR	-0.000720	0.000450	-1.599803	0.1173
LNFLPR(-1)	-0.000591	0.000569	-1.038322	0.3052
LNFLPR(-2)	0.001062	0.000618	1.718701	0.0932
LNFLPR(-3)	-7.50E-05	0.000416	-0.180564	0.8576
LNFLPR(-4)	-4.71E-05	0.000495	-0.095122	0.9247
LNFLPR(-5)	0.001039	0.000558	1.863413	0.0696
LNFLPR(-6)	-0.000898	0.000514	-1.746986	0.0881
R-squared	0.617143	Mean dependent var		9.63E-05
Adjusted R-squared	0.308990	S.D. dependent var		0.000150
S.E. of regression	0.000125	Akaike info criterion		-14.83559
Sum squared resid	6.39E-07	Schwarz criterion		-13.78500
Log likelihood	590.3346	Hannan-Quinn criter.		-14.41610
F-statistic	2.002714	Durbin-Watson stat		2.181145
Prob(F-statistic)	0.017734			

Appendix B: Heteroskedasticity Test.

Heteroskedasticity Test: Harvey

F-statistic	0.715407	Prob. F(33,41)	0.8378
Obs*R-squared	27.40559	Prob. Chi-Square(33)	0.7417
Scaled explained SS	34.55056	Prob. Chi-Square(33)	0.3937

Appendix C Autocorrelation Test

Sample: 1999Q1 2019Q1

Included observations: 75

Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation	A C	PAC	Q-Stat	Prob*	
.*.	.*.	1	-0.077	-0.077	0.4596	0.498
.*.	.*.	2	-0.189	-0.196	3.2966	0.192
.*.	.*.	3	-0.110	-0.149	4.2676	0.234
.*.	** .	4	-0.137	-0.215	5.7866	0.216
.*.	** .	5	-0.089	-0.210	6.4358	0.266
. .	.*.	6	-0.007	-0.179	6.4399	0.376
. *	. .	7	0.164	0.003	8.7358	0.272
. .	. .	8	0.050	-0.047	8.9487	0.347
. .	. .	9	0.036	0.016	9.0647	0.431
.*.	.*.	10	-0.074	-0.073	9.5490	0.481
.*.	.*.	11	-0.122	-0.118	10.882	0.453
. .	. .	12	0.000	-0.041	10.882	0.539

*Probabilities may not be valid for this equation specification.

Appendix D: Estimated Long Run Coefficients using the ARDL Approach

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPCGDP	-0.720217	0.311731	-2.310380	0.0260
LNCEGDP	-0.108833	0.393294	-0.276721	0.7834
LNGCFPGDP	1.373832	0.369689	3.716186	0.0006
LNTPGDP	-1.807506	0.217442	-8.312586	0.0000
LNMOPR	0.165374	0.069216	2.389261	0.0216
LNFLPR	0.541354	0.236195	2.291984	0.0271
C	7.502435	0.731819	10.251758	0.0000

Appendix E: Estimated Short Run Coefficients using the ARDL Approach

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNRGDPPC(-1))	0.516266	0.121217	4.259035	0.0001
D(LNPCPGDP)	-0.552153	0.109254	-5.053860	0.0000
D(LNPCPGDP(-1))	0.263212	0.107915	2.439059	0.0191
D(LNGEPGDP)	-0.020921	0.072621	-0.288081	0.7747
D(LNGCFPGDP)	0.554400	0.131938	4.201975	0.0001
D(LNGCFPGDP(-1))	-0.195136	0.134054	-1.455651	0.1531
D(LNGCFPGDP(-2))	0.010578	0.116634	0.090697	0.9282
D(LNGCFPGDP(-3))	-0.589537	0.134889	-4.370539	0.0001
D(LNGCFPGDP(-4))	0.830778	0.154738	5.368945	0.0000
D(LNGCFPGDP(-5))	-0.361665	0.095069	-3.804246	0.0005
D(LNTPGDP)	-0.266664	0.145820	-1.828720	0.0747
D(LNTPGDP(-1))	0.188560	0.262530	0.718241	0.4767
D(LNTPGDP(-2))	-0.019073	0.254762	-0.074868	0.9407
D(LNTPGDP(-3))	1.136968	0.263961	4.307339	0.0001
D(LNTPGDP(-4))	-1.536140	0.285564	-5.379322	0.0000
D(LNTPGDP(-5))	0.612818	0.168844	3.629490	0.0008
D(LNMOPR)	0.013028	0.014238	0.915006	0.3655
D(LNMOPR(-1))	-0.013726	0.013187	-1.040832	0.3041
D(LNMOPR(-2))	-0.003496	0.010595	-0.329981	0.7431
D(LNMOPR(-3))	0.001042	0.012695	0.082056	0.9350
D(LNMOPR(-4))	0.034287	0.012689	2.702113	0.0100
D(LNFLPR)	0.004611	0.047833	0.096398	0.9237
D(LNFLPR(-1))	0.103841	0.065655	1.581614	0.1214
D(LNFLPR(-2))	-0.019048	0.044162	-0.431323	0.6685
D(LNFLPR(-3))	-0.013765	0.052635	-0.261512	0.7950
D(LNFLPR(-4))	0.149155	0.059250	2.517400	0.0158
D(LNFLPR(-5))	-0.095175	0.054592	-1.743364	0.0888
CointEq(-1)	-0.192228	0.056413	-3.407541	0.0015

$$\text{Cointeq} = \text{LNRGDPPC} - (-0.7202 * \text{LNPCPGDP} - 0.1088 * \text{LNGEPGDP} + 1.3738 * \text{LNGCFPGDP} - 1.8075 * \text{LNTPGDP} + 0.1654 * \text{LNMOPR} + 0.5414 * \text{LNFLPR} + 7.5024)$$

Appendix F: Real Data entered in the Regression

Time	RGDP PC	PCPGD P	GEPG DP	GCFPG DP	TPGD P	MOPR	FLPR
1999Q1	3064	2.5	0.5	0.8	0.3	0.01	0.3
1999Q2	3127	2.4	0.5	0.8	0.3	0.01	0.3
1999Q3	3189	2.4	0.6	0.8	0.3	0.01	0.3
1999Q4	3251	2.3	0.6	0.7	0.3	0.01	0.3
2000Q1	3314	2.2	0.6	0.7	0.3	0.03	0.35
2000Q2	3359	2.3	0.6	0.7	0.3	0.03	0.35
2000Q3	3405	2.4	0.6	0.8	0.3	0.03	0.35
2000Q4	3450	2.4	0.6	0.8	0.3	0.03	0.35
2001Q1	3496	2.5	0.5	0.8	0.3	0.04	0.42
2001Q2	3486	2.5	0.6	0.9	0.3	0.04	0.42
2001Q3	3477	2.6	0.6	0.9	0.3	0.04	0.42
2001Q4	3468	2.6	0.6	0.9	0.3	0.04	0.42
2002Q1	3459	2.7	0.6	1.0	0.3	0.07	0.5
2002Q2	3419	2.6	0.5	0.9	0.3	0.07	0.5
2002Q3	3380	2.6	0.5	0.9	0.3	0.07	0.5
2002Q4	3340	2.5	0.5	0.8	0.3	0.07	0.5
2003Q1	3300	2.5	0.5	0.8	0.3	0.07	0.56
2003Q2	3389	2.4	0.5	0.8	0.3	0.07	0.56
2003Q3	3477	2.4	0.4	0.8	0.3	0.07	0.56
2003Q4	3565	2.3	0.4	0.9	0.3	0.07	0.56
2004Q1	3653	2.2	0.4	0.9	0.4	0.21	0.65
2004Q2	3734	2.2	0.4	0.9	0.4	0.21	0.65
2004Q3	3815	2.1	0.4	0.8	0.4	0.21	0.65
2004Q4	3896	2.1	0.4	0.8	0.4	0.21	0.65
2005Q1	3977	2.1	0.4	0.7	0.4	0.54	0.8
2005Q2	4058	2.0	0.3	0.7	0.4	0.54	0.8
2005Q3	4139	2.0	0.3	0.7	0.4	0.54	0.8
2005Q4	4220	1.9	0.3	0.7	0.4	0.54	0.8
2006Q1	4300	1.9	0.3	0.7	0.4	1.1	0.92
2006Q2	4384	1.8	0.3	0.6	0.4	1.1	0.92
2006Q3	4467	1.7	0.3	0.6	0.4	1.1	0.92
2006Q4	4551	1.6	0.3	0.5	0.3	1.1	0.92
2007Q1	4634	1.6	0.2	0.5	0.3	1.5	1.09
2007Q2	4716	1.5	0.2	0.5	0.3	1.5	1.09
2007Q3	4799	1.4	0.2	0.4	0.3	1.5	1.09
2007Q4	4881	1.3	0.2	0.4	0.3	1.5	1.09
2008Q1	4963	1.3	0.2	0.4	0.3	2.36	1.08
2008Q2	5039	1.2	0.2	0.4	0.3	2.36	1.08
2008Q3	5114	1.1	0.1	0.3	0.3	2.36	1.08
2008Q4	5190	1.1	0.1	0.3	0.3	2.36	1.08
2009Q1	5266	1.0	0.1	0.3	0.3	4.75	1.07

2009Q2	5394	1.0	0.1	0.3	0.3	4.75	1.07
2009Q3	5521	1.0	0.1	0.3	0.3	4.75	1.07
2009Q4	5649	1.0	0.1	0.3	0.4	4.75	1.07
2010Q1	5777	1.0	0.1	0.3	0.4	7.82	1.04
2010Q2	5806	1.0	0.1	0.3	0.4	7.82	1.04
2010Q3	5836	0.9	0.1	0.3	0.4	7.82	1.04
2010Q4	5865	0.8	0.1	0.3	0.4	7.82	1.04
2011Q1	5895	0.8	0.1	0.3	0.4	12.8	0.92
2011Q2	6158	0.7	0.1	0.3	0.4	12.8	0.92
2011Q3	6421	0.7	0.1	0.3	0.4	12.8	0.92
2011Q4	6684	0.6	0.1	0.3	0.3	12.8	0.92
2012Q1	6948	0.6	0.1	0.3	0.3	17.67	0.86
2012Q2	7035	0.6	0.1	0.3	0.3	17.67	0.86
2012Q3	7123	0.6	0.1	0.3	0.3	17.67	0.86
2012Q4	7211	0.6	0.1	0.3	0.3	17.67	0.86
2013Q1	7299	0.6	0.1	0.3	0.3	20.3	0.8
2013Q2	7381	0.5	0.1	0.3	0.3	20.3	0.8
2013Q3	7462	0.5	0.1	0.3	0.3	20.3	0.8
2013Q4	7544	0.5	0.1	0.3	0.3	20.3	0.8
2014Q1	7625	0.5	0.1	0.3	0.3	22.21	0.84
2014Q2	7862	0.5	0.1	0.3	0.3	22.21	0.84
2014Q3	8098	0.5	0.1	0.3	0.3	22.21	0.84
2014Q4	8335	0.4	0.1	0.2	0.3	22.21	0.84
2015Q1	8571	0.4	0.1	0.2	0.3	27.86	0.88
2015Q2	8644	0.5	0.1	0.3	0.3	27.86	0.88
2015Q3	8718	0.6	0.1	0.3	0.3	27.86	0.88
2015Q4	8791	0.6	0.1	0.4	0.3	27.86	0.88
2016Q1	8864	0.7	0.1	0.4	0.3	38.29	1.11
2016Q2	11212	0.7	0.1	0.4	0.3	38.29	1.11
2016Q3	13561	0.7	0.1	0.4	0.3	38.29	1.11
2016Q4	15909	0.7	0.1	0.4	0.3	38.29	1.11
2017Q1	18258	0.7	0.1	0.4	0.2	37.15	1.11
2017Q2	18494	0.6	0.1	0.4	0.2	37.15	1.11
2017Q3	18731	0.6	0.1	0.3	0.2	37.15	1.11
2017Q4	18968	0.6	0.1	0.3	0.2	37.15	1.11
2018Q1	19205	0.6	0.1	0.3	0.2	36.2	1.11
2018Q2	19494	0.6	0.1	0.3	0.2	36.2	1.11
2018Q3	19783	0.5	0.1	0.3	0.2	36.2	1.11
2018Q4	20071	0.5	0.1	0.3	0.2	36.2	1.11
2019Q1	20360	0.5	0.1	0.3	0.2	39.8	1.02
Source	N	N	N	N	N	Ethio	Ethio
	B	B	B	B	B	telecom	telecom
	E	E	E	E	E		