ENERGY EFFICIENCY AND ECONOMIC GROWTH IN ETHIOPIA

TIME SERIES ANALYSIS

MSc THESIS

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WOLKITE UNIVERSITY

WOLKITE, ETHIOPIA

AUGUST, 2020

WOLKITE UNIVERSITY

SCHOOL OF GRADUATE STUDIES

ENERGY EFFICIENCY AND ECONOMIC GROWTH IN ETHIOPIA

TIME SERIES ANALYSIS

By

DESALEGN DEBEBE SORATO

A THESIS SUBMITTED TO THE DEPARTMENT OF ECONOMICS, COLLEGE OF BUSINESS AND ECONOMICS, SCHOOL OF GRADUATE STUDIES WOLKITE UNIVERSITY IN PARTIALS FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF DEVELOPMENT ECONOMICS

JUNE, 2020

WOLKITE, ETHIOPIA

DECLARATION

I, Desalegn Debebe, declare that this thesis entitled “The relationship between energy efficiency and economic growth, time series analysis” is outcome of my own effort and study and that all sources of materials used for the study have been duly acknowledged.

To the best of my knowledge, this study has not been submitted for any degree in this University or any other University. It is offered for the partial fulfilment of the degree of Masters of Development Economics.

By: Desalegn Debebe Sorato

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Date: 22/06/2020

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This is to certify that the thesis entitled "The relationship between energy efficiency and economic growth, time series analysis" submitted in partial fulfilment of the requirements for the degree of Master's with specialization in Development Economics, the Graduate Program of the Department/School of Business and Economics, and has been carried out by Desalegn Debebe Id. No GSE/064/10, under my/our supervision. To the best of my knowledge, is an original work and not submitted earlier for any degree either at this University or any other University.

Therefore I/we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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We, the undersigned, member of the Board of Examiners of the final open defence by, Desalegn Debebe have read and evaluated his thesis entitled "The relationship between energy efficiency and economic growth, time series analysis" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfilment of the requirements for the degree of Masters in Development Economics.

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Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the School of Graduate Studies (SGS) through the Department/School Graduate Committee (DGC/SGC) of the candidate's department.

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ACKNOWLEDGMENT

First of all i give thanks to my Lord God for giving me this opportunity to advance my career and devotedly helped me all the way from beginning up to ending through the sequence of the study.

Next my heartfelt thankfulness goes to my research major advisor, Tesfaye Chofana (PhD) for his assistance, constructive comments and critical remarks. I recognize his closest guidance from start to the final write-up of the thesis. I also express my deepest thanks to Kassa Teshale (PhD) and co-advisor Hayatu Mude for their constructive advice and guidance to right point especially at the beginning of proposal of the thesis and to the end.

I would like to extend my thanks to all my family and friends who directly or indirectly provided me with moral support and wish for my success through their advice. Besides, I would also express my thanks to staff of National Bank of Ethiopia and Ministry of Finance by providing necessary information in preparation of this research thesis.

Finally, I would like to thank Economics Department of Wolkite University for good acceleration and adjusting of post graduate program that helped me and others became the holder of the second degree.

BIOGRAPHY SKETCH

The author was born on September 01, 1990 G.C in Suke Bakala rural kebele of Damot Pulasa Woreda, Southern Nation Nationalities and Peoples Regional State, Wolaita Zone in Southern part of Ethiopia. He attended his elementary school in Suke Bakala and Shanto Primary school respectively and senior secondary and preparatory school at Boditi high School. After successfully completion of his preparatory level of education, he joined Hawassa University in 2010 G.C College of Natural and Computational for his BA degree in Statistics and graduated in July, 2012. After graduation, he has been served field supervisor of data collection up to June, 2017 at central statistical agency and from June, 2017 still now serving as planning officer in Development Bank of Ethiopia. By the year 2018, he joined Wolkite University, school of post graduate studies to pursue his M.Sc. degree in Economics (Development Economics).

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ABBREVIATIONS AND ACRONYMS

Abbreviations	Acronyms
ADF	Augmented Dickey Fuller
AGR	Share of Agriculture to GDP
AIC	Akaike Information Criteria
BIC	Bayesian Information Criterion
CE	Cointegration Equation
CLRM	Classical Linear Regression Model
DSP	Difference Stationary Process
DW	Durbin Watson
ECM	Error Correction Mechanism
EI	Energy Intensity
EEA	Ethiopian Economic Association
FPE	Final Prediction Error
GHG	Greenhouse Gas Emission
GNP	Gross National Product
GWH	Gigawatt hour
HDM	Harrow Domar Model
HQC	Hanan Quinn Criteria
ICOR	Incremental Capital Output Ratio
IEA	International Energy Agency
IND	Share of industry Sector to GDP
IRENA	International Renewable Energy Agency
IRF	Impulse Response Function
LN	Natural Logarithm
LR	Likelihood Ratio
MoFEC	Ministry of Finance and Economic Cooperation
MoWE	Ministry of Water and Energy
NBE	National Bank of Ethiopia
NDC	Nationally Determination Contribution
OLS	Ordinary Least Square
OPEC	Organization of Petroleum Export Countries
PPP	Purchasing Power Parity
RGDP	Real Gross Domestic Product
SERV	Share of Service Sector to GDP
SIC	Schwarze Information Criteria
SSA	Sub Saharan Africa
SSR	Sum of Squared of Residual
TSP	Trend Stationary Process
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
VAR	Vector Autoregressive

VECM	Vector Error Correction Model
WDI	World Development indicator

ABSTRACT

We have limited studies on the relationship between energy efficiency and economic growth in the context of sub Saharan Africa where efficient energy supply is limited although energy is vital to meet sustainable development goals. Considering this, this study investigates the long run relationship between energy efficiency and the economic growth in Ethiopia for the period 1974/75 to 2017/18. Multivariate time series analysis was employed. The result indicated that the existence of unidirectional causality running from economic growth to energy efficiency. Similarly, for the sectoral share of GDP, the unidirectional causality runs from energy efficiency to industry share while as bidirectional causality runs from service shares to energy efficiency and vice versa. The speed of adjustment coefficient indicates that the previous period disequilibrium adjusts to equilibrium at the rate of 59.2% annually. Impulse response function specifies responsiveness of the energy efficiency in the model to the shocks in the error term indicated that economic growth has significant influence while variance decomposition measured the strength of causality relationship showed high causal effect to energy efficiency. The overall result showed that increased economic growth has a strong cause of energy efficiency in Ethiopia. The government needs to give more importance to sustain economic growth so that both the wellbeing and the energy efficiency of the nation are improved.

Key words: *Economic Growth, Energy Efficiency, Granger Causality, Impulse response, Sectoral Shares, VECM, Variance decomposition analysis, Ethiopia.*

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Energy is vital for the existence of life on the earth. Availability and utilization of energy is crucial to operate all economic activities. It has been considered as a key factor of production in addition to capital, labour and technology. It plays a major role in the economic growth of a country. Efficient use of energy may lead to higher economic growth, reduce emission of greenhouse gasses and energy to generate energy.

Energy insufficiency influences the lives of mass in various forms. For instance, energy is required for the wheel running on the roads, to provide services in hospitals, laboratories, educational institutions, private businesses and to operate heavy machines in manufacturing and agriculture. For the past decade's energy has used as the main input and cause for economic growth. Both business and financial economists have accounted the importance of energy, particularly by considering energy prices in their analysis (Poveda and Martinez, 2011). The theories of economic growth have continued to give little importance to the impact of energy on economic growth (Dizdarevic and Zikovic, 2010).

In the history of 1970, 1970's energy crisis was a period when the major industrial countries of the world particularly Japan, Western Europe, Canada, United States, Australia and New Zealand faced considerable petroleum shortages, real and perceived as well as elevated prices. The two worst energy crisis of the period were the 1973 oil crisis due to 1973 Arab-Israel war and 1979 crisis due to Islamic revolution. To address such challenges, International Energy Agency (IEA) was formed by member of 29 countries.

During the period of 1970's oil crisis that adversely affected both developed and developing countries. Moreover, in the same period net oil importers increased and energy has gained more attention. Since the oil cartel action of 1967 where Arab oil producing countries decided to limit oil supply to United States and United Kingdom in a move to discourage support to Israel and the resultant energy crisis of the 1970's encouraged studies on energy in the western world. Later scholars began to model energy economy interactions in developing economies (Blitzer, 1986; Rahman, 1982; Griffin and Schulman, 2005). The OPEC inspired oil crisis marked the end of low cost energy era (Dunkerley, 1983). The impact of costly fuel energy in the development of energy importing developing countries is a rich research field. (Blitzer, 1986) studied that developing economies consume only about one-sixth of the world oil.

During the past few years, numerous studies have been conducted to examine the relationship between energy consumption and economic growth of an economy. So far, it has been found that there is strong relationship between electricity consumption and economic growth. The issue on energy efficiency studied in over 100 countries and found that there is a strong correlation between electricity consumption and economic growth (Ferguson et al., 2002).

According to (Stern and Cleveland, 2004), energy has vital role to economic growth. If energy supply is considered as a homogenous input for the production function, then a policy constraint that affects energy supply harms economic development. When energy services are differentiated, emphasizing the existence of higher and lower quality forms of energy, society should make a choice in terms of optimal energy mix considering higher quality energy services could produce increasing returns to scale. This means that energy regulation policies supporting the shift from lower quality (typically less efficient and more polluting) to higher quality energy services could provide impulse to economic growth rather than be detrimental to the development process (Costantini and Martini, 2010).

Production and consumption activities need energy as an input (Lee, 2005). He found a relationship between energy consumption and GDP in Taiwan. He viewed energy acts as an engine for economic growth in long run and energy wastage may be harmful for economic growth. The relation between electricity consumption and real GDP of Turkey for the period of 1950 to 2000 and found that electric supply is necessary for economic growth investigated (Galip, 2005).

The importance of energy consumption and observed that in developing countries energy consumption has been increased was examined (Balat, 2007). Turkish government is encouraging national and international investors to invest in energy projects. He said that energy sector needs more investment for the progress of the country. He thought wind and solar energy as alternative sources.

Third world countries depends heavily on fossil fuels and hydroelectric power remain the potential sources of energy for commercial development, though biomass energy was account for a greater percentage in energy provision to the world poorest. However, such energy sources face challenges as noted by (Dunkerley, 1983) who argued that its expansion negatively affects the global sustainable forest management.

Ethiopia among sub Saharan Africa countries has abundant natural resource including potential energy sources. Economic growth is a prerequisite for a nation to move from a third world country to a developed country. With adequate utilization of energy potentials to meet the demand, the nation would experience high level of economic growth.

This paper investigated that the relationship between energy efficiency and economic growth in Ethiopia. Energy plays essential role in the development of a country. It has always been critical for the development and growth of the country. Adequate energy supply is necessary to meet the needs of the country. Energy is also necessary for poverty reduction. Since there is more energy it means there is an adequate access of water and electricity that is necessary for growth. (Yemane, 2010) tried to find the causal relation between real GDP and nuclear energy consumption for the period of 1971 to 2005. The author explained it is necessary to make energy sector efficient for economic growth.

1.2 Statement of the problem

Most studies on the relationship between energy efficiency and economic growth was on the developed countries, primarily the European countries. Advanced nations are rich with stable populations, low unemployment rate and have high economic growth. So, they tend to have energy efficiency that is improving constantly. Conversely, developing countries are generally poor and face high population growth rates and limited availability of energy. Their resources are too limited to develop better technology and afford energy conserving environment. Hence their energy intensities are unfavourable, showing no systematic improvement over time. Moreover, the empirical evidence on the relationship between energy consumption and economic growth was mixed and mostly inconsistent. According to (Nilsson, 1993) evaluated energy intensity trends for 31 countries for the period 1950 to 1988 found that energy intensity has decreased for about 50% of the countries under consideration.

Since the oil crisis in 1970th, the relationship between energy consumption and economic growth has been a hot issue in domestic and foreign academic research (Zhixin and Xin, 2011). Government, professionals and academics are concerned about the impact of energy consumption on the economy. Today, Nigeria is seen as one of the greatest developing nations in Africa with highly endowed natural resources including potential energy resources. However, increasing access to energy in Nigeria has proved to be not only a continuous challenge but also a pressing issue with the international community.

Energy consumption per capita is particularly low in Ethiopia as compared with most countries in the world (Dinkineh, 2012). The total energy consumption per capita is reported to be 0.40 tons of oil equivalents which are far below the average Sub Saharan energy consumption, which is about 0.80 toes (Gebreegziabher and Van Kooten, 2013). According to Ministry of Water and Energy (MoWE) even though the country has a large share of water and other energy sources in its energy mix, an devastating proportion (87%) of the country's energy consumptions is met by traditional energy sources such as firewood, charcoal, dung cakes and agricultural residues (MoWE, 2012). However, there is a gradual shift from traditional to modern energy sources, specifically to hydroelectric energy showed by the reports of International Energy Agency (IEA, 2014). The majority of the population relies on traditional biomass sources such as wood, agricultural residues and other primitive energy sources is exacerbating the problems of environmental and land degradation, increased stress on women and children in collecting firewood, health problems due to indoor air pollution International Renewable Energy Agency (IRENA, 2015).

The relationship between energy efficiency and economic growth has been debatable issue in the literatures reviewed. Some scholars argued that energy efficiency is an important requirement and catalyst for economic growth and social progress to take place. On the other hand, others argued that the rate of energy consumption is a small percentage of GDPs, therefore having a significant impact on economic growth are detached. However, empirical works do not provide any precise answer, and there is still no consensus among economists whether there is a causal relationship or not and if it exists, there is no clear cut answer about the direction of this causation (Ozturk, 2010).

Overall, although there are various studies that are conducted in the energy consumption and economic growth but most are cross -country panel and time series studies and a few studies are conducted in Ethiopia. But none studies conducted in Ethiopia considered the casual relationship between share of economic sectors to GDP and energy efficiency.

1.3 Objective of the study

The general objective of the study is to analyse the relationship between energy efficiency and economic growth in Ethiopia.

The specific objectives of the study are:
1. To examine the direction of causality between energy efficiency and economic growth;
2. To explain the relationship between growth in main economic sub-sectors and energy efficiency;
3. To investigate impulse response function and variance decomposition in the relationship between economic growth and energy efficiency.

1.4 Significance of study

Energy efficiency as the pillar to the economic growth and achieving economic wellbeing by providing an efficient energy source and it deserves the attention of policy makers. The outcomes of this study can be used as input for policy makers, helps to show resource centered of energy to the different sectors of the economy, government utility planners especially the ministry of energy for making policy decision. Moreover, the study used for further evidence and literature for those researchers who have the interest to conduct a study related to this area. The result of this study also contributes to individuals, business firms and associations that want to invest in energy sector. This investigation is expected to have a significant role in filling the knowledge gap in this area and motivate future researcher.

1.5 Scope and limitation of study

Geographically this study limited to Ethiopia. However, the result of the study is related to other countries with similar socio-economic conditions. The study analysed the relationship between energy efficiency and economic growth in Ethiopia for the period of 1974/75-2017/18. Understanding research on energy efficiency and economic growth at global levels is also a complex task as it requires huge finance, time, lack of relevant data source, and sufficient knowledge. And also there were unavoidable restrictions of time limit. The previous and current year (i.e., 2018/19 and 2019/20) could not be considered due to the unavailable data. The mentioned difficulties forced the researcher to undertake a research at national level. It examines the possible relationship of energy efficiency, the extent to which energy efficiency is transmitted to the overall economy and the study analysed the influences of energy efficiency and economic growth.

1.6 Organization of the thesis

The thesis has five chapters. This chapter, chapter one is introduction which consists of background of the study, statement of problem, objective of study, significance of study, scope and limitation of the study and organization of the paper. Chapter two presents about the theoretical and empirical literature review of the study which explains in detail about the relationship between energy efficiency and economic growth and conceptual frame work. The third chapter deals with the methodology of the study employed including the description of the study area, sources of data, methods of data analysis, model specifications, definition and description of variables and hypothesis testing. The fourth and fifth chapter explains the result and discussion and describes conclusion and recommendation respectively.

CHAPTER TWO

LITREATURE REVIEW

2.1 Theoretical literature review

2.1.1 Energy efficiency and Economic Growth

For the modern global economy the dynamism of energy forms the spark of life of the world economy as it is an essential input to producing almost all of the goods and services. It contributes to economic growth directly as it creates jobs and value associated with extracting, transforming, and distributing of energy. Supply interruptions of many sources of energy are known to have a great impact as they can harshly impact the economies of almost all countries.

Looking at Ethiopia, most of the energy needs of Ethiopia are filled by bio-fuels for cooking, heating, and off-grid lighting. Petroleum, including gasoline, diesel and kerosene supply less than 7% of the country's energy supply. Ethiopia generates most of its electricity from renewable energy, mainly hydropower on the Blue Nile. The country began a large program to expand electricity supply in the 2010s from 2,000 MW to 10,000 MW (Tesfaye, 2017). Renewable energy capacity, primarily hydro, and energy efficiency will play major roles in this growth by 2015 (World Economic Outlook, 2016).

Cost dynamic energy efficiency improvements can have positive macroeconomic impacts boosting economic activity and often leading to increased employment. Energy efficiency reduces the amount of energy needed to deliver services, such as mobility, lighting, heating and cooling. Lowering the cost of energy services frees up resources for households, businesses and governments. Energy efficiency's potential positive impact on GDP and Energy efficiency can induce job creation. The theoretical framework of the study was on the basis of classical and neo classical growth model developed by (Solow, 1956).

The literature proposes four different hypotheses regarding the causality relationship as discussed in (Belke et al., 2010).Theoretically four hypotheses have been put forward to explain the direction of causality between energy consumption and economic growth. These include neutrality hypothesis, conservation hypothesis, growth hypothesis and feedback hypothesis (Apergis and Payne, 2012). The neutrality hypothesis suggests that no causal relationship between energy consumption and economic growth. The conservation hypothesis suggests that a one way causality running from economic growth to energy consumption. It implies that an increase in economic growth increases the consumption of energy. Nevertheless, it is possible that a growing economy constrained by infrastructure or mismanagement of resources could produce inefficiencies and the reduction in the demand for goods and services, including energy consumption. If this is the case, an increase in economic growth would have an adverse effect on energy consumption (Apergis and Payne, 2012). While the other direction of causality asserted by the growth hypothesis. It implies that energy consumption plays an important role in economic growth both directly and indirectly in the production process as a complement to labour and capital. Therefore, as (Belke et al., 2010) argued that under growth hypothesis a decrease in energy consumption causes a decrease in real GDP in this case, the economy is energy defendant. So energy conservation policies will have a negative effect on economic growth.

According to (Toman and Jenelkova, 2003) argued that most of the literature on energy and economic development discusses how development affects energy use rather than its impact on the growth of the economy. This strand of literature considers economic growth as the main driver for energy demand and only advanced economies with a high degree of innovation capacity can decrease energy consumption without reducing economic growth.

The recent development in researchers have however, revealed that often times, most time series are not stationary as was conventionally thought. Therefore, different time series may not display the same feature. Hence, it is possible to see some time series that display the feature of diverging away from their mean over time while others may converge to their mean over time. Time series that diverge away from their mean over time are said to be non-stationary. Therefore, the classical estimation of the variables with this relationship most time gives misleading inferences or spurious regression. To overcome this problem of non-stationary, econometric analysis of time series data has increasingly moves towards the issue of co integration. The reason being that, cointegration is a powerful way of detecting the presence of steady state equilibrium between variables. Cointegration has become an over-riding requirement for any econometric model using non-stationary time series data. If the variables not cointegrated, then we have the problem of spurious regression and the results there in become almost meaningless. On the other hand, if the variables co-integrate then we have co-integration.

Theoretically, neo-classical and endogenous theories both suggest that energy use and efficiency are drivers of economic growth. Though there are many studies that find a direct relationship between productivity and energy efficiency in the industrialized world (Worrell et al., 2001) evidence from the developing world remains inconclusive.

2.1.2 The classical (Harro-Domar) growth model

Any net additions to the capital stock in the form of new investment financed from saving will bring about corresponding increases in the flow of national output this relationship between the K stock and total GNP is known incremental capital output ratio (ICOR). The classical (Harro-Domar) growth model the HDM is outlined as follows:

$$\mathrm{Y}_t = \mathrm{C}_t + \mathrm{S}_t \tag{1}$$

Y_t is total output at time t, C_t is consumption at time t, St is saving at time t and I_t is investment at time t in a closed economy. Total output is the sum of consumption and saving (income side).

Total output is defined as the sum of consumption and investment

$$\mathrm{Y}_t = \mathrm{C}_t + \mathrm{I}_t \tag{2}$$

2.1.3 Keynesian growth theory

Keynesian economics gets its name, theories and principles from British economist John Maynard Keynes (1883–1946), who is regarded as the founder of modern macroeconomics. The central tenet of this school of thought was that government intervention can stabilize the economy. Keynes intended government to play a much larger role in the economy. The vision was one of reformed capitalism and managed capitalism saved both from socialism and from itself. The founder talked about a somewhat comprehensive socialization of investment and the state's taking an ever greater responsibility for directly organizing investment. Fiscal policy would enable wise managers to stabilize the economy without resorting to actual controls.

The bulk of decision making would remain with the decentralized market rather than with the central planner. Keynes provided both a specific rationale for government's taking a bigger role in the economy and a more general confidence in the ability of government to intervene and manage effectively. So, the inadequacy of private investment will be replaced by the government investment (Yergin and Stanislaw, 1998 and Jahan et al., 2014). In the Keynesian model, increase in government expenditure (on infrastructures) leads to higher economic growth. Contrary to this view, the neo classical growth models argue that government fiscal policy does not have any effect on the growth of national output. However, it has been argued that government fiscal policy (intervention) helps to improve failure that might arise from the inefficiencies of the market (Sharma, 2002).

2.1.4 The Solow growth model

Solow Swan growth model or simply the Solow model named after Robert Solow and Trevor swan come in to existence after they published two path breaking article. The Solow model focuses on four variables: output (Y), capital (K), labour (L) and knowledge or the effectiveness of labour (A). At some time, the economy has some amounts of capital, labour and knowledge and these are combined to produce output. The output can change the inputs to production change. In particular the amount of output obtained from quantities of capital and labour rises overtime. There was technological progress only the amount of knowledge increases. AL implies that effective labour (Romer, 2006).

Higher saving investment rate leads to accumulation of more capital per worker and hence more output per worker. On the other hand, high population growth has a negative effect on economic growth simply because a higher fraction of saving in economies with high population growth has to go to keep the capital labour ratio constant. In the absence of technological change and innovation, an increase in capital per worker would not be matched by a proportional increase in output per worker because of diminishing returns .Hence capital deepening would lower the rate of return on capital.

2.1.5 The Endogenous growth theory

A new growth theory was developed as a reaction to the flows of the neoclassical (exogenous) growth theory. Romer endogenous growth theory was first presented in which he takes knowledge as an input in the production function. The theory aimed at explaining the long run growth by endogenizing productivity growth or technical progress. The major assumptions of the theory are increasing returns to scale because of positive externalities, Human capital (knowledge, skills, training on individuals) and production of new technologies are essential for long run growth. Private investment in research and development is the most important source of technological progress and finally knowledge or technical advances are non-rival good.

First, it is difficult using the exogenous growth model to explain the observed long run differences in performance exhibited by different countries. Second, the productivity changes that are assumed exogenous in the Solow model are, in fact, the result of conscious decisions on the part of economic agents. The important difference between the exogenous and endogenous growth models is that in the former the steady state growth rate is determined exogenously, e.g., technical change. In the latter, it is determined endogenously. The models are interesting because they often leave a role for policy (Ickes, 1996). It is easy to think of investments in infrastructure that make private production more profitable because with higher investment, and thus income, there is more government spending, which, since it is productive, makes for higher growth. But individual investors do not take into account the effect on growth from their investments (Ickes, 1996).

The endogenous growth theory which is known as new growth theory was developed as the reaction of the flow of neoclassical or exogenous growth theory. Theory aimed at explaining the long run growth by endogenizing productivity growth or technical progress. The Major assumptions of the theory are: Increasing returns to scale because of positive externalities; Human capital (knowledge, skill, and training of individuals) and the production of new technology are essential for long run growth; Private investment in research and development is the most important source of technological progress; Knowledge or technical progress is non-rival good.

2.2 Empirical literature review

This section presents different empirical findings of the relationship between economic growth and energy efficiency.

2.2.1 Causal relationship between energy efficiency and economic growth

The nature of the relationship between energy consumption, or any of its components, and economic growth has received great attention in the energy economics literature due to its implication for the design of energy policies. In a multivariate framework (Menegaki, 2011) examined the causal relationship between renewable energy consumption and economic growth for 27 European countries over the period 1997to 2007, using a random effect model, and found no causality between renewable energy consumption and GDP supporting the neutrality hypothesis.

According to the study of (Stern, 2004) has noted that the energy consumption of this sector has increased in Europe. The empirical evidence on the relationship between energy consumption and economic growth is mixed and mostly inadequate. As per the seminal study of (Kraft and Kraft, 1978) which found a unidirectional causality from national income to energy consumption in the USA over the 1947 up to 1974 periods. A growing literature has emerged to examine the causal relationship between energy consumption and economic growth in a wide range of countries and using different econometric techniques.

For the USA (Yu and Jin, 1992) examined the causal relationship between energy consumption, GNP and employment. Their results used monthly data over the period 1974:1–1990:4.They does not find any causality between energy consumption and economic growth. They support results of (Akarca and Long, 1980). Earlier studies of energy and growth relationships focused on U.S economy. Later on, these were extended to other countries. (Akarca and Long, 1980) used same data over the period of 1947 to 1972 and failed to support the (Kraft, 1978) results and found no causality between energy consumption and economic growth. So, there is no consensus in the causal direction even for the same country with data slightly different that is one using 1947 up to 1972 and another is using 1947 to 1974.

In another cross-country study, (Fuinhas and Marques, 2012) examined the nexus between primary energy consumption and economic growth in Portugal, Italy, Greece, Spain and

Turkey over the period 1965 to 2009. The empirical study of (Khan and Qayyum, 2008) inspected the association between real GDP and energy consumption in Bangladesh, India, Pakistan and Sri Lanka and their result reveals that unidirectional causality from energy consumption to GDP in each country both in short and long run. The study reasoned that being energy dependent economies, shortage in energy may retard growth in these South Asian countries. Therefore, strong policies for the development of energy sector need to be adopted.

Studied the causal relationship between energy consumption and economic growth in Turkey for the periods 1971 to 2009 and he found that economic growth leads to energy consumption but the reverse causality does not observe (Aqeel, 2011). The relationship between energy consumption and economic growth in China from the years 1953 to 2006 was investigated (Hou, 2009). Various causality tests applied in the study confirm the existence of bi-directional causality between energy consumption and economic growth. According to (Jamil and Ahmed, 2008), in Pakistan found the strong evidence for the presence of one way directional causality from economic activity to electricity consumption at aggregate level as well as in major sectors of the economy. In a later study (Jamil and Ahmad, 2011) further found that electricity demand is quite elastic with respect to the level of economic activity both at the aggregate and sectoral levels.

Engle Granger cointegration on Indian data (Paul and Bhattacharya, 2004) and found that two way causality exists between energy consumption and economic growth. In another India specific study (Adjaye, 2000) concluded that the energy consumption has significant impact on GDP growth rate in the long run. According to (Ghosh, 2002), no long run equilibrium relationship between electricity consumption and economic growth for India but found the unidirectional Granger causality running from economic growth to electricity consumption. The relationship between energy consumption and economic growth and found causal relationship between energy consumption and economic growth analysed (Nazar, 2012).

In the study of 14 oil-exporting countries over 1980 to 2007 (Mohammadi and Parvaresh, 2014) examined the long run relation and short run dynamics between energy consumption and output using panel estimation techniques dynamic fixed effect, pooled and mean-group estimators. They found a bidirectional causal relation in both long run and short run between energy consumption and output which supports the feedback hypothesis. It is expected that with the increase in services sector's shares in output aggregate energy intensity decline although (Nilsson, 1993) evaluated energy intensity trends for 31 countries for the period 1950 to 1988 and found that energy intensity has decreased for about 50% of the countries under Consideration.

Using panel unit root tests and panel cointegration analysis (Mehrara, 2007) examined the causal relationship between per capita energy consumption and per capita GDP in a panel of 11 oil exporting countries. The author found a unidirectional strong causality from economic growth to energy consumption for the studied group of oil exporting countries.

Using data on 17 African countries including Egypt, (Wolde-Rufael, 2006) found mixed results concerning the causality between electricity consumption and economic growth during the period 1971 to 2001. For the Egypt (Wolde-Rufael, 2006) found that there was positive bidirectional causality between electricity consumption and economic growth. In another study, (Wolde-Rufael, 2009) re-examined the causal relationship between energy consumption and economic growth in seventeen African countries including Egypt during the period 1971 to 2004, within a multivariate framework by including labour and capital as additional variables. A variance decomposition analysis was used to evaluate the importance of the causal effect of energy consumption on economic growth relative to labour and capital.

For Egypt, (Wolde-Rufael, 2009) found a unidirectional causality running from economic growth to energy consumption. Similar mixed results on the direction of causality between economic growth and energy consumption was found by (Akinlo, 2008) using a multivariate causality test for eleven Sub Sahara African countries (SSA). In a recent cross-country study, (Yildirım et al., 2014) used a trivariate model and a bootstrapped autoregressive metric causality approach to examine the causality between economic growth and energy consumption in 11 countries, including Egypt. The authors found evidence for the neutrality hypothesis of a no causal relationship between energy consumption and economic growth for all countries but for Turkey in which a unidirectional causal link was found from energy consumption to economic growth.

According to (Huang et al., 2008), divided the sample of 82 countries into groups for causality analysis. The study found no causality between economic growth and energy consumption for the low income countries, a positive causality from economic growth to energy consumption for middle income countries and a negative causality from economic growth to energy consumption for rich countries.

There was found no causality between the two variables (Cheng, 1996) for Venezuela and Mexico and (Wolde-Rufael, 2006) for Algeria, Congo Rep, Kenya, South Africa and Sudan have. For this category, conservation or expansion of energy usage may not affect the economic growth. Ambapour and Massamba (2005) have provided evidence for economic growth influencing energy consumption in Congo using co-integration and error correction mechanism for the period 1960-99.

In line with the specific objectives, the focus on studies that concentrated on the relationship between energy consumption and sectoral growth. For instance, (Mawejje and Mawejje, 2016) analysed the link between energy consumption and agriculture, industrial, and service sector growths independently. They employed the Johansen Cointegration test and Granger causality and their results support the growth hypothesis in the industrial sector.

According to (Yohannes et al., 2012) found that economic growth is cointegrated with energy consumption in Ethiopia, implying a long run relationship between the two. The, Granger causality test based on vector error correction model (VECM) reveals a unidirectional causality running from energy consumption to economic growth in Ethiopia.

The relationship between energy consumption and economic growth accompanied and the result revealed that the evidence of causality running from economic growth to energy consumption (Mehari, 2011). The tells that energy was no more than a minor contributing factor to output growth and certainly not the most important one when compared to capital and labour. As per the empirical finding of (Tesfaye, 2017) showed there was a unidirectional causality running from economic growth to energy consumption in the long run where as in the short run, there was no causality running from economic growth to energy consumption. The study found that economic growth causes electricity consumption but not vice versa in the long run in Ethiopia.

Based on the share to GDP, the service sector accounts for the lion's share in terms of four indicators which are structure of GDP 46%, contribution to GDP growth rate 58%, structure of capital investment 46% and structure of capital expenditure 75% (NBE, 2010). Agriculture share in the total output declined by 43 percentage point from its highest level of 85% in 1961 to 42% in 2011 (de Vries et al., 2013) and declined further to 38.8 % in 2014 (NBE, 2015). On the other hand, the output share in the service sector increased by 35 percentage points from 9% in 1961 to 44% in 2011 and 46.6% in 2014 (NBE, 2015).The manufacturing sector's output share has changed slightly from just 2% to 5.2% within fifty years (1961-2011). It exhibited the causal relationship with energy efficiency on behalf of economic growth.

Existing empirical evidence on the causal relationship between energy use and economic growth is inconclusive with mixed findings. The neutrality hypothesis has been supported for example by the findings of (Menegaki, 2011 and Yildirım et al., 2014). While the findings of (Ghali and El-Sakka, 2004; Belloumi, 2009; Apergis and Payne, 2012; Shahbaz et al., 2012; Fuinhas and Marques, 2012, Mohammadi and Parvaresh, 2014; Bloch et al., 2015) supported the feedback hypothesis. Among the studies whose findings support the conservation hypothesis include (Mozumder and Marathe, 2007 and Mehrara, 2007). The growth hypothesis was supported by the findings of (Lee, 2005).

The empirical literature on the energy growth nexus has been largely dominated by cross country studies and the findings were mixed. For example, using a panel error correction model, within a multivariate framework, (Apergis and Payne, 2012) investigated the relationship between renewable, non-renewable energy consumption and economic growth for 80 countries, including Egypt, over the period 1990 to 2007. They found bidirectional causality between renewable and non-renewable energy consumption, and economic growth in both the short- and long-run which is in line with the feedback hypothesis. Numerous studies have examined the causal relationship between energy consumption and economic growth since 1970s. The results of these studies can be generalized in four categories.

The first category includes the findings of unidirectional causality from economic growth to energy consumption. The pioneer study by (Kraft and Kraft, 1978) found a unidirectional causality from GNP growth to electricity consumption in the United States of America for the time period of 1947 to 1974. Later on (Cheng and Lai, 1997) examined the same relationship for Taiwan, (Soytas and Sari, 2002) for Italy and Korea, (Ghosh,

2002) for India, (Oh and Lee, 2004) for Korea, (Yoo, 2005) for Indonesia and Thailand, (Mehrara, 2006) for Oil Exporting Countries, (Wolde-Rufael, 2006) for Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe, (Mozumder and Marathe, 2006) for Bangladesh, (Zamani, 2006) for Iran for Pakistan have found the unidirectional relationship from economic growth to energy consumption. For this category, the policies for energy conservation can be implied with only little or no adverse effect on economic growth.

The second category of findings includes the findings of unidirectional causality from energy consumption to economic growth. According to the study of (Cheng, 1996) for Brazil, (Aqeel and Butt, 2001) for Pakistan, (Soytas and Sari, 2002) for Turkey, France, Germany and Japan, (Narayan and Singh, 2006) for Fiji Islands, (Altinay and Karagol, 2005) for Turkey, (Wolde-Rufael, 2006) for Benin, Congo Democratic Republic and Tunisia and (Yuan et al., 2008) for China have found unidirectional causality from energy consumption to economic growth. Restrictions on energy use for this category may lead to adverse feedback effect for economic growth and an improved energy provision may lead to higher economic growth. Johansen co-integration techniques and found that causality runs from energy consumption to economic growth (Ighodaro, 2010). Therefore, electric consumption harms economic growth.

Third category includes the studies that have found bidirectional causality between energy consumption and economic growth. Based on the findings of (Soytas and Sari, 2002) for Argentina, (Paul and Bhattacharya, 2004) for India, (Yoo, 2004) for Korea, (Yoo, 2005) for Malaysia and Singapore, (Wolde-Rufael, 2006) for Egypt, Gabon and Morocco and (Lise and Montfort, 2006) for Turkey have found bidirectional causality in their targeted countries. This category holds that higher energy consumption may lead to higher economic growth and then following a simultaneous bias effect, the higher economic growth may lead to even higher energy consumption and vice versa.

Fourth category consists of studies that have found no causality between economic growth and energy consumption. According to (Soytas and Sari, 2006) reported that energy consumption contributes to the manufacturing industry.

Many studies on the link between aggregated energy efficiency and economic growth in the developing world have mixed results and unclear findings (Akinlo, 2008; Mishra et al., 2009; Lee and Chang, 2008). While many studies from developed countries exist, only a handful of studies in the developing world have attempted to identify the link between firm level energy use efficiency and productivity.

In conclusion, the available literature review have not reached a consensus on the causal relationship between energy efficiency and economic growth and also most of them haven't seen sector wise relationship between energy efficiency and economic growth in developing countries like sub Saharan countries particularly, Ethiopia. This study deviated from the earlier work by analyses on the economic sectors shares to GDP with their linkage to energy efficiency.

2.2.2 Economic contribution and benefits of energy efficiency

Energy efficiency Improving is one of most constructive and cost-effective ways to address challenges of high energy prices, energy security and independence, air pollution and global climate change. The many benefits of energy efficiency include:

For environmental, increased efficiency can lower greenhouse gas emissions and other pollutants, as well as decrease water use. For economic, improving energy efficiency is generally less expensive than investing in new generation and transmission. Energy efficiency can also boost the local economy and create downward pressure on natural gas prices and volatility. In utility system benefits, when integrated into energy resource plans, energy efficiency can provide long term benefits by lowering base load and peak demand and reducing the need for additional generation and transmission assets. In the risk Management, energy efficiency also diversifies utility resource portfolios and can be a hedge against uncertainty associated with fluctuating fuel prices and other risk factors.

Energy efficiency and employee productivity in all sectors case in the industrial sector, counting the portion of industrial employees that are dedicated to making an efficient product, such as a hybrid car or an efficient refrigerator can be difficult. The manufacturing of inefficient cars and refrigerators may involve just as many workers as producing efficient ones. Also, a person building the hybrid drivetrain has a genuine efficiency job, whereas a person installing seat belts into the hybrid car arguably has a car industry job with no direct connection to energy efficiency. In some cases, the transition to more efficient products can initiate manufacturing changes that reduce labour intensity. This is the case with light emitting diode lighting, which require fewer employees to produce products that each last much longer than their predecessors.

Energy efficiency can contribute to meeting all three goals of energy policy, namely security of supply, competitiveness and protection of the environment through reduced Greenhouse Gas (GHG) emissions. The economic benefits include direct savings, lower fuel costs and a reduction in the need for investment in supply. Energy efficiency can be achieved through technological, behavioural or economic changes. When we talk about the search of more energy efficient world, we talk about responsibility. The main advantage of investing in energy efficiency is obviously a long-term decision. If we commit to being more responsible with the environment, we will be investing in a better future for all of us. In addition, we will manage to save on our bills in the long term, as well as being more responsible in the use of natural resources.

Some benefits of energy efficiency are Improve indoor comfort, Save money on energy bills, Breathe healthy fresh clean air, Reduce moisture issues (mold, leaks, condensation) Increase building resale value, Reduce fossil fuel use and greenhouse gas emissions, Reducing the impact of greenhouse gases, Decreasing costs in energy from houses and businesses, Reducing the energetic dependence from outside, Increasing the security of the energy supply, Reducing the consumption of natural resources, Decreasing production costs, improving the competitively of enterprises, Reducing the environment degradation, related with the exploitation of resources and Reducing environmental damage and pollution.

2.2.3 Source of energy efficiency

A source from which useful energy can be extracted or recovered either directly or by means of a conversion or transformation process (e.g. solid fuels, liquid fuels, solar energy, biomass, etc.). Efficient energy uses simply called energy efficiency, is the goal to reduce the amount of energy required to provide products and services. Primary energy sources take many forms, including nuclear energy, fossil energy like oil, coal and natural gas and renewable sources like wind, solar, geothermal and hydropower.

Solar energy:-Solar power harvests the energy of the sun through using collector panels to create conditions that can then be turned into a kind of power. Large solar panel fields are often used in desert to gather enough power to charge small substations and many homes use solar systems to provide for hot water, cooling and supplement their electricity. The issue with solar is that while there is plentiful amounts of sun available, only certain geographical ranges of the world get enough of the direct power of the sun for long enough to generate usable power from this source.

Wind energy:-Wind power is becoming more and more common. The new innovations that are allowing wind farms to appear are making them a more common sight. By using large turbines to take available wind as the power to turn, the turbine can then turn a generator to produce electricity. While this seemed like an ideal solution to many, the reality of the wind farms is starting to reveal an unforeseen ecological impact that may not make it an ideal choice.

Geothermal energy:-Geothermal energy is the energy that is produced from beneath the earth. It is clean, sustainable and environment friendly. High temperatures are produced continuously inside the earth's crust by the slow delay of radioactive particles. Hot rocks present below the earth heats up the water that produces steam. The steam is then captured that helps to move turbines. The rotating turbines then power the generators.

Geothermal energy can be used by a residential unit or on a large scale by an industrial application. It was used during ancient times for bathing and space heating. The biggest disadvantage with geothermal energy is that it can only be produced at selected sites throughout the world. The largest group of geothermal power plants in the world is located at The Geysers, a geothermal field in California, United States.

Hydrogen energy:-Hydrogen is available with water and is most common element available on earth. Water contains two-thirds of hydrogen and can be found in combination with other elements. Once it is separated, it can be used as a fuel for generating electricity. Hydrogen is a tremendous source of energy and can be used as a source of fuel to power ships, vehicles, homes, industries and rockets. It is completely renewable, can be produced on demand and does not leave any toxic emissions in the atmosphere.

Tidal energy:-Tidal energy uses rise and fall of tides to convert kinetic energy of incoming and outgoing tides into electrical energy. The generation of energy through tidal power is mostly prevalent in coastal areas. Huge investment and limited availability of sites are few of the drawbacks of tidal energy. When there is increased height of water levels in the ocean, tides are produced which rush back and forth in the ocean. Tidal energy is one of the renewable sources of energy and produce large energy even when the tides are at low speed.

Hydroelectric energy:-What many people are not aware of is that most of the cities and towns in the world rely on hydropower and have for the past century. Every time you see a major dam, it is providing hydropower to an electrical station somewhere. The power of the water is used to turn generators to produce the electricity that is then used. The problems faced with hydropower right now have to do with the aging of the dams. Many of them need major restoration work to remain functional and safe, and that costs enormous sums of money. The drain on the world's drinkable water supply is also causing issues as townships may wind up needing to consume the water that provides them power too.

Biomass energy:-Biomass energy is produced from organic material and is commonly used throughout the world. Chlorophyll present in plants captures the sun's energy by converting carbon dioxide from the air and water from the ground into carbohydrates through the process of photosynthesis. When the plants are burned, the water and carbon dioxide is again released back into the atmosphere. Biomass generally includes crops, plants, trees, yard clippings, wood chips and animal wastes. Biomass energy is used for heating and cooking in homes and as a fuel in industrial production. This type of energy produces large amount of carbon dioxide into the atmosphere.

Nuclear power:-While nuclear power remains a great subject of debate as to how safe it is to use and whether or not it is really energy efficient when you take into account the waste it produces the fact is it remains one of the major renewable sources of energy available to the world. The energy is created through a specific nuclear reaction, which is then collected and used to power generators. While almost every country has nuclear generators, there are moratoriums on their use or construction as scientists try to resolve safety and disposal issues for waste.

2.3 Energy Situation of Ethiopia

Ethiopia is one of the least developed countries in the world. Approximately 34 % of its over 100 million inhabitants live below poverty line. It has one of the lowest rates of access to modern energy services, whereby the energy supply is primarily based on biomass.

Based on the status of Ethiopian energy sector, Ethiopia is gifted with a variety of renewable energy resources including hydro, wind, geothermal, solar and bio-energy. The gross hydro energy potential of the country is estimated at 650,000 GWh per year of which 25% (160,000 GWh per year) could be economically exploited for power. Woody biomass resources estimate for the standing stock and annual yield is about 1,149 million tons and 50 million tons respectively, for year 2000. This translates into a per capita yield of about 0.79 tons of woody biomass (Ethiopian National Energy Policy, 2012).

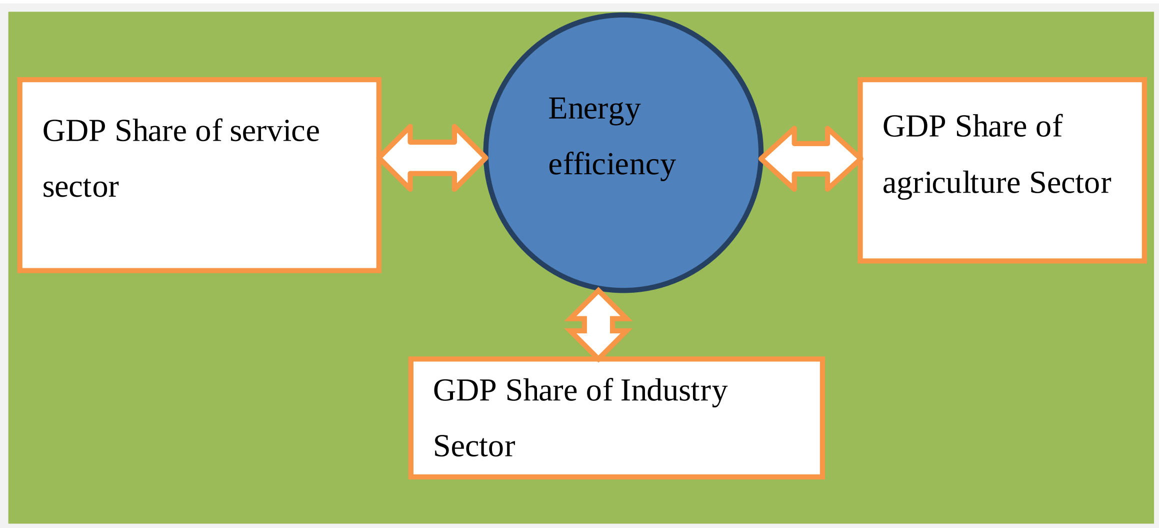
The country has huge wind and geothermal energy resource potential estimated about 1,035 Giga watts and more than 7,000 MW respectively. With respect to solar energy, the national average radiation received at ground level is estimated at 5.2 kWh/m2 per day. This potential however varies from season to season, with lowest potential being 4.55 kWh/m2 per day, and the highest potential being about 6.25 kWh/m2 per day. The country also has natural gas reserve estimated at 112 billion cubic meters. There is 4 TCF natural gas deposit in the Eastern part of the county. Oil shale deposit is estimated at 112 million tons. Coal resource estimate is 320 million tons distributed in 9 sites mainly located in the Northern, Central and South western part of the country. Resource quality ranges from medium to low grade (sub-bituminous to lignite). Some of better quality coal deposits are located in the high forest areas in the South-Western part of the country where development of sites will potentially have serious environmental consequences (Ethiopian National Energy Policy, 2012).

With a share of 92.4% of Ethiopia’s energy supply, waste and biomass are the country’s primary energy sources, followed by oil (5.7%) and hydropower (1.6%). At the same time the economy is one of the fastest growing in the world, with an average growth of 10.8% since 2005. Besides it has ambitious plans to achieve a climate resilient development till 2025. It was the first developing country which submitted its NDC (Nationally Determined Contribution) at the UNFCCC (United Nations Framework Convention on Climate Change) and therefore takes a leading role in climate policy of the most vulnerable countries to climate change. Projected demand for 2030 shows that biomass demand will decrease to 71.6 % while, demand for petroleum and electricity increase to 22.6% and 5.8% respectively (Ethiopian National Energy Policy 2012).

2.4 Energy and economic growth framework

As discussed above about energy efficiency and economic growth, the following conceptual framework has shown the most explanatory variables on Economic growth. As shown here below figure 1, the study used variables of energy intensity, as the proxy of energy efficiency and measured by the energy consumption to real GDP while the other independent variables of economic sectors such as share of agriculture, industry and service sectors to RGDP. The researcher is conducted the long run relationship between energy efficiency and sub economic sectors of GDP share. The arrow indicated in each variable below figure 1 is to see the causal relationship between energy intensity and share of each sectors of GDP. The causal relationship among the variables was either to support one of the four hypotheses (i.e., feedback hypothesis, growth hypothesis, conservation hypothesis or neutral hypothesis) for analysis.

Figure 1.Representation of relationship between variables



Source: Author computation (2020)

CHAPTER THREE

RESEARCH METHODOLOGY

This part of the study presents methodology that used in this study. It structured in four sections. The first section describes the study area. The second part is about data sources. The third one is method of research analysis. The fourth one is model specification. The fifth section of the chapter presents definition and descriptions of the variables. The last section of the chapter is hypothesis testing. That is description of empirical model on the relationship between energy efficiency and economic growth.

3.1 Description of the study area

Ethiopia is located in east between the Equator and Tropic of Northern hemisphere. The land size of Ethiopia is 1,000,000 square kilometres and water body is 104,300 square kilometres, making it the 27^{th} largest nation in the world with a total area of 1,104,300 square kilometres. It is placed in the horn of Africa bordered by Eritrea to the north, Djibouti and Somalia to the East, Sudan and South Sudan to the West and Kenya to the South which have high plateau that varies from 1290 to 3000 m (4,232 to 9,843 ft.) above sea level, with the highest mountain reaching 4,533 m (14,872 ft.) having longitude and latitude of $40^{0}29^{'}22.8^{''}$E and 9^{0} 8’ 42”N respectively. It has total population of 102,374,044 implying vast population number, population density 102.37/$km^{2,}$ GDP (PPP) of 175 dollar and GDP per capita of 1,900 dollars. It is the fastest growing economy in the region; it is also one of the poorest, with a per capita income of 783 USD. Ethiopia’s government intentions were to reach lower-middle-income status by 2025 (World Bank, 2017).

Figure 2.Map of Ethiopia

Source: Federal Democratic Republic of Ethiopia (2020)

3.2 Sources of data

For the analysis of this thesis on the relationship between energy efficiency and economic growth in Ethiopia secondary data was collected for the period 1974/75 to 2017/2018 making the observation size 44. The data was collected from National Bank of Ethiopia (NBE), Ministry of Finance and Economic Development (MoFEC) and World Development Indicators (WDI, 2010).

3.3 Method of data analysis

In the purpose of using data analysis, the paper used both descriptive and econometric analysis together. For descriptive statistics analysis the study used mean, standard deviation, minimum, maximum, Skewness and kurtosis for description by using observation size of 44 period data while for the econometric part of the paper to investigate the relationship between energy efficiency and economic growth in Ethiopia, econometric model was employed. It was analysed by the researcher using Eviews software version 8.

3.4 Model specification

This study investigates the empirical relationship between economic growth and energy efficiency in Ethiopia for the period between 1974/75 to 2017/2018 using time series data. The variables considered in multivariate time series analysis are energy efficiency, real per capita economic growth and the share of agriculture, service and Industry sector in GDP as independent variables. The researcher tested all the variables are non-stationary at original form of data and all the variables entered in regression should be integrated of order one I (1) by using augmented dickey fuller test. Most empirical studies in econometrics were to determine whether a change in one variable causes a change in or helps to predict another variable.

3.5 Definition and descriptions of the variables

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

Real GDP (RGDP): Economic growth is an increase in the capacity of an economy to produce goods and services, compared from one period of time to another. It represents the monetary value of all goods and services produced within a country over a specified period of time. Also, GDP is the sum of consumer spending, investment made by industry, excess of exports over imports and government spending. It takes into account the country's entire economic output. It doesn't matter whether they are sold domestically or overseas. It can be measured in nominal or real terms, the latter of which is adjusted for inflation. In the presence of inflation can't reflects the real economic growth and increases GDP. With this regard the inflation rate must be withdrew from the GDP to get the real growth percentage called the real GDP. Therefore, the study used the real GDP as a proxy to denote economic growth.

Energy efficiency: Energy efficiency is a practice that is undertaken with the purpose of reducing the consumption of energy. Energy efficiency is improved when a given level of service is provided with reduced amount of energy inputs or services to boost the economy.

Energy intensity (abbreviated EI): Energy intensity usually defined as energy consumption per GDP which indicates the total energy being used to boost economic and social activities, (Poveda and Martinez, 2011). It is used as a proxy of energy efficiency. It measures how much a bit of energy benefits the economy. The value is calculated by taking the ratio of total primary energy used (TPES) (all the fuels and flows that a country uses to get energy) to GDP (the total money made in a country). This quantity (measured MJ/$) is used to indicate how efficiently a certain economy is using their fuels and flows. When country reduces wasted energy, it becomes more efficient and lowers its EI (lower EI is better). Energy intensity is often used as proxy of energy efficiency of an economy.

Share of economic sectors to GDP: For this study the real GDP share of three main sub sectors were considered. The remaining sectors were incorporated within these main sectors.

Agriculture sector (AGR): Agriculture is the mainstay of the Ethiopian economy which contributing 41.4% of the country's gross domestic product (GDP), 83.9% of the total exports and 80% of all employment in the country (Matousa, Todab and Majoc, 2013). This sector plays premeditated role in the process of economic growth of the country.

Energy efficiency in agriculture improvement is defined as the decrease of primary energy consumption for the production of a unit of agricultural product (expressed in weight or volume units), within the farm boundaries. The use of machines and chemicals in agriculture has made energy one of its key inputs. Additionally, agriculture has always used solar energy, storing it in its produce that later serves as food, fuel, or other materials.

Energy use in agriculture is typically classified as direct energy and indirect energy use. Direct energy used in agriculture refers to energy that is consumed directly in agriculture activities such as operating farm machinery, trucks, vehicles, equipment, drying operations, overhead and marketing. Indirect energy used in agriculture refers to the energy used to manufacture and as chemical inputs in the production of fertilizer, pesticides and other chemicals utilized in agriculture.

Industry sector (IND): The share of industry sector contributing 15.6% in GDP (World Fact book, 2016). The Manufacturing part includes units mainly involved in the physical or chemical transformation of materials, substances or components into new products. The mining division comprises the components that mainly extract naturally occurring mineral solids, such as coal and ores; liquid minerals, such as crude petroleum; and gases, such as natural gas. The term mining is used in the broad sense to include underground or open cut mining; dredging; quarrying; well operations or evaporation pans; recovery from ore dumps or tailings as well as beneficiation activities (i.e. preparing, including crushing, screening, washing and flotation) and other preparation work customarily performed at the mine site, or as a part of mining activity.

Service sector (SER): It also known as the tertiary sector is the third stage of the three sector economy. Ethiopia is getting an economic structure which is shifting from the traditional agriculture sector to the modern service sector. The service sector accounts for the lion's share in terms of the structure of GDP 46.6% taking the lead from the agriculture sector (NBE, 2015).On the other hand, the service sector GDP is projected to increase at an annual average rate of 10.1%, lower than its previous period average growth. It is also anticipated to show a modest decline in its share of GDP from 43.4% (2014) to 41.6% by the end of 2019/20 (NPC, 2015).

This sector includes service of education and training, health care and social assistance, electricity, gas, water and waste services, accommodation and food services, transport, postal and warehousing, information media and telecommunications, financial and insurance services, rental, hiring and real estate services, professional, scientific and technical services, administrative and support services, public administration and safety, arts and recreation services and other services division includes a broad range of personal services; religious, civic, professional and other interest group services; selected repair and maintenance activities; and private households employing staff. units in this division are mainly engaged in providing a range of personal care services, such as hair, beauty and diet and weight management services; providing death care services; promoting or administering religious events or activities; or promoting and defending the interests of their members.

Multivariate time series analysis: an econometric approach examines the relationship between two or more independent variables and a dependent variable (examples of these economic models are vector autoregressive and vector error correction models).

Exogenous variable: The variable that is not determined in the system and not correlated with the random error and always appears at right hand side of the multivarious time series analysis setup.

Endogenous variables: the variables that determined in the system and its number of equations depends with its number of variables. Each endogenous variable appears once at the left hand side, correlated with random error and each equation have its lagged value appears at the right hand side of equation.

Table 1.Variables considered in the system of equations

Sr. No	Variable	Description	Measurement	Expected Sign
1	EI	Energy Intensity	Energy consumption to GDP ratio	Not expected
2	RGDP	Real Gross Domestic Product	Level of economic activity	Positive (+)
2	AGR	Share of Agriculture Sector	Percentage change of agriculture to RGDP ratio	Positive (+)
3	IND	Share of Industry Sector	Percentage change of industry to RGDP ratio	Positive (+)
4	SERV	Share of Service Sector	Percentage change of service to RGDP ratio	Positive (+)

Source: Author Computation (2020)

To investigate the empirical relationship between energy efficiency and economic growth the Cobb-Douglas Production Function was used.

$$\mathrm{EI_t} = \exp(\mathrm{RGDP_t} \times \mathrm{v_t}) \tag{3}$$

The logarithmic transformation of equation (3) is:

$$\mathrm{LN(EI_t)} = \mathrm{LN}(RGDP_t) + \mathrm{v_t} \tag{3a}$$

Where $\mathrm{EI_t}$ denotes energy intensity in time t, $\mathrm{RGDP_t}$ represents real GDP in time t and $\mathrm{v_t}$ is the random error in time t.

The Cobb-Douglas specification for the sub-sectors is expressed as:

$$\mathrm{EI_t} = \exp(\beta_1 \mathrm{AGR_t} \times \ \beta_2\ \mathrm{IND_t} \times \beta_3 \mathrm{SERV_t}\ \times \mathrm{u_t}) \tag{4}$$

The logarithmic transformation of equation (4) is given by:

$$\mathrm{LN(EI_t)} = \beta_1 LN\mathrm{AGR_t} + \beta_2 \mathrm{LN\ IND_t} + \beta_3 LN\mathrm{SERV_t} + \mathrm{u_t} \tag{4a}$$

Where, $LNEI_t$ is natural logarithm of energy intensity at time t, $LNAGR_t$ is natural logarithm of the share of agriculture sector in real GDP at time t, $LNIND_t$ is natural logarithm of the share of Industrial sector in real GDP at time t and $LNSERV_t$ is natural logarithm of the share of service sector in real GDP at time t. While β_1, β_2, *and* β_3 are parameters to be estimated and u_t is the error term at time t.

Modeling dynamic relationships

Given that time series variables are dynamic, in the sense that their current values determination be correlated with their past values, and they are related to current and past values of other variables, we need to ask how to model the dynamic nature of relationships.

The dynamic relationship between energy efficiency and economic sub-sectors is given by

$$\mathrm{EI_t} = \beta_O + \sum_{q=1}^{N} \beta_1 \mathrm{EI_{t-q}} + \sum_{q=0}^{N} \beta_2 \mathrm{AGRI_{t-q}} + \sum_{q=0}^{N} \beta_3 \mathrm{IND_{t-q}} + \sum_{q=0}^{N} \beta_4 \mathrm{SER_{t-q}} + \varepsilon_t \tag{5}$$

Energy efficiency measured as energy intensity. Energy intensity is defined as total energy consumed per RGDP. Thus, the relationship between energy intensity and real GDP share of three subsectors can be described as

$$\frac{\mathrm{EC_t}}{\mathrm{RGDP_t}} = \frac{\mathrm{AGR_t}}{\mathrm{RGDP_t}} + \frac{\mathrm{IND_t}}{\mathrm{RGDP_t}} + \frac{\mathrm{SERV_t}}{\mathrm{RGDP_t}P} + \mathrm{u_t} \tag{6}$$

Where EC_t represents energy consumption at time t, $RGDP_t$ represents real GDP at time t and u_t is the error term at time t.

3.6 Unit root test

Unit root test is one of the scenario or precondition to test stationarity before proceeding to Johansen cointegration test, VECM and Granger causality analysis. The stationary of the series implies mean and variance constant over time and covariance are depends only two time series periods not over time (Banerjee, et.al, 2003) while non-stationary series was one whose statistical properties change over time (Priestley, 1983 and Bellegem, 2003).

Two models which have been frequently used to characterize non-stationarity used are

The random walk model with drift:

$$\mathrm{EI_t} = \quad \mu + \mathrm{EI_{t-1}} - \mathrm{RGDP_{t-1}} + \mu_t \tag{7}$$

Where the series EI_t has constant forecast value, μ_t is stationary random disturbance term and conditional on time.

And deterministic trend process (TSP)

$$\mathrm{EI_t} = \quad \alpha + \beta_t \ + \mu_t \tag{8}$$

The model could be generalized to the case where EI_t is an explosive process (DSP):

$$\mathrm{EI_t} = \quad \mu \ + \Phi\ \mathrm{EI}_{t-1} \ + \mu_t \tag{9}$$

where $\Phi > 1$ Typically the explosive case was ignored and used Φ=1 to characterize the non-stationary because Φ>1 does not describe many data series in economics and it had an intuitively unappealing property: shocks to the system were not only persistent through time; they are propagated so that a given shock will have an increasingly large influence.

Using non-stationary time data in empirical analysis may lead to high of spurious regression results for which no references could be made since the standard statistical tests are invalid. As a result the conventional econometric regression model necessitates that all the time series variables included in the model regression should be stationary and the disturbance term was assumed to have constant mean and variance. Therefore the standard unit root test of Augmented Dickey Fuller test is used to determine the order of integration of the variables considered in this empirical analysis.

The early and pioneering work on testing for a unit root in time series was done by Dickey and Fuller (Dickey and Fuller, 1979). Non stationary series has to be differenced 1 time to become stationary, so it is said to be integrated of order 1. This first step was essential because the causality tests were very sensitive to the stationary of the series (Stock and Watson, 1989). In (Bellomi, 2009 and Nelson, 1993) the majority of macroeconomic series were not stationary. Therefore, the Augmented Dickey Fuller (ADF) tests performed to test whether the data were difference stationary.

Augmented Dickey Fuller (ADF) test

The paper adopted ADF unit root test to stationary test of energy intensity (EI), real economic growth (RGDP), share of agriculture (AGR), share of industry (IND) and share of service (SERV) series separately. It is one of the widely used approaches of unit root testing in this study which is conducted with critical value of 1%, 5% and 10% for test. Non-stationary data should be first converted into stationary data to undertake the tests. This kind of problem (unit root problem) can be solved by differencing the data set (Gujarati, 2004). Meanwhile, the variable is stationary without differencing and then it is integrated of order zero, I (0). A variable is said to be integrated of order one, or I (1), if it is stationary after differencing once. According to (Asteriou and Hall, 2007), most economic variables are cointegrated of order 1.

Moreover, ADF test indicated that all the variables were non-stationary at levels, but stationary after first difference and thus all the variables are integrated of order one, I (1). Regressing two series that are non-stationary yields a spurious regression. In sense spurious regression means regressing two variables that are not related but in according to their regression result they are related because two variables moving together and that is why they are significant and high R^2. So the result was misleading. Unit root tests are conducted first, with real GDP, sectoral share of GDP and energy efficiency as the time series variables. These variables are cointegrated in order to avoid a spurious regression situation and to ensure whether they are stationary or not.

To detect the existence, the study compared Durbin Watson statistics and $R^{2.}$ In order to avoid spurious regression the time series variables in the regression analysis are tested for the existence of unit root using the standard Augmented Dickey Fuller (ADF) test.

In testing for the existence of unit root of a time series Yt (Ho: δ=0), Out of the following three possible forms of the ADF test our model is selected.

$$\Delta \mathrm{EIt} = \rho\Delta \mathrm{EIt} - 1\sum_{j=1}^{N} \psi j_j \Delta \mathrm{EI}_{t-j} + \mathcal{E}t \qquad (10)$$

$$\Delta EIt = \rho\Delta EIt - 1\sum_{j=1}^{N}\psi j_j \Delta EIt_{t-j} + \mathcal{E}t + \alpha \tag{11}$$

$$\Delta EIt = \rho\Delta EEt - 1\sum_{j=1}^{N}\psi j_j \Delta EIt_{t-j} + \mathcal{E}t + \alpha + \beta t \tag{12}$$

The difference between the three regressions concerns the presence of the deterministic elements α and β for choosing the best one among the three equations.

In this regard, the null hypothesis of ADF test was that time series was non-stationary (unit root). The null was rejected when the absolute value of augmented dickey fuller test statistics is greater than 5% critical value, however, if that is not the case; we fail to reject the null hypothesis.

3.7 Optimal lag length

It is used to determine from which time onward the effects of energy efficiency affected by the independent variables real domestic growth and other independent variables statistically affects the energy efficiency. So, the optimal lag length is used as one of the precondition to run Johansen cointegration, VECM and Granger causality analysis.

Using too many lags lead to manipulate too many parameters that loss degree of freedom can lead multicollinearity problem while as too few lags leads misspecification errors and finally end up serial correlation in the error terms. Accordingly, the researcher checked the annual data of 41 observations to conduct the relationship between energy efficiency and economic growth in Ethiopia. The study selected few lags by using some trial and error method lag length selection criteria to run for time series annual data.

There are various lag length selection criteria such as the Akaike information criterion (AIC), Schwarz information criterion (SIC), Hannan Quinn criterion (HQC), Final prediction error (FPE) and Bayesian information criterion (BIC) have been employed. The optimum lag length is decided underneath with recommended Information Criteria. All the criteria were sufficient and equally good to choose the optimal lag length. Based on the guide line lower the information criteria value the better the model. Lag that provides the smallest value is selected as the optimal lag length that means, among the Information Criteria(IC) that provides majority lag has been choose as optimal lag length.

As the outcomes of these criteria influenced the ultimate findings of a study, a throughout understanding on the empirical performance of these criteria is necessary. Akaike Information Criterion (AIC) developed by Hirotugu Akaike (Greene, 2003) has been found to be nearly unbiased estimator of selecting lag order and also it was a large sample size measure of thirty and more items, while the Schwarz Information Criterion (SIC) is a small sample measure of less than thirty observations. First, these criteria managed to pick up the correct lag length at least half of the time in small sample. Second, this performance increases substantially as sample size grows. Third, with relatively large sample (120 or more observations), HQC is found to outshine the rest in correctly identifying the true lag length. In contrast, AIC and FPE should be a better choice for smaller sample. Fourth, AIC and FPE are found to produce the least probability of under estimation among all criteria under study. Finally, the problem of over estimation, however, is negligible in all cases. As many econometric testing procedures such as unit root tests, causality tests, co-integration tests and linearity tests involved the determination of autoregressive lag lengths, the findings in this simulation study may be taken as useful guidelines for future economic researches.

Thus, the ability to correctly locating the true lag order depends on IC the ordinary least Squares regression model is run starting with lag zero upwards, since according to (Engle, 1969) it is the mostly used and recommended methodology was used to determine the lag length. Accordingly, lag that provides the minimum value is chosen as the optimal lag length. Alternatively, among the IC that provides majority lag is chosen as optimal lag length. On the basis of one or more of these criteria this paper was used a model that is the highest R^2 or the lowest value of AIC or SIC or BIC.

In determining lag lengths for the Johansen’s procedure, we chose between using Akaike’s (AIC) and the Schwarz’s Bayesian (SBIC) information criterion processes. The SBIC is usually more consistent but inefficient, while AIC is not as consistent but is usually more efficient (Brooks, 2008). As per Brooks (2008), SBIC will usually give a larger average variation in Johansen cointegration analysis of American and European Stock Market Indices. Therefore this study preferred to use AIC in determining lag lengths. Literature surrounding cointegration analysis have used both AIC and SBIC with neither alternative firmly agreed upon between studies.

Therefore, as per the same guide line of AIC, SIC, and HQ about the least is better for optimum lag length criteria, the study used the majority selection criteria to choose optimum lag length.

3.8 Stable system

In this study stability system is used as to check whether the system is stable or not to run the suggested model. To do this, the unit root circle is used. Since all points lied within the unit root circle, the researcher infers that the model is stable. Considering our model:

$$\mathrm{EI_t} = \alpha_O + \sum_{q=1}^{N} \alpha_1 \mathrm{EI}_{t-1} + \sum_{q=1}^{N} \alpha_2 \mathrm{AGR}_{t-1} + \sum_{q=1}^{N} \alpha_3 \mathrm{IND}_{t-1} + \sum_{q=1}^{N} \alpha_4 \mathrm{SER}_{t-1} + \mathcal{E}t \qquad (13)$$

Where EI_t and EI_{t-1} are energy consumption to economic growth in current and previous period respectively, AGR_{t-1} is the agriculture sector in previous period, $IND_{t-1}$is the industry sector in previous period, $SERV_{t-1}$ is the service sector in previous period and α_O is intercept term α_2, α_3 and α_4 are known as coefficient parameters of regression.

3.9 Cointegration test

Cointegration implies the causality exists between the two variables but it does not indicate the direction of causality relationship. The presence of Cointegration among the variables rules out the possibility of spurious regression (Belloumi, 2010). The approaches tested for cointegration are roughly Johansen approach. A group of time series variables are individually integrated at the same order and there is at least one linear combination between them, so different series have one linear association is stationary, then the variables said to be cointegrated (Harris, 2003 and Enders, 2004). From this assumption the study confirmed, couldn’t talk about linear combination without it is stationary at the first difference. So, the cointegrated variables never move far apart and attract to their long run relationship. Therefore, cointegration is detected by the long run analysis.

The Eviews software made two or more variables have two or more system equations respectively depends on the number of variables listed. In addition to that it could have another exogenous variable that is not determined within the system but determined outside the system. Coefficients with its signs used to decide whether the variable have exhibited positive or negative impact on the long run cointegration, standard errors in parenthesis that told the deviation that occurred from predicting slope parameters or coefficients correctly estimate and t-statistics in squared bracket obtained by dividing coefficients to it respective standard errors which measures the number of standard errors that the coefficient was from zero.

The long run analysis: The long run relationship between the variables is done by cointegration which is used for in Johansen criteria. So, long run analysis was about the association among all variables over 44 years. Johansen Cointegration suggests that integration of the same order means the variables were non-stationary at the level, I (0), and stationary at the first difference I (1) is required for Johansen Cointegration. The study used this for testing cointegration of several I (1) time series. This test is generally used in modified autoregressive model VAR. Cointegration is the existence of long run relationship between two or more variables. However, the correlation does not necessarily mean long run. It is simply about a measure of the degree of mutual association between two or more variables.

In VECM, each endogenous variable in the system is considered as the lagged value of all endogenous variables in the system, thus the univariate autoregressive model is generalized to the modified vector autoregressive model consisting of multivariate time series variables. In the Eviews version 8 system, exogenous variables are not determined in the system and always appeared in the right hand side of the model while endogenous variables determined in the system and appeared in both side in the model but it will appears at once in the left hand side depending upon its variables number. So, the modified VAR system tells about regressing the variable itself in lagged form and lagged values of other independent variables.

Generally, cointegration relationship between variables in VECM model tested with the (Johannsen and Juselius, 1988) method. Cointegration tests analyse non-stationary time series process that have variances and means that vary over time. In other words, the method allows estimating the long run parameters or equilibrium in systems with unit root variables.

The two criteria for the Cointegration test for the long run analysis explained as follows:

Estimating VAR model: - The short run association between the series is checked by the Vector Auto Regression (VAR) test. It indicated that from which time onward the effect of the energy efficiency of the independent variables by inferring the significancy of output from the Eviews software. It cannot confirm the existence of the long run relationship among the series but only show the short run association between the variables.

Trace statistics and Maximum Eigen value

The decision criterion in order to confirm the existence of long run relationship among the series using Johansson cointegration is confirmed by two tests, namely trace statistics and Maximum Eigen value (Johansen, 1991). In both cases acceptance and rejection of the null hypotheses is decided by comparing the test statistics with special critical values compiled by Johansen.

Then, from the description the study used both the null and alternative hypothesis of the two test statistic's hypothesized as null hypothesis was that there is no cointegration among the variables versus alternative hypothesis was that there is cointegration among the variables. So the paper referred about long run association between the series.

Trace Test statistic is that the likelihood ratio statistic (LR) for the trace test as suggested by Johannsen (1988) can be specified as:

$$\lambda_{\mathrm{trace}}(\mathrm{r}) = -\mathrm{T} \sum_{\mathrm{i}=\mathrm{r}+1}^{\mathrm{k}} \ln(1 - \hat{\lambda}_{\mathrm{i}}) \qquad (14)$$

Where, λ_i hat is the ith largest trace value of matrix θ and T is the number of observation. In the trace test, the null hypothesis is that the number of distinct cointegrating vector was less than or equal to the number in this statistics λ trace has been small when the values of the characteristic roots were closer to zero. The Trace test was a joint test that tested the null hypothesis of no Cointegration (H_0: r = 0) against the alternative hypothesis of cointegration (H_1: r > 0).

Maximum Eigen value test: The second test statistic was known as the maximal Eigen value test which computes the null hypothesis that there were exactly r cointegrating vectors in E_t. The maximum Eigen value test as suggested by (Johansen, 1988) examines the null hypothesis of exactly r cointegrating relations against the alternative of r+1 cointegrating relation with the test statistic and is given by:

$$\lambda_{\max}(r, r + 1) = -T\ln(1 - \lambda \wedge r + 1) \quad (15)$$

where λ hat $r + 1$ *is the* $(r + 1)$, λ_i is the largest Eigen value. In the trace test, the null hypothesis of r=0 is tested against the alternative of r+1 cointegrating vector. Since the estimated value of the characteristic root was close to zero, then the λ_{max} should small. The Maximum Eigenvalue test conducted tests on each eigenvalue separately. It verified the null hypothesis that the number of cointegrating vectors is equal to or against the alternative of r+1 cointegrating vectors (Brooks, 2008).

Generally, for trace statistic, the null hypothesis was the number of cointegrating vectors is less than or equal to cointegrating vectors (r) against an unspecified alternative. In the case of maximum Eigen value cointegration test, the null hypothesis was the number of cointegrating vectors (r) against the alternative of 1 + r. Since trace statistic is greater than the Eigen value (critical value), we concluded that the model contains at least one cointegrating equation. Where this condition is violated at a higher order, determines the maximum number of cointegrating equations. Therefore, this study suggested Johansen approach.

3.10 The Short run dynamics

For running and interpreting the vector error correction model, the paper have information of all variables were stationary at first difference (from unit root test), the optimum lag selection criteria decision and Johansen cointegration tested (Trace & Max Eigen Value statistics) are fulfilled. After these all steps, the study has seen the short run dynamics by using vector error correction model. VECM which was restricts the long run behaviour of endogenous to converge to their cointegrating relationships. It is constructed to examine long run as well as short run dynamics of the cointegrated series.

It is corrected by the Vector Error Correction Method (VECM). The series drift from the long run path and there was disequilibrium happened in the long run among the series, it turned in opposite way to enter in the normal long run path. Error Correction Model of short run model that incorporates a mechanism which restores a variable to its long term relationship from a disequilibrium position. To know the time period or percentage to turn to its long run path the study use the vector error correction model and which is also known that the speed of adjustment. So, it is negative and statistically significant in assumption. Therefore, vector error correction is detected by the short run analysis.

The study used Vector Error Correction Model (VECM) in order to test the long run and short run causality among the energy efficiency and GDP. So, the short run dynamics has shown the association among all variables over a given period of time.

According to (Enders, 2004) there are four cases to consider when working with non-stationary variables. First when all variables are stationary, the classical regression model (CLRM) (i.e., OLS) is appropriate. Secondly when the sequences of the dependent and explanatory variables are integrated of the different orders, regression results using such variables are meaningless. Thirdly when the series is integrated of the same order and the residual sequence contains a stochastic trend, the regression is spurious. The results from such spurious regressions are meaningless in that all errors are permanent. Lastly the no stationary sequences are integrated of the same order and the residual sequence is stationary; that is, the sequences are cointegrated. This necessitates the estimation of an error correction model.

The study used VECM for first differenced stationary time series data and cointegrated variables. The development of unit root testing and cointegration for non stationarity variables integrated of I (1) are replaced in general representation of VECM as follows:

$$\Delta \mathrm{EI_t} = \alpha_O + \sum_{q=1}^{N-1} \alpha_1 \Delta \mathrm{EI_{t-1}} + \sum_{q=1}^{N-1} \alpha_2 \Delta \mathrm{RGDP_{t-1}} + \lambda_1 \mathrm{ECT}_{\ t-1} + \mathcal{E}_{1t} \tag{16}$$

$$\Delta \mathrm{RGDP_t} = \alpha_3 + \textstyle\sum_{q=1}^{N-1} \alpha_4 \Delta \mathrm{EI_{t-1}} + \sum_{q=1}^{N-1} \alpha_5 \Delta \mathrm{RGDP_{t-1}} + \lambda_2 \mathrm{ECT}_{\ t-1} + \mathcal{E}_{2t} \tag{17}$$

Where ΔEI_t change of energy intensity at time t, $\Delta RGDP_t$ is change of real GDP at time t, parameters α_O and α_3 are intercepts and α_1, α_2, α_4 and α_5 are coefficients that measure short run relationship, the ε_{1t} and ε_{3t} are error terms in the time trend of the model denotes lag length of the auto regressive process and Δ denotes the first difference operator. While λ_1 and λ_2 are the speed of adjustment to long run equilibrium with negative sign and statistical significance valued. ECT_{t-1} the error correction term which has the lagged value of residuals obtained from the cointegration regression of the dependent variable on the repressors.

The test is based on the following regressions since $RGDP_t$ was the sum of economic sectors of agriculture, industry and service sectors.

$$\Delta EI_t = \alpha_O + \sum_{q=1}^{N-1} \alpha_{1q}\Delta EI_{t-q} + \sum_{q=1}^{N-1} \alpha_{2q}\Delta AGR_{t-q} + \sum_{q=1}^{N-1} \alpha_{3q}\Delta IND_{t-q} + \sum_{q=1}^{N-1} \alpha_{4q}\Delta SER_{t-q} + \lambda_1 ECT_{t-1} + \varepsilon_{0t} \quad (18)$$

$$\Delta AGR_t = \mu_O + \sum_{q=1}^{N-1} \mu_{1q}\Delta EI_{t-q} + \sum_{q=1}^{N-1} \mu_{2q}\Delta AGR_{t-q} + \sum_{q=1}^{N-1} \mu_{3q}\Delta IND_{t-q} + \sum_{q=1}^{N-1} \alpha_{4q}\Delta SER_{t-q} + \lambda_2 ECT_{t-1} + \varepsilon_{1t} \quad (19)$$

$$\Delta IND_t = \emptyset_O + \sum_{q=1}^{N-1} \emptyset_{1q}\Delta EI_{t-q} + \sum_{q=1}^{N-1} \varphi_{2q}\Delta AGR_{t-q} + \sum_{q=1}^{N-1} \emptyset_{3q}\Delta IND_{t-q} + \sum_{q=1}^{N-1} \emptyset_{4q}\Delta SER_{t-q} + \lambda_3 ECT_{t-1} + \varepsilon_{2t} \quad (20)$$

$$\Delta SER_t = \theta_O + \sum_{q=1}^{N-1} \theta_{1q}\Delta EI_{t-q} + \sum_{q=1}^{N-1} \theta_{2q}\Delta AGR_{t-q} + \sum_{q=1}^{N-1} \theta_{3q}\Delta IND_{t-q} + \sum_{q=1}^{N-1} \theta_{4q}\Delta SER_{t-q} + \lambda_4 ECT_{t-1} + +\varepsilon_{3t} \quad (21)$$

Where ΔEI_t change of Energy intensity at time t, ΔAGR_t is change of share of agriculture at time t; IND_t is change of share of industry sector at time t; ΔSER_t is change of share of service sector at time t. And also, parameters α_O, μ_O, $\emptyset_O$, θ_O, are intercepts and α_1, α_2, α_3,

α_4, μ_1, μ_2, μ_3, μ_4, $\emptyset_1$, $\emptyset_2$, $\emptyset_3$, $\emptyset_4$, θ_1, θ_3, θ_4 are coefficients that measure short run relationship ε_0, ε_1, ε_2, and ε_3 are error terms in the time trend of the model denotes lag length of the auto regressive process and Δ denotes the first difference operator. The difference operation reduces a lag (that is lag decreased by 1 so N-1 instead of N). While λ_1, λ_2 λ_3 and λ_4 is the speed of adjustment to long run equilibrium with negative sign and statistical significance valued. ECT_{t-1} Is the error correction term is the lagged value of residuals obtained from the Cointegration regression of the dependent variable on the repressors.

Therefore, the presence of cointegration suggests the existence of a corresponding error correction representation. This implies that the change in dependent variable are the function of disequilibrium level in the cointegration relationship captured through the error correction term and change in explanatory variables for analysis of short run dynamics. The ECT representing the residual series derived from the long run cointegrating regression and entered in one period lag as error correction mechanism in the short run dynamic model. The coefficient of ECT measures the speed of adjustment for short run deviation of the dependent variable due to the event of shocks towards the long run equilibrium trend and expected that statistically significant and negative sign. The existence of cointegration implies granger causality. However, it does not point out the direction of causality. In order to assess the direction, the study employed a vector error correction (VEC) modelling .Hence, the variables in concern are cointegrated vector and error correction model should be estimated rather than a VAR as a standard granger causality test (Granger, 1969).

3.11 Residual diagnostics and stability diagnostics test

Breusch Godfrey test: This test was preeminent test for autocorrelation or similar logic serial correlation which allowed measuring the correlation between error term and multiple lagged error terms at the same time, seen there was no serial correlation. It has stated hypothesis of null and alternative says that:

Null hypothesis is that there was no serial correlation versus alternative hypothesis is that there was serial correlation. According to the guideline, when the probability value is above 5% significance level, then the study fails to reject the null hypothesis. This implies the model was not suffering from serial correlation.

Breusch Pagan Godfrey test: Is the desired test for heteroskedasticity. For this model the study have used the logarithmic conversions that used to reduce the impact of extreme values in the data and make consistent standard error estimates. One of the assumptions in regression analysis was the errors term had a constant variance. Since the error term didn't have constant variance there was heteroscedasticity. In the general linear model, OLS estimate are consistent but not efficient when the disturbances are hetroscedastic (Gujarati, 2004).So study checked whether the model suffered from heteroskedasticity or not. It has hypothesis of null and alternative states that:

Null hypothesis is that residuals do not suffered from heteroskedasticity versus alternative hypothesis is that the residuals do suffer from heteroskedasticity. As per the guideline, when the probability value is above 5% significance level, then the study fails to reject the null hypothesis. This implies the model was not suffering from heteroskedasticity.

Jarque-Bera test: The test of normality is used by both in graphical and numerical technique to detect whether residuals were normally distributed or not to check for normality of data, in Eviews version 8. Through graphical method, it has checked the data by drawing histogram and through numerical methods and the Jarque-Bera tests are used with its corresponding probability (Park, 2008). In this fashion it has hypothesis stated here below:

Null hypothesis is that the residuals follow normal distribution versus alternative hypothesis is that the residuals not follow normal distribution. Since the Jarque-Bera test value's corresponding probability is above 5% significance level, then the study accepted null hypothesis.

CUSUM test: is based on the cumulative sum of recursive residuals. It guaranteed that the parameters of the model are stable over time. It has been detected that the blue line was between the two dashed red lines in the figure. So the study determined that the coefficients of the model were stable over observations or the model was dynamically stable over time.

CUSUM of Squares test: The test of CUSUM of Squares test is applied to check that the variance of residuals is stable over the time. Since the blue line was between the two dashed red lines in the figure. So, from verification of the figure the coefficients of the model were stable over observations or the model was dynamically stable over time.

3.12 Granger causality test

The Causality which is dealt by Granger causality to show direction the long run relationship among the variables and it is also some times as pairwise causality. The Granger causality test was a statistical hypothesis test for determining whether one time series was useful in forecasting another. However, it remains a popular method for causality analysis in time series due to its computational simplicity.

To show the direction of causality the further test is employed. If the past values of each endogenous variable help in predicting the lagged values itself and other independent variables, then the study said granger cause of one variable on the other. In here, the most important steps were granger causality the model when the presence of granger causality of endogenous variables with its respective lagged variables. Then the numbers of lags that were significant to first step have taken to second step and add the lags of other endogenous variables in the first created model and then re-estimate the model. Later we find out how many of these coefficients of the lags of added endogenous variables were significant. Finally, researcher have used tests of t-statistics of individual coefficient and F-tests for the joint tests based on their Null and alternative hypothesis respectively.

$$\Delta \mathrm{EI_t} = \alpha_0 + \sum_{q=1}^{N-1} \alpha_1 \Delta \mathrm{EI_{t-1}} + \sum_{q=1}^{N-1} \alpha_2 \Delta \mathrm{RGDP_{t-1}} + \varepsilon_{1t} \tag{22}$$

$$\Delta \mathrm{RGDP_t} = \alpha_3 + \textstyle\sum_{q=1}^{N-1} \alpha_4 \Delta \mathrm{EI_{t-1}} + \sum_{q=1}^{N-1} \alpha_2 \Delta \mathrm{RGDP_{t-1}} + \varepsilon_{2t} \tag{23}$$

Where, ΔEI_t and $\Delta RGDP_t$ were the variables tested, and ε_{1t} *and* ε_{2t} were mutually uncorrelated white noise errors, and t denotes the time period. Δ denotes the first difference operator.

From the above model, considering representing two variables $RGDP_t$ and EI_t, $RGDP_t$ is said to Granger-cause EI, meanwhile lagged values of $RGDP_t$ predicted EI well. If lagged values of $RGDP_t$ predict EI and at the same time lagged values of EI predict $RGDP_t$, then there is a bi-directional causality between EI and According to Granger (1969), a variable RGDP is said to be Granger cause another variable EI (Energy intensity) the analysis values of energy efficiency help to predict GDP. Four patterns of causality are distinguished for the relationship between energy efficiency and economic growth.

1) Unidirectional causality from RGDP to EI means RGDP does Granger cause EI;

2) Unidirectional causality from EI to RGDP means EI does Granger causes RGDP;

3) Bi-directional or feedback causality from RGDP to EI and also EI to RGDP;

4) No causality or independence causality between EI and real GDP.

The standard (Granger, 1969) test is employed in the relevant literature test the causal relationship between two variables. This test state that, the past values of a variable real GDP significantly contribute to influence the values of another variable, EI is said to granger cause of $RGDP_t$ to vice versa. Since real GDP was the sum of economic sectors of agriculture, industry and service sectors, then the test is based on the following regressions model.

$$\Delta EI_t = \beta_O + \sum_{q=1}^{N-1} \beta_{1q}\Delta EI_{t-q} + \sum_{q=1}^{N-1} \beta_{2q}\Delta AGR_{t-q} + \sum_{q=1}^{N-1} \beta_{3q}\Delta IND_{t-q} + \sum_{q=1}^{N-1} \beta_{4q}\Delta SER_{t-q} + \varepsilon_{1t} \quad (24)$$

$$\Delta AGR_t = \mu_O + \sum_{q=1}^{N-1} \mu_{1q}\Delta EI_{t-q} + \sum_{q=1}^{N-1} \mu_{2q}\Delta AGR_{t-q} + \sum_{q=1}^{N-1} \mu_{3q}\Delta IND_{t-q} + \sum_{q=1}^{N-1} \mu_{4q}\Delta SER_{t-q} + \varepsilon_{2t} \quad (25)$$

$$\Delta IND_t = \emptyset_O + \sum_{q=1}^{N-1} \emptyset_{1q}\Delta EI_{t-q} + \sum_{q=1}^{N-1} \varphi_{2q}\Delta AGR_{t-q} + \sum_{q=1}^{N-1} \emptyset_{3q}\Delta IND_{t-q} + \sum_{q=1}^{N-1} \emptyset_{4q}\Delta SER_{t-q} + \varepsilon_{3t} \quad (26)$$

$$\Delta SER_t = \varphi_O + \sum_{q=1}^{N-1} \varphi_{2q}\Delta EI_{t-q} + \sum_{q=1}^{N-1} \varphi_{3q}\Delta AGR_{t-q} + \sum_{q=1}^{N-1} \varphi_{4q}\Delta SIND_{t-q} + \sum_{q=1}^{N-1} \varphi_{5q}\Delta SER_{t-q} + \varepsilon_{4t} \quad (27)$$

Where EI_t, $AGRI_t$, IND_t, and $SERV_t$ are the variables to be tested, and ε_{1t}, ε_{2t}, ε_{3t}, and ε_{4t} are mutually uncorrelated white noise errors, and t denotes the time period and q is the number of lags. The four variables were measured by their natural logarithm so that their first difference approximates their growth rates. Hypothesis that used for Granger was that

The null hypothesis was $\beta_i = \mu_i = \emptyset_i = \varphi_i = 0$. i=1, 2, 3 and 4 for all versus Alternative hypothesis is that $\beta i \neq \mu i \neq \emptyset i \neq \varphi i \neq 0$ at least some i=1, 2, 3 and 4 (Granger, 1986) the test is valid if the variables are not cointegrated. Second, the results of Granger causality are very sensitive to the selection of lag length. If the chosen lag length is less than the true lag length, the omission of relevant lag length is more; the irrelevant lags in the equation cause the estimates to be inefficient.

3.13 Impulse response function and variance decomposition

This shows the responsiveness of the dependent variable in the model to the shocks in the error term. The term impulse response means which will give shock while as response term implies how the variable will reacting when there is change. First we checking the impulse response we have to run VECM and then we can check it. In order to analyse dynamic effects of the model responding to certain shocks as well as how the effects are among the three variables, further analysis is made through impulse response function based on VECM. From the equation (28) simply realize that when there is shock or change in one of the error will affect the whole VECM system. For instance, if the innovation existed in ε_{0t} in first model, it will immediately affect energy efficiency.

Variance decomposition technique suggested by (Sims, 1980) is useful devices in the modified VAR framework for testing the sources of variability. The impulse response function (IRF) can trace the response of the endogenous to a variables shock in another variable. The variance decomposition breaks down the variance of the forecast error for each variable into components that can be attributed to each of the endogenous variables.

Thus, when innovations occur in the system, energy efficiency makes a short run adjustment to restore the long run equilibrium.

$$\Delta EI_t = \alpha_O + \sum_{q=1}^{N} \alpha_1 \Delta EI_{t-q} + \sum_{q=1}^{N} \alpha_2 \Delta AGR_{t-q} + \sum_{q=1}^{N} \alpha_3 \Delta IND_{t-q} + \sum_{q=1}^{N} \alpha_4 \Delta SER_{t-q} + \varepsilon_{0t} \quad (28)$$

$$\Delta AGR_t = \mu_O + \sum_{q=1}^{N} \mu_1 \Delta EI_{t-q} + \sum_{q=1}^{N} \mu_2 \Delta AGR_{t-q} + \sum_{q=1}^{N} \mu_3 \Delta IND_{t-q} + \sum_{q=1}^{N} \mu_4 \Delta SER_{t-q} + \varepsilon_{1t} \quad (29)$$

$$\Delta IND_t = \emptyset_O + \sum_{q=1}^{N} \emptyset_1 \Delta EI_{t-q} + \sum_{q=1}^{N} \varphi_2 \Delta AGR_{t-q} + \sum_{q=1}^{N} \emptyset_3 \Delta IND_{t-q} + \sum_{q=1}^{N} \emptyset_4 \Delta SER_{t-q} + \varepsilon_{2t} \quad (30)$$

$$\Delta SER_t = \theta_O + \sum_{q=1}^{N} \theta_1 \Delta EI_{t-q} + \sum_{q=1}^{N} \theta_2 \Delta AGR_{t-q} + \sum_{q=1}^{N} \theta_3 \Delta IND_{t-q} + \sum_{q=1}^{N} \theta_4 \Delta SER_{t-q} + \varepsilon_{3t} \quad (31)$$

Where ΔEI_t is change of Energy efficiency at time t, ΔAGR_t is change of share of agriculture at time t; ΔIND_t is change of share of industry sector at time t; ΔSER_t change of share of service sector at time. And also, parameters α_O, $\emptyset_O$, μ_O, and θ_O are intercepts and α_1, α_2, α_3, α_4, μ_1, μ_2, μ_3, μ_4, $\emptyset_1$, $\emptyset_2$, $\emptyset_3$, $\emptyset_4$, θ_1, θ_2, θ_3 and θ_4 are coefficients that measure long run relationships.ε_0, ε_1, ε_2, and ε_3 Is error terms in the time trend of the model denotes lag length of the auto regressive process and Δ, denotes the first difference operator.

CHAPTER FOUR

RESULT AND DISCUSION

In this chapter, the study analysed the relationship between energy efficiency and economic growth in Ethiopia using annual data from 1974/75 to 2017/18 resulting in 44 observations. Before both descriptive and empirical analysis, here the paper addressed the unit root test of the variables to consider the stationarity of variables. Moreover, before considering empirical analysis various tests were used to determine the optimal lag length and the long run association between variables.

4.1 Descriptive statistical analysis

Before engaging to regression analysis, it is essential to have known the description of the data set. In this portion the paper described whether the data is normally distributed or not, are there outliers of data, useful for parametric tests and provided information on the measures of central tendency, measures of dispersion and measures of normality.

Table 2 shows the descriptive statistics of variables consisting of 44 observations. The summary of descriptive statistics made for raw variable, but not for log transformed variables. From the table below the average mean value of the variables energy efficiency and economic growth were 480.588 and 280379 respectively. Maximum and minimum tells about the highest and lowest for each of the variables used for the study. From the output, the maximum observation for the variables EI and RGDP are 496.085 and 958643.800 while as the minimum observations are 471.952 and 102406.600 respectively. The standard deviations of EI and RGDP were 6.872 and 235461.000 which told about the deviation from sample mean to the respect of each of the variable.

Skewness which measures the degree of asymmetry of the series having normal (having the value of zero) mean. It is positive skewed when its value greater than zero which means long right tailed (more values than the mean) and negative skewed valued when it has less than zero description which means long left tailed (more lower values than mean).From the result we confirm that all the values of the variables are positively skewed, having long right tailed more values than the average mean. While as kurtosis measures the peakness or flatness of the distribution of the series. The kurtosis is one of mesokurtic have normal distribution with kurtosis value of 3, Leptokurtic have positive kurtosis or peaked curve which have more values than the average mean of each variable and platykurtic which implies negative kurtosis or flatted curve, having more lower values than the average mean of each variable. From the table below energy efficiency is platykurtic but the RGDP are leptokurtic or peaked valued.

Table 2. Descriptive analysis results

Variables	Measures of Summery Statistics					
	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
EI	480.588	6.872	471.952	496.085	0.750	2.481
RGDP	280379.000	235461.000	102406.600	958643.800	1.531	4.190

Note: Observations 44
Source: Author computation (2020) using Eviews software version 8

As per the table of 3, the result of the relationship between shares of economic sectors of GDP and energy efficiency regression result also confirms the above result. The average mean values of share of agriculture, industry and service sectors in GDP were 147988.300, 50008.670 and 122870.70 respectively. Skewness and kurtosis have the same conclusion with the above table 2.

Table 3. Descriptive analysis results of sectoral shares

Variables	Measures of Summery Statistics					
	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
EI	480.588	6.872	471.952	496.085	0.750	2.481
AGR	147988.300	128811.700	59202.960	600878.100	2.559	8.871
IND	50008.670	100885.000	7949.936	464433.800	3.286	12.532
SERV	122870.700	156742.700	27503.590	673943.000	2.356	7.863

Note: Observations 44
Source: Author computation (2020) using Eviews software version 8

4.2 Unit root test results

As per the result, for both series (i.e., two variables which tested as separately) in table 4, the values of ADF test statistics at level was less than critical values at the 5% level of significance in absolute term. And also their corresponding probability values were greater than 5% significance level. Then, the study failed to reject the null hypothesis of non-stationarity at levels for specified variables. The result implies the series were non-stationary at their levels.

Table 4. Augmented Dickey Fuller tests

Variable	Constant and Intercept Only					Decision
	Test Statistics	1% level	5% level	10% level	P-Value	
LNEI	0.780	-3.592	-2.931	-2.604	0.993	unit root
LNRGDP	1.945	-3.606	-2.937	-2.607	1.000	unit root

Note: Unit root mean variables are non-stationary at level
Source: Author computation (2020) using Eviews software version 8

According to the result of table 5, for four series (i.e., four variables which tested as separately), the values of ADF test statistics at level was less than critical values at the 5% level of significance in absolute term. And also their corresponding probability values were greater than 5% significance level. Then the study accepted the null hypothesis (i.e., variables are non-stationarity at levels for all variables). The result implies the series were non-stationary at their original form of variables.

Table 5. Augmented Dickey Fuller test for sectoral shares

Variable	Constant and Intercept only					Decision
	Test Statistics	1% level	5% level	10% level	P-Value	
LNEI	0.780	-3.592	-2.931	-2.604	0.993	unit root
LNAGR	-2.009	-3.592	-2.931	-2.604	0.282	unit root
LNIND	1.121	-3.592	-2.931	-2.604	0.997	unit root
LNSERV	0.519	-3.592	-2.931	-2.604	0.986	unit root

Note: Unit root mean variables are non-stationary at level
Source: Author computation (2020) using Eviews software version 8

In order to reduce the fluctuations of the data, first order difference implemented on the five series separately. Then, the result of ADF values at first difference in table 6 was greater than the significant value of 5% in absolute term. Indeed, its corresponding probability value was less than 5% significance level, which implies the sequences were stationary at their first difference.

Table 6. Augmented Dickey Fuller test

Variable	First Difference and Trend					Decision
	Test Statistics	1% level	5% level	10% level	P-Value	
LNEI	-4.636	-4.219	-3.533	-3.198	0.003	I(1)
LNRGDP	-6.686	-4.199	-3.524	-3.193	0.000	I(1)

Note: I (1) mean variables are stationary after first difference
Source: Author computation (2020) using Eviews software version 8

The table 7, the same procedure was employed for the sectoral shares of GDP and energy efficiency relationship. Accordingly, the result of ADF values at first difference was greater than the significant value of 5% in absolute term. Indeed, its corresponding probability value was less than 5% significance level, which implies that series were stationary at their first difference.

Table 7. Augmented Dickey Fuller test for sectoral shares

Variable	First Difference and Trend					Decision
	Test Statistics	1% level	5% level	10% level	P-Value	
LNEI	-4.636	-4.219	-3.533	-3.198	0.003	I(1)
LNAGR	-6.734	-4.192	-3.521	-3.191	0.000	I(1)
LNIND	-5.884	-4.192	-3.521	-3.191	0.000	I(1)
LNSERV	-7.340	-4.192	-3.521	-3.191	0.000	I(1)

Note: I (1) mean variables are stationary after first difference
Source: Author computation (2020) using Eviews software version 8

Therefore, the results of ADF showed that the variable have the same order of integration. This implies both energy efficiency and GDP series were not stationary at level and Stationary after first difference I (1). And also sectoral shares of GDP and energy efficiency relationship exhibited the same order. Therefore, the study applied Johansen's cointegration test to find the long run relationship between energy efficiency and GDP and results are mentioned below in Tables 10-13.

4.3 Optimal lag length

The displayed results of Eviews software have given the six information criteria (IC) as shown in Table 8. The paper chosed optimum lag length from given the IC. The lag length was 1 as all IC were significant at lag length of one. This lag length was used for Johansen cointegration test, VECM estimation, and Granger causality test. The Akaike information criterion in Table 8 suggests that 1 time period lag would be appropriate for Johansen cointegration test.

Table 8. Lag length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	140.730	NA	0.000	-6.606	-6.523	-6.576
1	260.694	222.7901*	1.85e-08*	-12.12827*	-11.88004*	-12.03728*
2	262.621	3.395	0.000	-12.030	-11.616	-11.878

* 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
Sample: 44 and included observations: 42

Source: Author computation (2020) using Eviews software version 8

The result of sub sectors in GDP and energy efficiency in table 9 showed that all the criteria suggested to choose lag length one. Thus, the study has chosen the lag length one to run the model. The Akaike information criterion in Table 9 suggests that 1 time period lag would be appropriate for Johansen cointegration test.

Table 9. Lag length selection of sectoral shares

Lag	LogL	LR	FPE	AIC	SC	HQ
0	213.075	NA	0.000	-9.956	-9.790	-9.895
1	347.843	237.4481*	1.96e-12*	-15.61156*	-14.78410*	-15.30827*
2	361.793	21.922	0.000	-15.514	-14.025	-14.968

* 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
Sample: 44 and included observations: 42

Source: Author computation (2020) using Eviews software version 8

4.4 Stable system

According to the appendix-I result of the study, the system is considered us stable due to the root of the coefficient parameters are less than 1 in absolute value and all points in unit circle are inside the circle in the figure. So, the study recognized that the model was stable and confirms that there was existence of long run relationship between all series.

4.5 Cointegration test

The table of 10, 11, 12 and 13 below reported the regression output of Johansen cointegration test based on the Trace and Max Eigen value. This two test statistics confirms the existence of long run association between the variables. To make decision the researcher inferred the null hypothesis values of both statistics with their corresponding probability.

In table 10 the resulted values of trace test statistics of the relationship between energy efficiency and economic growth (i.e., EI and GDP) indicates the existence of 1 cointegrating equation at the 5% significance level. In this cointegrating equation, one linear combination exists between the variables that force these indices to have a relationship over the entire 1 time year's period.

However potential deviation from equilibrium level in the short run. The trace statistics values greater than 5% critical level values and also their corresponding probability values were less than 5% significance level at none only. According to the guideline, when p-value is less than 5% level of significance, then reject the null hypothesis and accept the alternative one. So, the studies rejected the null hypothesis and accepted the alternative hypothesis while as the remaining hypothesis failed to reject the null hypothesis. This implies that there was one cointegrated equation, meaning both the variables are moving together in the long run.

Table 10. Cointegration results of Trace test

Null Hypothesis	Series: LNEI LNRGDP			
Hypothesized Number of Cointegrating equation	Eigenvalue	Trace Statistic	5% Critical Value	Probability
None *	0.322	16.358	12.321	0.010
At most 1	0.000	0.018	4.130	0.912

Trace test indicates 1 cointegrating equation at the 0.05 level
Note: "* "denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Author computation (2020) using Eviews software version 8

The maximum Eigen value test resulted in table 11 also shows 1 cointegrating equation at 5% significance level which confirming Trace test. The maximum Eigen values were greater than 5% critical level values and also their corresponding probability values less than 5% significance level at none only. Accordingly, the study rejected the null hypothesis and accepted the alternative hypothesis at none while as in at most 1, the study failed to reject the null hypothesis. This implies that there was one cointegrated equation, meaning both series were moving together in the long run.

Table 11. Cointegration results of Maximum Eigenvalue test

Null Hypothesis	Series: LNEI LNRGDP			
Hypothesized Number of Cointegrating equation	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Probability
None *	0.322	16.340	11.225	0.006
At most 1	0.000	0.018	4.130	0.912

Max-eigenvalue test indicates 1 cointegrating equation at the 0.05 level
Note: "* "denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Author computation (2020) using Eviews software version 8

From the tabulated result of table 12, the trace test Statistics result of the sub sectors of GDP share and energy efficiency (i.e., EI, AGR, IND and SERV) relationship indicates that existence of long run relationship among the variables. As the result shown, there was one cointegrating equation. In this cointegrating equation, one linear combination exists between the variables that force these indices to have a relationship over the entire 1 time year's period. However potential deviation from equilibrium level in the short run.

Meanwhile, the trace statistics values greater than 5% critical level values and also their corresponding probability values were less than 5% significance level at none and their test statistics were less than 5% critical level. According to the output the paper rejected the null hypothesis and accepted the alternative one. While as the remaining three cases the study failed to reject the null hypothesis. This implies that there was one cointegrated equation, meaning all the variables are moving together in the long run.

Table 12. Cointegration results of Trace test (sectoral shares)

Null Hypothesis	Series: LNEI LNAGR LNIND LNSERV			
Hypothesized Number of Cointegrating equation	Eigenvalue	Trace Statistic	5% Critical Value	Probability
None *	0.489	48.715	47.856	0.041
At most 1	0.321	20.536	29.797	0.387
At most 2	0.096	4.260	15.495	0.882
At most 3	0.000	0.021	3.841	0.885

Trace test indicates 1 cointegrating equation at the 0.05 level
Note: "* "denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Author computation (2020) using Eviews software version 8

In table 13, the maximum Eigen value test result of sectoral shares of GDP and energy efficiency showed the long run relationship among the variables. It has one cointegrating equation at 5% significance level which confirming Trace test. The maximum Eigen values were greater than 5% critical level values and also their corresponding probability values less than 5% significance level at none only. Accordingly, the study rejected the null hypothesis and accepted the alternative hypothesis while as the remaining three hypothesis, failed to reject the null hypothesis. This implies that there was one cointegrated equation, meaning all series were moving together in the long run.

Table 13. Cointegration results of Maximum Eigen value test(sectoral shares)

Null Hypothesis	Series: LNEI LNAGR LNIND LNSERV			
Hypothesized Number of Cointegrating equation	Eigenvalue	Trace Statistic	5% Critical Value	Probability
None *	0.489	28.179	27.584	0.042
At most 1	0.321	16.275	21.132	0.209
At most 2	0.096	4.239	14.265	0.833
At most 3	0.000	0.021	3.841	0.885

Max-eigenvalue test indicates 1 cointegrating equation at the 0.05 level
Note: "* "denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Author computation (2020) using Eviews software version 8

Therefore the Trace and Maximum Eigen value above tests indicates that the variables were cointegrated at 5% statistical significance level. The cointegration tests established were the existence of long run equilibrium among variables. Johansen cointegration test denotes the rejection of the null hypothesis of non-cointegration between the variables included in the model and thus supports the long-run hypothesis. So, we can estimate both short run and long run by using appropriate estimation techniques vector error correction (VECM) models).

So, based on both the Trace statistics and Maximum Eigen statistics values have the same indication for cointegration test and the study concluded that there exists significant long run relationship between the variables under investigation. This result is contradicts with the findings of (Luintel & Khan, 1999, and Roman, 2012). They found that the trace statistics is more robust than the maximum Eigen value statistics in testing for cointegration. Generally, from the test results of Johansen cointegration test (i.e., in above tables) the study implies that:

1) The series exhibited a long run relationship among energy efficiency and economic growth and also for the sectoral shares of GDP relationships;

2) Indicates the series are related and can be joined in linear method;

3) Even if there are shocks in the short run, they would converge with time in the long run;

4) Have given the road map to estimate both short run and long run models;

5) Therefore, the appropriate estimation technique used was vector error correction model.

Table 14. *Normalized cointegration coefficient result*

1 Cointegrating Equation		Log likelihood	255.314
LNEI	LNRGDP		
1.000	-0.559		
	(0.012)		
	[47.379]		
Adjustment coefficients			
D(LNEI)	-0.0001		
	(0.001)		
D(LNRGDP)	-0.077		
	(0.018)		

Note: Standard errors in parentheses & t statistics in brackets
Source: Author computation (2020) using Eviews software version 8

From the table 14 above the Johansen normalization result, the study has identified the existence of one cointegrating equation, so the researcher confirmed that there was stable equilibrium relationship present. The result was normalized on the LNEI. Due to normalization process the signs are reversed to enable proper interpretation. The long run cointegrating vector indicates that RGDP has registered the expected sign and statistical significant.

LNRGDP has the positive sign and statistically significant effect on energy efficiency at the 5 % level in the long run. So, it can be interpreted as a 1% increase in economic growth led to 55.9% increase energy efficiency. However, the positive adjustment coefficients of the LNEI and LNRGDP indicate that the extent to which these variables may deviate from its long run steady state path after a certain shock.

Table 15. Normalized cointegration coefficient result of sectoral shares

1 Cointegrating Equation		Log likelihood	351.526
LNEI	LNAGR	LNIND	LNSERV
1.000	0.021	0.005	-0.059
	(0.006)	(0.006)	(0.011)
	[3.390]	[0.939]	[5.441]
Adjustment coefficients			
D(LNEI)	-0.501		
	(0.115)		
D(LNAGR)	2.249		
	(5.115)		
D(LNIND)	16.266		
	(7.733)		
D(LNSERV)	8.074		
	(3.916)		

Note: Standard errors in parentheses and t-statistics in brackets
Source: Author computation (2020) using Eviews software version 8

From the table 15 above the Johansen normalization result confirms the relationship between energy efficiency and economic growth as in table 14. The long run cointegrating vector indicates that all variables have registered the expected sign statistical significance. LNAGR have the negative sign and statistically significant coefficients at 5 % level, LNIND have the negative sign and statistically insignificant coefficients and LNSERV have the positive sign and statistically significant coefficients according to values shown.

In the long run LNSERV have positive impact on LNEI while as LNAGR has negative impact on LNEIs, on average, ceteris paribus.

Therefore, the coefficients of agriculture share, industry share and service sector share are interpreted as a 1% increase in AGR led to in 2.1% decrease in LNEI, on average, ceteris paribus. A 1% increase in IND led to in 0.5% decrease in LNEI, on average, ceteris paribus and a 1% increase in SERV led to in 5.9% increase in LNEI, on average, ceteris paribus. The speed of adjustment of LNAGR, LNIND and LNSERV adjusted toward their long run equilibrium by 224.9%, 1626.6% and 807.4% respectively.

4.6 Short run dynamics

The vector error correction estimates result told about both the long run model and short run coefficients. In table 16 cointegrating equations was about the breakdown of error correction term equation and representing the long run relationship among the variables also shown the short run coefficients and adjustment coefficients. So this table implies the long run, the short run and causal effects of the variables.

Table 16. Vector error correction estimates

Cointegrating equation	CE	
LNEI(-1)	1.000	
LNRGDP(-1)	-0.021	
	(0.001)	
	[-16.858]	
C	-5.920	
Error correction	D(LNEI)	D(LNRGDP)
CE	-0.592	1.178
	(0.149)	(3.492)
	[-3.971]	[0.337]
D(LNEI(-1))	0.200	0.621
	(0.135)	(3.169)
	[1.478]	[0.196]
D(LNRGDP(-1))	0.008	0.337
	(0.007)	(0.173)
	[1.110]	[1.949]
C	0.001	0.035
	(0.001)	(0.012)
	[1.056]	[2.849]
R-squared	0.417	0.105
Adjusted R-squared	0.370	0.034
Sum squared residuals	0.000	0.122
Standard error equation	0.002	0.057
F-statistic	9.043	1.486
Log likelihood	195.570	63.143
Akaike AIC	-9.122	-2.816
Schwarz SC	-8.957	-2.651
Mean dependent	0.001	0.053
S.D. dependent	0.003	0.058
Determinant residual covariance		0.000
Determinant residual covariance		0.000
Log likelihood		259.013
Akaike information criterion		-11.858
Schwarz criterion		-11.444
Included observations: 42		

Note: Standard errors in parentheses and t-statistics in brackets
Source: Author computation (2020) using Eviews software version 8

4.6.1 The long run relationship

According to table 16, the upper part (block) of the result was the breakdown of error correction term. Its equation specified including concern variable, endogenous variables and ECT term at right hand side of equation as shown method section and after rearranging the equation it yields required model, known as error correction model. The error correction coefficient, ECT (-1) measures the speed at which the energy efficiency adjusts in the long run equilibrium was statistically significant at 5% level and implies there was long run relationship. The equation (32) was about error correction equation meaning the cointegrating equation and the long run model.

$$\text{ECT}_{t-1} = \text{EI}_{t-1} + \beta_1 \text{RGDP}_{t-1} + \beta_0 \quad (32)$$

Plugged the coefficients in equation (32) into the equation given (33), resulted error correction equation signifying long run relationship among the variables.

$$\text{ECT}_{t-1} = 1.000 \text{ LNEI}_{t-1} - 0.021 \text{ LNRGDP}_{t-1} - 5.920 \quad (33)$$

Where ECT_{t-1} is error correction term in previous period, EI_{t-1} is logarithm of energy efficiency in previous period and $RGDP_{t-1}$ is represented as real GDP at one period lag time and β_0 is intercept having 1 and β1 known as coefficient parameters of regression which was given as minus 0.021.

The long run part of the VECM was not normalized by the Eviews software version 8. So, the study has normalized in terms of the variables in order to get an economically meaningful interpretation of the estimated coefficient. With this regard the sign is reversed and showed a positive coefficient of variables (i.e., changed from -0.021 to 0.021) implies there was straight forward relationship among energy efficiency and economic growth in the long run. The results of the long run coefficients found that real GDP have a positive and statistically significant influence on energy efficiency. This shows that any increase in the real GDP might have increase the energy efficiency in long run. As a result, energy consumption has grown more rapidly than real GDP, which is supported by Huang et al. (2008).

Generally, from the modelled result of ECT, explains the previous period deviation from long run equilibrium influences the short run movement in the energy efficiency.

Therefore, from the output the paper understood that the 1% change in real GDP resulted in a 0.021% increase in energy efficiency.

4.6.2 The short run relationship

The value resulted in table 16 in the middle part (block) result was the adjustment coefficient, endogenous variables coefficient and constant with their standard error value and t-statistics. Cointegration equation (34) showed the short run coefficients including adjustment coefficient and endogenous variable coefficients.

$$\Delta \mathrm{EI}_{\mathrm{t}} = -0.592\ \mathrm{ECT}_{\ t-1} + 0.200\Delta\ \mathrm{LNEI}_{\ t-1} + 0.008\Delta \mathrm{RGDP}_{\mathrm{t}-1} + 0.001 \qquad (34)$$

Where ΔEI_t and ΔEI_{t-1} are represents change in energy intensity at current and one period lag time t respectively, $\Delta RGDP_{t-1}$ is represents change in real GDP at one period lag time. The coefficient -0.592 was an adjustment coefficient and it has exhibited negative sign and statistically significant implies there was long run causal relationship. It expressed that at 59.2 rates it adjusts the prior period disequilibrium of the system. From the value of adjustment coefficient the study depicts that the energy efficiency converges to the long run equilibrium trend quickly due to high value of adjustment coefficient. This result is in line with the findings of (Tesfaye, 2007) and also according to the finding of (Bannerjee et al., 2003) as cited in (Kidanemarim, 2014), the highly significant error correction term further confirms the existence of a stable long-run relationship.

Based on the result, real GDP have positive sign and statistically insignificant effect to energy efficiency at 5% level. From this, the study concluded that there was no relationship among the energy efficiency and economic growth in the short run.

Before interpreting the parameters, first the paper specified the log-log information that means the relationship among variables is an elasticity relationship. So interpretations of Coefficients from the above regression model are:

1) Adjustment Coefficient C (1): The coefficient of ECT estimated at -0.592 was statistically significant at 1 percent level. It suggests that any short run deviation of the energy efficiency from its long run equilibrium trend is adjusted by about 59.2% within a year. So, it corrects the previous period disequilibrium at the rate of 59.2% annually.

2) Energy efficiency coefficient C (2): inferred as on average a percentage change in energy efficiency was associated with 20 percentage increase in one year lagged value of itself, ceteris paribus in the short run.

3) RGDP coefficient C (3): inferred as a percentage change in real GDP was associated with 0.8 percentage increase in energy efficiency on average, ceteris paribus in the short run.

Table 17. Dependent variable

Variable	Coefficient	Standard error	t-statistic	Probability
C(1)	-0.592	0.149	-3.971	0.000
C(2)	0.200	0.135	1.478	0.148
C(3)	0.008	0.007	1.110	0.274
C(4)	0.001	0.001	1.056	0.298
R-squared	0.417	Mean dependent var		0.001
Adjusted R-squared	0.370	S.D. dependent var		0.003
S.E. of regression	0.002	Akaike info criterion		-9.122
Sum squared resid	0.000	Schwarz criterion		-8.957
Log likelihood	195.570	Hannan-Quinn critr.		-9.062
F-statistic	9.043	Durbin-Watson stat		2.066
Prob(F-statistic)	0.000			

Source: Author computation (2020) using Eviews software version 8

From the result of VECM in table 17, the output of vector error correction of C (1), C (2), C (3) and C (4) were the ciphers of adjustment coefficients, energy intensity, economic growth and constant respectively. Out of them C (2) and C (3) were short run coefficients. The probability value (i.e., 0.000) showed that there was highly significant error correction term. The highly significant error correction term further confirms the existence of a stable long run relationship.

The study decided that the Durbin Watson Statistics (i.e., its value was above 2) suggests that the residual series were free from the serial autocorrelation problem. Moreover, when the R-squared value of the model which is resulted 0.417 is smaller than Durbin-Watson statistics valued as 2.066 expressed that error correction model was not spurious regression. The R-squared is reported 0.417 which indicates that the variation in endogenous or explanatory variables within the estimated error correction model jointly explain over 41.7% of the total systematic change in energy efficiency in a given year. The

F-statistics with its corresponding probability strongly rejects the null hypothesis that the estimated coefficients were jointly equal to zero at 1% level of significance. This implies that the goodness of fit of model. The table of 18 is used to see the relationship between sectoral shares of GDP and energy efficiency in long run as well as short run relationship. The output employed is based on their data from 1974/75-2017/18 for 44 observations.

Table 18. Vector error correction estimate of sub sectoral shares

Cointegrating equation	CE			
LNEI(-1)	1.000			
LNAGR(-1)	0.021			
	(0.006)			
	[3.389]			
LNIND(-1)	0.005			
	(0.006)			
	[0.938]			
LNSERV(-1)	-0.059			
	(0.011)			
	[-5.443]			
C	-6.065			
Error Correction	D(LNEI)	D(LNAGR)	D(LNIND)	D(LNSERV)
CE	-0.501	2.249	16.266	8.074
	(0.115)	(5.115)	(7.733)	(3.916)
	[-4.350]	[0.439]	[2.104]	[2.062]
D(LNEI(-1))	0.094	1.862	-0.909	-2.914
	(0.132)	(5.882)	(8.893)	(4.503)
	[0.707]	[0.317]	[-0.102]	[-0.647]
D(LNAGR(-1))	0.005	-0.176	-0.927	-0.328
	(0.006)	(0.277)	(0.419)	(0.212)
	[0.799]	[-0.636]	[-2.213]	[-1.545]
D(LNIND(-1))	0.004	0.148	0.767	0.234
	(0.006)	(0.274)	(0.414)	(0.210)
	[0.642]	[0.541]	[1.851]	[1.114]
D(LNSERV(-1))	-0.016	-0.159	-0.316	-0.127
	(0.012)	(0.515)	(0.778)	(0.394)
	[-1.411]	[-0.309]	[-0.407]	[-0.322]
C	0.001	-0.008	0.018	0.017
	(0.000)	(0.020)	(0.031)	(0.015)
	[2.844]	[-0.409]	[0.598]	[1.112]
R-squared	0.363	0.024	0.208	0.157

Adj. R-squared	0.275	-0.112	0.098	0.040
Sum sq. resids	0.000	0.478	1.093	0.280
S.E. equation	0.003	0.115	0.174	0.088
F-statistic	4.105	0.174	1.888	1.340
Log likelihood	193.730	34.385	17.027	45.608
Akaike AIC	-8.940	-1.352	-0.525	-1.886
Schwarz SC	-8.691	-1.103	-0.277	-1.638
Mean dependent	0.001	-0.003	0.044	0.022
S.D. dependent	0.003	0.109	0.183	0.090
Determinant residual covariance		0.000		
Determinant resid cov		0.000		
Log likelihood		351.526		
AI criterion		-15.406		
Schwarz criterion		-14.248		

Note: Standard errors in parentheses and t-statistics in brackets
Source: Author computation (2020) using Eviews software version 8

4.6.3 The long run relationship of share of sectors

The study computed table 18 have seen the relationship between energy efficiency and three main sub sector share of GDP for 44 years time series data. The error correction coefficient, ECT (-1) measures the speed at which the energy consumption adjusts in the long run equilibrium was statistically significant at 5% level. It confirms the results discussed in table 17 and used the same scenario as long run relationship. Cointegrating equation of (35) computed below implies the relationship between energy efficiency and economic growth.

The results of the short run dynamics showed that the estimated coefficient of ECT is -0.501 which indicates that the deviation from the long term equilibrium path is corrected by nearly 50.1 percent over the following year. Negative and significant coefficient of the ECT shows that share of sub sectors to GDP and energy efficiency has long run relationship. This result is in line with the findings of (Tesfaye, 2017) and also according to the finding of (Bannerjee et al., 2003) as cited in (Kidanemarim, 2014), the highly significant error correction term further confirms the existence of a stable long-run relationship.

Thus, error correction term represented captures the long run information the variables. The equation computed as follows:

$$\mathrm{ECT}_{t-1} = 1.000\ \mathrm{LNEI}_{t-1} + 0.021\mathrm{AGR}_{t-1} + 0.005\mathrm{IND}_{t-1} - 0.059\mathrm{SERV}_{t-1} - 6.065 \quad (35)$$

Where ECT_{t-1} is error correction term in previous period, LNEI_{t-1} is logarithm of energy use in previous period which is taken as, AGR_{t-1} is the logarithm of agriculture sector in previous period, IND_{t-1} is the logarithm of industry sector in previous period, and SERV_{t-1} is the logarithm of service sector in previous period. It implies that there was long run relationship between sub sectoral shares of GDP and energy efficiency. In general, from the modelled result of ECT, explains the previous period deviation from long run equilibrium influences the short run movement in the energy efficiency.

In order to get an economically meaningful interpretation of the estimated coefficients, the study has normalized in terms of the variables in the long run part of the VECM. So, the sign is reversed and showed the negative coefficients to agriculture and industry shares. While as for service sector share to GDP it displayed positive coefficient implies there was direct relationship with energy efficiency in the long run. The results of the long run coefficients found that agriculture share of GDP have a negative and significant impact on energy efficiency. While as share of service sector to GDP have positive and statistically significant impact on energy efficiency. This shows that any increase in the share of service sector to GDP might have increase the energy efficiency.

The paper specified the log-log information for interpretation of the parameters. That means the relationship among variables was in elasticity relationship. Coefficients from the above regression model are interpreted as follows:

1) A 1% change in share of agriculture to real GDP resulted in a 0.021% decrease in energy intensity.
2) A 1% change in share of industry to real GDP resulted in a 0.005% decrease in energy intensity.
3) A 1% change in share of service sector to real GDP resulted in a 0.059% increase in energy intensity.

4.6.4 The short run relationship of share of sectors result

The result of table 19 expressed the short run dynamics, long run and causal effects of the study. C (1), C (2), C (3) C (4), C (5) and C (6) standards for the codes of adjustment coefficients, energy efficiency, share of agriculture sector, industry sector share, service sector share and constant respectively. The adjustment coefficient is negative and statistically significant at 1% level implies that the model showed long run relationship and there was causal effect in the short run respectively.

$$\Delta \mathrm{EI_t} = -0.501\ \mathrm{ECT}_{\,t-1} + 0.094\Delta\ \mathrm{LNEI}_{\,t-1} + 0.005\Delta\mathrm{AGR_{t-1}} + 0.004\Delta\mathrm{IND_{t-1}} - 0.016\Delta\mathrm{SERV_{t-1}} + 0.0016 \tag{36}$$

From the equation 36, -0.501was the coefficient of error correction term, also known as speed of adjustment which measures the speed at which energy efficiency returned to equilibrium after changes occurred in three sub sectors of real GDP. It has exhibited negative sign and statistically significant implies there was long run causal relationship. It also implies the quickness of the energy efficiency restores back to long run equilibrium. So it captures the movement in the system. Its statistical significance at 1% level confirms that there was long run relationship among sub sectoral shares to GDP and energy efficiency. It expressed that at 50.1 rates it adjusts the prior period disequilibrium of the system. Therefore, from the value of adjustment coefficient the study depicts that the energy efficiency converges to the long run equilibrium trend quickly due to high value of it.

The short run coefficients, the coefficients of agriculture and industry shares were positive and service share to GDP was negative. Their short run coefficients were statistically insignificant impact at 5% level. From this, the study concluded that there was no short run relationship among the stated series in this model. The study linked with (Bjork, 1999 and Baumol et al. 1985).

The model was specified by log-log method. Due to this, the interpretation is given by elasticities form. Before interpreting the parameters, first the paper specified the log-log information that means the relationship among variables is an elasticity relationship. So Coefficients are interpreted as:

1) Adjustment Coefficient C (1): It expressed that at what rate it adjusts the prior period disequilibrium of the system. So from our regression model it was interpreted as the preceding year deviation from long run equilibrium was corrected in the current period as an adjustment speed of 50.1%. So, correcting the previous period disequilibrium at the rate of 57.20% annually;

2) Energy efficiency coefficient C (2): inferred as on average a percentage change in energy efficiency was associated with 9.4 percentage increase in one year lagged value of itself, ceteris paribus in the short run;

3) Share of agriculture sector coefficient C (3): inferred as on average a percentage change in Share of agriculture was associated with 0.5 percentage increase in one year lagged value of energy efficiency, ceteris paribus in the short run;

4) Share of industry sector coefficient C (4): inferred as on average a percentage change in Share of industry was associated with 0.4 percentage increase in one year lagged value of energy efficiency, ceteris paribus in the short run;

5) Share of service sector coefficient C (5): inferred as on average a percentage change in Share of service was associated with 1.6 percentage decrease in one year lagged value of energy efficiency, ceteris paribus in the short run.

Table 19. Dependent variable

Variable	Coefficient	Standard error	t-statistic	Probability
C(1)	-0.501	0.115	-4.350	0.000
C(2)	0.094	0.132	0.707	0.484
C(3)	0.005	0.006	0.800	0.429
C(4)	0.004	0.006	0.642	0.525
C(5)	-0.016	0.012	-1.411	0.167
C(6)	0.001	0.000	2.844	0.007
R-squared	0.363	Mean dep var		0.001
Adj R-squared	0.275	S.D. dependent var		0.003
S.E. of regression	0.003	AI criterion		-8.940
SSR	0.000	Schwarz criterion		-8.691
Log likelihood	193.730	HQ criterion		-8.849
F-statistic	4.105	DW statistics		2.062
Prob(F-statistic)	0.005			

Source: Author computation (2020) using Eviews software version 8

The result of VECM are presented in table 19 above reported that there was highly significant error correction term. This implies that it further confirms the existence of a stable long run relationship. The study decided that the Durbin Watson Statistics (i.e., its value was above 2) suggests that the residual series were free from the serial autocorrelation problem. Moreover, when the R-squared value of the model which is resulted 0.363 is smaller than Durbin-Watson statistics valued as 2.062 expressed that error correction model was not spurious regression. The R-squared is reported 0.363 which indicating that the variation in explanatory variables within the estimated error correction model jointly explain over 36.3% of the total systematic change in energy efficiency in a given year. The F-statistics with its corresponding probability strongly rejects the null hypothesis that the estimated coefficients were jointly equal to zero at 1% level of significance. This implies that the goodness of fit of model.

Moreover, the study applied Wald test statistics of join significance test (F-test). In table 20, the value implies that the paper expected to reject the null hypothesis and accept the alternative hypothesis of not equally zero. Therefore, the RGDP variables energy efficiency variable at one period lag was jointly significant to influence the energy efficiency in the short run analysis. So, it indicates that the variables are jointly affects energy efficiency.

Table 20. Wald Test

Test Statistic	Value	df	Probability
F-statistic	9.043	(3, 38)	0.000
Chi-square	27.129	3	0.000
Null Hypothesis: C(1)=C(2)=C(3)=0			
Null Hypothesis Summary:			

Source: Author computation (2020) using Eviews software version 8

According to joint significance test of shares of sectors to economic growth as tabled in 21 below, implies there was influence of three major sectors of GDP on overall energy efficiency. Based on the result of the probability value, the p-value was less than 5% significance level. The study inferred that all variables are jointly affects energy efficiency. This result is in line with the findings of (Bjork, 1999 and Baumol et al. 1985).

Table 21. Wald Test of sectoral shares

Test Statistic	Value	df	Probability
F-statistic	4.105	(5, 36)	0.005
Chi-square	20.524	5	0.001

Null Hypothesis: C(1)=C(2)=C(3)=C(4)=C(5)=0

Null Hypothesis Summary:

Source: Author computation (2020) using Eviews software version 8

From the table 22 below, the speed of adjustment is calculated by multiplying the coefficient of variable in the cointegrating equation by the coefficient of the error correction term ECT where the first difference of the variable was the dependent variable. The study inferred the chosen dependent variable had negative sign, have magnitude of -0.592 which was less than the ideal speed of adjustment -0.05 and was significant at 5 percentage level. So from this the researcher concluded that even if the model experienced shock in current time period then it will converge back to the long run equilibrium covering 59.2% in last period.

Table 22. The speed of adjustment result

Variable	Coefficient in ECT	Coefficient of ECT where variable is dependent variable	Speed of adjustment
LNEI	1.000	-0.592	-0.592
LRGDP	-0.021	1.178	-0.024
Sectoral shares of RGDP with energy efficiency relationship			
LNEI	1.000	-0.501	-0.501
LNAGR	0.021	2.249	0.048
LNIND	0.005	16.266	0.086
LNSERV	-0.059	8.074	-0.474

Source: Author computation (2020) using Eviews software version 8

4.7 Residual diagnostic and stability diagnostic tests

4.7.1 Residual diagnostic tests

The appendix from II-IV presents the results of the diagnostic tests. The results of the diagnostic tests shows that the selected Johansen Cointegration model is normally distribution, not suffering from serial correlation and not has heteroscedasticity. Here their result discussed separately below.

Breusch Godfrey test

The result from the appendix-II showed that the probability value of observed R-squared was 54.6% which exceeds 5% level of significance. As per the guide line the study failed to reject the stated null hypothesis rather accepted. In another sense the researcher rejected the alternative hypothesis. Therefore, the test result decided that there was no autocorrelation means that the residuals were not serially correlated. So it was desirable good to analysed models in both short and long run.

Breusch Pagan Godfrey test

The result of Breusch Pagan Godfrey test in appendix-III hypothesized that the variance of the residual was homoscedastic as null hypothesis and the variance of the residuals were hetroscedastic as the alternative hypothesis. When the observed values of R-squared probability value is resulted 8.04%, which was more than 5% normal level of significance. Then the null hypothesis not rejected meaning that accepted the null and rejected the alternative hypothesis. From this hypothesis the study decided that there is no heteroscedasticity.

Jarque-Bera test

As per the result of appendix-IV, from the histogram of normality distribution test, the Jarque-Bera statistics and its corresponding probability had the value of 9.69% which was greater than 5% significance level. According to the rule of thumb, we failed to reject the null hypothesis rather we accept it and reject the alternative hypothesis. So the result confirms that residuals were normally distributed.

4.7.2 Stability diagnostic tests

The appendix V and VI showed that the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable. Interpreting the two results distinctly looks like as follows:

CUSUM Test

Is based on the cumulative sum of recursive residuals and guaranteed that the parameters of the model were stable over time. From this stability check of figure in appendix-V, the study assumed that the energy efficiency was stable or not on the long run as well as short run, using stability diagnostic check of recursive estimate. The figure explains that the blue line was between the two dashed red lines; our dependent variable which was energy efficiency was stable. So, from verification of the figure, the researcher concluded that the coefficients of the model were stable over observations or the model was dynamically stable over time.

CUSUM of Squares test

The CUSUM of Squares test applied to check that the variance of residuals was stable over the time. From the figure in appendix-VI inferred that as long as blue line was remains within boundaries of dashed red line, the study decided that the model was dynamically stable over time.

4.8 Granger causality analysis

Table 23.Pairwise Granger causality test

Sr. No	Direction of causality (Null Hypothesis	Lag	P-value	Decision	Outcome
1	LNRGDP does not Granger Cause LNEI	Lag 1	0.000	Reject null hypothesis	LNRGDP does Granger cause LNEI
2	LNEU does not Granger Cause LNRGDP	Lag 1	0.952	Do not reject null hypothesis	LNEU does not Granger cause LNRGDP

Source: Author computation (2020) using Eviews software version 8

The results of short run pairwise granger causality test in table 23 revealed that to reject the null hypothesis and accept the alternative hypothesis due to their corresponding probability value (i.e., 0.000) was less than 5% significance level. There exists a unidirectional causality running from economic growth to energy efficiency (LNRGDP does Granger Cause LNEI). From this result, the causality runs from economic growth to energy efficiency. This finding in lines with (Ambapour and Massamba, 2005).However, their finding contradicts that of (Belke et al, 2011).

The paper suggests that conservation hypothesis of one way positive causality running from economic growth to energy efficiency. The implication of conservation hypothesis shows that energy management strategies considered to decrease energy consumption and waste may not reduce real output. This indicates an increase in economic growth increases the energy efficiency in long run relationship. This result is in line with the findings of (Tesfaye, 2017) and (Mehari, 2011) support this conservation hypothesis.

With regards, the results are consistent with those obtained in an earlier study by (Jamil and Ahmad, 2010). This also supports conservation hypothesis while focusing mainly on energy efficiency rather than all forms of energy. The results are also in agreement with the findings of (Huang et al., 2008) for poor countries. The economic growth encourages energy efficiency in developing countries. Therefore, one way causality which runs from economic growth to energy efficiency implies energy upkeep.

Table 24.Pairwise Granger causality test of sub sectors

Sr. No	Direction of causality (Null Hypothesis)	Lag	P-value	Decision	Outcome
1	LNAGR does not Granger Cause LNEI	Lag 1	0.101	Reject null hypothesis	LNAGR does not Granger Cause LNEI
2	LNEI does not Granger Cause LNAGR	Lag 1	0.950	Do not reject null hypothesis	LNEI does not Granger Cause LNAGR
3	LNIND does not Granger Cause LNEI	Lag 1	0.549	Reject null hypothesis	LNIND does not Granger Cause LNEI
4	LNEI does not Granger Cause LNIND	Lag 1	0.022	Do not reject null hypothesis	LNEI does Granger Cause LNIND
5	LNSERV does not Granger Cause LNEI	Lag 1	0.030	Reject null hypothesis	LNSERV does Granger Cause LNEI
6	LNEI does not Granger Cause LNSERV	Lag 1	0.008	Do not reject null hypothesis	LNEI does Granger Cause LNSERV
7	LNIND does not Granger Cause LNAGR	Lag 1	0.568	Reject null hypothesis	LNIND does not Granger Cause LNAGR
8	LNAGR does not Granger Cause LNIND	Lag 1	0.021	Do not reject null hypothesis	LNAGR does Granger Cause LNIND
9	LNSERV does not Granger Cause LNAGR	Lag 1	0.849	Reject null hypothesis	LNSERV does not Granger LNAGR Cause LNAGR
10	LNAGR does not Granger Cause LNSERV	Lag 1	0.064	Do not reject null hypothesis	LNAGR does not Granger Cause LNSERV
11	LNSERV does not Granger Cause LNIND	Lag 1	0.321	Do not reject null hypothesis	LNSERV does not Granger Cause LNIND
12	LNIND does not Granger Cause LNSERV	Lag 1	0.869	Do not reject null hypothesis	LNIND does not Granger Cause LNSERV

Source: Author computation (2020) using Eviews software version 8

To see the sectoral share of GDP and energy efficiency relationship, the structural changes could be a strait forward through which an economy may also affect energy consumption and energy efficiency. When a country develops it generally becomes more industrial and service oriented. Service sector is less energy intensive as compared to industrial sector. Therefore, energy efficiency is expected to decline due to transformation of economy from agriculture to industrial sector. Another hand the energy efficiency is expected to improve due to transformation of economy from industrial sector into services sector. It is widely believed that a large services sector reduces energy intensity in the long run (Bjork, 1999) and (Baumol et al., 1985).

The tabulated value in table 24 from Eviews software result displayed the mixture of independence, unidirectional and bidirectional causality relationship of share of sub sectors to GDP and energy efficiency. For the share of agriculture sector to GDP has no causality at 5% significance level, share of industry sector to GDP has one directional causality and share of service sector to GDP has bidirectional causality.

Share of agriculture sector were insignificant (LNAGR does not Granger Cause LNEI and vice versa) which means that there is no short run causality exists in the system by referring their corresponding probability at 5% significance level. Based on the study the reason to why the independence causality between share in agriculture and energy efficiency may have substantial dependence on old-fashioned agriculture (i.e., relies greatly on human and animal power rather than machinery and the little practice of agricultural mechanization) which were less energy intensive in Ethiopia during the study period. Agriculture sector in Ethiopia is less energy efficient sector as compare to industry and service sectors.

The results in the short run causality test revealed that there exists a unidirectional causality running from energy efficiency to industry share (LNEI does Granger Cause LNIND). Therefore, energy efficiency was one of the crucial issues for economic growth mainly in industry sector of real GDP. Adopting policies to the use of energy in industrial sectors to achieve the purpose of energy efficiency sensibly affect economic growth. This finding was consistent with the studies (Soytas and Sari, 2006).

The empirical result of the study about share of service sector and energy efficiency showed that there was bidirectional causality between the variables. This implies that the contribution of the service sector to GDP has interdependence relationship with energy efficiency (LNSERV does Granger Cause LNEI and vice versa) which means creating policy to both energy sector and energy has great impact to each other. This finding was consistent with the studies (Mustapa et al, 2011). On other hand, the statistically significant output of shares of services to GDP is expected to increase energy efficiency and these effects are statistically significant at 1% levels of significance respectively. So, energy efficiency is expected to change significantly in response to changes in the GDP share of service. The result supports (Stern, 2004) who has noted that the energy consumption of service sector has increased in Europe.

Among four theory of hypothesis, the study supports Conservation and feedback hypothesis. Among from the main economic sectors, industry and service are one of the back bones of the economic growth, so this implies an increase in economic growth increases the consumption of energy. It may be due to high share of economic sectors in economic growth and economic growth is vital for the energy efficiency in Ethiopia. This result is not in line with (Tesfaye, 2015) who found that there is unidirectional causality running from energy consumption to economic growth.

With related to above discussion on the relationship of major economic sectors to economic growth and energy efficiency, also important to investigate how energy efficiency is expected to change when structure of the economy changes in long run.

VECM needs building impulse response and variance decomposition functions with reason that interpreting all coefficients is difficult some easiest way is to undertake by producing impulse response function and variance decomposition.

4.9 Impulse response function and variance decomposition results

In this section, the study analysed the impulse response function and variance decomposion in relationship between energy efficiency and economic growth in Ethiopia using annual data from 1974/75 to 2017/18 resulting in 44 observations.

4.9.1 Impulse response

In the appendix VIII, the results for 5 period’s prediction are obtained. The blue line was the impulse response function while two red lines above and below are simply implying 95% confidence intervals. From this inference, the impulse responses function always within the 95% confidence interval.

The impulse response function diagram shows one standard deviation shock on energy efficiency, then how the economic growth are reacting to energy efficiency 5 years into future. The interpretation is given as follows:

From the result, response on energy efficiency to energy efficiency itself implies that if we give one standard deviation positive shock to energy efficiency, the energy efficiency will initially declines up to fourth period. Beyond year 4 it will decreases gradually and exhibits steady until period 5.Then it declines very slowly even though they are still in negative zones. So shocks to LNEI will have negative impact on LNEI itself.
As shown from the diagram in appendix-VIII, if one standard deviation positive shock is given to energy efficiency, the economic growth reaction gradually going up till third period. After third period the response will rise slowly until period 4 and still positive. Then it becomes stay at a stable level at fifth period. So, into future until five year economic growth will be positive means that economic growth and energy efficiency have positive association.

Generally, this suggests that positive shock energy efficiency has significant influence at increasing and the significance influence has relatively long sustained effectiveness. An energy efficiency change has the short run encouraging result on economic growth, and this effect tends to be moderate in the long term.

4.9.2 Variance decomposition

In the econometric model it gives the proportion of movements in the dependent variables that are due to their own shocks versus shocks to the other variables. Its forecast error provides the percentage of unexpected variation in each variable that is produced by shocks from other variable. So it indicates the relative impact that a variable has on another. To see the result we have selected forecast period of 5 years due to the data is annual collected. So the figure in the box was about percentage forecast error variance in LNEI and LNRGDP which is assumed as in short run forecast error for 1-2 years and 3-5 years assumed for long run forecast error variance.

Table 25. Variance decomposition result

Period	S.E.	LNEI	LNRGDP
1	0.002	100.000	0.000
2	0.003	85.196	14.804
3	0.003	63.736	36.264
4	0.004	49.534	50.466
5	0.004	40.940	59.060
Variance decomposition of LNRGDP			
Period	S.E.	LNEI	LNRGDP
1	0.057	1.420	98.580
2	0.093	0.759	99.241
3	0.123	0.487	99.513
4	0.148	0.361	99.639
5	0.170	0.297	99.703
Cholesky Ordering: LNEI LNRGDP			

Source: Author computation (2020) using Eviews software version 8

According to table 25, the interpretation given as in EI predicted variance, contribution of EI change begins to gradually decline from the first period 100 %, reaches 40.94% in the fifth period. In short run in year one a 100% of forecast error variance in energy efficiency is explained by itself. Economic growth have do not have strong influence in energy efficiency. On that case economic growth have strong exogenous impact on the energy efficiency. Exogenous means that they don't influence the regressand at all in short run. Meanwhile in year two logarithm of economic growth have influences of weak on the energy efficiency which is below 15%.Those economic growth exhibits strong exogeneity that is they have weak influence in predicting in the future. In the long run from year three up to year five in our forecast error variance explained by energy efficiency itself results gradually falls down and ends 40.94%.So, energy efficiency showing strong influence from the short run to long run period into the future. While as logarithm of the remaining endogenous variable influences on energy efficiency are not significant means weak. In economic growth was strongly predicts itself from first year forecast period up to fifth year while energy efficiency in the model was not significant. Lastly when we run from first period into future the energy efficiency is very weak predictor of economic growth as the year we goes to long run likewise as we move to future a forecast error variance on economic growth itself is increasing.

In summary, it can be seen that, in the short term, the energy efficiency have great influence on itself. In the long run, the influence is demolishing off. As presented in the model, the growth of energy efficiency is related to not only the current variables, but also the variable in the lag period. The finding is consistent with our previous result. Therefore, economic growth increasing energy efficiency in the long runs in Ethiopia.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

This chapter deals with summaries of the whole bodies of the paper through conclusion and gives recommendation for the nation based on analysed time series data.

5.1 Conclusion

The key objective of this study was to examine the relationship between energy efficiency and economic growth in Ethiopia. Moreover, the study examined the relationship between sectoral GDP share and energy efficiency. To this end this study has used annual time series data of Ethiopia over the time period ranging from 1974/75 to 2017/18, 44 years observation. Multivariate time series was applied. The variables controlled were energy efficiency, real GDP and real GDP share of major economic sub-sectors including agriculture, industry and service sectors. This paper used energy intensity as a proxy for energy efficiency.

The theoretical model used in this study was Keynesian theory of economic growth support the active participation of government in comforting economic growth which gives basic framework to analyse the relationship between energy efficiency and economic growth. The methodology used was Johansen and Granger causality test for short run and long run causality and models are verified with the help of diagnostic and stability tests.

The empirical analysis used Johansen multivariate cointegration model, vector error correction model (VECM) for long run as well as short run, granger causality analyses were conducted so as to give more efficient results, towards achieving the objectives of the paper. Moreover, Augmented Dickey Fuller tests applied to test the unit root, cointegration tests used to report long run relationship, residual diagnostic tests, stability diagnostic tests, and impulse response function and variance decomposition were checked.

For the purpose of analysis, the paper made use of both descriptive and econometric analysis. In descriptive part of the study, the study examined the variables without transformation. The summery statistics showed that major economic sectors have high contribution to energy efficiency in Ethiopia. The empirical model showed existence of a stable long run relationship between energy efficiency and economic growth.

Mainly, the estimation of model displayed that the long run relationship between real GDP and energy efficiency was positive and significant. Whereas in sectoral real GDP share results magnifies that share of service was positive and significant in affecting energy efficiency in the long run. However, agriculture shares have negative and statistically significant effect on energy efficiency in the long run. Johansen cointegration test showed that long run relationship exists between energy efficiency and economic growth. For the short run result, the study found that real GDP has positive and statistically insignificant coefficient. While the share of agriculture and industry have positive statistically insignificant coefficient but the share of service sector has negative and statistically insignificant coefficient. Based on the Wald test the study inferred that all variables are jointly significant to affects energy efficiency. The results from vector error correction method showed that energy efficiency was increasing with economic growth. As a result, energy consumption has grown more rapidly than GDP, which is supported by (Huang et al., 2008).

According to Granger causality analysis, the causality goes from real GDP to energy efficiency which has one-directional causality between the variables. This study supports the conservation hypothesis which means that there is unidirectional causality running from economic growth to energy efficiency for Ethiopia. This indicates that economic growth was a vital for energy efficiency in the long run. In the light of this discussion, it is reflected that economic growth as an engine of energy efficiency and energy efficiency can be affected by changes in economic growth. The increase in energy efficiency may also be the result of structural changes. The study found that the causality runs from energy efficiency to share of industry implying energy efficiency is dynamic to boost industrial growth and pairwise causality between service share and energy efficiency. This is expected to increase energy efficiency and service sector since the shares of service to real GDP increase. These results have an implication of share of service are driver of economic growth in developing countries (i.e., Ethiopia).

The result of the short run dynamics, the speed of adjustment coefficient have negative and statistically significant indicates that there was long run relationship in Ethiopia and causality exists. The estimated coefficient of ECT is -0.592 which indicates that the deviation from the long term equilibrium path is corrected by 59.2% over the following year. So, correcting the previous period disequilibrium at the rate of 59.20% annually. The adjustment value told that it takes few periods for energy efficiency to turn back to its equilibrium once it drifts away from its long run equilibrium value.

The outcome of Impulse response indicates that if one standard deviation positive shock given up to energy efficiency there is long run and short run impact on economic growth. And both impulse response and variance decompositions indicate that the economic growth has a long run impact on energy efficiency. This finding confirms the above finding which is the economic growth has no short run influence on energy efficiency. The variance decomposition analysis measured the strength of this causal relationship, tells that the economic growth has high contributing factor to energy efficiency.

5.2 Recommendation

In the light of above findings, the existing study advocates the following recommendations.

The unidirectional causality from economic growth to energy efficiency has implication to the government to improve the economic growth by implementing policies for economic progress. These policy measures could involve improved macroeconomic conditions (i.e. create stable economic climate of low inflation and positive economic growth, creating free market supply side policies (i.e. lower taxes, less regulation to stimulate private sector investment, privatization), increase spending on public good, creating export oriented growth and diversification away from agriculture). Policy makers expected to develop energy conserving policies of economic growth for future development without affecting current economic growth.

As per the finding of the study, the one directional causality from the energy efficiency to industry share to economic growth. Since the current period in the nation industry sector is more energy intensive sector. So, the government to use energy efficient managing policy for this sector and endorse industry sector to use more energy efficient technology system to improve the economic growth by allocating and spending high budget in this sector and create favourable environment for employers to participate in industrial sector to boost growth.

Ethiopia needs economical energy to support its evolving industry and infrastructure in the long run. Any policy regarding energy efficiency considered to ensure that it affects economic growth in industry sector. Also, the government needs to promote public and private enterprises achieve energy management and reduction of energy consumption and also to carry out technological improvement and advance the production practice to reduce their energy efficiency.

Based on the finding of study, the interdependence relationship between the contribution of the service sector to GDP and energy efficiency showed creating conducive policy to both service sector and energy efficiency has great progressive influence to each other. Enhancing the performance of service require further consideration by policy makers and government. The policy makers and government to give attention to the performance of different service sectors would help in developing, monitoring and evaluating suitable policies for the service sector.

Government and nongovernment organizations stimulate service sector through adopting innovative policies to the growth of service, grasping the benefits from ICT in services and creating conducive environment to youths to adopt technology. The effective policy design is expected regarding energy efficiency to ensure that it affects economic growth in service sector. Hence, service sector is more energy efficient and able to contribute effectively to national development.

Finally, there is important to conduct a more detailed study to make prediction for future energy requirements in order to be better knowledgeable for forming reliable strategies for the energy sector. It also recommends areas for more research so that future researchers can select these areas and study further.

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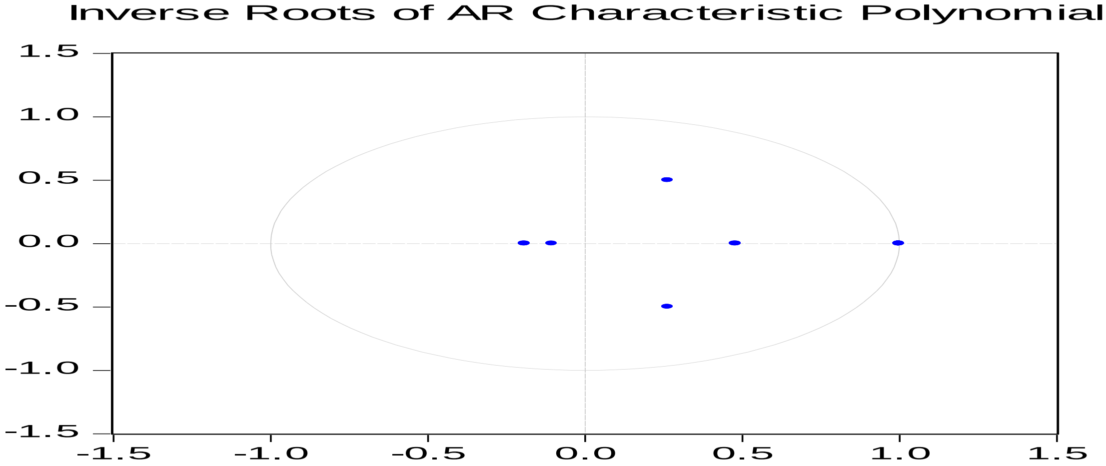
APPENDIXES

Appendix-I: Figure of Stable system test



Source: Author computation (2020) using Eviews software version 8

Residual diagnostics test of VECM (From appendix II-IV)

Appendix-II: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.325	Prob. F(1,37)	0.572
Obs*R-squared	0.365	Prob. Chi-Square(1)	0.546

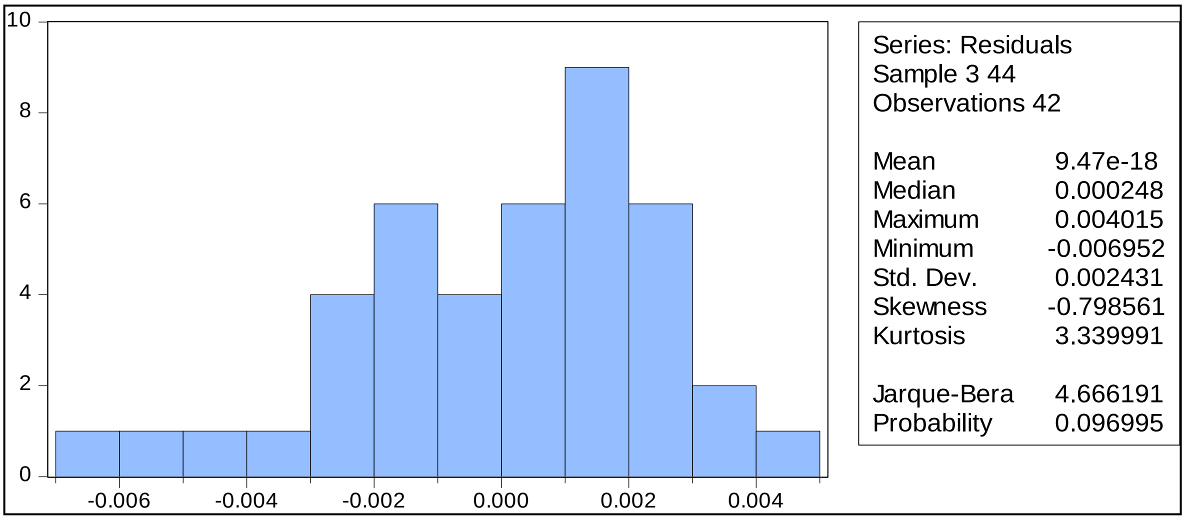
Source: Author computation (2020) using Eviews software version 8

Appendix-III: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	2.286469	Prob. F(4,37)	0.0784
Obs*R-squared	8.324183	Prob. Chi-Square(4)	0.0804
Scaled explained SS	17.47193	Prob. Chi-Square(4)	0.0016

Source: Author computation (2020) using Eviews software version 8

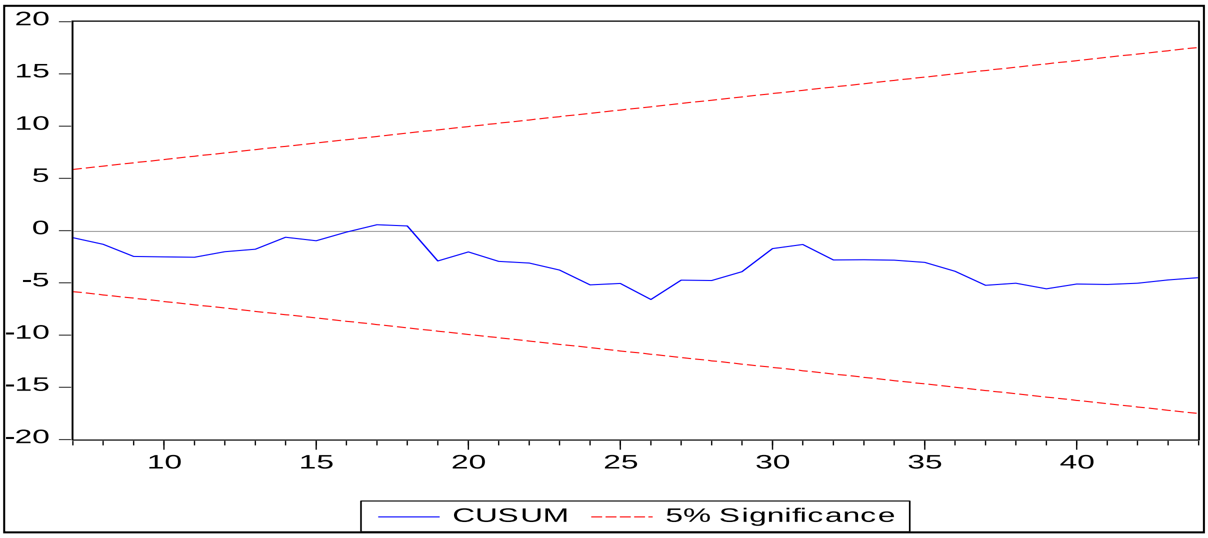
Appendix-IV: Residual normality test of VECM



Source: Author computation (2020) using Eviews software version 8

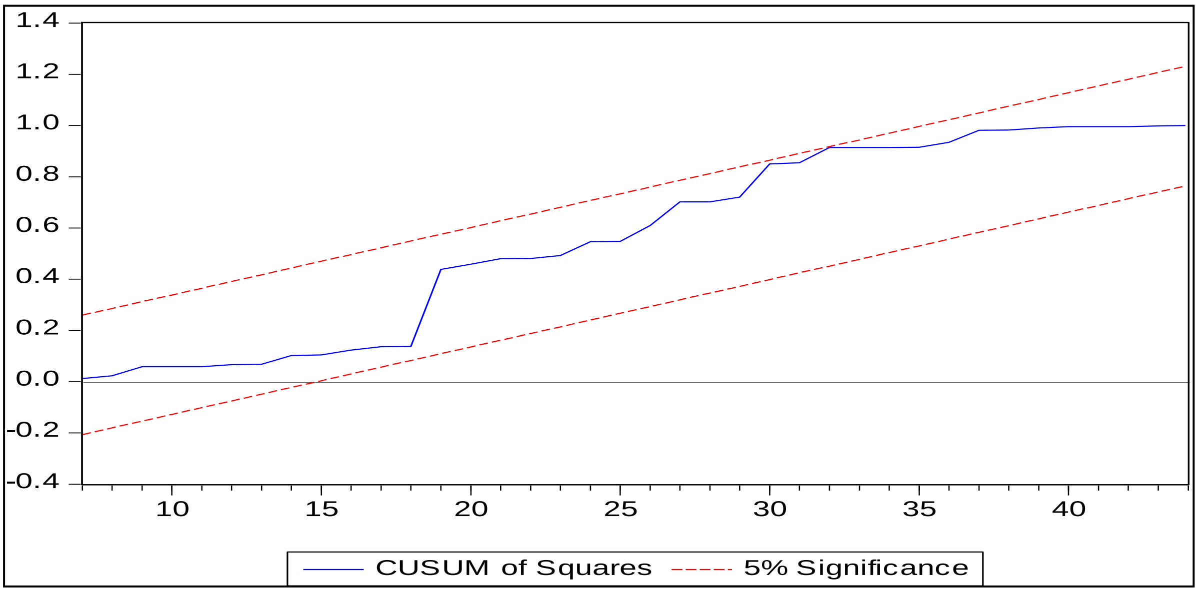
Stability diagnostics test of VECM (appendix V and VI)

Appendix-V: Figure of stability diagnostics, recursive estimate (OLS only)



Source: Author computation (2020) using Eviews software version 8

Appendix-VI: Figure of stability diagnostics, recursive estimate (OLS only)



Source: Author computation (2020) using Eviews software version 8

Appendix-VII: Granger causality test

Pairwise Granger Causality Tests

Date: 05/30/20 Time: 10:25
Sample: 1 44
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LNRGDP does not Granger Cause LNEI	43	22.5045	3.E-05
LNEI does not Granger Cause LNRGDP		0.00370	0.9518

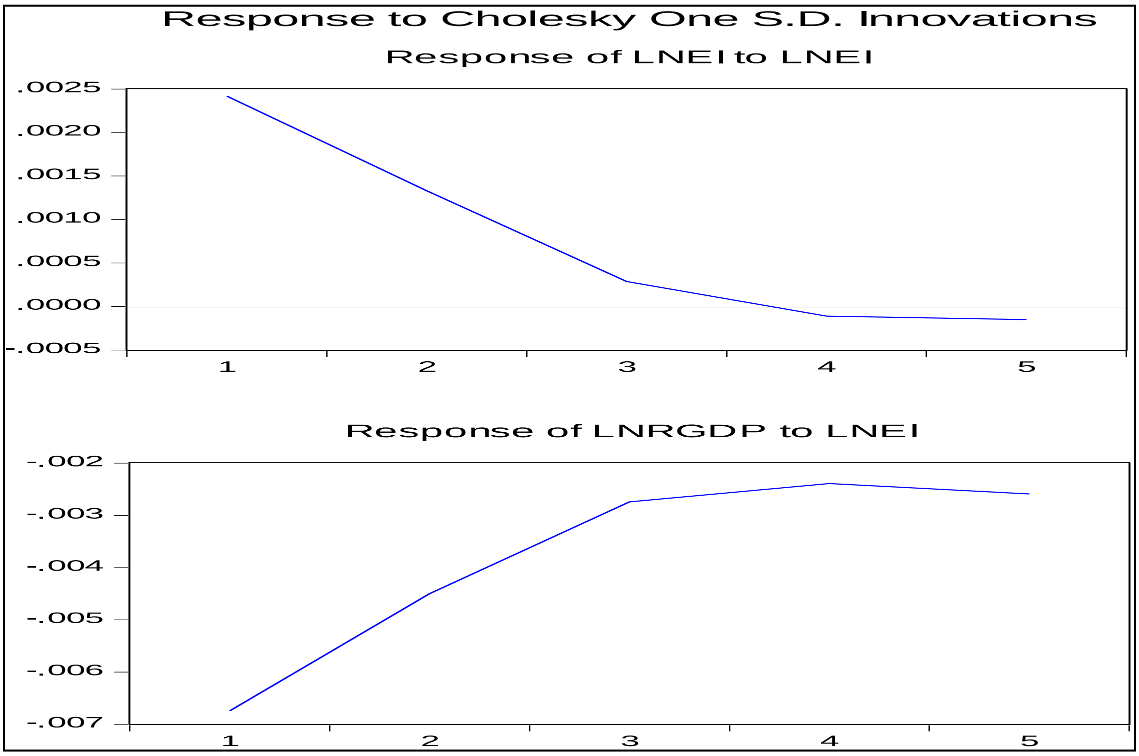
Source: Author computation (2020) using Eviews software version 8

Pairwise Granger Causality Tests
Date: 05/30/20 Time: 10:28
Sample: 1 44
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LNAGR does not Granger Cause LNEI	43	2.81805	0.1010
LNEI does not Granger Cause LNAGR		0.00395	0.9502
LNIND does not Granger Cause LNEI	43	0.36448	0.5494
LNEI does not Granger Cause LNIND		5.65310	0.0223
LNSERV does not Granger Cause LNEI	43	5.06142	0.0300
LNEI does not Granger Cause LNSERV		7.83637	0.0078
LNIND does not Granger Cause LNAGR	43	0.33210	0.5677
LNAGR does not Granger Cause LNIND		5.80060	0.0207
LNSERV does not Granger Cause LNAGR	43	0.03694	0.8486
LNAGR does not Granger Cause LNSERV		3.63648	0.0637
LNSERV does not Granger Cause LNIND	43	1.00831	0.3213
LNIND does not Granger Cause LNSERV		0.02753	0.8691

Source: Author computation (2020) using Eviews software version 8

Appendix-VIII: Impulse response function



Source: Author computation (2020) using Eviews software version 8

Appendix-IX: Data used for the study

E.F.Y	Year	Agriculture sector	Industry sector	Service sector	Energy intensity	Real Gross Domestic Product
1967	1974/75	73,783.916	8,712.993	28,753.887	473.782	102,406.578
1968	1975/76	74,379.664	7,970.865	29,214.975	471.952	103,100.215
1969	1976/77	74,672.147	8,211.522	29,171.196	472.095	104,154.650
1970	1977/78	74,930.780	7,949.936	27,503.591	472.052	103,566.842
1971	1978/79	75,599.495	8,920.633	30,624.607	473.664	108,532.637
1972	1979/80	79,089.087	9,829.184	32,016.068	474.565	113,795.189
1973	1980/81	78,155.216	10,099.137	33,293.068	475.120	115,224.112
1974	1981/82	75,323.197	11,050.865	34,677.371	475.871	115,110.576
1975	1982/83	85,564.475	11,759.042	36,170.828	474.608	126,706.987
1976	1983/84	74,832.087	12,534.551	36,046.511	474.973	118,729.135
1977	1984/85	59,202.959	13,502.833	36,154.843	474.660	107,221.237
1978	1985/86	68,689.610	14,169.165	36,860.656	474.514	117,837.325
1979	1986/87	81,575.008	15,151.738	42,372.243	475.151	134,380.237
1980	1987/88	79,319.385	14,250.149	44,096.261	477.806	134,308.813
1981	1988/89	80,135.653	13,112.222	42,746.206	477.464	134,767.014
1982	1989/90	84,390.292	12,279.627	45,137.783	477.922	140,247.624
1983	1990/91	88,751.608	10,866.272	37,142.479	478.903	135,164.664
1984	1991/92	86,323.558	9,930.577	34,696.101	478.128	130,176.978
1985	1992/93	91,559.054	12,624.537	41,870.813	472.506	145,798.546
1986	1993/94	88,216.186	13,242.613	45,062.376	474.980	148,275.621
1987	1994/95	91,206.073	14,287.340	48,483.417	476.557	156,247.196
1988	1995/96	104,590.898	15,080.874	52,189.528	478.029	172,839.412
1989	1996/97	108,362.469	15,743.165	56,673.424	478.905	180,910.931
1990	1997/98	96,286.776	16,325.789	60,763.888	477.898	178,301.487
1991	998/99	99,948.694	17,466.119	64,646.448	478.278	188,990.358

1992	1999/00	102,145.293	17,718.235	69,406.054	477.671	199,102.153
1993	2000/01	111,963.402	18,634.223	72,856.886	481.493	215,630.479
1994	2001/02	109,865.629	20,158.617	75,294.160	482.405	218,896.669
1995	2002/03	98,336.026	21,375.326	79,436.106	482.689	214,166.132
1996	2003/04	114,962.645	23,676.976	84,150.457	484.045	243,233.535
1997	2004/05	130,528.590	25,879.018	94,600.833	484.630	271,980.924
1998	2005/06	144,753.809	28,430.837	107,605.640	482.906	301,449.050
1999	2006/07	158,429.531	30,645.292	124,116.108	483.940	335,983.099
2000	2007/08	170,332.611	33,915.217	144,068.581	485.597	372,230.818
2001	2008/09	181,186.061	37,250.518	163,947.726	486.761	404,996.387
2002	2009/10	195,002.154	41,988.292	185,103.923	486.732	455,825.636
2003	2010/11	212,469.712	49,780.498	216,616.659	486.690	515,078.541
2004	2011/12	222,927.682	59,556.305	237,419.455	489.176	559,621.564
2005	2012/13	238,752.109	73,910.992	258,830.200	490.194	618,842.229
2006	2013/14	251,756.289	86,507.150	292,369.300	492.145	682,358.509
2007	2014/15	267,812.776	103,675.526	325,042.518	493.130	753,229.736
2008	2015/16	544,082.120	343,924.000	575,877.100	494.115	808,488.889
2009	2016/17	580,412.300	413,848.700	619,258.900	495.100	890,121.500
2010	2017/18	600,878.100	464,433.800	673,943.000	496.085	958,643.750