Addis Ababa University School of Graduate Studies

Center for Regional and Local Development Studies

College of Development Studies

Interconnectedness of Electricity Consumption and Economic Growth in Ethiopia

By

Ephrem Tesfaye

A Thesis Submitted to Addis Ababa University
School of Graduate Studies, College of Development Studies,
Center for Regional and Local Development Studies
In Partial Fulfillment of the Requirements for the Degree of Master of Arts in
Regional and Local Development

Advisor: Andualem Goshu (PhD)

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Approved by Board of Examiners	**Signature**
ANDUALEM GOSHU (PHD) **ADVISOR**	______________________
KUMELA GUDETA (PHD) **INTERNAL EXAMINER**	______________________
BAMLAKU ALEMAREW (PHD) **EXTERNAL EXAMINER**	______________________

June, 2019

Declaration

This thesis is my original work and has not been presented for a degree in any other university and that all sources of material used for this thesis have been dully acknowledged.

Declared by

Name: EPHREM TESFAYE BELAYNEH

Signature: ________________________

Date: ___________________________

Confirmed by

Name of Advisor: ANDUALEM GOSHU (PH. D.)

Signature: ________________________

Date: ____________________________

Place and date of submission: Addis Ababa, June, 2019

"Sustainable Energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive."

Former UN Secretary-General Ban Ki-moon

May 2014

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Abstract

Globally, until recently, the Electricity Consumption - Economic Growth debate had produced conflicting and interesting outcomes. In order to provide support and useful information for policy advisers and to fill the knowledge gap in the area, this thesis investigated the short-run and long-run causal relationships between Economic Growth and Electricity Consumption as target variables in Ethiopia during the period 1988–2017. The research also included additional variables such as FDI, Government Expenditure and Net Export and will be the first in its kind on this topic while studied as a single country study in the Ethiopian case. This thesis employed Autoregressive Distributed Lag (ARDL) and Error Correction Model (ECM), as an econometric approach, with the help of statistical software EViews. The results have shown that all variables are I(0) and I(1); there is co-integration relation between the variables; but there is no causal relationship between electricity consumption and economic growth. Moreover, the results of the Granger Causality test confirm the neutrality hypothesis. Despite its enormous hydroelectric potential, Ethiopia does not yet meet its energy requirements in the power sector and Electricity Consumption accounts for only 2% of total Energy Consumption. The results should, therefore, be interpreted with care as Electricity is at the heart of development. Overall, the results of this study show that the long-run equilibrium relationship between electricity consumption and economic growth in Ethiopia needs further attention in future research.

Keywords: Economic Growth, Electricity Consumption, ARDL and ECM.

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List of Acronyms

AIC: Akaike Information Criterion
ADF: Augmented Dickey Fuller Test
ARDL: Autoregressive Distributed Lag
CSL: Co-integration, Saikkonen and Lütkepohl
EC: Electricity Consumption
EG: Economic Growth
EEP: Ethiopian Electric Power
EEU: Ethiopian Electric Utility
FDI: Foreign Direct Investment
GDP: Gross Domestic Product
GoE: Government of Ethiopia
HDI: Human Development Index
IPP: Independent Power Producer
JJC: Johansen and Juselius Co-integration
MDGs: Millennium Development Goals
MoWIE: Ministry of Water, Irrigation and Electricity
LR: Long-run
OECD: Organization for Economic Co-operation and Development
SDGs: Sustainable Development Goals
SR: Short-run
VAR: Vector Auto Regression Model
UN: United Nations

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the Study

Energy is an essential part of people's life to all lengths and widths of human activity, it is becoming a crucial input to nearly all of the goods and services of the modern society. Access to clean and affordable modern energy is at the heart of development, it is one of the most essential inputs into sustaining people's livelihoods. (World Bank, 2018). Some studies like (IHS CERA, 2012) even described modern energy as "The Oxygen of the Economy". Because without power and light people cannot build or run the factories and cities that provide goods, jobs and homes.

As compared to sub-Saharan African countries, Ethiopia is endowed with significant renewable energy resources. However, Ethiopia's energy consumption has mainly been based on traditional energy sources, such as fuelwood, charcoal and dung cakes ((JICA), 2010). According to the Ethiopian Ministry of Water, Irrigation and Electricity, in 2017, eighty-seven percent of the total energy consumption was from Traditional Biomass energy sources. Although much progress has been made in increasing the supply of electricity and electrification rate, Ethiopia's population still have a low access to electricity. In 2017 the total access to electricity was about 42.9[1] percent, leaving behind more than 60 million people in darkness. In the same period, the country has also low level of power generation capacity which is about 4,228[2] Mega Watt (MW) installed capacity.

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[1] Source: World Bank Data
[2] Source: World Bank Data

In modern societies one of the indispensable prerequisites for sustainable development is the sustainable growth of the industrial sector. It is essential to developing countries, to widen their development base and meet growing needs. The growing labor force in developing countries cannot be alone absorbed by the agriculture sector. Industry must provide these expanding societies not solely with employment but with products and services. The Energy Sector in general and the Power Sector in particular have a great importance to industrialization of countries and play a pivotal role in the economic transformation process (United Nations, 2016).

Various studies (Indrawati, 2015; HIS CERA, 2012: David I. Stern, 2016) have shown that modern Energy is incredibly necessary for development. Without it, people will conduct a primitive life. Besides necessary public services like health care and education can't be accessed, and businesses can operate under a difficult condition. Electricity is a secondary and flexible form of energy which is produced from the primary natural resources such as, hydropower, geothermal, wind, solar, oil, gas, coal, etc. In rural communities for instance, without electricity women are forced to travel long distances and spend hours fetching water, clinics cannot use refrigerators, students cannot do homework in the evening and more generally countries cannot transform their economies to be middle income and industrialized economies which intern create decent and value-adding jobs and grow the entire economy (Indrawati, 2015).

In general, energy security is now seen as an important prerequisite for sustainable development (Sami, 2011). In this regard, unlike the eight Millennium Development Goals (MDGs), cognizant of the role of modern energy in development, the United Nations (UN) encompassed Goal Seven - “Ensure access to affordable, reliable, sustainable and modern energy for all” in the 17 Sustainable Development Goals (SDGs). As further stated by the UN, Goal Seven is additionally necessary to achieve the targets of even other SDGs and is also essential for the process of tackling climate change (United Nations, 2015).

According to the UN 2018 report, from 2000 to 2016, access to electricity in the world increased tremendously, with the number of people living without electricity dropping from 78 per cent to 87 per cent or in absolute terms below 1 billion people, but these improvements were largely offset by population growth during the same period. The report further showed that in 2016, three billion individuals, nearly 41 percent of the world’s population were still cooking with polluting traditional fuels. Finally, the report concluded that national priorities and policy ambitions still must be reinforced to fulfill the energy targets by 2030 (UN, 2018).

Inadequate access to modern energy is also considered as a core dimension of poverty (Filho, 2012). Improving access to modern energy services requires a huge investment and needs to be supported by an enabling environment with the right policies and institutions (World Bank, 2018). On top of this, in order to attract investors in the sector it is important to have a deep understanding of the causal relationship and the direction of influence between electricity consumption and economic growth. The main aim of this thesis is therefore, to empirically determine the interconnectedness between electricity consumption and economic growth in Ethiopia over the sample period of 1988 to 2017.

In this framework, to support the rapid economic growth, use the huge potential of the Ethiopia’s energy resource potential and to meet the anticipated growth of the industrial sector, the Government of Ethiopia (GoE) implemented several plans and strategies including the current Growth and Transformation Plan II (GTP II). However, the country is still unable to lift more than half of the population out of energy poverty. In addition to this the inadequate and unreliable supply of electricity has been a bottleneck for both existing and new investors in the agricultural, service and industrial sectors.

1.2. Statement of the Problem

According to the World Bank (2018), over the past fourteen years, Ethiopia's economy has witnessed notable growth, with an average annual growth rate of 10.6%. However, Ethiopia also faces various development challenges including lowest rates of access to modern energy services like electricity, whereby the energy supply is predominantly based on biomass. For instance in 2017, the contribution of electricity to the total energy consumption was about 2% of the total energy consumption. This indicates that Ethiopia's electricity sector is underdeveloped.

Access to modern energy like electricity is strongly linked with poverty eradication (Filho, 2012). In connection to this Ethiopia was ranked 101 out of 105 countries with multidimensional poverty measure (OPHI, 2018). Even though, modern energy is crucial to reduce poverty and to bring economic development, the role of energy in general and electricity in particular on economic growth is not well recognized (Cleveland, 2004). There are many papers like for instance (Stern, 2013; Harrod, 2010; Cleveland, 2004) on the determinants of growth but most of them didn't consider electrical energy as one of the major inputs. This diverted the attention of policy makers to focus on other factors other than electric power.

It can, therefore, be inferred from this that reliable electricity is one of the important factors for development, especially for changing the lives of poor and marginalized people, for poverty alleviation and transforming the economy. Furthermore, electricity is one of the major important energy types that is environmentally friendly with zero pollution towards the end use point, which makes electricity a preferred source of modern energy. In order to invest more on electricity production, understanding the extent and effect of electricity on growth is quite important. Several studies supported the importance of reliable electricity supply to economic development; for instance, a survey conducted on a sample of more than a hundred countries endorsed the existence of a strong correlation between electricity usage and the level of economic growth (Ferguson, 2000). However, this study did not show the causal relationship between electricity consumption and economic growth. Other researchers extended Ferguson's analysis by including causality tests in both in developing and developed countries. But the different studies lack agreement on whether economic growth results in increased electricity consumption or is electricity the stimulant of economic growth. This electricity-growth debate and major disagreements together with other reasons attracted researchers to investigate the direction of causality between these variables" (Jakovac, 2018).

The causality relationship examined in six different studies reviewed namely from: Nigeria (Ogundipe, 2016), South Africa (M.Odhiamb, 2009), Ghana (Iyke, 2014), China (Shengfeng, 2012), Poland (Rafał Kasperowicz, 2014) and India (Chaturvedi, 2014) have shown that the causality relationship can be categorized into four classifications namely: One-way causality from Electricity Consumption to Economic Growth (EC→EG), one-way causality from Economic Growth to Electricity Consumption (EG→EC), a bi-directional causality from Electricity Consumption to Economic Growth and vice-versa (EC↔EG) and no causality between the two variables.

To the best of the researcher's knowledge, to date, two pieces of researches were done analyzing the case of Ethiopia. The first single-country study was entitled "Energy consumption and economic growth in Ethiopia" (Nyasha, 2016). This study focused on the wider scope of the energy sector specifically on the major traditional energy sources such as fuelwood, charcoal and dung cakes based on the data collected from the periods 1971 to 2013. The second study was a multi-country study under the title “The Analysis of Relationship between Economic Growth and Electricity Consumption in Africa by ARDL Method” done for 11 African countries including Ethiopia by (Bildirici, 2013). The second study is similar to what this thesis investigating but the drawback of the second study was that it failed to include most of the recommendations that are believed to alleviate the discrepancies and inconsistencies between the various studies results observed in the literature. Therefore, based on the recommendations given by researchers like for instance by (Apergis, 2009) and (Jakovac, 2017) and in the intention of increasing the robustness of the final causality results, this research, in addition to the two target variables (Electricity Consumption and Economic Growth), incorporated additional variables namely: Foreign Direct Investment (FDI), Government Expenditure and Net Export in the analysis. In doing so, this research is able to avoid omitted variable bias to some extent, since these variables can affect both Economic Growth as well as Electricity Consumption. Apart from that, this thesis is a single country study for Ethiopia and focuses on the period 1988–2017 and the corresponding data, this makes the research to match the causal relationship analysis to the sampling period because, since 1988, Ethiopia has gradually moved to the path of economic growth.

Ethiopia has been performed very well in terms of economic growth, however, the power sector in Ethiopia is exposed to many challenges like Scarcity of Finance, Low Performance Capacity, Low Private Investment (Foreign Direct Investment), low and non-cost reflective tariff, high losses and frequent outages. Besides, Ethiopia does not yet meet its energy requirements in the power sector and Electricity Consumption accounts for only 2% of total Energy Consumption. The ability to establish the exact causal pattern between Electricity

Consumption and Economic Growth has a huge relevance to the country's power sector policy direction. Therefore, to provide support and useful information for policy advisers and to fill the knowledge gap in the area, the causality between electricity consumption and economic growth in the Ethiopian context needs to be investigated separately and this will be the first of its kind and content.

1.3. Research Questions

The general and specific objectives of the study would be achieved by way of seeking answers to the following research questions in the Ethiopian context:

- What are the short-run and/or long-run relationships among Electricity Consumption and Economic Growth?
- What is the direction of causality between Electricity Consumption to Economic Growth?
- What is the combined effect of Electricity Consumption, FDI, Government Expenditure and Net Export on Economic Growth/GDP?

1.4. Objectives of the Study

The primary objective of this research is to examine the causality between economic growth and electricity consumption in Ethiopia.

Specific objectives will be:

- To determine the short and long run relationships between electricity consumption and economic growth;
- To define the direction of causality between economic growth and electricity consumption;

- To examine the individual and combined impacts of Electricity Consumption, Foreign Direct Investment (FDI), Government Expenditure and Net Export on Economic Growth/GDP.

1.5. Significance of the Study

Studying the causality between Economic Growth (EG) and Electricity Consumption (EC) in Ethiopia can help to make contributions in the following areas:

- Currently, the Government of Ethiopia (GoE) has been making huge investments in the power sector expecting that the demand/consumption will grow by the time the power plants are ready for use. Therefore, this study can support the GoE to plan its infrastructure investment priorities both at national, regional and local levels;
- The study can help the Ethiopian Ministry of Energy and the Ethiopian Electric Power (EEP) to prepare a least cost Power Sector Development Programs and to predict the electricity demand both in the short and long-run, as the economy grows;
- It can provide support and useful information for the policymakers by defining the causal link between EC and EG. This can assist policy makers in framing the Energy and Electricity Policies, and Energy and Electricity Conservation Policies of Ethiopia. The strategies that can be developed from these policies will attract Foreign Direct Investment (FDI) and positively impact stakeholders and various sectors of the economy. This will eventually facilitate the creation of decent and value-adding jobs.
- In addition to this, it can provide information for entrepreneurs who have the interest to come to the country and participate in the manufacturing sector. At the same time, policymakers can use this information to attract investment into the country.

- Last but not least, the study can contribute to the existing literature on EC and EG relationship.

1.6. Scope and Limitation of the Study

This research aimed at finding the causal relationship and the direction of influence between Economic Growth and Electricity Consumption in Ethiopia by incorporating additional variables indicated above. The data used in the analysis cover the period 1988–2017. The Electricity Consumption data used in the analysis only cover the data of the main electricity grid users, obtained from the Ethiopian Electric Power. This study did not cover some of the few electricity users that get their electricity supply from private and off-grid electricity supply sources like small solar panels, mini and micro hydropower plants found in remote rural areas. The limitation of this study is, therefore, set by the inclusion of electricity consumption data from the main grid and by excluding small off-grid electricity supply sources in the analysis.

In addition to the two target variables namely Economic growth and Electricity Consumption, due to time constraint and limitation of the scope, the analysis only incorporated macro level data like FDI, Government Expenditure and Net Export as additional variables in the analysis, it did not include other variables like Total Population, Financial development, Carbon dioxide emissions, etc., which may have impact in the outcome of the study. On top of this, even though, it is easier to find evidence for causal effects using more disaggregated micro level data, the study did not use disaggregated micro level data to see the distinct features of the different sectors of the economy.

1.7. Organization of the Study

The rest of the thesis is organized in to four chapters. The second chapter is concerned with the review of different researches and related literature dealing with the assessment of interconnectedness among electricity consumption and economic growth. This chapter also includes an overview of the Ethiopian economy and the Electricity sector. The third chapter presents methodologies used in conducting the study, research design, data sources, data collection procedures and methods of data analysis. In Chapter four the main body of the research findings of the econometric and statistical data analysis is shown. Finally, Chapter five recapitulates the study in terms of summary, conclusions, and recommendations of the study.

CHAPTER TWO

2. REVIEW OF THE THEORETICAL LITERATURE AND EMPIRICAL EVIDENCE

This chapter provides a review of literature that has attempted to explain the relationship between economic growth and electricity consumption. It begins with the theoretical literature where it deals with basic theories on the topic then it will move to empirical literature followed by the conceptual framework.

2.1. Review of the Theoretical Literature

Physical theory or Physical Science shows that energy is necessary for economic growth and production, it is one of the essential factors of production and continuous supplies of energy are needed to maintain existing levels of economic activity; however, the mainstream theory of economic growth, apart from specialized resource economics models, pays no attention to the role of energy. Understanding the role of energy in the mainstream theory of growth isn't thus simple and the role of energy in production, economic growth and development are downplayed (Cleveland, 2004). For instance, according to (Stern, 1996) mainstream economists usually think, of capital, labor, and land as the primary factors of production, while goods such as fuels and materials are intermediate inputs. The prices paid for all the various inputs are seen as eventually being payments to the owners of the primary inputs for the services provided directly or embodied within the produced intermediate inputs. This approach has led to a focus in mainstream growth theory on the primary inputs, and in particular, capital and labor, and the attribution of a lesser and somewhat indirect role to energy.

One of the mainstream theories of growth, known as the neoclassical growth model, is the Nobel prize-winning work by Robert Solow (Solow, 1956). The initial Solow model doesn't embody energy resources, however, the model later was extended with nonrenewable resources, renewable resources, and a few waste assimilation services. These extended models, however, have solely been applied within the context of debates about environmental sustainability, not in normal macroeconomic applications (Cleveland, 2004).

Ecological Economics, referred to as the biophysical economics approach that relies on thermodynamics, usually argue that substitution between capital and resources, like energy, will solely play a restricted role in mitigating the insufficiency of resources (Georgescu-Roegen, 1971; Cleveland et al., 1984; Hall et al., 2001; Ayres and Warr, 2009; Murphy and Hall, 2010). Furthermore, according to Stern (1996) some ecological economists argue that after we account for the role of energy, there's very little role left for technological amendment in driving economic growth (Hall et al., 2001). In order to better integrate the biophysical and mainstream economics approaches, Stern and Kander (2012) modified Solow’s neoclassical growth model by adding an energy input that has low interchangeability with capital and labor, whereas permitting the elasticity of substitution between capital and labor to stay one. This is the alleged nested constant elasticity of substitution (CES) production function. The model also breaks down technological change into innovations that directly increase the productivity of energy (energy-augmenting technological change) and those that increase the productivity of people (labor-augmenting technological change) (Stern, 2016).

Depending on the deficiency of energy, the modified model displays either neoclassical or energy-constrained behavior (Stern and Kander, 2012). When energy is abundant the extent of the capital stock and output are determined by the identical factors as in the Solow model. However, once energy is comparatively scarce, the dimensions of the capital stock and also the level of output rely on the extent of energy supply and also the level of energy-augmenting technology. In the pre-industrial era when energy was scarce, the model suggests that increases in energy availability and energy-augmenting technology had a lot of larger effects on economic growth than they are doing in developed economies these days. Till the Industrial Revolution, output per capita was typically low and economic growth was not sustained (Maddison, 2001). After the Industrial Revolution, as energy became more and more abundant, the long-run behavior of the model economy becomes progressively similar to the mainstream Solow growth model.

Kander (2012) demonstrated that this modified model can simulate the observed features of one of the developed countries economy within the last two centuries, together with the fall in the cost share of energy and the decline in energy intensity over time. He found out that increments in energy use and energy-augmenting technological changes are the main contributors to economic growth within the nineteenth and early Twentieth Centuries. In the second half of the Twentieth Century labor-augmenting technological change becomes the main driver of growth in income per capita as it is in the Solow growth model.

If this modified model is a realistic demonstration of the growth process, mainstream economists aren't therefore so wrong to ignore the role of energy in economic growth in developed economies where energy is abundant. Their models may, however, have limited applicability to both earlier historical periods and possibly to today's developing countries. For the lowest-income economies, energy availability is potentially a "binding constraint" to economic growth in the sense of Hausmann, Rodrik, and Velasco (2008). In spite of the fact that energy is internationally traded and so countries are not necessarily limited to their domestic resources, its cost in poor countries is high relative to labor, and importing and using energy requires investment in infrastructure.

Reducing the scarcity of energy would possibly therefore, be expected to supply larger advantages in terms of economic growth in developing economies than in developed economies (Bacon and Kojima, 2016).

Modern Energy or electric power is a top quality energy carrier– more productive and flexible than other energy vectors, with zero pollution towards the end use point. Electric power is far more thermodynamically efficient than any alternative innovation in applications such as lighting and information communication technologies (Kaufmann, 1994).

In contrast to this, traditional fuels are polluting and often require significant inputs of household labor in gathering, handling, and use. Economic development offers market opportunities for employment and the way to stay away from the negative impacts of conventional power sources such as traditional fuels is important. Along these lines, as incomes increase, families steadily climb an "energy ladder" by consuming higher quality technologies such as clean electricity (Hosier, 2004), although this does not mean giving way traditional fuels altogether (van der Kroon, Brouwer, and van Beukering, 2013) or that incomes are the only factor relevant to household energy transitions (Burke and Dundas, 2015).

In addition to this, several scholars (Burke, 2013; Burke and Csereklyei, 2016; Rubio, 2016) have shown that there is a move to a higher share of electric power in energy use as income per capita increases. This close connection between electricity and economic activity has led some scholars to use "night light data" to improve the measurement of economic growth (e.g. Henderson, Storeygard, and Weil, 2012).

As outlined by Toman and Jemelkova (2003) some of the ways in which increased energy availability could disproportionally affect development outcomes. Most of them are particularly applicable to electricity: reallocation of family time, particularly for women and girls, away from energy provision towards improved education and income generation; increased productivity of education investment because children will have the ability to study at night; the ability to use new technologies including computers and cell phones; and health benefits resulting from outcomes such as reduced indoor air pollution, availability and use of modern clinics, vaccinations and the ability to refrigerate (Toman and Jemelkova, 2003).

Therefore, although the mainstream theory of growth pays less attention to the role of energy in production, economic growth and development, the theoretical and empirical proof demonstrated that energy use and output are tightly coupled with energy availability playing an important role in enabling growth. The experience of developed countries exhibited that the electricity sector played a critical role in their economic development not only as a crucial input in their industrial development but also as a key factor in improving the quality of life of their people which is important for the general well-being of individuals and societies (Rosenberg, 1998).

2.2. Empirical Literature Review

As stated by (Jakovac, 2018; Apergis and Payne, 2009) a number of empirical studies have been done on the causal relationship between electricity consumption and economic growth both in developed and developing countries. However, the empirical findings from these studies have been mixed and contradictory. This difference might be related to the use of different econometric methodologies, different data set and different countries' characteristics.

According to (Jakovac, 2018) the first research paper that is believed to be done on the topic of interconnectedness between electricity consumption and economic growth was done by Ramcharran, 1990. He stated that the causal link between electricity consumption and economic growth can be categorized into four hypotheses: The first is the hypothesis that emphasizes one-way causality from electricity consumption to economic growth. In this case an economy will grow if policymakers increase the amount of electricity in a country which also means that a shortage of electricity may adversely affect economic growth; secondly, the conservation hypothesis which postulates one-way causality from economic growth to electricity consumption; thirdly, the neutrality hypothesis that recommends the absence of a causal relationship between electricity consumption and economic growth and finally the fourth hypothesis is the feedback hypothesis that emphasizes the interdependent relationship between electricity consumption and economic growth in which causation runs in both directions (Jakovac, 2018).

In order to compare and contrast the empirical researches done with regards to the causal relationship between electricity consumption and economic growth, this study separately analyzed the studies done in developing and developed countries and further explored the studies for a single-country and multi-country studies done for several countries.

2.3. Empirical Literature of Developing and European Countries

2.3.1. Developing Countries Analysis

2.3.1.1. Country-Specific Studies

The country-specific studies that this study analyzed for developing countries include the studies done for, Uganda (Sekantsi, 2016), Burkina-Faso (Ouédraogo, 2012), Ghana (Iyke, 2014), Nigeria (Ogundipe, 2016), Cameroon (Tambaa, 2017), Pakistan (Shahbaz, 2012), Botswana (Amusa, 2013), South Africa (M.Odhiamb, 2009) and China (Shengfeng, 2012). These countries are categorized as Lower income, Lower middle-income, and Upper middle-income countries by the World Bank in 2017.

As can be seen from the studies listed in Table 1 below, the study results are mixed and do not follow any pattern. For instance, if we compare the low-income countries, like Uganda and

Burkina-Faso the study results showed different findings. The study result for Uganda supported conservation hypothesis in the short-run and feedback hypothesis in the long-run but that of Burkina-Faso showed the feedback hypothesis that emphasizes the interdependent relationship between electricity consumption and economic growth in which causation runs in both directions.

Similarly, the lower middle-income countries namely: Ghana, Nigeria, Cameroon, and Pakistan, showed mixed results. Nigeria's results showed that the direction of causality is running from electricity consumption to GDP. The study from Ghana is the opposite and it supported conservation hypothesis which postulates one-way causality from economic growth to electricity consumption. The study result for Cameroon is different from the others and it supported the neutrality hypothesis which emphasizes the absence of a causal relationship between electricity consumption and economic growth.

In the same manner, mixed results were observed for the three upper-middle income countries Botswana, South Africa, and China. The result for Botswana showed that Electricity Consumption does not have a short-run effect on Economic Growth but it has a significantly positive effect on GDP in the long-run while the study done for South Africa showed a one-way causality running from electricity consumption to economic growth, the study for China supported the feedback hypothesis that emphasizes the interdependent relationship between electricity consumption and economic growth in which causation runs in both directions.

Table 1: Summary of literature review for EC and EG for selected Developing Countries - Country-specific Studies

No.	Author	Country	Income Group	Period	Methodology	Results
1	Sekantsi, Lira Peter, 2016	Uganda	Low income	1981 - 2013 (done 2016)	ARDL bounds testing and Granger causality tests	Supported conservation hypothesis in the SR and feedback hypothesis in the LR
2	Ouédraogo, Idrissa M., 2012	Burkina-Faso	Low income	1968-2003	Bound testAAAaaAAAA	GDP, Electricity Consumption EC ↔ EG
3	Iyke, Bernard N., 2014	Ghana	LMI	1971–2012 (done 2014)	Trivariate ARDL	EG➔ EC
4	Ogundipe, Adeyemi A., 2016	Nigeria	LMI	1980–2008 (done 2009)	JJC technique based on the Cobb-Douglas VECM & the Pairwise Granger Causality test	EC ➔ EG
5	Tambaa, Jean Gaston 2017	Cameroon	LMI	1971–2013 (done 2017)	Johansen co-integration test, VAR model, and the Granger causality test	Supported neutrality hypothesis
6	Shahbaz, Muhammad, 2012	Pakistan	LMI	1972 – 2009 (done 2012)	ARDL bounds testing approach to CSL structural break unit root test and VECM Granger causality	Supported feedback hypothesis EC ↔ EG. Both in the SR and LR
7	Amusa, Kafayat, 2013	Botswana	UMI	1981 - 2010 (done 2013)	ARDL technique of bounds test approach to co-integration	EC does not have a SR effect on EG, but it has a significantly positive effect on GDP in the LR
8	M.Odhiamb, Nicholas, 2009	South Africa	UMI		Employment Rate included Trivariate causality framework	EC ➔ EG Both in the SR and LR
9	Shengfeng, Xiao, 2012	China	UMI	1953-2009 (done 2012)	VEC	EC ↔ EG Both in the SR and LR

Source: Prepared by the researcher from the various single country studies

Note: EG = Economic Growth, EC = Electricity Consumption VAR = Vector Auto regression Model; ARDL approach = Autoregressive Distributed Lag approach; VECM = Vector Error Correction Model; Co-integration, Saikkonen and Lütkepohl (CSL), Autoregressive Distributed Lag (ARDL), Johansen and Juselius Co-integration (JJC), Short-run=SR, Long-run (LR), Lower middle income=(LMI), Upper middle income=(UMI)

2.3.1.2 Multi-Country Studies

The detailed multi-country studies that this study reviewed for developing countries include the studies done by (Wolde-Rufael, 2004) and (Bildirici, 2013). Wolde-Rufael included 17 African countries namely Algeria, Benin, Cameroon, Congo DR., Congo, Rep., Egypt, Gabon, Ghana, Kenya, Morocco, Nigeria, Senegal, South Africa, Sudan, Tunisia, Zambia, Zimbabwe. This paper tested the long-run and causal relationship between electricity consumption per capita and real gross domestic product (GDP) per capita for the aforementioned countries for the period 1971–2001 using the Pesaran cointegration test and using a modified version of the Granger causality test by Toda and Yamamoto (1995).

As can be seen from the studies listed in Table 2 below, the study results showed that there exists a long-run relationship between electricity consumption per capita and real GDP per capita for only 9 countries and Granger causality for only 12 countries. For 6 countries there was a unidirectional causality running from real GDP per capita to electricity consumption per capita; an opposite causality for 3 countries and bidirectional causality for the remaining 3 countries. The fact that the paper was done 14 years ago and by taking into consideration the level of development of the Economy and the Power Sector at the time of analysis, the result should be interpreted with care. In addition to this, the study tested the causal relationship between electricity consumption per capita and real gross domestic product (GDP) per capita which is different from comparing the causal relationship between electricity consumption and real gross domestic product (GDP) as done for the other studies.

Table 2: Summary of literature review for EC per capita and GDP per capita for selected Developing Countries – Multi-country Studies

No.	Country	Results
1	Algeria	No causality
2	Benin	Electricity Consumption → GDP per capita
3	Cameroon	GDP per capita → Electricity Consumption
4	Congo, DR.	Electricity Consumption → GDP per capita
5	Congo, Rep.	No causality
6	Egypt	Electricity Consumption ↔ GDP per capita
7	Gabon	Electricity Consumption ↔ GDP per capita
8	Ghana	GDP per capita → Electricity Consumption
9	Kenya	No causality
10	Morocco	Electricity Consumption ↔ GDP per capita
11	Nigeria	GDP per capita → Electricity Consumption
12	Senegal	GDP per capita → Electricity Consumption
13	South Africa	No causality
14	Sudan	No causality
15	Tunisia	EC →GDP per capita
16	Zambia	GDP per capita → Electricity Consumption
17	Zimbabwe	GDP per capita → Electricity Consumption

Source: Wolde-Rufael, Yemane, 2004

The second multi-country study reviewed in this study was done by (Bildirici, 2013). The research paper examined the relationship between Electricity Consumption and Economic Growth by using Autoregressive Distributed Lag (ARDL) bounds testing approach and vector error-correction models (VECM) in Cameroon, Congo, Ethiopia, Gabon, Ghana, Guatemala, Kenya, Senegal, Togo and Zambia for the period 1970-2010. The study results showed that there is co-integration relation between electricity consumption and economic growth in ten of the eleven countries. The study results further described that in the short-run growth hypothesis exists in Cameron, Congo Rep., Ethiopia, Kenya and Mozambique and the conservation hypothesis in Senegal and Zambia. For Gabon, Ghana and Guatemala, there exists a bi-directional causality between economic growth and electricity consumption both in the short and long-term. In the long-run, the study results showed that there exists a bidirectional causality running between economic growth and electricity consumption for all countries except for Cameron and Togo. The study results are shown in Table 3 below.

Table 3: Summary of literature review for EC and EG for selected Developing Countries – Multi-country Studies

No.	Country	Results
1	Cameroon	Growth Hypothesis Electricity Consumption ➔ Economic Growth in the short-run and Neutrality Hypothesis in the long-run
2 3 4 5	Congo Rep. Ethiopia Kenya Mozambique	Growth Hypothesis or Electricity Consumption ➔ Economic Growth in the short term and Electricity Consumption ↔ Economic Growth in the long-run
6 7	Senegal Zambia	Conservation Hypothesis Economic Growth ➔ Electricity Consumption in the Electricity Consumption ↔ Economic Growth
8 9 10	Gabon Ghana Guatemala	Bi-directional Causality Electricity Consumption ↔ Economic Growth both in the short term and in the long-run
11	Togo	No causality

Source: (Bildirici, 2013)

The single and multi-country studies have shown similar results for Cameroon in the short-term but opposite results for Ghana (Single country study showed EG➔ EC and in the multi-country study showed EC ↔ EG).

2.3.2. European Countries

The causal relationship shown in table 4 contains around 79 studies in Europe. The result of the study for these European countries, like the studies mentioned in the above section does not follow any pattern. For instance, high-income countries like France, Luxembourg, Norway, Germany, Portugal and United Kingdom empirical results showed the absence of a causal relationship. But other high income countries analyzed in the study showed different results like for example the direction of causality for Portugal and Poland showed bidirectional (GDP↔EC), for Switzerland, Netherlands and Finland a unidirectional causality running from GDP to electricity consumption

(GDP→EC) and for Italy and Portugal a unidirectional causality running from electricity consumption to GDP (GDP←EC).

By the same token, Jakovac, 2017 studied the existing literature for both European and non-European countries. The study divided the pieces of literatures into OECD member countries and non-OECD countries (Organization for Economic Co-operation and Development). Accordingly, the causality analysis results of OECD countries showed that in 35.48% of cases, electricity consumption affects economic growth compared to 33.87% of cases where causality runs from GDP to electricity consumption. In the case of non-OECD countries, the study revealed that that electricity consumption affects GDP in 58.92% of cases as compared to 54.26% of cases where it is found that causality runs from economic growth to electricity consumption. The list of the analyzed European countries is shown in table 4 below and the studies that were done worldwide are listed in table 13 in the Appendix A.

2.4. Overview of the Ethiopian Economy and the Electricity Sector

2.4.1 Overview of the Ethiopian Economy

Ethiopia is located in the Eastern part of Africa with a population of about 105[3] million people with an annual population growth rate of 2.5%[4] per annum. This makes the country to be the second most populous country in Africa after Nigeria (World Bank 2017). As reported by the World Bank, Ethiopia remains one of the poorest countries in the world with per capita income of $767.6[5] per annum in 2017. Although, according to the World Bank, poverty headcount ratio at

3 Source: World Bank
4 Source: World Bank
5 Source: World Bank

national poverty lines as a percentage of population has fallen from 44.2[6] percent in 1999 to 23.5[7] percent in 2015, an estimated 23 million people are still living below the poverty line in 2017 ((AfDB)).

Ethiopia's economy is predominantly based on agriculture and it accounts for about 35.8% of the country's gross domestic product (GDP), 70% of the total exports and 68% of total employment. (World Bank 2017).

Ethiopia has been a good performer in terms of economic growth and the expansion of social services over the past decade (UNDP, 2018). According to the World Bank data, economic growth averaged 10.6[8] percent between 2004 and 2017 (Figure 2 depicts the year to year GDP Growth of Ethiopia). GDP at current US$ more than doubled from US$30 billion in 2010 to US$ 81 billion in 2017 (Figure 3) (World Bank, 2017). According to official statistics, the growth was at 10.9% during fiscal year 2017. Agriculture, construction and services accounted for most of the growth, with modest contribution from the manufacturing sector. Private consumption and public investment explain demand-side growth. The growth in real GDP was mainly attributed to 10.3 percent growth in services, 6.7 percent in agriculture and 18.7 percent in industrial sectors in 2017 (National Bank of Ethiopia (NBE), 2018).

Ethiopian Foreign direct investment or net inflows (BoP, current US$) increased from US$ 0.0017 in 1988 to US$ 0.278 billion in 2012 and further to USD 4.0176 billion in 2017. In the same manner the FDI as a percentage of GDP increased from 0.643 in 2012 to 5.464 in 2016 but slightly deceased to 4.986 percent in 2017 (World Bank 2017).

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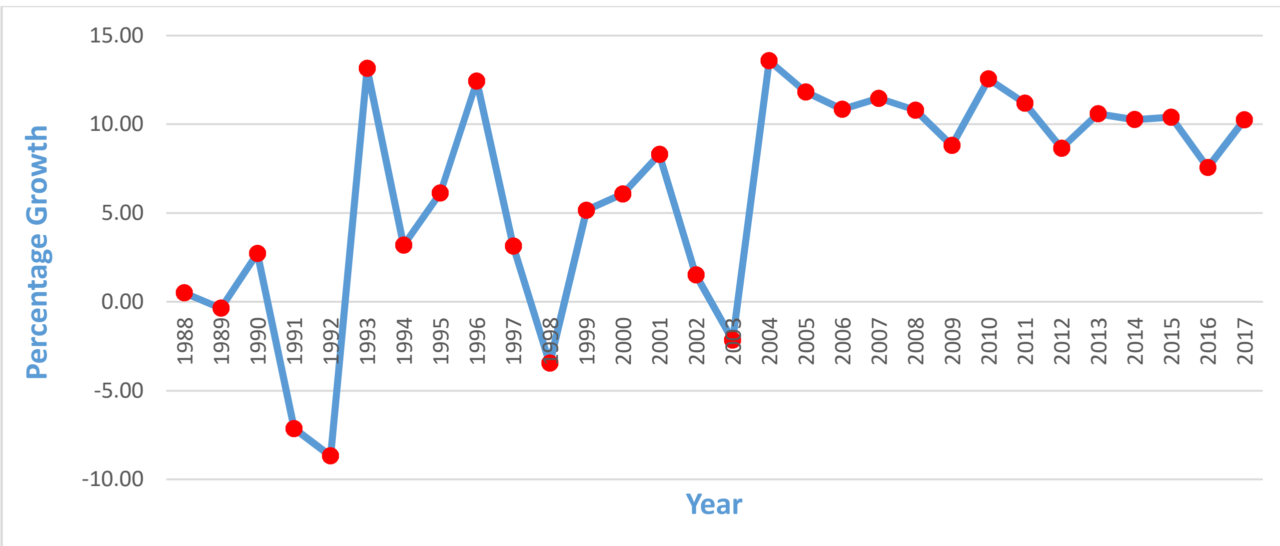
6 Source: World Bank

7 Source: World Bank

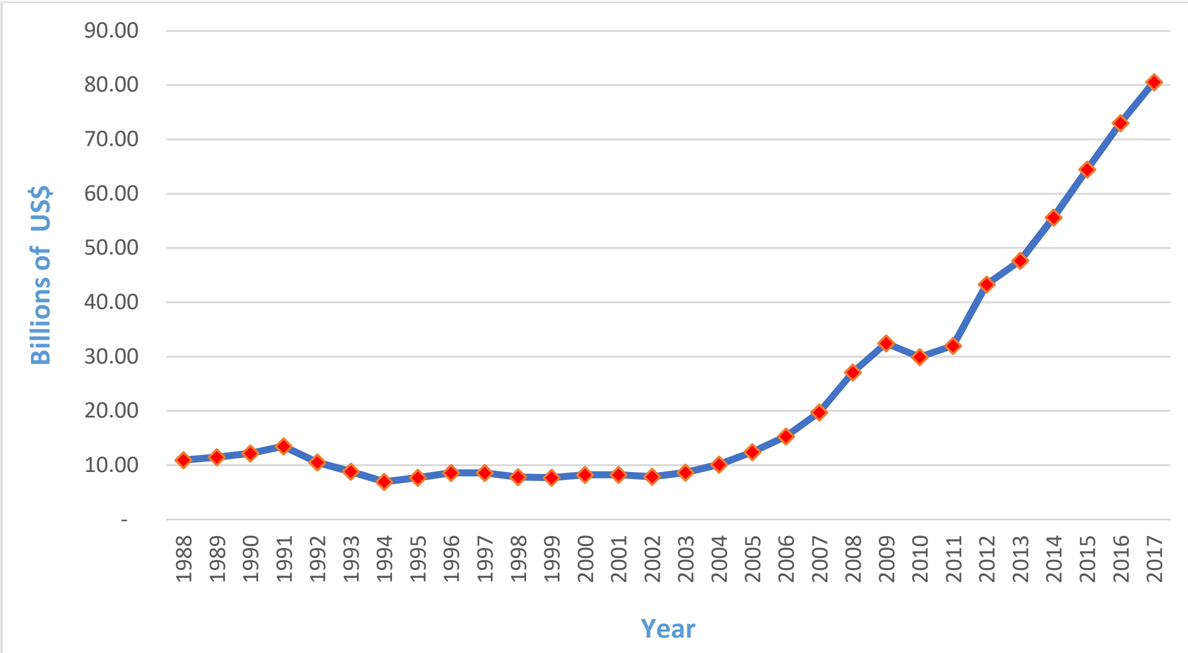
8 Calculated from World Bank data

Following the first Growth and Transformation Plan, in 2016 the Government of Ethiopia (GoE) prepared and published the current five-year plan (2015/16-2019/20) known as the Growth and Transformation Plan II (GTP II). GTP II aims to continue expanding physical infrastructure through public investments and to transform the country into a manufacturing hub. GTP II targets an average of 11% GDP growth annually, and in line with the manufacturing strategy, the industrial sector is set to expand by 20% on average, creating more jobs. According to this plan Ethiopia aims to reach lower-middle-income status by 2025.



Source: Made by the researcher from World Bank Data

Figure 1: Year to year GDP growth of Ethiopia



Source: Made by the researcher from World Bank Data

Figure 2: GDP of Ethiopia (Billions of US$)

2.4.1.1. Ethiopia's Development Challenges

According to the World Bank, Ethiopia's main development challenges include sustaining its positive economic growth and accelerating poverty reduction, which both require major progress in job creation as well as improved governance. The GoE has allocated excessive percentage of its budget to pro-poor programs and infrastructure investments. The pro-poor programs are also supported by the various donors. (World Bank, 2018)

The major challenges include:

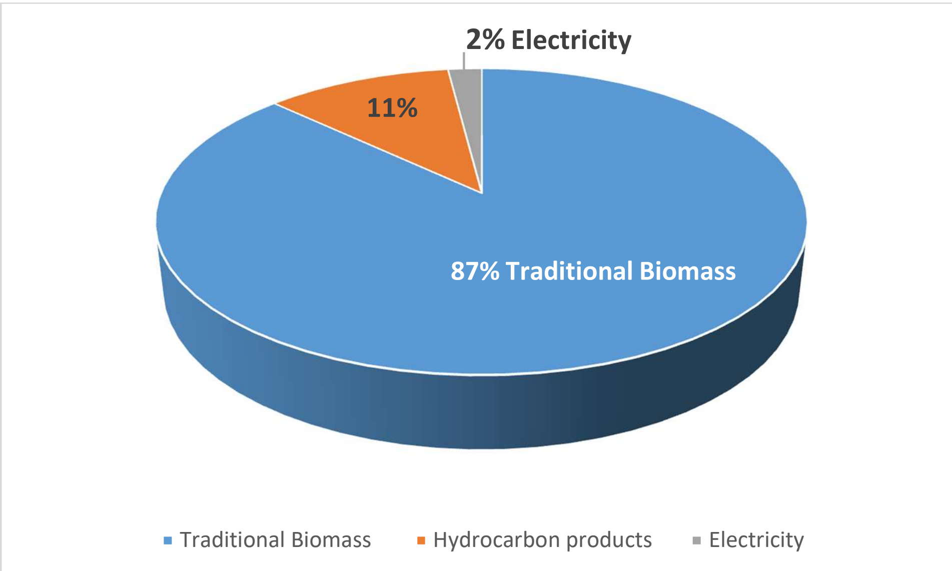
- Low competitiveness with poor private sector participation in major economic sectors, which constrains the development of manufacturing, the creation of jobs and the increase of exports;
- An underdeveloped private sector, which would limit the country's trade competitiveness and resilience to shocks.

- Political instability in the country, related mainly with social turmoil due to ethnic conflicts, could negatively impact growth through lower FDI, tourism and exports.
- Government debt and scarcity of foreign currency etc. (World Bank, 2018).
- Low Human Development Index (HDI). The HDI (long and healthy life, access to knowledge and a decent standard of living) for 2017 is 0.463. Ethiopia is ranked at 173 out of 189 countries (UNDP, 2018);
- In general Ethiopia has an insufficient or low productive capacity in all its forms namely: Low Productive resources, low Entrepreneurial capabilities and low Production linkages or linkages amongst enterprises. The combination and dynamic interaction of these elements determine a country's capacity to produce goods and services, to generate sufficient employment opportunities for a growing population, and to integrate successfully into international trade (United Nations, 2018);

2.4.2. The Electricity Sector in Ethiopia

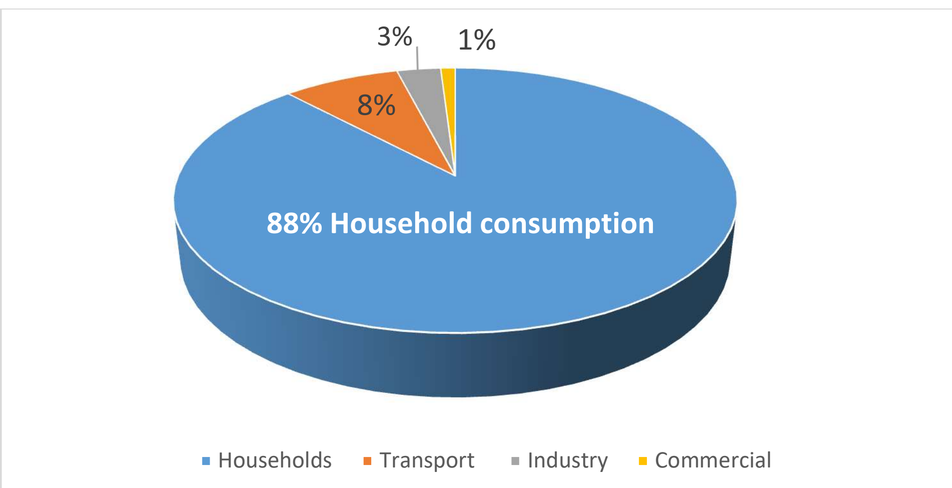
The Ethiopian Energy policy emphasize the need for equitable development of the sector in parallel with social and economic development. Specific policy lines include, "the attainment of self-sufficiency through the development of indigenous resources with minimum environmental impact and equitable distribution of electricity in all regions." The policy envisages the development of hydro, geothermal, natural gas, wind and solar energy resources based on their technical, financial and economic viability, social and environmental acceptability (MoWE, 2013).

As reported in figure 3, in 2017, the Ethiopian Energy consumption is predominantly dominated by Traditional fuels/Biomass energy sources representing 87 percent of the total energy consumption. The remaining 11% and 2% came from Hydrocarbons and Electricity respectively. In the same year, in terms of sectorial proportion 88 percent of the total energy produced was consumed by households. Transport, Industries and commercial sectors consumed 8%, 3%, and 1% respectively (Figure 4) (MoWIE, 2018).



Source: Made by the researcher from the data obtained from the Ministry of Water, Irrigation and Electricity

Figure 3: Ethiopian Energy Consumption by type in 2017



Source: Made by the researcher from the data obtained from the Ministry of Water, Irrigation and Electricity

Figure 4: Ethiopian Energy Consumption by sector in 2017

To support rapid and sustainable growth and industrialization, Growth and Transformation Plan II (GTP II) highlighted developing the manufacturing sector and processed agricultural products by increasing the power generating capacity of the country to 8000MW by the end of the planning period. This was planned to be achieved by building major dams like the Grand Ethiopian Renaissance Dam (GERD), Gibe III and other hydropower projects. (Federal Democratic Republic of Ethiopia National Planning Commission, 2016).

Electricity generally passes through three-step phases before getting to the final user. First power is produced from generators which are located far from the load centers. Power is then transferred to the transmission grid, which comprises transmission lines, transformers, and other components, to the bulk load distribution substations. From the bulk load distribution substations power is delivered to the individual customer sites using distribution lines.

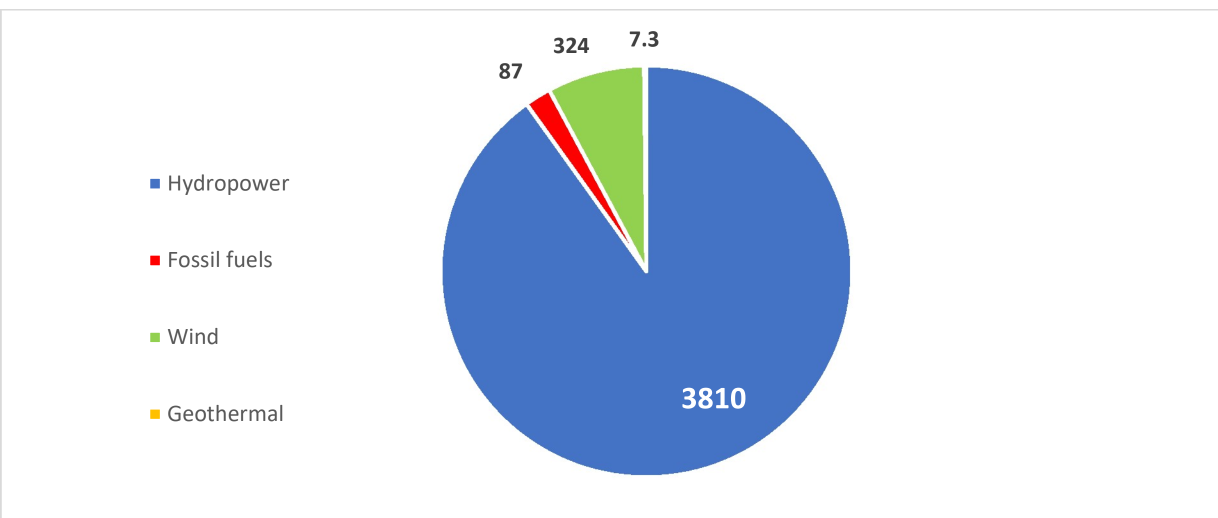
The Ethiopian Power Sector is totally owned by the Ethiopian Government and these three-step process are controlled by two different utility companies. These utilities are the Ethiopian Electric Power (EEP), which is responsible for transmission and Generation of electricity and Ethiopian Electric Utility (EEU) is responsible for distribution and sales of electricity.

Ethiopia is endowed with a huge potential of Hydropower, Geothermal, Solar and wind energy resources. Ethiopia has an under-developed Electricity sector, currently from the exploitable reserve of 45,000MW hydropower potential, the country is able to exploit less than 10% and this restrained the economic activities in the country. In 2017, the country has only 4,228[9] MW of installed generation capacity, with 90[10] percent produced from hydropower, 8 percent from wind, 2.0 percent from fossil fuels and 0.2 percent from geothermal sources (Figure 4). The electricity sector has experienced significant growth over the last twenty years. The electricity generation

9 Data obtained from the Ethiopian Electric Power
10 Calculated from the data obtained from the Ethiopian Electric Power

increased from 1,048 Giga Watt hour (GWh) in 1989 to 3,547 in 2008 and to 11,756 GWh in 2017 showing a 3 folds increase in the last ten years. In the same manner the electricity consumption increased from 879 GWh in 1989 to 2,836 in 2008 and to 9,710 GWh in 2017. The electricity consumption has also shown the same trend with a 3 folds increase in the last ten years (Figure 7). In addition to the local consumption, currently, Ethiopia is exporting a total of 195MW[11], which is 140 MW to Sudan and 55 MW to Djibouti. (EEP, 2017)

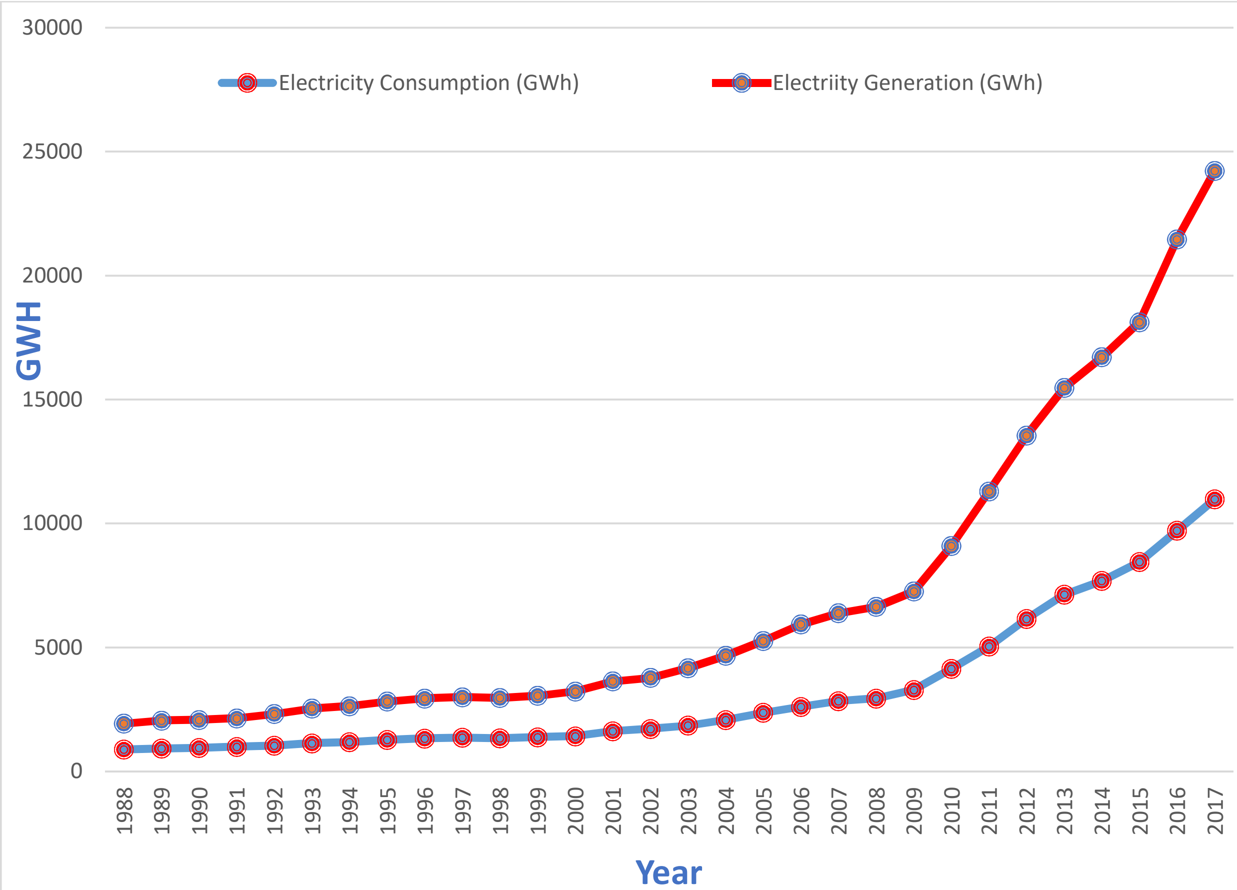
Ethiopia is one of the few countries in Sub-Saharan Africa, which generates 99 per cent of its electricity from renewable resources. The per capita electricity consumption of Ethiopia is approximately 70[12] kWh/year which is substantially less 483[13] KWh/year per capita compared to all Sub-Saharan Africa excluding higher income countries. Moreover in 2017, only 42.9[14] per cent of the population has access to electricity, which is almost doubled as compared to 21.7[15] per cent access in 2008. (WB, 2018).



Source: Made by the researcher from the data obtained from Ethiopian Electric Power

11 The data about export is found from the Ethiopian Electric Power
12 World Bank data
13 World Bank data
14 World Bank data
15 World Bank data

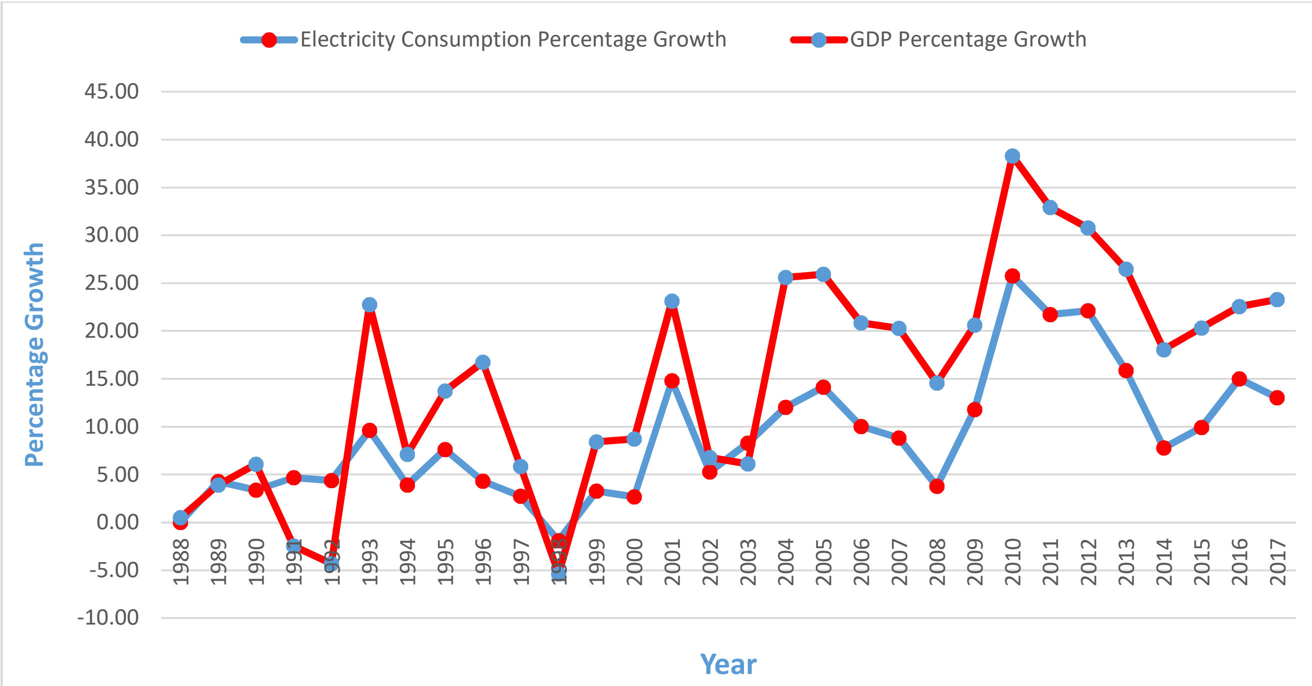
Figure 5 : Installed Capacity (MW) by Fuel Type in 2017



Source: Made by the researcher from the data obtained from Ethiopian Electric Power

Figure 6 : Electricity Generation and Consumption from 1988 - 2017 (GWh)

Figure 7 shows the trends in electricity consumption and GDP growth from 1988-2017. As can be seen from the graph, GDP growth increased from 0.5 percent in 1988 to 2.73 percent in 1990 but fell to -7.14% in 1991 and further increased to an all-time high of 13.14% in 1993; electricity consumption, on the other hand, first increased to 4.28% then slightly decreased to 3.36% and again increased to its highest value 25.76% in 2010 over the same period.



Source: Made by the researcher from the data obtained from Ethiopian Electric Power for EC and World Bank for GDP

Figure 7: Year to year growth in Electricity Consumption and GDP from 1988 -2017

2.4.2.1. Challenges of the Electricity Sector in Ethiopia[16]

According to Khanna and Rao, providing a reliable supply of electricity requires costly investment as well as skilled control of the electricity network. The complexity & costs of electricity sector management and high investment, makes the power supply often less reliable and challenging in developing countries than in developed countries (Rao, 2009). Similar to other developing countries the power sector in Ethiopia is exposed to many challenges. Among others the major current problems and challenges of the Power Sector in Ethiopia are:

i. Scarcity of Finance

The source of finance for the sector is the revenue collected from sell of Electricity to different customers but due to the low electricity tariff the revenue collected by the utility has not been

[16] Information about the Challenges are obtained through interviews, unpublished reports and EEP Annual Report

adequate (EEP, 2017). According to the World Bank the average domestic tariff rate, last revised in 2006, is US$0.03 per kWh, one of the lowest in Sub-Saharan Africa, with a proposed average domestic tariff rate of US$0.06 per kWh. (WB, 2018). This created a financial challenges for the power sector and made the utility to be unable to do proper operation and maintenance with in the planned schedule. Furthermore, some of the mega projects are done by government's finance for example it has been argued that the Great Ethiopian Renaissance Dam (GERD) has a total estimated cost of US$4.8 billion which is approximately 6% of Ethiopia's GDP of US$80.56 billion in 2017 (Behailu, 2016). In contrast to this, the capacity of the economy for generating foreign currency through exports and other means has been very limited.

In connection to this the other problem which is also related to finance is the scarcity of Foreign Currency. At country level there is scarcity of foreign currency and this is also reflected in the activities of the electricity utilities. Most of the materials used for the expansion and maintenance of distribution lines, transmission lines, generators and sub-stations are imported materials (for example transformers, wires, fuses and protection equipment used in substations are all imported). The Foreign Currency problem also created a delay on the payment of construction supervision consultants, which intern slowed down the completion of some of the projects (EEP, 2017).

In addition to the mega projects which are done with the government's own finance, there are also a number of projects that are under construction through local and foreign loans, this intern increased the government's burden. On top of this, in order to get new foreign loans it takes a long time, and sometimes difficult. In the long run all this will lead to delay of projects which in turn will lead to supply deficits and load shading (EEP, 2017).

ii. Low Performance Capacity

The performance capacity of the utilities both in projects and operational activities have deteriorated, mostly because of performing many projects, the unmanageable growth of the sector and the availability of skilled manpower. This is reflected in frequent outages, high technical losses, high theft of both electricity and materials, etc. The performance capacity is also directly and indirectly related with the limitation of finance, quality of education, corruption, etc. (EEP, 2017).

iii. Low Private Investment (Foreign Direct Investment) in the Power Sector

Until now, involvement of the private sector in the energy sector has been very limited only in the participation of construction and consultancy. Although the law in Ethiopia allows private investors to invest in the generation and distribution of electricity, entry in to the sector has been very difficult because of unwillingness and the political ideology of the government. But recently the first Power Purchase Agreement (PPA) was signed between an American private company and EEP for the development of a 1000MW geothermal power plant as an Independent Power Producer (IPP).

In summary major problems still exist in the sector, namely: the utility is not a creditworthy purchaser of electricity for IPPs; tariff rates are not cost reflective; the transmission and distribution system are suffering from high losses and frequent outages, the purchasing power of citizens is also very low due to the low per capita income etc. (Power Africa (USAID), 2016).

2.5. Development Relevance of Electrification and linkages to Local and Regional Development

In 2015 the 17 Sustainable Development Goals were endorsed. But countries in East Africa, which belong to the Least Developed Countries (LDCs) category, have low productive capacity

(Productive resources, Entrepreneurial capabilities and Production linkages) required to achieve the SDGs. Insufficient productive capacity lead s to limited national demand or consumption of modern energy services. Hence the isolated electricity markets in LDCs alone hardly provide the economic incentive for enhanced development of renewable energy resources which is crucial to the realization of the anticipated sustainable energy transition. Most renewable energy generation projects, for example large hydropower projects in Ethiopia, makes better economic sense when harnessed in large scale, and that essentially requires larger energy market in the region to be viable in economic terms (United Nations, 2018).

In connection with this it was also argued that Energy is at the heart of many of these Sustainable Development Goals (SDGs). The SDG 7 is responsible for targeting energy issues and it aims at "ensuring access to affordable, reliable, sustainable and modern energy for all" by the end of 2030 (United Nations (UN), 2015). Furthermore, according to the statement of the local and regional government's constituency task force, the achievement of these Sustainable Development Goals depends on the full ownership by local communities, cities and regions. This is because Sustainable Development is local, regional and global in nature ((UN), 2018).

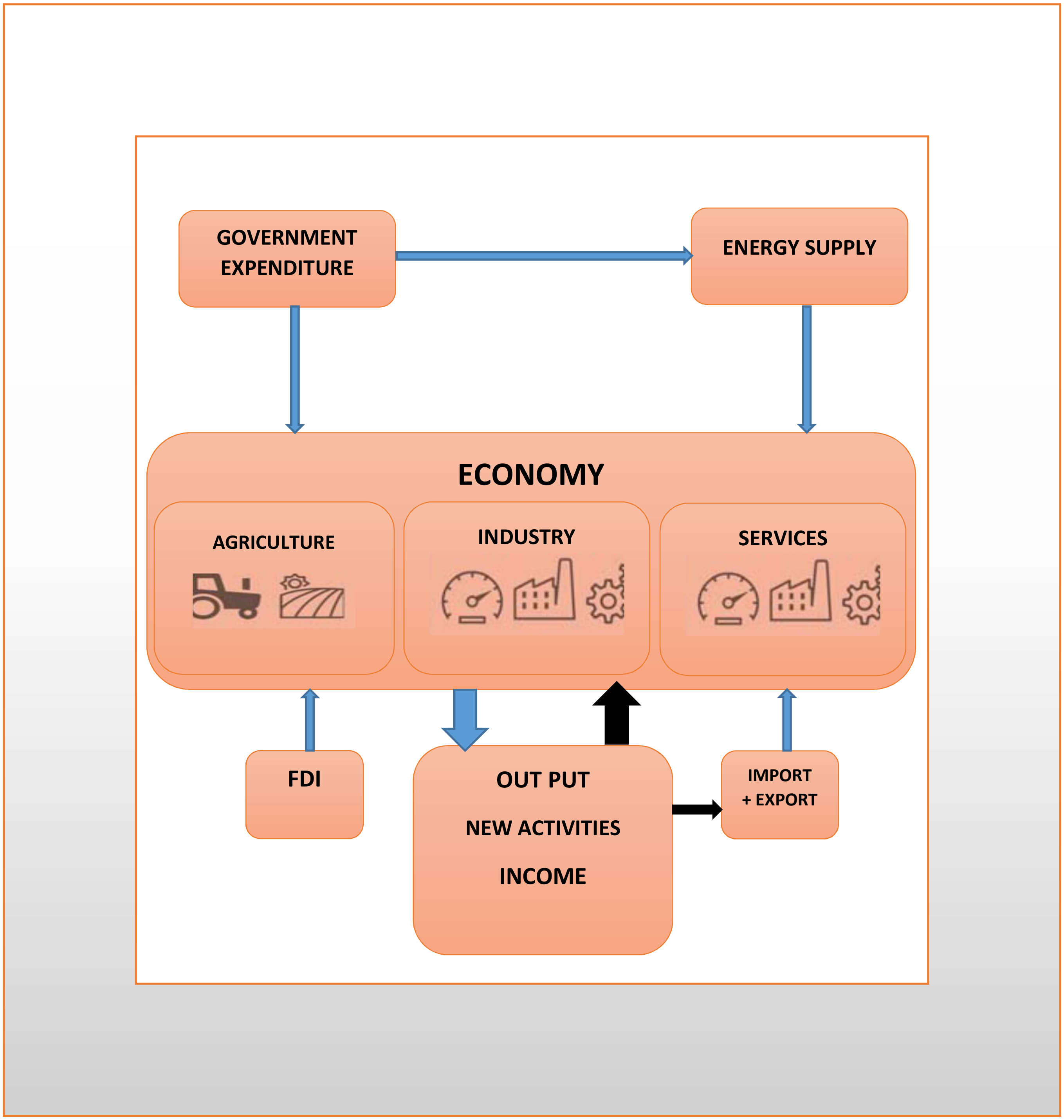
In order to ensure access to affordable, reliable, sustainable and modern energy for all developing countries including Ethiopia, the provision of Electricity Infrastructure is crucial. This is because knowing about the effect of infrastructure provision is crucial for local and national governments when making policy decisions about resource allocation. Access to electricity is particularly crucial to human development and is important in improving people's standard of living. Because in practice, electricity is indispensable for certain basic activities, such as lighting, refrigeration and the running of household appliances. Individuals' access to electricity is one of the most clear and un-distorted indication of a country's energy poverty status. Electricity access is increasingly at the forefront of governments' preoccupations, especially in the developing countries. As a consequence, a lot of rural electrification programs and national electrification agencies have been created in these countries to monitor more accurately the needs and the status of rural development and electrification (Cook, 2011).

Furthermore, electrification enables livelihoods in several ways: for instance by stimulating employment and income generating activities, where people build assets such as the expansion of dairy milk production and achieve better cash flows. Electrification also enables people to use surplus resources through their entrepreneurship skills that contribute to the emergence of credit and savings schemes based on the newly available cash. Extra electric lighting and improved water from better pumping facilities are likely to reduce women's drudgery in fetching water and create opportunities to set up other businesses. A research study conducted by (Singh, 2009) found out that rural electrification could substantially accelerate the process of both productivity growth in agriculture and the expansion of rural non-farm activities. Businesses in rural areas of developing countries with access to electricity such as home businesses, small commercial shops, grain mills, saw mills, coffee and tea processing, brick kilns and other small scale enterprises can benefit from rural electrification programmes. Therefore, it can be concluded that Electrification is important for the development of communities and under the right policies and circumstances it can result in significant economic growth at all levels.

2.6. Conceptual Framework of the Study

The conceptual framework is presented in Figure 1 below. In connection with this the analysis procedure flow chart followed by the researcher for the analysis is shown in Figure 2. A detailed description of the analysis procedure is explained in section 3.

Figure 8: Conceptual Framework of the Study



Source: Made by the researcher, 2019

CHAPTER THREE

3. RESEARCH METHEDOLOGY

The purpose of this chapter is to present the assumptions underpinning this research, as well as to introduce the research strategy and the empirical techniques which are applied. This chapter defines the scope and limitations of the research design, and situates the research amongst existing researches.

3.1. Research Design

The research tested the dynamic causality relation between Economic Growth/GDP, Electricity Consumption, FDI, Government Expenditure and Net Export, assuming other things remained constant. The researcher used explanatory research design to identify the extent and nature of cause-and-effect relationships.

3.2. Model Specification and Procedure of Analysis

The researcher used Autoregressive Distributed-lag (ARDL) model and Error Correction Model (ECM) with the help of EViews statistical tool throughout the analysis. The ARDL and ECM model is employed because it is relatively more efficient in the case of small and finite sample data size. On the top of this the model allows to possess mixed order of integration and uses a combination of endogenous and exogenous variables, unlike a VAR model which is strictly designed for endogenous variables.

In the beginning, EG/GDP was considered as the dependent variable and EC, FDI, Government Expenditure and Net Export were taken as independent variables and the analysis continued by making the remaining variables as a dependent. The modal is based on ARDL definition of causality.

Employing dynamic causality analysis by using the ARDL model to determine the relation between EC, GDP, FDI, Government Expenditure and Net Export includes 8 steps:

Step 1. Specify the Model

The generalized ARDL (p, q) model is specified as:

$$Y_t = \gamma_{0i} + \sum_{i=1}^{p} \delta_i Y_{t-1} + \sum_{i=0}^{q} \beta'_i X_{t-1} + \varepsilon_{it} \qquad \text{.....(3.1)}$$

Where Y'_t is a vector and the variables in X'_t are allowed to be I(0) or I(1) or co-integrated; β and δ are coefficients that we are estimating, γ is a constant or intercept in the model; I is the number of variables in the model and can range from 1 up to k, "p", "q" are optimal lag orders. The Lags are denoted by "p" and "q". "p" is associated with the lag values of the dependent variables and "q" is for the lag value of the regressors. ε_{it} is a vector of the error terms. As can be seen from the model the dependent variable Y_t is explained by its own lag and also the current and lag value of the regressors (Gujarati D. , 2012).

The following equation shows the long-run ARDL (p, q_1, q_2, q_3, q_4, q_5) model:

$$\Delta GDP\_Gr\_Rat_t = a_{01} + b_{11} GDP\_Gr\_Rat_{t-1} + b_{21} lnElect\_cons_{t-1} + b_{31} lnFDI_{t-1} + b_{41} Net\_exp_{t-1} + b_{51} LnGov\_exp_{t-1} + \sum_{i=1}^{p} a_{1i} \Delta GDP\_Gr\_Rat_{t-1} + \sum_{i=0}^{q} a_{2i} LnElect\_cons_{t-1} + \sum_{i=0}^{q} a_{3i} LnFDI_{t-1} + \sum_{i=0}^{q} a_{4i} Net\_Exp_{t-1} + \sum_{i=0}^{q} a_{5i} LnGov\_exp_{t-1} + \varepsilon_{1t} \qquad \text{.....(3.2)}$$

$$\mathbf{lnElect\_cons}_t = a_{02} + + b_{12} GDP\_Gr\_Rat_{t-1} + b_{22} lnElect\_cons_{t-1} + b_{32} lnFDI_{t-1} + b_{42} Net\_exp_{t-1} + b_{52} lnGov\_exp_{t-1} + \sum_{i=1}^{p} a_{1i} \Delta lnElect\_cons_{t-1} + \qquad \text{.....(3.3)}$$

$\sum_{i=0}^{q} a_{2i}\, GDP\_Gr\_Rat_{t-1} \; + \; \sum_{i=0}^{q} a_{3i}\, LnFDI_{t-1} \; + \sum_{i=0}^{q} a_{4i}\, Net\_Exp_{t-1} \; +$
$\sum_{i=0}^{q} a_{5i}\, LnGov\_exp_{t-1} \; + \; \varepsilon_{2t}$

$\mathbf{lnFDI_{t}} = \; a_{03} + b_{13}GDP\_Gr\_Rat_{t-1} + \; b_{23}lnElect\_cons_{t-1} + \boldsymbol{b_{33}lnFDI_{t-1}} +$
$b_{43}Net\_exp_{t-1} + b_{53}LnGov\_exp_{t-1} + \sum_{i=0}^{p} \boldsymbol{a_{1i}\, LnFDI_{t-1}} \; + \sum_{i=0}^{q} a_{2i}\, LnElect\_cons_{t-1} \; +$
$+ \sum_{i=1}^{q} a_{3i}\, \Delta GDP\_Gr\_Rat_{t-1} + \sum_{i=0}^{q} a_{4i}\, Net\_exp_{t-1} \; + \sum_{i=0}^{q} a_{5i}\, LnGov\_exp_{t-1} \; + \; \varepsilon_{3t}$

……………………………………………………………(3.4)

$\mathbf{Net\_exp_{t}} = a_{04} + b_{14}GDP\_Gr\_Rat_{t-1} + \; b_{24}lnElect\_cons_{t-1} + b_{34}lnFDI_{t-1} +$
$b_{44}Net\_exp_{t-1} + b_{54}Gov\_exp_{t-1} + \sum_{i=0}^{p} \boldsymbol{a_{1i}\, Net\_exp_{t-1}} \; + \sum_{i=1}^{q} a_{2i}\, \Delta GDP\_Gr\_Rat_{t-1} +$
$+ \sum_{i=0}^{q} a_{3i}\, LnElect\_cons_{t-1} \; + \sum_{i=0}^{q} a_{4i}\, LnFDI_{t-1} \; + \sum_{i=0}^{q} a_{5i}\, LnGov\_exp_{t-1} \; + + \varepsilon_{4t}$

……………………………………………………………(3.5)

$\mathbf{lnGov\_exp_{t}} = \; a_{05} + b_{15}GDP\_Gr\_Rat_{t-1} + \; b_{25}lnElect\_cons_{t-1} + b_{35}lnFDI_{t-1} +$
$b_{45}Net\_exp_{t-1} + \boldsymbol{b_{55}LnGov\_exp_{t-1}} + \sum_{i=0}^{p} \boldsymbol{a_{1i}\, LnGov\_exp_{t-1}} \; +$
$\sum_{i=1}^{q} a_{2i}\, \Delta GDP\_Gr\_Rat_{t-1} + \sum_{i=0}^{q} a_{3i}\, LnElect\_cons_{t-1} \; + \sum_{i=0}^{q} a_{4i}\, LnFDI_{t-1} \; +$
$\sum_{i=0}^{q} a_{5i}\, Net\_Exp_{t-1} \; + \; \varepsilon_{5t}$

……………………………………………………………(3.6)

Where: **GDP_Gr_Rat** is Gross Domestic Product growth rate, **Elect_cons** is Electricity Consumption, **FDI** is Foreign Direct Investment, **Gov_exp** is Government Expenditure and **Net_exp** is Net Export.

Step 2. Perform Stationary Test: series can be level stationary variables or $I(0)$ and of order one $I(1)$ or the combination of the two but not of order two ($I(2)$)

It is a requirement that the (ARDL) model is constructed only if the variables are integrated of order zero and/or one that is stationarity after first difference.

To confirm the integration order of variables we start by performing unit root test by using Augmented Dickey Fuller Test (ADF). The ADF is a unit root test for Stationarity (Lütkepohl, 2004).

H_0= Model is non-stationary

T statistic vs. 5% critical value

We have assumed that if the absolute value of T statistic is greater than absolute value of 5% critical value, we can reject **H_0.**

Step 3. Determine Optimal Lag Length (k) for the model

Here we determine how many lags we should use in the system to be developed. An appropriate lag selection is chosen based on Akaike information criterion (AIC).

Step 4. Run ARDL model (Short-run model)

If the variables are not co-integrated we specify only short-run ARDL model. The ARDL (p, q_1, q_2, q_3, q_4, q_5) model is specified as:

$$\Delta \boldsymbol{GDP\_Gr\_Rat_t} = a_0 + \sum_{i=1}^{p} a_{1i}\, \Delta GDP\_Gr\_Rat_{t-1} + \sum_{i=1}^{q} a_{2i}\, \Delta LnElect\_cons_{t-1} + \sum_{i=1}^{q} a_{3i}\, \Delta LnFDI_{t-1} + \sum_{i=1}^{q} a_{4i}\, \Delta Net\_Exp_{t-1} + \sum_{i=1}^{q} a_{5i}\, \Delta LnGov\_exp_{t-1} + \boldsymbol{\varepsilon_t} \quad \text{.........(3.7)}$$

Step 5. Perform Bounds Integration Test

The bounds testing procedure is based on the joint F-statistic or Wald statistic that tests the null hypothesis of no co-integration. The conditional ARDL (p, q_1, q_2, q_3, q_4, q_5) with 5 variables are specified as shown in Equation 3.4 to 3.7. Each variable in the model was made to be dependent variable and a Bounds Integration Test was tested and the outcomes was observed.

The null hypothesis of no co-integration among the variables is:

$\boldsymbol{H_0}: \boldsymbol{b_{1i} = b_{2i} = b_{3i} = b_{4i} = b_{5i} = 0}$ (Where b_1, b_2, b_3, b_4, b_5, are coefficients of the long-run model and i=1,2,3,4,5)

The null hypothesis implies that there is no co-integration against the alternative hypothesis.

The alternative hypothesis:

$\boldsymbol{H_1}: \neq \boldsymbol{b_{1i}} \neq \boldsymbol{b_{2i}} \neq \boldsymbol{b_{3i}} \neq \boldsymbol{b_{4i}} \neq \boldsymbol{b_{5i}} \neq \mathbf{0}$

After estimating the equation in EViews the next step is to check the F statistic t–bound test and f–bound test.

The null hypothesis is that there is no levels relationship. The criteria is if F-statistic value is below the I(0) bound we cannot reject the null.

Likewise if we are using the t–Bound test:

If the absolute value of the t-statistic value is lower than the *I*(0) bound at 5% we cannot reject the null;

If we are unable to reject the null hypothesis then we can only specify the short-run model which in this case denotes no co-integration among the variables. But if we reject the null hypothesis in favor of the alternative then we continue to specify VECM or ECM model.

Step 6. If the variables are co-integrated, specify ECM if not specify VECM model;

From the bound test results if the variables are co-integrated, we specify both short-run ARDL model and co-integrated (VECM) models or ECM as case may be;

If there is co-integration, the **Error Correction Model (ECM)** is specified as:

$$\Delta \boldsymbol{GDP\_Gr\_Rat_t} = a_0 + \sum_{i=1}^{p} a_{1i}\, \Delta GDP\_Gr\_Rat_{t-1} + \sum_{i=1}^{q} a_{2i}\, \Delta LnElect\_cons_{t-1} + \sum_{i=1}^{q} a_{3i}\, \Delta LnFDI_{t-1} + \sum_{i=1}^{q} a_{4i}\, \Delta Net\_Exp_{t-1} + \sum_{i=1}^{q} a_{5i}\, \Delta LnGov\_exp_{t-1} + \boldsymbol{\lambda ECT_{t-1}} + \boldsymbol{\varepsilon_t}$$

……………………………………………………….(3.8)

Where:

- $\boldsymbol{\lambda} = (1-\sum_{i=1}^{p} \boldsymbol{\delta}_i)$**,** speed of adjustment parameter with a negative sign;
- ECT – (GDP_Gr_Rat$_{t-1}$ $- \theta X_t$) is the mathematical representation of the Error Correction Term resulting from the long-run equilibrium relationship;
- $\boldsymbol{\theta} = \frac{\sum_{i=0}^{q} \boldsymbol{\beta}_i}{\boldsymbol{\alpha}}$**,** is the long-run parameter and
- a_{1i} , a_{2i} , a_{3i} , a_{4i} , and a_{5i} are the short-run dynamic coefficients to be estimated.

Step 7. Perform Causality Test;

After examining, in the earlier sections, the unit root and co-integration in the time series setting, the next step is to know the direction of causality. And for this, we apply Granger Causality test.

The test represents that for a two variables (say X and Y); if X is influenced by both lagged values of X and lagged values of Y, then it is called as Y Granger causes X (Y→X). Similarly if

Y is influenced by its lag and the lagged values of X, then we call it X Granger causes Y (X→Y). However between X and Y, if X Granger causes Y and Y Granger causes X, we call it bi-directional causality. If only one exists, then it is the case of uni-directional causality. If both do not exist, then the variables are independent to each other. The Pairwise Granger-causality test method is selected to be used in this study over other alternative techniques because of its favorability, particularly, for small samples in empirical works, as cited in Seung-Hoon Yoo, 2004. This study applied Pairwise Granger Causality test.

Pairwise Granger Causality test tells the direction of Causality:

$\mathbf{H_0}$ = no Granger Causality,

$\mathbf{H_A}$ = the null hypothesis is not true,

Decision Criteria: Reject the null hypothesis if the Probability Value of F-Statistic is less than or equal to 0.05 (F-Statistic ≤ 5%).

Step 8. Perform diagnostic tests, Normality, Serial correlation, Heteroscedasticity (ARCH);

After estimating ARDL models there are some diagnostic tests which are vital for ensuring that the results obtained from ARDL estimation can be used for forecasting. Important post-estimation tests which are mostly performed on the residual of the model are Lagrange Multiplier (LM) test for residual autocorrelation, Jarque-Bera test for residual normality, Autoregressive Conditional Heteroscedasticity (ARCH) test for the presence of heteroscedasticity in the residuals and test for model stability. Testing for autocorrelation helps to identify any relationships that may exist between the current values of the regression residuals and any of its lagged values (Brooks, 2002). The null hypothesis of the LM test for autocorrelation is that the residuals are not serially correlated, while the alternative is that the residuals are serially correlated. If the P-value is less than 0.05 then we reject the null hypothesis (Harris, 1995).

The Jarque-Bera normality test is used to determine whether the regression errors are normally distributed. Under the null hypothesis of normally distributed errors, the test statistic has a Chi-Square distribution. Thus, if the Jarque-Bera statistic is significant, that is, the p-value is less than 0.05; the null of normality is rejected at the 5% level of significance (Brooks, 2002: 181). Furthermore, the test for heteroscedasticity investigates whether the variance of the errors in the model are constant or not. In ARCH test for heteroscedasticity the null hypothesis states the residuals are homoscedastic and independent of the regressors, and that there is no problem of misspecification. If the ARCH test statistic is significant, that is, P-value is less than 0.05; the null hypothesis of homoscedasticity and no misspecification will be rejected (Brooks, 2002: 445).

Test for existence of serial correlation

The research uses **Breusch-Godfrey serial** correlation Lagrange Multiplier (LM) test

$\mathbf{H_0}$ = there is serial correlation,

Rule if prob. Chi-Square (2) < 0.05 or 5% we can reject $\mathbf{H_0}$

Test for Heteroscedasticity,

We use Breusch-Pegan_Godfryl test

$\mathbf{H_0}$ = there is no **Heteroscedasticity**,

Rule: if prob. Chi-Square (2) < 0.05 or 5% we can reject $\mathbf{H_0}$

Test of normality which is residual test, test of Jarque –Bera test,

$\mathbf{H_0}$ = residual is normally distributed,

Rule: if prob. Chi-Square (2) < 0.05 or 5% we can reject $\mathbf{H_0}$

3.3. Data Sources

The study utilizes Annual Time-Series Secondary data, from 1988 to 2017. The data sources for this study are the Ethiopian Electric Power (EEP), National Bank of Ethiopia (NBE), the Ministry of Finance and Economic Development (MOFED), Ethiopian Revenues and Customs Authority (ERCA) and Word Bank data base (Word Bank Development Indicators data). In the paper, electricity consumption is expressed in terms of Megawatt hours (MWh), GDP in current MUS$, Foreign direct investment, net inflows (BoP, current MUS$), Government Expenditure (MUS$) and Net Export in MUS$.

CHAPTER FOUR

4. DATA ANALYSIS AND DISCUSSION

4.1. Unit Root Test Results

As indicated above in the methodology, after specifying the model, the first step towards the investigation of the existence of causality between electricity consumption and economic growth is the identification of the order of integration of the series under consideration. For this purpose, as the property of the data recommends, the study employed Augmented Dickey and Fuller (1981) (ADF) unit root test. This test is based on the null hypothesis that the considered series has a unit root against the alternative of the series being stationary.

The results reported in Table 5 shows that individual unit root test does not reject the null hypothesis for GDP and Electricity Consumption at levels. The study further applied the unit root test in the first differences of all the variables and the results reject the null hypothesis for all variables, implying that all the variables are stationary at first difference. The detailed results are also shown in Appendix B.

Table 4: Augmented Dickey-Fuller Unit Root Test

Augmented Dickey-Fuller Unit Root Test		**Level**	**1st Difference**	Null Hypothesis
		Intercept		
		t-Statistic	**t-Statistic**	
1. GDP_GR_RAT				
Augmented Dickey-Fuller test statistic		-3.494374	-7.198922	Rejected and the data is stationary at both level and 1st difference
Test critical values:	5% level	-2.967767	-2.976263	
2. LNELECT_CONS				
Augmented Dickey-Fuller test statistic		-3.868549	-6.84051	Rejected and the data is stationary at both level and 1st difference
Test critical values:	5% level	-2.967767	-2.971853	
3. LNFDI				
Augmented Dickey-Fuller test statistic		-1.29276	-8.208458	Rejected and the data is Stationary at 1st difference
Test critical values:	5% level	-3.587527	-2.986225	
4. NET_EXP (Billion)				
Augmented Dickey-Fuller test statistic		1.003151	-4.685252	Rejected and the data is Stationary at 1st difference
Test critical values:	5% level	-2.967767	-2.971853	
5. LNGOV_EXP				
Augmented Dickey-Fuller test statistic		1.141102	-3.666006	Rejected and the data is Stationary at 1st difference
Test critical values:	5% level	-2.967767	-3.689194	

Source: Own computation using EViews 10

4.1.1. Determining the Optimal Lag Length (k) for the model

Estimating the lag length of autoregressive process for a time series is a crucial econometric exercise in most economic studies. This study determined Optimal Lag Length (k) for the model by using Akaike Information Criteria (AIC).

The study used EViews to determine the lag length by using the lag length information criteria. As displayed in table 6 below, from the six information criteria to choose, we have to look for the least figure and highlighted by asterisks (*) that indicates lag order selected by the criterion. Therefore, the optimal lag length that best fits our model is 1. This is done by applying the maximum lag of 4.

Table 5: VAR Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: GDP_GR_RAT LNFDI LNGOV_EXP LOGELC_SA NEIB
Exogenous variables: C
Date: 06/11/19 Time: 11:23
Sample: 1988 2017
Included observations: 26

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-9.69653	NA	2.13E-06	1.130502	1.372444	1.200172
1	92.73043	157.5799*	5.76e-09*	**-4.825418***	-3.373768*	-4.407395*
2	116.0106	26.86178	8.37E-09	-4.69313	-2.03177	-3.92675

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Own computation using EViews 10
The bold and asterisks number indicates the optimal lag.

4.2. Estimation of ARDL Model (Short-run model) Results

According to the pre-estimation test, the criteria that is required for ARDL regression model is fulfilled. Therefore, this study estimated the ARDL regression model to investigate the causality between Economic Growth and Electricity Consumption (target variables).

Table 6: Estimation of ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDP_GR_RAT (-1)	-0.363818	0.233947	-1.555128	0.1383
LNGOV_EXP	88.68603	30.03261	2.952991	0.0089
LNGOV_EXP (-1)	-66.57953	26.55993	-2.506766	0.0226
LNFDI	7.908538	2.112920	3.742942	0.0016
LNFDI (-1)	-13.04648	3.174275	-4.110065	0.0007
LOGELC_SA	-3.850911	1.315852	-2.926553	0.0094
LOGELC_SA(-1)	-5.976762	2.442520	-2.446966	0.0256
NEIB	-2112.568	1264.676	-1.670442	0.1131
NEIB(-1)	2055.837	1158.124	1.775144	0.0938
C	-2.292891	39.35136	-0.058267	0.9542
R-squared	0.648063	Mean dependent var		6.901189
Adjusted R-squared	0.461744	S.D. dependent var		6.162307

Source: Own computation using EViews 10

As reported in table 7 above, the percentage change in government expenditure affect economic growth positively in the short-run, which is 1% increase in government expenditure increases economic growth by 89%. The finding is in line with the Keynesian theory that says in the short-run increasing government spending encourages economic growth (Vane, 2005) .

In the same manner the percentage change in FDI affect economic growth positively in the short-run, which is 1% increase in FDI increases economic growth by 8%. On the other side, Electricity Consumption and Net Export are negatively associated with Economic Growth. A percentage change in Electricity Consumption decreases Economic Growth by 4%. This means that according to the historical data in Ethiopia the Electricity Consumption does not significantly contributed to the economic growth. One possible reason for this is because the Ethiopian economy is an agrarian society and the country's energy consumption is highly dominated by traditional biomass.

4.3. F-Bounds Co-integration Test Results

The ARDL bounds testing follows estimation of regressions in order to check whether the variables under consideration are co-integrated or not. Accordingly, this study used F-Bounds Co-integration Test. The results obtained after undertaking the F-Bounds Co-integration Test.

Table 7: Co - integration Test Result (F- bound test)

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	6.110853	10%	2.2	3.09
k	4	5%	**2.56**	**3.49**
		2.5%	2.88	3.87
		1%	3.29	4.37
Actual Sample Size	27		Finite Sample: n=35	
		10%	2.46	3.46
		5%	2.947	4.088
		1%	4.093	5.532

Source: Own computation using EViews 10

It is to be recalled from the methodology that according to the F-bound test the variable are co-integrated if F-statistic value is greater than both the lower bound and upper bound value. As displayed in table 8 above, the findings of the study revealed that the F-statistic = 6.110853, the lower bound $I(0) = 2.56$ and upper bound $I(1)= 3.49$ at 5% Significance level, which ascertains that the variables are co-integrated and implies the existence of a long-run relationship between variables.

4.4. Error Correction Model ECM Estimation Results

The F-Bounds Co-integration test results have shown that the variables are co-integrated, therefore, the next step after co-integration is to do the ECM Regression.

Table 8: ARDL Error Correction Regression Result

ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNGOV_EXP)	88.68603	20.71993	4.280229	0.0005
D(LNFDI)	7.908538	1.694901	4.666076	0.0002
D(LOGELC_SA)	-3.850911	0.779509	-4.940178	0.0001
D(NEIB)	-2112.568	838.3846	-2.519807	0.0220
CointEq(-1)*	-1.363818	0.197990	-6.888321	0.0000
R-squared	0.730242	Mean dependent var		0.278495
Adjusted R-squared	0.681195	S.D. dependent var		7.038629
Log likelihood	-72.80193	Hannan-Quinn criter.		5.834461
Durbin-Watson stat	1.847255			

Source: Own computation using EViews 10

As shown in table 9 above the ARDL Error Correction Regression result revealed that a percentage change in government expenditure and a percentage change in FDI affect Economic Growth positively and significantly in the long-run. This means that, in the long-run one percent increase in government spending increases Economic Growth by about 89%. In the same manner a one percent increase in FDI increases Economic Growth by about 8%. In contrast to this a percentage increase in Electricity Consumption and Net Export negatively affects Economic Growth in the long-run. One possible reason for this could be because of low productive capacities of the economy and inadequate supply of electricity for productive activities.

The "CointEq(-1)*" in the table above is the previous year's deviation of the variables from their equilibrium point and it is adjusted by 1.36% speed to the equilibrium point. This shows that the variables are converging to their long-run equilibrium point.

4.5. Pairwise Granger Causality Tests Results

After examining, in the earlier sections, the unit root and co-integration in the time series setting, the next step is to know the existence of causality between variables. And for this purpose this study applied Pairwise Granger Causality test.

Table 9 : Pairwise Granger Causality Tests Results

Null Hypothesis:	Obs	F-Statistic	Prob.	Decision
Log of Electricity Consumption (LOGELC_SA) does not Granger Cause GDP Growth Rate	29	0.69572	0.4118	Accepted*
GDP Growth Rate does not Granger Cause Log of Electricity Consumption (LOGELC_SA)		1.48955	0.2332	Accepted
Log of FDI does not Granger Cause GDP Growth Rate	27	0.38796	0.5392	Accepted
GDP Growth Rate does not Granger Cause Log of FDI		4.23435	0.0506	Rejected*
Log of Government Expenditure (LGE) does not Granger Cause GDP Growth Rate	29	2.53505	0.1234	Accepted
GDP Growth Rate does not Granger Cause Log of Government Expenditure		11.0899	0.0026	Rejected
Net Export (billions) (NEIB) does not Granger Cause GDP Growth Rate	29	2.96370	0.097	Accepted
GDP Growth Rate does not Granger Cause NEIB		0.99306	0.3282	Accepted

*Accepted indicates the study failed to reject the null hypothesis Rejected
*Rejected indicates the study rejected the null hypothesis

Source: Own computation using EViews 10

As displayed in table 10 of Pairwise Granger Causality tests results there is no causality between Electricity Consumption and Economic Growth in Ethiopia. Here we have identified an independent relationship between the two variables. Possible reasons for this relationship could be the low level of electricity consumption in the country. Which is in 2017 the electricity sector contributed only 2% of the total energy consumption and only 42.9 per cent of the population has access to electricity. Moreover the countries industrial and manufacturing sector is under developed and even if the supply of electricity increases in the country bulk electricity consumers were very limited. Therefore forecasting based on the historical data might not give the required results.

In addition to this results, similar findings were obtained by other researchers in the literature. Table 14 in Appendix B provides a summary of some studies which have shown a similar findings. These countries supported the neutrality hypothesis or did not see any causal link between energy consumption and economic growth. Such studies include those of Murray and Nan (1994) Sari (2003) Narayan and Prasad (2008) for twenty four developed countries; Akinlo (2008b), and Wolde-Rufael (2009).

In the same vein, Net Export does not Granger Cause Economic growth and vice versa. This implies that there is no relationship between the two variables.

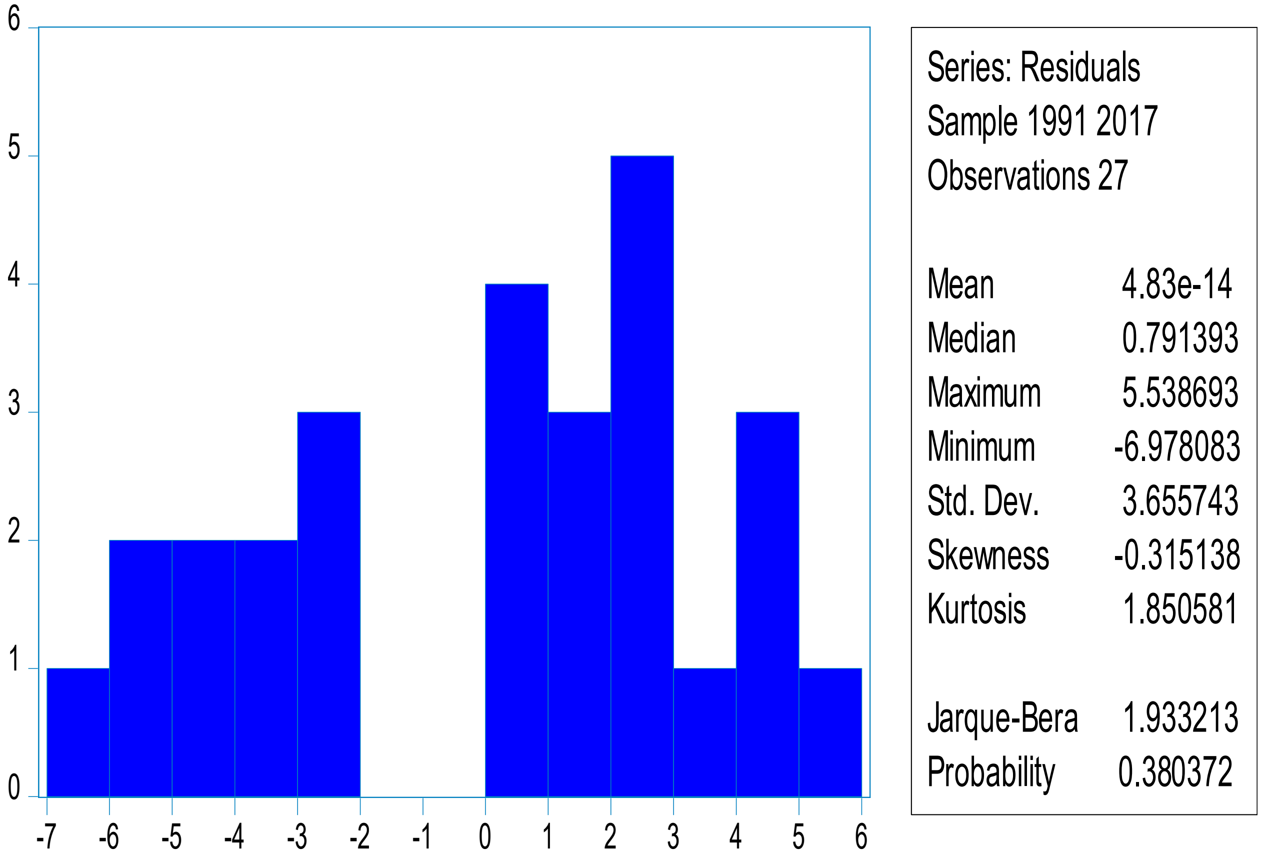
The study findings have also shown that Government Expenditure and FDI does not Granger Cause Economic Growth. However, the Economic Growth Granger Cause both Government Expenditure and FDI. This might be because as economic growth increase government spending increases and also the inflow of FDI is encouraged.

4.6. Post Estimation Diagnostic Test Results

A. Normality test

The residual or error term are normally distributed when the probability value is greater than 5% significance level. As shown in the Jarque-Bera test (figure 9), the probability value of this study is 38% which is far above the required criteria for normality test. Therefore, the error term of this study is normally distributed.

Figure 9: Jarque-Bera Histogram Normality Test Results



Source: Own computation using Eviews 10

B. Autocorrelation Test

Concerning the Autocorrelation test, Breusch-Godfrey Serial Correlation LM test was used for the analysis. Accordingly, the model is not suffering from autocorrelation problem. As shown in table 11 below the P-value (0.0858) is greater than 5%. Because of this the analysis failed to reject the null hypothesis which says no serial correlation between the residuals.

Table 10: Serial Correlation LM Test Results

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.667955	Prob. F(2,15)	0.2218
Obs*R-squared	4.912195	Prob. Chi-Square(2)	0.0858

Source: Own computation using EViews 10

C. **Heteroscedasticity Test**

In order to check the presence of Heteroscedasticity, this study employed ARCH Test. Accordingly, the result obtained from the ARCH Test shows that there is no problem of Heteroscedasticity because the P-value (21%) is far above the 5% significance level. Therefore the study accepts the null hypothesis which says no Heteroscedasticity problem.

Table 11: Heteroscedasticity Test Results

Heteroscedasticity Test: ARCH			
F-statistic	1.5065	Prob. F(1,24)	0.2316
Obs*R-squared	1.5356	Prob. Chi-Square(1)	0.2153

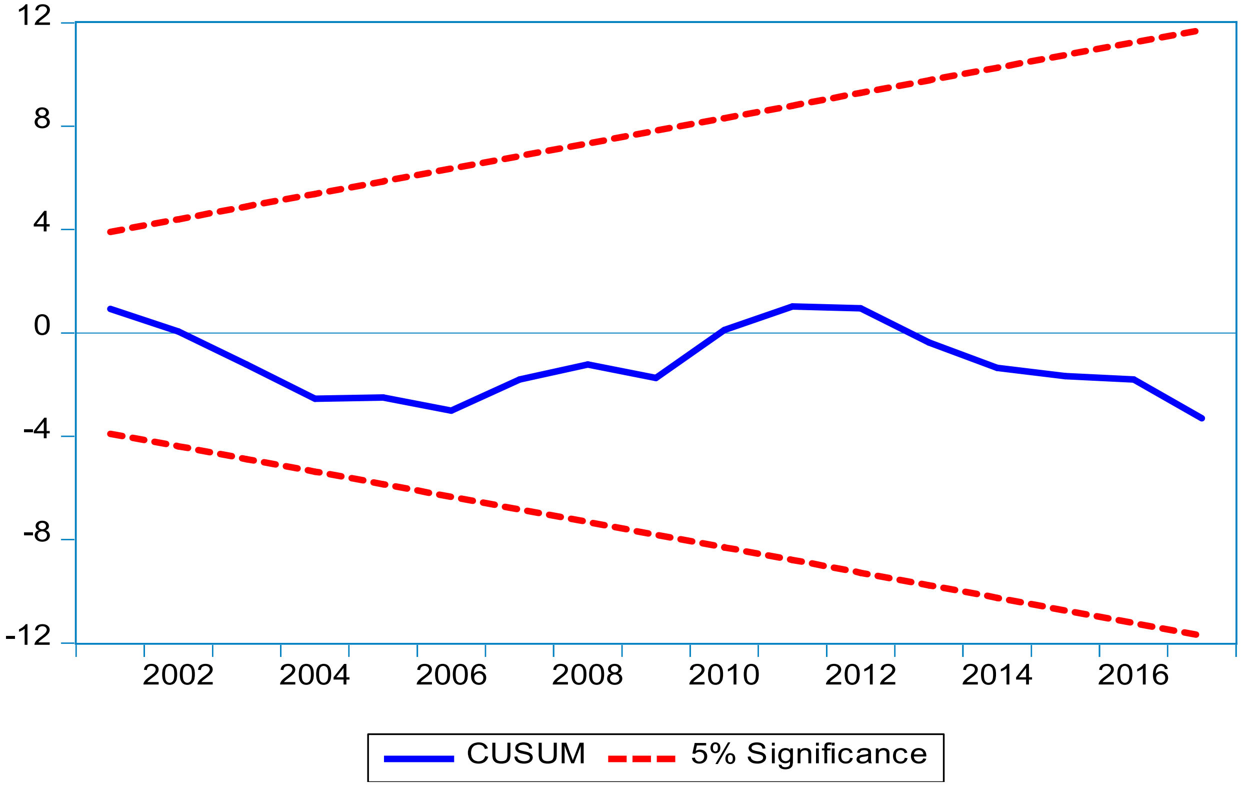
Source: Own computation using Eviews 10

D. **Stability Test**

In model specification, checking the stability of the variables are very crucial. In order to check the causality between the variables must be stable. As shown in the CUSUM tests figure 10 and 11below show that the model is stable because it lies between the 5% significance boundaries. Furthermore, the study also conducted CUSUM square tests to verify the stability of the model and got the similar result.

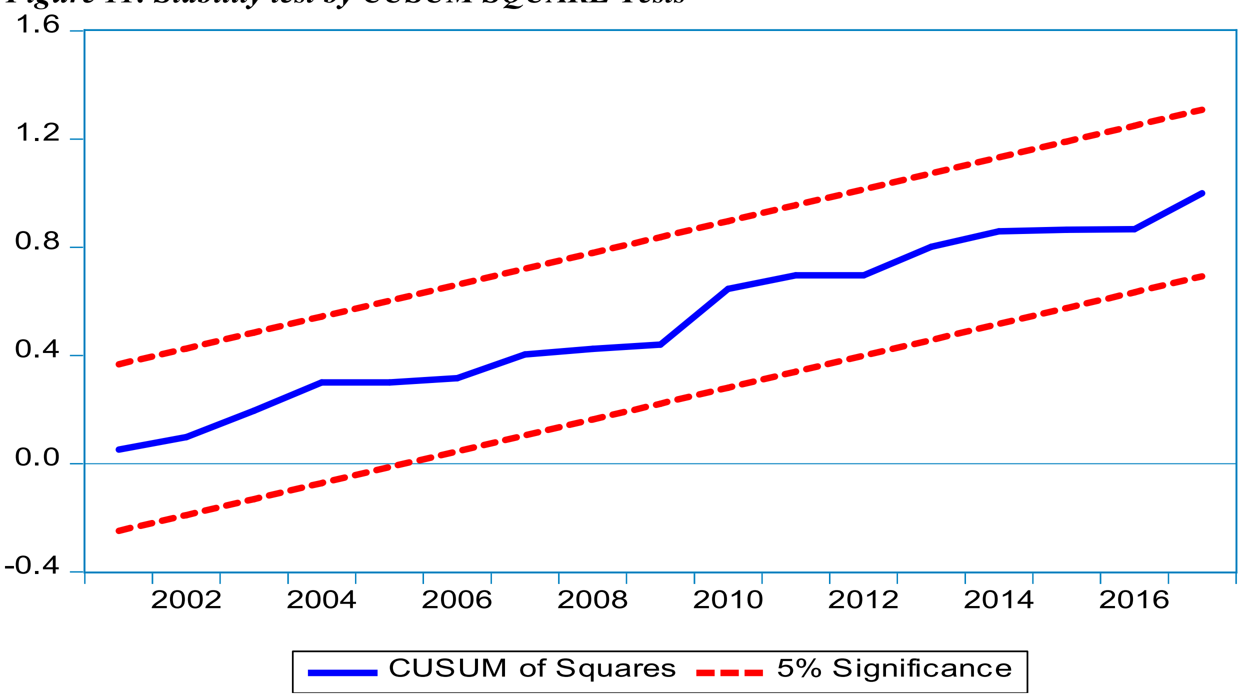
The CUSUM square tests is also used to show whether there is a Structural Break or not in the model. As can be seen in figure 11 below, from the CUSUM square tests it can be seen that there is no digression out of the 5% significance level boundary which tells us that there is no Structural Break in the model.

Figure 10: Stability test by CUSUM Tests



Source: Own computation using Eviews 10

Figure 11: Stability test by CUSUM SQUARE Tests



Source: Own computation using EViews 10

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Although Ethiopia has been a good performer in terms of economic growth and the expansion of social services over the past decade, Ethiopia remains one of the poorest countries in the world and ranked 101 out of 105 countries with multidimensional poverty measure. Moreover, the Ethiopian economy continued to be challenged by high government debt, shortage of foreign currency, insufficient or low productive capacity which lowered the country's capacity to produce goods and services, generate sufficient employment opportunities for its growing population, and to integrate successfully into international trade. In the same manner, although the Ethiopian Electricity sector has shown growth in the past 20 years, the Energy consumption is still predominantly been dominated by Traditional Biomass energy sources which in 2017 represents 87 percent of the total energy consumption. In the same year the electricity consumption was only 2% of the total energy consumption, which by any measure is one of the lowest coverage in the world. On top of this, in 2017 only 42.9 per cent of the population has access to electricity.

The objective of this paper was to investigate the short-run and long-run causal relationships between Economic Growth/GDP and Electricity Consumption as target variables and by considering additional variables such as FDI, Government Expenditure and Net Export in Ethiopia during the period 1988–2017, assuming other things remained constant. The study employed Autoregressive Distributed Lag (ARDL) and Error Correction Model (ECM), as an econometric approach, with the help of statistical software EViews. The study was motivated by the fact that the literature on this important debate – the electricity-growth debate – is limited in Ethiopia. That is, those studies that were specifically done for Ethiopia were very few in number. Besides, these few available studies on Ethiopia have some limitations or they failed to include some of the recommendations that were believed to alleviate the discrepancies and inconsistencies between the various studies results observed in the literature. Consequently, in the intention of increasing the robustness of the final causality results, this research, in addition to the two target variables (Electricity Consumption and Economic Growth), incorporated additional variables namely: Foreign Direct Investment (FDI), Government Expenditure and Net Export in the analysis. In doing so, this research was able to avoid omitted variable bias to some extent, since these variables can affect both Economic Growth as well as Electricity Consumption.

The causality test, based on the Autoregressive Distributed Lag (ARDL), Error Correction Model (ECM) and Pairwise Granger Causality framework, found out that there is no causality between Electricity Consumption and Economic Growth in Ethiopia both in the short run and in the long run. In the same vein, there is an independent relationship between Net Export and Economic growth and vice versa. The study findings have also shown that Government Expenditure and FDI does not Granger Cause Economic Growth. However, the Economic Growth Granger Cause both Government Expenditure and FDI. This might be because, as the economy grows government spending increases and also the inflow of FDI is encouraged.

Even though the results of the study supported the neutrality hypothesis found in the literature, or cannot scientifically support the existence of a unidirectional or a bidirectional relationship, by looking at global practices and the far reaching social, political, economic and environmental benefits of electricity, the researcher urge policy-makers to implement strategies that improve supply of electric power generation in Ethiopia. Moreover, despite its enormous hydroelectric potential, Ethiopia does not yet meet its energy requirements in the sector. Therefore, it must implement a strong policy of generating, transmitting and distributing electricity from varying technologies and by allowing private investment in the sector, in order to satisfy demand, contribute to economic development and achieve the Sustainable Development Goals.

5.2. Recommendations

Overall, the results of this study show that the long-run equilibrium relationship between electricity consumption and economic growth in Ethiopia needs further attention in future researches.

For that reason, in order to make future empirical results as robust and as representative as possible and more interesting to potential interested parties, it is recommended that future research to incorporate longer time series and additional data sets over and above the one considered in the analysis, such as: total population, financial development, carbon dioxide emissions, etc. It may also be interesting to investigate causality between electricity consumption and GDP by using more disaggregated and sectorial micro level data.

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APPENDICES

APPENDIX A: SUMMARY OF LITERATURE REVIEW

Table 12: Summary of literature review for electricity consumption and economic growth for selected European countries

Study	Country	Period	Methodology	Results
OECD member countries				
Murray and Nan (1996)	7 countries[1]	1970-1990	VAR	Mixed results
Altinay and Karagol (2005)	Turkey	1950-2000	Dolado-Lütkepohl and Granger-causality test	GDP←EC
Ciarreta and Zarraga (2007)	Spain	1971-2005	Johansen-Juselius and ARDL approach; no co-integration; VAR; Toda-Yamamoto and Dolado-Lütkepohl causality test	GDP→EC
Erbaykal(2008)	Turkey	1970-2003	ARDL approach; co-integration; VEC	GDP←EC
Narayan and Prasad (2008)	23 OECD Member countries[2]	1960-2002	Bootstrapped Granger-causality test	Mixed results
Acaravci(2010)	Turkey	1977-2006	ARDL approach; co-integration; VEC	GDP←EC
Acaravci and Ozturk (2010)	3 countries[3]	1990-2006	Pedroni; no co-integration	No causality
Ciarreta and Zarraga(2010)	12 countries[4]	1970-2007	Pedroni; co-integration panel VEC	GDP←EC
Shahbaz et al. (2011)	Portugal	1971-2009	ARDL approach; co-integration; VEC	GDP↔EC
Acaravci and Ozturk (2012)	Turkey	1968-2006	ARDL approach; co-integration; VEC	GDP←EC
Bildirici et al. (2012)	4 countries[5]	1970-2010	ARDL approach; co-integration; VEC	GDP→EC
Georgantopou los (2012)	Greece	1980-2010	Johansen-Juselius; co-integration; VEC	GDP←EC
Gurgul and Lach (2012)	Poland	2000 - 2009	Johansen-Juselius; co-integration; VEC and Toda-Yamamoto causality test	GDP↔EC
Baranzini et al. (2013)	Switzerland	1950-2010	ARDL approach; co-integration; VEC	GDP→EC
Non-OECD countries				
Acaravci and Ozturk (2010)	12 countries[6]	1990-2006	Pedroni; no co-integration	No causality
Kayhan et al. (2010)	Romania	2001-2010	Dolado-Lütkepohl, Toda-Yamamoto and Granger-causality test	GDP←EC
Bildirici and Kayikçi (2012)	11 countries[7]	1990-2009	Pedroni and ARDL approach; co-integration; panel VEC	Mixed results29

Source: Jakovac, Pavle, 2017

1. France, Luxembourg, Norway, Germany, Portugal and United Kingdom (no causality); Turkey (GDP←EC).
2. Austria and Belgium (no causality), Czech (GDP←EC), Denmark (no causality), Finland (GDP→EC), France, Greece and Ireland (no causality), Island (GDP↔EC), Italy (GDP←EC), Luxembourg (no causality), Hungary (1965-2002; GDP→EC), Netherlands (GDP→EC), Norway, Germany and Poland (no causality), Portugal (GDP←EC), Slovakia (1971-2002; GDP←EC), Spain, Sweden and Turkey (no causality), United Kingdom (GDP↔EC). 3. Czech, Poland and Slovakia. 4. Austria, Belgium, Denmark, Finland, France, Italy, Luxembourg, Netherlands, Norway, Germany, Sweden and Switzerland. 5. Italy, France, Turkey and United Kingdom. 6. Albania, Belarus, Bulgaria, Estonia (member of OECD since 2010), Latvia, Lithuania, FYR Macedonia Moldova, Romania, Russia, Serbia & Ukraine. 7. The sample consists of 11 former soviet republics classified in three panels: Panel A) Azerbaijan, Belarus, Kazakhstan and Russia – GDP p/c 1900-2500$); Panel B) Kyrgyzstan, Moldova, Tajikistan and Uzbekistan – GDP p/c 300-800$; Panel C) Armenia, Georgia and Ukraine – GDP p/c 1000-1500$.

Table 13: Summary of Literature Review for EC and EG - Worldwide

Study	Country	Period	Methodology	Results
OECD member countries				
Fatai et al. (2004)	Australia	1960-1999	Johansen-Juselius and ARDL approach; co-integration; VEC, Granger and Toda-Yamamoto causality test	GDP→EC
Narayan and Smyth (2005)	Australia	1966-1999	ARDL approach; co-integration; VEC	GDP→EC
Yoo (2005)	South Korea	1970-2002	Johansen-Juselius; co-integration; VEC	GDP↔EC
Chen et al. (2007)	South Korea	1971-2001	Johansen-Juselius; Pedroni; co-integration; VEC	GDP→EC
Narayan and Prasad (2008)	7 OECD Member countries	1960-2002	Bootstrapped Granger causality test	mixed results
Narayan et al. (2010)	G-6 countries	1980-2006	Pedroni; co-integration; Canning-Pedroni causality test	GDP↔EC **(-)**
Bildirici et al. (2012)	Japan Canada and USA	1970-2010	ARDL approach; co-integration; VEC	GDP→EC GDP←EC
Non OECD countries				
Yang (2000)	Taiwan	1954-1997	Engle-Granger; no co-integration; Granger causality test (Hsiao version)	GDP↔EC
Aqeel and Butt (2001)	Pakistan	1955-1996	Engle-Granger; no co-integration; Granger causality test (Hsiao version)	GDP←EC
Ghosh(2002)	India	1950-1997	Johansen-Juselius; no co-integration; VAR	GDP→EC
Jumbe (2004)	Malawi	1970-1999	Engle-Granger; co-integration; VEC	GDP→EC[4]
Shiu and Lam (2004)	China	1971-2000	Johansen-Juselius; co-integration; VEC	GDP←EC
Lee and Chang(2005)	Taiwan	1954-2003	Johansen-Juselius; co-integration; weak exogenity test	GDP←EC
Squalli and Wilson(2006)	6 countries	1980-2003	ARDL approach; co-integration; Toda-Yamamoto causality test	mixed results
Wolde- Rufael	17 countries	1971-2001	Toda-Yamamoto causality test	mixed results
Yoo (2006)	Indonesia and Thailand Malaysia and Singapore	1971-2002	Engle Granger and Johansen-Juselius; no co-integration; Granger causality test (Hsiao version)	GDP→EC GDP↔EC

Study	Country	Period	Methodology	Results
Chen et al. (2007)	9 countries	1971-2001	Johansen-Juselius; Pedroni; cointegration (6 countries plus entire panel); VEC; VAR (3 countries)	Mixed results– country by country entire panel: GDP↔EC
Ho and Siu(2007)	Hong Kong	1966-2002	Johansen-Juselius; cointegration; VEC	GDP←EC
Mozumder and Marathe (2007)	Bangladesh	1971-1999	Johansen-Juselius; cointegration; VEC	GDP→EC
Narayan and Singh (2007)	Fiji	1971-2002	ARDL approach; cointegration; VEC	GDP←EC
Squalli (2007)	11 OPEC member countries	1980-2003	ARDL approach; cointegration; VEC and Toda-Yamamoto causality test	Mixed results
Yuan et al. (2007)	China	1978-2004	Johansen-Juselius; cointegration; VEC	GDP←EC
Tang (2008)	Malaysia	1972-2003	ARDL approach; no cointegration; Toda- Yamamoto causality test	GDP↔EC
Yuan et al. (2008)	China	1963-2005	Johansen-Juselius; cointegration; VEC; IR	GDP↔EC
Abosedra et al. (2009)	Lebanon	1995-2005	VAR	GDP←EC
Akinlo (2009)	Nigeria	1980-2006	Johansen-Juselius; cointegration; VEC	GDP←EC
Narayan and Smyth(2009)	6 countries	1974-2002	Westerlund; cointegration; panel VEC	GDP↔EC
Odhiambo (2009a)	Tanzania	1971-2006	ARDL approach; cointegration; VEC	GDP←EC
Odhiambo(2009 b)	South Africa	1971-2006	Johansen-Juselius; cointegration; VEC	GDP↔EC
Pao (2009)	Taiwan	1980-2007	Johansen-Juselius; cointegration; VEC	GDP→EC
Chandran et al. (2010)	Malaysia	1971-2003	Engle-Granger; Johansen-Juselius and ARDL approach; cointegration; VEC	GDP←EC
Lorde et al. (2010)	Barbados	1960-2004	Johansen-Juselius; cointegration; VEC; IR; VD	GDP↔EC
Ouédraogo (2010)	Burkina Faso	1968-2003	ARDL approach; cointegration; VEC	GDP↔EC
Yoo and Kwak (2010)	7 countries	1975-2006	Johansen-Juselius; cointegration (2 countries); VEC; Granger causality test – Hsiao version (5 countries)	mixed results
Adebola (2011)	Botswana	1980-2008	ARDL approach; cointegration; VEC	GDP←EC16

Study	Country	Period	Methodology	Results
Kouakou (2011)	Ivory Coast	1971-2008	ARDL approach; cointegration; VEC	GDP↔EC
Ozturk and Acaravci(2011)	11 countries	1971-2006	ARDL approach; cointegration; VEC	mixed results
Bildirici et al. (2012)	4 countries	1970-2010	ARDL approach; cointegration; VEC	mixed results
Shahbaz and Lean(2012)	Pakistan	1972-2009	Johansen-Juselius and ARDL approach; cointegration; VEC	GDP↔EC
Shaari et al. (2013)	Malaysia	1980-2010	Johansen-Juselius; cointegration; Granger causality test	GDP→EC
Solarin and Shahbaz (2013)	Angola	1971-2009	ARDL approach; cointegration; VEC	GDP↔EC
Tang and Tan (2013)	Malaysia	1970-2009	ARDL approach; cointegration; VEC	GDP↔EC
Countries classified by major world regions				
Narayan et al. (2010)	93 countries	1980-2006	Pedroni; cointegration; Canning-Pedroni causality test	mixed results
Other causality studies				
Wolde-Rufael(2004)	Shanghai	1952-1999	Toda-Yamamoto causality test	GDP←EC

Source: Jakovac, Pavle 2017

Table 14: Selected Studies on the Neutrality Thesis

Author(s)	Countries	Methodology	Conclusion(s)
Ozturk and Acaravci (2011)	11 Middle East and North Africa(mena) Countries (1971–2006)	ARDL-Bounds Testing Procedure	ELC~Y
Wolde-Rufael(2009)	17AfricanCountries (1971–2001)	Multivariate Granger Causality	EC ~ Y; Cameroon, and Kenya
Narayan and Prasad (2008)	30 OECD Countries	Bootstrapped Causality Tests	ELC~Y; Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Slovakia, Spain, Sweden, Switzerland, Turkey, and USA
Akinlo (2008b)	11Sub-SaharanAfrican Countries	ARDL - Bounds Testing Procedure	EC~Y; Cameroon, Cote d'Ivoire, Nigeria, Kenya, and Togo
Wolde-Rufael(2006)	17AfricanCountries (1971–2001)	ARDL-Bounds Testing Procedure	EC ~ Y; Algeria, Congo, Kenya, South Africa, Sudan
Soytas and Sari(2003)			EC~Y; Canada, Indonesia, Poland, USA and UK
Masih and Masih (1997)	India, Indonesia, Pakistan, Malaysia, Singapore, and the Philippines (varying sample periods)	VECM	ELC ~ Y; Malaysia, Singapore, and the Philippines
Murray and Nan(1994)	Germany, Israel, Portugal, USA, UK, Zambia, France, and Norway(1970–1990)	Granger Causality; VAR	ELC~Y

Notes "→"denotes uni-directional causality,"↔" denotes bi-directional causality,"~" denotes no causality; EC, ELC, and Y represent energy consumption, electricity consumption, and income (GDP), respectively.
Source: Iyke, Bernard N. (2014)

APPENDIX B: ANALYSIS RESULTS

1. Stationary Tests for GDP Growth Rate

Null Hypothesis: GDP_GR_RATE has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=7)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.494374	0.0155
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	
*MacKinnon (1996) one-sided p-values.			

Source: Own computation using EViews 10

2. Stationarity Tests for Log of Electricity Consumption

Null Hypothesis: LOGELC_SA has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=7)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.868549	0.0063
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	
*MacKinnon (1996) one-sided p-values.			

Source: Own computation using EViews 10

3. Stationarity test for log of Government Expenditure

Null Hypothesis: D(LGOV_EXP) has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=7)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.666006	0.0106
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	
*MacKinnon (1996) one-sided p-values.			

Source: Own computation using EViews 10

4. Stationarity test for log of Foreign Direct Investment

Null Hypothesis: D(LFDI) has a unit root			
Exogenous: Constant			
Lag Length: 1 (Automatic - based on SIC, maxlag=6)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.208458	0.0000
Test critical values:	1% level	-3.724070	
	5% level	-2.986225	
	10% level	-2.632604	
*MacKinnon (1996) one-sided p-values.			

Source: Own computation using EViews 10

5. Stationarity test for Net Export in billion US$

Null Hypothesis: D(NEIB) has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=7)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.685252	0.0009
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	
*MacKinnon (1996) one-sided p-values.			

Source: Own computation using EViews 10

6. Optimal Lag selection for each variable

6.1. Optimal Lag for FDI

VAR Lag Order Selection Criteria

Endogenous variables: LFDI

Exogenous variables: C LOGELC_SA LGE NEIB GDP_GR_RAT

Date: 06/08/19 Time: 10:05

Sample: 1988 2017

Included observations: 24

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-7.479308	NA	0.166669	1.039942	1.285370	1.105054
1	-4.908120	3.856782*	0.146894	0.909010	1.203523*	0.987144
2	-4.643946	0.374245	0.157220	0.970329	1.313928	1.061486
3	-2.128260	3.354249	0.139823*	0.844022*	1.236706	0.948201*
4	-1.875498	0.315952	0.150600	0.906292	1.348062	1.023493

Source: Own computation using EViews 10

6.2.Optimal Lag for Electricity Consumption

VAR Lag Order Selection Criteria

Endogenous variables: LOGELC_SA

Exogenous variables: C LFDI LGE NEIB GDP_GR_RAT

Date: 06/08/19   Time: 10:07

Sample: 1988 2017

Included observations: 26

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-33.05625	NA*	1.098973*	2.927404*	3.169345*	2.997074*
1	-32.43312	0.958663	1.135396	2.956393	3.246723	3.039998
2	-32.30915	0.181185	1.220805	3.023781	3.362499	3.121319
3	-32.30907	0.000102	1.327669	3.100698	3.487805	3.212171
4	-31.38657	1.206350	1.347983	3.106659	3.542154	3.232066

Source: Own computation using EViews 10

6.3.Optimal Lag for GDP Growth Rate

VAR Lag Order Selection Criteria

Endogenous variables: GDP_GR_RAT

Exogenous variables: C LFDI LGOV_EXP E NEIB LOGELC_SA

Date: 06/08/19   Time: 10:08

Sample: 1988 2017, Included observations: 26

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-78.14965	NA*	35.27233*	6.396127*	6.638068*	6.465797*
1	-77.84949	0.461774	37.35807	6.449961	6.740291	6.533565
2	-76.80237	1.530409	37.41479	6.446336	6.785054	6.543875
3	-76.05003	1.041708	38.40216	6.465387	6.852493	6.576859
4	-75.29340	0.989430	39.49041	6.484108	6.919603	6.609515

Source: Own computation using EViews 10

6.4. Optimal Lag for Government Expenditure

VAR Lag Order Selection Criteria

Endogenous variables: LGE

Exogenous variables: C LFDI GDP_GR_RAT NEIB LOGELC_SA

Date: 06/08/19 Time: 10:10

Sample: 1988 2017

Included observations: 26

Lag	LogL	LR	FPE	AIC	SC	HQ
0	25.45849	NA	0.012195	-1.573730	-1.331788	-1.504059
1	41.13107	24.11167*	0.003959*	-2.702390*	-2.412060*	-2.618786*
2	41.24909	0.172493	0.004259	-2.634546	-2.295827	-2.537007
3	41.27083	0.030099	0.004624	-2.559295	-2.172188	-2.447822
4	41.31971	0.063926	0.005021	-2.486132	-2.050637	-2.360725

Source: Own computation using EViews 10

6.5. Optimal Lag for Net Export

VAR Lag Order Selection Criteria

Endogenous variables: NEIB

Exogenous variables: C LFDI GDP_GR_RAT LOGELC_SA LGE

Date: 06/08/19 Time: 10:11

Sample: 1988 2017

Included observations: 26

Lag	LogL	LR	FPE	AIC	SC	HQ
0	137.2199	NA	2.25e-06	-10.17076	-9.928816	-10.10109
1	150.6977	20.73519*	8.65e-07*	-11.13059*	-10.84026*	-11.04699*
2	150.8159	0.172788	9.31e-07	-11.06277	-10.72405	-10.96523
3	151.4624	0.895052	9.63e-07	-11.03557	-10.64846	-10.92409
4	151.6105	0.193650	1.04e-06	-10.97004	-10.53454	-10.84463

Source: Own computation using EViews 10

7. Estimation of ARDL Model

Dependent Variable: GRGDP				
Method: ARDL				
Date: 06/09/19 Time: 07:49				
Sample (adjusted): 1991 2017				
Included observations: 27 after adjustments				
Maximum dependent lags: 1 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (1 lag, automatic): LGOV_EXP LFDI LOGELC_SA NEIB				
Fixed regressors: C				
Number of models evalulated: 16				
Selected Model: ARDL(1, 1, 1, 1, 1)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDP_GR_RAT (-1)	-0.363818	0.233947	-1.555128	0.1383
LGOV_EXP	88.68603	30.03261	2.952991	0.0089
LGE(-1)	-66.57953	26.55993	-2.506766	0.0226
LFDI	7.908538	2.112920	3.742942	0.0016
LFDI(-1)	-13.04648	3.174275	-4.110065	0.0007
LOGELC_SA	-3.850911	1.315852	-2.926553	0.0094
LOGELC_SA(-1)	-5.976762	2.442520	-2.446966	0.0256
NEIB	-2112.568	1264.676	-1.670442	0.1131
NEIB(-1)	2055.837	1158.124	1.775144	0.0938
C	-2.292891	39.35136	-0.058267	0.9542

R-squared	0.648063	Mean dependent var	6.901189
Adjusted R-squared	0.461744	S.D. dependent var	6.162307
S.E. of regression	4.521034	Akaike info criterion	6.133476
Sum squared resid	347.4758	Schwarz criterion	6.613416
Log likelihood	-72.80193	Hannan-Quinn criter.	6.276187
F-statistic	3.478238	Durbin-Watson stat	1.847255
Prob(F-statistic)	0.012966		

*Note: p-values and any subsequent tests do not account for model selection.

Source: Own computation using EViews 10

8. Bounds Co- integration Test (F- bound test)

ARDL Long Run Form and Bounds Test

Dependent Variable: D(GDP_GR_RAT)

Selected Model: ARDL(1, 1, 1, 1, 1)

Case 2: Restricted Constant and No Trend

Date: 06/11/19 Time: 12:30 Sample: 1988 2017, Included observations: 27

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.292891	39.35136	-0.058267	0.9542
GDP_GR_RAT (-1)*	-1.363818	0.233947	-5.829592	0.0000
LFDI(-1)	-5.137938	2.339745	-2.195939	0.0423
LGE(-1)	22.10650	12.06225	1.832701	0.0844
LOGELC_SA(-1)	-9.827673	3.088139	-3.182394	0.0055
NEIB(-1)	-56.73041	878.7589	-0.064557	0.9493
D(LFDI)	7.908538	2.112920	3.742942	0.0016
D(LGOV_EXP)	88.68603	30.03261	2.952991	0.0089
D(LOGELC_SA)	-3.850911	1.315852	-2.926553	0.0094
D(NEIB)	-2112.568	1264.676	-1.670442	0.1131

* p-value incompatible with t-Bounds distribution.

Levels Equation Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFDI	-3.767319	1.736393	-2.169623	0.0445
LGOV_EXP	16.20927	8.863591	1.828748	0.0850
LOGELC_SA	-7.205999	2.101409	-3.429128	0.0032
NEIB	-41.59676	643.5806	-0.064633	0.9492
C	-1.681229	28.87349	-0.058227	0.9542

EC = GDP_GR_RAT - (-3.7673*LFDI + 16.2093*LGOV_EXP -7.2060*LOGELC_SA -41.5968*NEIB -1.6812)

F-Bounds Test — Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	6.110853	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37
Actual Sample Size	27		Finite Sample: n=35	
		10%	2.46	3.46
		5%	2.947	4.088
		1%	4.093	5.532
			Finite Sample: n=30	
		10%	2.525	3.56
		5%	3.058	4.223
		1%	4.28	5.84

Source: Own computation using EViews 10

9. Estimation of Error Correction Model (ECM)

ARDL Error Correction Regression

Dependent Variable: D(GDP_GR_RAT)

Selected Model: ARDL(1, 1, 1, 1, 1)

Case 2: Restricted Constant and No Trend

Date: 06/09/19 Time: 07:55

Sample: 1988 2017

Included observations: 27

ECM Regression

Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGOV_EXP)	88.68603	20.71993	4.280229	0.0005
D(LFDI)	7.908538	1.694901	4.666076	0.0002
D(LOGELC_SA)	-3.850911	0.779509	-4.940178	0.0001
D(NEIB)	-2112.568	838.3846	-2.519807	0.0220
CointEq(-1)*	-1.363818	0.197990	-6.888321	0.0000

R-squared	0.730242	Mean dependent var	0.278495
Adjusted R-squared	0.681195	S.D. dependent var	7.038629
S.E. of regression	3.974211	Akaike info criterion	5.763106
Sum squared resid	347.4758	Schwarz criterion	6.003075
Log likelihood	-72.80193	Hannan-Quinn criter.	5.834461
Durbin-Watson stat	1.847255		

* p-value incompatible with t-Bounds distribution.

Source: Own computation using EViews 10

10. Results of Pairwise granger causality tests

Pairwise Granger Causality Tests			
Date: 06/09/19 Time: 07:57			
Sample: 1988 2017			
Lags: 1			
Null Hypothesis:	Obs	F-Statistic	Prob.
LGE does not Granger Cause GDP_GR_RAT	29	2.53505	0.1234
GDP_GR_RAT does not Granger Cause LGE		11.0899	0.0026
LFDI does not Granger Cause GDP_GR_RAT	27	0.38796	0.5392
GDP_GR_RAT does not Granger Cause LFDI		4.23435	0.0506
LOGELC_SA does not Granger Cause GRGDP	29	0.69572	0.4118
GDP_GR_RAT does not Granger Cause LOGELC_SA		1.48955	0.2332
NEIB does not Granger Cause GRGDP	29	2.96370	0.0970
GDP_GR_RAT does not Granger Cause NEIB		0.99306	0.3282
LFDI does not Granger Cause LGOV_EXP	27	30.3444	1.E-05
LGOV_EXP does not Granger Cause LFDI		1.09503	0.3058
LOGELC_SA does not Granger Cause LGE	29	0.50175	0.4850
LGOV_EXP does not Granger Cause LOGELC_SA		0.69313	0.4127
NEIB does not Granger Cause LGE	29	0.31501	0.5794
LGE does not Granger Cause NEIB		6.05017	0.0209
LOGELC_SA does not Granger Cause LFDI	27	1.10848	0.3029
LFDI does not Granger Cause LOGELC_SA		0.01583	0.9009
NEIB does not Granger Cause LFDI	27	2.60839	0.1194
LFDI does not Granger Cause NEIB		1.77741	0.1950
NEIB does not Granger Cause LOGELC_SA	29	0.26672	0.6099
LOGELC_SA does not Granger Cause NEIB		1.07772	0.3088

Source: Own computation using Eviews 10