ENERGY CONSUMPTION AND ECONOMIC GROWTH IN ETHIOPIA

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Abstract

The study investigated the empirical relationship between economic growth and energy consumption in Ethiopia over the period 1974/75–2014/15, applying a multivariate framework that incorporates export, saving, labor, and capital as sporadic variables. In analyzing the long run and short run relationship between energy consumption and economic growth the study applied Johansen's co-integration test, VAR, VECM, and Granger causality test. Moreover, Variance decomposition and Generalised impulse response analysis were employed. Empirical findings shows there is a unidirectional causality running from economic growth to energy consumption in the long run where as in the short run, there is no causality running from economic growth to energy consumption. The study found that economic growth causes electricity consumption but not vice verse in the long run. The study investigate that there is a unidirectional running from economic growth energy importin the long run.The short run speed of adjustment coefficient of -0.7394 indicates that 73.94 % of the short run adjustment made within a year. The results of Impulse response also indicate the economic growth has a significant impact on energy consumption. The strength of causality relationship, as measured by the variance decomposition analysis, reveals that, energy has high contributing factor to output growth and certainly the most important one when compared to capital and labor. Finally, the study recommend, policy makers should consider expanding their energy-mix options, and adjust the industrial structure, development high value-added industries, promote energy conservation structures, and improve energy efficiency, enhance the level of efficiency in the energy sectorfor Ethiopia.

Keywords:*Economic growth, Granger-Causality, Energy consumption, Impulse response, Variance decomposition analysis, Ethiopia.*

1. Introduction

Looking at developed countries, as a basic factor of production, energy is the same as the labor and capital, making an obvious influence on economic growth. Rashe and Tatom (1977), who was advanced to introduce the energy into consumption of neoclassical production function, attempted to look for the basic law of the actual process between energy use and economic growth and quantitatively explained the relationship between energy and economic development. With the impact of energy on economic development gradually expanding, the method of study from new classical economists was to exam effects of relative prices on world energy on

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potential GNP, income distribution, capital formation and economic welfare, and the like on the basis of a priori theory.

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. In 2011, over 96% of Ethiopia's electricity was from hydropower.[1] The country began a large program to expand electricity supply in the 2010s from 2,000 MW to 10,000 MW. This was to be done mainly with renewable sources. Wind and geothermal were included to offset seasonal differences in water levels. Ethiopia plans to export electricity to neighboring countries but transmission lines will need to be upgraded and expanded (Ethio Resource Group, 2012).Ethiopia has small reserves of oil and natural gas. As of January 2003, the country's crude oil and natural gas reserves were placed at 428,000 barrels (68,000 m^3) and 880 billion cubic feet (2.5×10^{10} m^3), respectively. Ethiopia has no crude oil refining capacity and must import all refined petroleum products. Imports of refined petroleum products totaled 24,910 barrels per day (3,960 m^3/d), with consumption was an estimated 23,000 barrels per day (3,700 m^3/d) in 2001(Government of Ethiopia, 2011).

Investments in renewable energy[2] resources and hydropower in particular have been key drivers of economic growth in recent years. Ethiopia's existing generation capacity totals 2,145 MWs, up more than 200% since 2008. Projections suggest the total demand for power will grow by 30% per year. In 2012/13, hydropower comprised 90% of the electricity supplied in Ethiopia (Power Africa, 2014).

Despite strong overall growth, Ethiopia remains one of the poorest countries in Africa. To address the remaining challenges, the government has created ambitious economic development targets. The country's five-year (2010 -2015) economic strategy, the growth and Transformation Plan (GTP), seeks to achieve the Millennium Developments Goals and middle income status by 2025.In the energy sector, the Ethiopian government's main stated objective is to use a carbon neutral growth pathway to improve the living conditions of its population.The GTP includes an aggressive energy policy framework designed to expand installed electricity capacity from approximately 2,000 MWs to 8,000 MWs, build 132,000 Kms of new distribution lines, and increase the number of customers from two million to four million by 2015. Renewable energy capacity, primarily hydro, and energy efficiency will play major roles in this growth by 2015 (World Economic Outlook, 2016).Although Ethiopia has crafted ambitious energy targets, access challenges remain. Over half of the population is located geographically close to the electricity grid, but actual interconnection rates are just 25% per capita domestic electricity consumption is less than 100KWh per year. Traditionally, biomass for household cooking also accounts for 89% of total domestic energy consumption (EEA, 2015).

[2]Energy is the material basis of human progress and social development, economic growth requires energy for power. On a certain level of technological development, the greater economies of scale, the more energy demand. Ethiopia's rapid economic growth has led to the continued growth in demand for energy. Since the total amount of energy resources is limited, following the strategy of sustainable development, energy conservation and improving the efficiency of energy use has become an inherent requirement to achieve sustained economic development.

A new Energy Law, Proclamation 810/2013, came into force in January 2014. The law broadly expands upon the previous policies governing the sector, including a specific focus on independent Power Purchase Agreements (PPAs), fully off grid systems, and on grid energy efficiency policies as well as standards. This new legal framework further reinforces the government's stated commitment to sustainable development practices as outlined in its Climate Resilient Green Economy Strategy and the ambitious renewable energy goals of the GTP (European Commission, 2015).

Although Ethiopia endowed by large modern energy resources, availability of modern energy resources per se is not sufficient for the social and economic problems facing the country. Ethiopia has one of the lowest rates of access to modern energy services and its energy supply is primarily based on biomass. With a share of 93% of Ethiopia's energy supply, waste and biomass are the country's primary energy sources, followed by oil (5.7%) and hydropower (1.3%) as per IEA 2011 report. Hence, the supply of modern energy is supposed to be an essential requirement for economic and social development. The power investment that is presently going on in Ethiopia is part of the process of the recognition that the quality and quantity of modern power supply can play a crucial role in the country's social and economic development. This investment process is implicitly based on the assumption that investment in modern energy sector more efficient can be the engine of the economic growth (Energy and Resources Institute, 2014).

Although energy use is a reflection of climatic, geographic and economic factors (such as the relative prices of energy), in developing economies growth in energy use is closely related to growth in the modern sectors (industry, motorized transport and urban areas). "There is a strong connection between the energy sector and a national economy. In other words, energy demand, supply and pricing have significant impact on socio-economic development and the overall quality of life of the people. On the other hand, the nature of economic structure and the change in that structure, the prevailing macro-economic conditions are key factors of energy demand and supply" (EEA, 2015).

Based on the data Word development data for the periods 1974/75 to 2014/15 shows that RGDP per capita have strong correlation coefficient of 0.9 with energy consumption. Even though the existence of correlation between the two implies the existence of causality, on the other hand it is basis of doubt, on the part of many growth theorists. The economic growth tends to be strongly correlated with energy consumption does not a priori mean that energy consumption is the cause of the growth. Indeed, most economic models assume the opposite: that economic growth is responsible for increasing energy consumption. It is also believable that both consumption and growth are simultaneously caused by some third factor (WDI, 2015).

Even though there are several studies that have investigated the causal relationship between energy consumption and economic growth using a production function framework for developed and some developing countries, very few studies that examined the relationship between energy consumption and Economic growth in Ethiopia. The research about African countries is almost exclusively based on the bivariate causality with energy consumption used as the sole factor input.

Most economists believe that capital, labor, and technical change play a significant role in determining output. “When there is more than one input both capital and natural resources there are many alternative paths that economic growth can take, determined by both the nature of technology and institutional arrangements. When relevant variables are omitted from the model, there will be no co-integration and a spurious regression will result” (Stern, 2011).

The study conducted by Chontanawat*et al*., (2006) although it includes Ethiopia, the model is based on the bivariate causality model with energy consumption used as the sole factor input. It is possible that the introduction of capital and labor in the causality framework may not only alter the direction of causality but also the magnitude of the estimates (Loizides and Vamvoukas, 2005; Odhiambo, 2008 as cited by WoldeRufael, 2008 and Mehari, 2011).

Wolde-Rufael (2008) re-examine the causal relationship between energy consumption and economic growth for seventeen African countries in a multivariate framework by including labor and capital as additional variables and the most prominent result he found from the empirical evidence is that the introduction of both gross capital formation and labor has altered the direction of causality and the study conducted by Wolde-Rufael (2008) did not include Ethiopia albeit his model is multivariate including capital and labour. Hence, the bivariate causality tests between energy consumption and economic growth may be invalid due to the omission of important variables affecting both energy consumption and economic growth. The multivariate methodology is vital since changes in energy consumptions are often challenged by the substitution of other factors of production resulting in an insignificant overall impact on output (Stern, 2003).

In the same way, Yohannes (2010) examined co- integration and causality relationship between economic growth and energy consumption in Ethiopia, using the Autoregressive Distributive Lag model and Johansen test for co- integration. The study has shown a unidirectional causality running from energy consumption to economic growth.

Furthermore, Mehari (2011) the results give the evidence of causality running from economic growth to energy consumption. The reveals 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 labor. The answers to questions pose in the hypothesis, which are recognized in many previous studies, have important implications for policy makers.

As noted by Wolde-Rufael cited in Mehari (2011), amongst others, if causality runs from energy consumption to RGDP then it implies that an economy is energy dependent and thus, energy is a motivation to growth implying that a shortage of energy may negatively affect economic growth or may cause poor economic performance, leading to a fall in income and employment. On the other hand, energy is a limiting factor in economic growth (Stern, 2000) whereas if causality only runs from RGDP to energy consumption this implies that an economy is not energy dependent. Thus, as noted by Masih (1998) amongst others, energy conservation policies may be implemented with no adverse effect on growth and employment. If, on the other hand, there is no causality in either direction, which referred to as the ‘neutrality hypotheses, it implies that energy consumption is not correlated with RGDP, so that energy conservation policies may be pursued without adversely affecting the economy.

Almost non-existence of such research work in the country, at least to the knowledge of the research worker, shows there is a gap to be filled, so that energy policy lesson can be drawn. Still there are inconclusive empirical results which make it difficult to draw a conclusion about Ethiopia and the important role energy plays in economic development in country, the purposes of this study is thus to fill this gap by attempting to undertake the energy economic growth nexus employing multivariate model consisting of RGDP, capita, labour, energy consumption, export and saving. Moreover, similar to other developing countries Ethiopia is also an energy intensive growing economy, and as in most other non-oil producing countries its energy needs are met by large quantities of imports. Hence, to meet its growing demands of energy, Ethiopia faces both energy shortages from the supply side and demand side policies (ibid). Therefore, for any such policy making it is essential to determine the causal relationship between energy consumption and economic growth. Hence, the aim of this study is to determine such a relationship. This was done by examining Granger Causality between growth in energy consumption and RGDP growth. To further enrich this study was analyzed the sectoral relationship viz-a-viz, imported energy and electricity consumption growth with that of RGDP growth. Energy consumed consists of both domestic and imported sources. Thus, it would be useful to outline appropriate policies regarding each component.

Having different school of thought with regard to energy consumption, there are many researches which have tried to figure out the casual relationship between energy use growth and economic development. The relationship between energy consumption and economic development is nowadays well established in the literature, yet the direction of causation of this relationship remains controversial. That means, whether economic development leads to energy consumption or energy consumption is the engine of economic development. The direction of causality has significant policy implications. Empirically it has been tried to find the direction of causality between energy consumption and economic activities for the developing as well as for the developed countries employing the Granger techniques. But, results are still mixed. Thus, this study investigates the causal relationship between energy consumption and economic growth in Ethiopia by applying techniques of co-integration and Granger causality.

In general, the above reviewed studies revealed that there is no common consensus the causality between energy consumption and economic growth in the developed and developing countries in general and in Ethiopia in particular. To best of the researcher, none of them have tried to study the sectoral relationship between energy and economic growth. Hence, still there are inconclusive empirical results which make it difficult to draw a conclusion about Ethiopia (Mehari and Yohannes) and the important role energy plays in economic development in country. More, as per the researcher reviewed there is only two researches (Mehari and Yohannes) had done on the relationship between Energy use and economic growth in Ethiopia, and no one done on Energy consumption and economic growth with sectoral relationship. As a result this study also attempts contribute to the constraint of literature paucity.

This study mainly aimed to investigate empirically the existence and direction of causal relationship between energy consumption and economic development in Ethiopia, and to analyze the Sectoral relationship vise, imported energy and electricity consumption growth with that of RGDP growth.Specifically**,** test the direction of causality between the energy consumption and economic growth; investigate empirically the long-run and short run effect of energy consumption on economic growth in Ethiopia; to determine the casual relationship between the components of energy consumption and economic growth; to test whether the growth in components of energy consumption affects the long term economic growth of the country; to identify the causal relationship between the growth in labor, capital, export, gross domestic saving and economic growth; to evaluate how the causal impact of energy consumption on economic growth relative to intermittent variables.

2. General Overview of Energy Consumption in Ethiopia

The energy sector of Ethiopia is one of the least developed in the world despite the presence of an enormous energy resource endowment. This is reflected by the low per capita energy consumption of households. Furthermore, heavy reliance on traditional energy of rural households of Ethiopian has been focused by a number of studies. For example, Jargstorfstated that Ethiopia is the third largest user in the world of traditional fuels for household energy use, with 96% of the population dependent on traditional biomass (e.g., fuel wood and dung) to meet their energy needs. This is in comparison to 90% for Sub-Saharan Africa and approximately 60% for the African continent. The excessive deforestation, which led to the depletion of tree stock, caused what is known as the household energy crisis in Ethiopia. For the great majority of the population wood and other biomass fuels are the only source of energy which has negative environmental, ecological, and economic as well as health impacts on the life of the rural poor (David, 2008).

Energy as a Factor of Production and Unified Models of Energy and Growth

Primary factors of production are defined as inputs that exist at the beginning of the period under consideration and are not directly used up in production (though they can be degraded or accumulated from period to period), while intermediate inputs are those created during the production period under consideration and are used up entirely in production. Mainstream economists usually think of capital, labour, and land as the primary factors of production, and goods (such as fuels and materials) as intermediate inputs. The prices paid for the various intermediate inputs are seen as eventually being payments to the owners of the primary inputs for the services provided directly or embodied in the produced intermediate inputs. This approach has led to a focus in mainstream growth theory on the primary inputs, and in particular, capital and labour. The classical factor of land, including all natural resource inputs, slowly diminished (Stern, 2011).

The mainstream growth models ignore energy in the economic growth, by contrast, the ecological economics literature posits a central role for energy in driving growth but argues that limits to substitutability and/or technological change might limit or reverse growth in the future. However, none of the models and theories reviewed so far really provides a satisfactory explanation of the long-run history of the economy. Until the industrial revolution, output per capita was generally low and economic growth was not sustained. Ecological economists point to the invention of methods to use fossil fuels as the cause of the industrial revolution. However, the mainstream growth models that ignore energy resources can at least partly explain economic growth over the last half a century (Mehari, 2011).

There are currently two principal mainstream theories that explain the growth regimes of both the preindustrial and modern economies and the cause of the industrial revolution, which formed the transition between them. These are endogenous technical change approach, and the second approach is represented by two sectors- Malthusian Sector and Solow Sector. The approximations inherent in the use of a single-sector equilibrium model based on the Cobb–Douglas production function result in a potentially misleading mathematical implication: namely that the output elasticities of the factors should correspond to payments in the National Accounts. However, the national accounts reflect payments only to capital (as interest, dividends, rents and royalties) and to labor (as wages and salaries). The accounts do not reflect payments to 'nature'. This fact, in combination with other standard economic assumptions and mathematical characteristics of the Cobb- Douglas function implies that resource (energy) flows do not contribute much to aggregate productivity and thence cannot be a significant contributor to growth (Ayres, 2001).

To integrate the different approaches, Stern (2011) proposed to modify Solow's growth model. In the model Stern added an energy input that has low substitutability with capital and labor, while allowing the elasticity of substitution between capital and labor to remain at unity. In this model, depending on the availability of energy and the nature of technological change, energy can be either a constraint on growth or an enabler of growth. Omitting time indexes for simplicity, the model consists of two equations:

$$Y = [(1-\phi)(A_L{}^{\alpha} B^{\alpha} K^{1-\alpha} + \phi(A_E E)^{\psi})]^{\frac{1}{\psi}} \quad \text{..(1)}$$

$$\Delta K = s(Y - P_E E) - \delta K \quad \text{..(2)}$$

Equation (1) embeds a Cobb–Douglas production function of capital (K) and labor (L) in a constant elasticity of substitution (CES) function of value added and energy (E) that produces gross output Y.

where, $\phi = \frac{\delta - 1}{\delta}$; Where δ is the elasticity of substitution between energy and the value added aggregate; PE the price of energy; and ϕ is a parameter reflecting the relative importance of energy and value added.AL and AE are the augmentation indexes of labor and energy, which can be interpreted as reflecting both changes in technology that augment the effective supply of the factor in question and changes in the quality of the respective factors.

Equation (2) is the equation of motion for capital that assumes like Solow that the proportion of gross output that is saved is fixed at s and that capital depreciates at a constant rate δ .

As $\delta \rightarrow 1$ and $\phi \rightarrow 0$ we have the Solow model as a special case, where in the steady state, K and Y grows at the rate of labor augmentation. Additionally, depending on the scarcity of energy, the model displays either Solow-style or energy constrained behavior.

3. Research methodology

3.1 Sources of Data

This study investigates the empirical relationship between energy consumption and economic growth in Ethiopia. This relationship between economic growth and energy consumption was dealt based on the data of the real GDP capita measured in constant ETB and labor force, capital, domestic saving and export. Energy consumption is measured in Kilo tone of oil equivalent per capita.The data was used the annual time series data covering the period from 1974/75 to 2014/15 for Ethiopia regarding 2010/11 as a base year. The data was sourced from the National Bank of Ethiopia, Ministry of Finance and Economic Development-MoFED (2015/16), Central Statistics Agenecy (CSA), Ethiopian economic association (EEA), Ethiopia Electric Power cooperation (EEPCo.).

3.2 Definitions of the Variables

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

***Real GDP (RGDP[3])*:** Real Gross Product is a macroeconomic measure of the value of economic output adjusted for price changes (i.e., inflation or deflation). This adjustment transforms the money-value measure, nominal GDP, into an index for quantity of total output. GDP is the sum of consumer spending, Investment made by industry, Excess of Exports over Imports and Government Spending. Due to inflation GDP increases and does not actually reflect the true growth in economy. That is why inflation rate must be subtracted from the GDP to get the real growth percentage called the real GDP. Most of the studies conducted on the relationship of economic growth with any variables used the Gross Domestic Product (GDP) as the measurement of economic growth. Hence, this study was used the growth form of real GDP as a proxy to represent economic growth.

***Total Energy consumption (ENU)*:** is total energy consumption in the country. Energy use kilo tone of oil equivalent in real terms. That is change in real GDP and change in real energy consumption was used to estimate the model.

Energy imports (EIMP): is a net energy import, percentage of energy use. Since energy consumed consists of both domestic and imported sources, it would be useful to drawn appropriate policies regarding each component. In most non-oil producing countries its energy needs are met by large quantities of imports, and this is why this imported source of energy was taken as important variable.

Electric power consumption (EPC): it is measured in KWh per capita, and it represents the domestic sources of energy. In Ethiopia there is high demand for electricity consumption. Thus, to meet its growing needs, it is essential to determine the causal relationship between electricity consumption and economic growth.

Gross capital formation (GGG): it is the gross fixed capital formation and in line with many researchers, in the absence of capital stock for all African countries, gross capital formation has been used as proxy for the stock of physical capital. However, getting such a readymade time series data in Ethiopia is difficult. The capital stock series is constructed from real gross capital formation using the perpetual inventory assumption with depreciation rate set equal to 5 percent (Wang and Yao, 2003). As a result, in this study, gross investment was used as proxy of physical capital accumulation and have been expected a positive impact on economic growth.

[3] This study use RGDP and Y; TLF and L; K and GCF; E and ENU; GDS and S; X and EXP interchangeable.

Gross Domestic Saving (GDS): The Neo-Classical growth model which states that St = It (where S is savings), is modified when we come to the case of Ethiopia. This is because of the existence of an enormous gap between domestic savings and investment in Ethiopia. Hence, investment comprises of both saved fund (S) and borrowed fund (BF) that comes from credit given to the private sector (PRIV) and external resource such as foreign borrowing or as an alternative foreign aid (FA). Thus, this study used gross domestic saving, which is saved fund as one of the explanatory to avoid misspecification bias and since saving is one of the macro variables that enhance economic growth, and have been expected a positive impact on economic growth in general. However, it depends on the potential of saving that given countries have.

***Labor (TLF)*:** it is the labor inputs, and labor force 15+ years and below 60 years. It is one of the key inputs in production of output yet. Thus, we expect the positive relationship between economic growth and labor force.

Exports of goods and service (EXP): it is the total exports of goods and service to the rest of the world. It is supposed that export of a country's is one of the macroeconomic determinants of economic growth. The expected sign of this variable is expected to be positive.

3.3Econometric Model Specification

To investigate the empirical relationship between energy use and output growth we use the modern economic growth theory based on the conventional neo-classical one sector aggregate production technology where we treat capital, labor, and energy as separate inputs. That is

$RGDP_t = F(GGG_t, TLF_t, ENU_t, EXP_t, GDS_t)$ ---(3)

Where RGDPt is a real aggregate output, GGG is gross capital formation, TLF is the total labor force, ENU is total energy consumption (or energy use), EXP is export, GDS is gross domestic saving and the subscript t denotes the time period.

All variables are transformed into their natural logarithm so that their first differences approximate their growth rates. On the other hand, to eliminate the impact of heteroscedasticity for economic variable time series data, all variables are in natural logarithm. The empirical model was designed to model the three variables after logarithmic transformation for the linear model, is easy to verify, so the transformed model:

$\ln RGDP_t = F(\ln GGG_t, \ln TLF_t, \ln ENU_t, \ln EXP_t, \ln GDS_t)$ --(4)

The growth rate of a variable refers to its proportional rate of change. That is, the growth of rate of X refers to the quantity $\frac{\dot{X}_t}{X_t}$. A key fact about growth rates is that the growth rate of a variable equals the rate of change of its natural log. That is, $\frac{\dot{X}_t}{X_t}$ equals $\frac{d \ln X(t)}{dt}$

By using Euler's theorem implies that a function that is homogenous degree of one can be decomposed as:

$F(GGG_t, TLF_t, ENU_t, EXP_t, GDS_t) = F_{GGG} GGG_t + F_{TLF} TLF_t + F_{ENU} ENU_t + F_{EXP} EXP_t + F_{GDS} GDS_t$

---(5)

Taking the total derivative of equation 1, we get:

$$\frac{dRGDP_t}{dt} = F_{GGG}\frac{dGGG_t}{dt} + F_{TLF}\frac{dTLF_t}{dt} + F_{ENU}\frac{dENU_t}{dt} + F_{EXP}\frac{dEXP_t}{dt} + F_{GDS}\frac{dGDS_t}{dt}$$

$$\dot{RGDP}_t = F_{GGG}\,\dot{GGG}_t + F_{TLF}\,\dot{TLF}_t + F_{ENU}\,\dot{ENU}_t + F_{EXP}\,\dot{EXP}_t + F_{GDS}\,\dot{GDS}_t$$

$$= F_{GGG}GGG_t\frac{\dot{GGG}_t}{GGG_t} + F_{TLF}TLF_t\frac{\dot{TLF}_t}{TLF_t} + F_{ENU}ENU_t\frac{\dot{ENU}_t}{ENU_t} + F_{EXP}EXP_t\frac{\dot{EXP}_t}{EXP_t} + F_{GDS}GDS_t\frac{\dot{GDS}_t}{GDS_t} - (6)$$

divide through equ.(4) by RGDPt to get growth equation and rearranging the resulting expression, we get the following growth equation.

$$\frac{\dot{RGDP}_t}{RGDP_t} = F_{GGG}\frac{GGG_t}{RGDP_t}\frac{\dot{GGG}_t}{GGG_t} + F_{TLF}\frac{TLF_t}{RGDP_t}\frac{\dot{TLF}_t}{TLF_t} + F_{ENU}\frac{ENU_t}{RGDP_t}\frac{\dot{ENU}_t}{ENU_t} + F_{EXP}\frac{EXP_t}{RGDP_t}\frac{\dot{EXP}_t}{EXP_t} +$$

$$F_{GDS}\frac{GDS_t}{RGDP_t}\frac{\dot{GDS}_t}{GDS_t} - (7)$$

$$\dot{y}_t = \mu\dot{k}_t + \phi\dot{l}_t + \gamma\dot{e}_t \text{ ---} (8)$$

$$\dot{y}_t = \mu\dot{k}_t + \phi\dot{l}_t + \gamma\dot{e}_t + \pi\dot{x}_t + \varsigma\dot{s}_t$$

Where a dot on the top of a variable means that the variable is now in a growth rate form. The constant parameters μ, ϕ, γ, π and ς are the elasticities of output with respect to capital, labor, energy, export and saving respectively.

The relationship between output and capital, labor, domestic saving, export and energy inputs described by the production function in equation (4) suggests that their long-run movements may be related.Additionally, if we allow for short-run dynamics in factor-input behavior, the analysis above would also imply that past changes in capital, labor, domestic saving, export and energy will be contain useful information for predicting the future changes of output, keeping other being constant. These implications can be easily investigated using tests for multivariate co-integration and Granger-causality.

4. Result and Discussion

4.1 Unit Root Test

Apparently, it is necessary to test the nature of stationarity of the variables before running regression analysis. This test was done using the Augmented Dickey-Fuller (ADF) unit root tests. The results of ADF test for unit root of variables used in the study is presented in the following table 1.

Table 1: Results of Augmented Dickey Fuller Test

Variables	ADF t-statistic at level, I(0)		ADF t-statistic at first difference, I(1)		Decision (Order of integration)
	Intercept only	Intercept and trend	Intercept only	Intercept & trend	Decision
LNRGDP	4.341003***(S)	0.9059790(NS)	-1.93515(NS)	-6.650391*** (S)	Stationary (I(1))

LNENU	2.099343(NS)	-0.327623(NS)	-5.495215(s)	-6.135400***(S)	Stationary (I(1))
LNGDS	0.147702(NS)	-3.108926 (NS)	-8.583135(s)	-8.881271***(S)	Stationary (I(1))
LNEXP	0.835672(NS)	-1.606373(NS)	-5.344502(s)	-5.660028***(S)	Stationary (I(1))
LNGGG	1.933125(NS)	-0.963244(NS)	-6.972381(s)	-7.751710***(S)	Stationary (I(1))
LNTLF	1.957285(NS)	-0.922402(NS)	-5.939767(s)	-6.463128***(S)	Stationary (I(1))
LNEPC	2.743293 (NS)	-0.013692 (NS)	-5.242882 (s)	-6.163507***(S)	Stationary (I(1))
LNEIMP	-0.513052(NS)	-3.13007 (NS)	-6.486246 (s)	-6.479374*** (S)	Stationary (I(1))
MacKinnon (1996) with constant, no trend Test critical values: 1% level -3.621 5% level -2.943 10% level -2.610			with constant and trend Test critical values: 1% level -4.227 5% level -3.537 10% level -3.200		

Where NS & S represent not stationary and Stationary respectively
Source: Own computation (2017)

Table1 shows unit root results of the series at level and first differences. The absolute values of the calculated test statistics for all variables are less than its critical value at 5 per cent level of significance. The result indicates that all variables are non-stationary at level, and all the variables are stationary at first difference. Thus, with the establishment of the order of integration, the study proceeded to testing for long-run relationship by employing Johansen approach to test co-integration. However, before applying this test, we need to determine first the appropriate lag length, and check the stability since Johansen's co-integration test and thus VER is very sensitive to lag length determination.

4.2 Optimum lag length

The optimal lag order is determined with sequential modified Likelihood Ratio test statistics (LR), the Final Prediction Error (FPE), the Akaiki Information Criterion (AIC), the Schwarz Information Criterion (SC) and the Hannan-Quinn Information Criterion (HQ). While, checking up to three lag orders to include the 5% significance level suggest that lag 1 would be the optimum lag length for multivariate model and this has been confirmed by LR, FPE, SC and HQ in both cases. The lag exclusion test confirms the first lag to be the appropriate lag. For the trivariate model up to five lag order was checked to include the 5% significance level suggest that lag 3 would be the optimum lag length. Thus, this study was employed the optimal lag length of one and three multivariate and trivariate model respectively for estimation techniques.

Table 2: VAR Lag Order Selection Criteria
Table 2.1: VAR Lag Order Selection Criteria for Multivariate model[4]

[4]In this study multivariate was used for more than three variables

VAR Lag Order Selection Criteria
Endogenous variables: LNRGDP LNENU LNGDS LNEXP LNGGG LNTLF
Sample: 1- 41
Included observations: 38

Lag	LogL	LR	FPE	AIC	SC	HQ
0	169.8389	NA	7.25e-12	-8.623101	-8.364535	-8.531106
1	416.5587	402.5428*	1.13e-16*	-19.71362	-17.90365*	-19.06964*
2	448.4007	41.89734	1.64e-16	-19.49477	-16.13341	-18.29883
3	499.2522	50.85151	1.14e-16	-20.27643*	-15.36367	-18.52851

* 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

Table 2.2: VAR Lag Order Selection Criteria for Trivariate Model

VAR Lag Order Selection Criteria
Endogenous variables: LNRGDP LNEPC LNEIMP
Exogenous variables: C
Sample: 1 41
Included observations: 36

Lag	LogL	LR	FPE	AIC	SC	HQ
0	43.71163	NA	2.09e-05	-2.261757	-2.129797	-2.215700
1	156.4984	200.5098	6.57e-08	-8.027688	-7.499848*	-7.843458*
2	164.6729	13.17008	6.96e-08	-7.981829	-7.058109	-7.659426
3	177.7464	18.88389*	5.72e-08*	-8.208132*	-6.888533	-7.747556
4	181.8229	5.208888	7.96e-08	-7.934605	-6.219126	-7.335857
5	185.4825	4.066273	1.18e-07	-7.637919	-5.526560	-6.900998

* 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

4.3 Johansen Co-Integration Test for Long Run Relationship

The next step is to estimate Johansen test of co-integration, VECM, Granger causality and Impulse response and variance decomposition models. Both λ trace and maximum Eigen value (λmax) conclude that there is one co integrating vector among the variables and there is only one Eigen value significant at 1% level and this outcome determines that the rank of the co integration is unity. It can be conclude that among the variables there is one long run relationship. The result of testing the number of co-integrating vectors is shown in table 3.1 and table 3.2.

Table 3: Johansen co integration result for Multivariate model

Sample (adjusted): 3 41
Included observations: 39 after adjustments
Series: LNRGDP LNENU LNGDS LNEXP LNGGG LNTLF
Lags interval (in first differences): 1 to 1

Table 3.1: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.728670	123.9305	107.3466	0.0026
At most 1	0.540955	73.05805	79.34145	0.1354
At most 2	0.428980	42.69241	55.24578	0.3881
At most 3	0.250225	20.83952	35.01090	0.6525
At most 4	0.218275	9.608243	18.39771	0.5188
At most 5	0.000113	0.004402	3.841466	0.9462

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 3.2: Unrestricted Cointegration Rank Test (Maximum Eigen value)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.728670	50.87243	43.41977	0.0066
At most 1	0.540955	30.36563	37.16359	0.2450
At most 2	0.428980	21.85289	30.81507	0.4084
At most 3	0.250225	11.23128	24.25202	0.8247
At most 4	0.218275	9.603840	17.14769	0.4348
At most 5	0.000113	0.004402	3.841466	0.9462

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

Source: Own computation (2017)

Both the maximum Eigen Value and trace statistic confirm that the variable is cointegrated of at most one. Table 3.1 and 3.2 reports that the null of no co-integration vector is rejected by both trace statistics and maximum eigen value at 1% significance level. On the other hand, one co-integration vector is not rejected by tests, we can concluded that there exists only one co-integration vector, and thus there exists meaningful long run relationship between the economic growth and energy consumption, gross capital formation, labor force, export, and domestic saving.

In addition to this, the existence of one co integrating vector indicates that the first row of β coefficient and the first column of α vectors are important for further analysis. Thus, table 3.3 below reports β vector.

Table 3.3: Estimates of β coefficients normalized to LNRGDP

Vector Error Correction Estimates
Sample (adjusted): 3-41

Included observations: 39 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LNRGDP(-1)	1.000000
LNENU(-1)	-8.390586 (1.31134) [-6.39847]
LNGDS(-1)	0.006089 (0.01745) [0.34901]
LNEXP(-1)	-0.120451 (0.01109) [-10.8585]
LNGGGG(-1)	-0.035206 (0.02500) [-1.40823]
LNTLF(-1)	-4.418151 (0.39839) [-11.0899]
@TREND(1)	0.105446
C	113.9666

Note: Since the table is not in equation form, the real sign of the coefficients are changed

Source: Own computation (2017)

Table 4: Johansen co integration result for Trivariate model

Sample (adjusted): 5 41
Included observations: 37 after adjustments
Trend assumption: Linear deterministic trend
Series: LNRGDP LNEPC LNEIMP
Lags interval (in first differences): 1 to 3
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.425178	34.35614	29.79707	0.0139
At most 1	0.311418	13.86940	15.49471	0.0866
At most 2	0.001727	0.063942	3.841466	0.8004

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized		Max-Eigen	0.05

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.425178	20.48674	21.13162	0.0613
At most 1	0.311418	13.80546	14.26460	0.0590
At most 2	0.001727	0.063942	3.841466	0.8004

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

1 Cointegrating Equation(s):		Log likelihood	183.8585

Normalized cointegrating coefficients (standard error in parentheses)

LNRGDP	LNEPC	LNEIMP
1.000000	-1.515270	1.270095
	(0.32128)	(0.51191)

Adjustment coefficients (standard error in parentheses)

D(LNRGDP)	0.030425
	(0.06035)
D(LNEPC)	0.238485
	(0.06390)
D(LNEIMP)	-0.070273
	(0.11786)

Source: Own computation (2017)

It can be shown from the table 4 that the unrestricted cointegration rank test (Trace) shows two cointegrating vectors at the 5% critical value in the system while table, the unrestricted cointegration rank test (Maximum Eigen value) shows no co-integrating vectors in the system. Sporadically, the trace and the maximum eigen value test statistics yield conflicting results. In such a case the trace statistics is more robust than the maximum eigen value statistics in testing for co-integration (Luintel & Khan, 1999, and Roman, 2012). Hence, based on trace statistics result we can conclude that there exists meaningful long run relationship between the variables under investigation.As it is presented in table 4, the long run Cointegrating vector indicates that all variables have registered the expected sign and statistically significant. A 1% change in LNEPC will result in 1.51% increase in LNRGDP, on average. A 1% change in LNEIMP will result in 1.27% decrease in LNRGDP, on average. The speed of adjustment of LNRGDP and LNEPCadjusted toward their long run equilibriumby 3.04% and 23.84% respectively. Nonetheless, the adjustment coefficients of the LNEIMP is positive which indicate the extent to which this variable may deviate from its long run steady state path after a certain shock.

4.4 Long-run and Short-run Models

4.4.1 The Long run Impact of Variables on Economic Growth

The long run relationship is derived by normalizing growth in real GDP from table 3.3.
The normalized co-integration equation can be written as:

$$LNRGDP = 8.392586LNENU - 0.006089LNGDS + 0.120451LNEXP + 0.035206LNGGG + 4.418151LNTLF + 0.105446@TREND + 113.9666$$

The numbers in parenthesis under the estimated coefficients are the asymptotic standard errors. For the coefficients that are normalized to 1, standard errors will not be shown. Where, T is time trend. The trend exerts a positive effect on growth in RGDP. This implies that holding all other factors constant in the long run, as time passes by one year, the growth in real GDP of Ethiopia increase by about 10.54% each year. This can due to the fact that the country is on process of achieving high growth.

As it is presented in table 3.3, and from the above equation it can be observed that LNENU, LNEXP and LNTLF have positive and statistically significant relationship with real GDP in the long run. However, domestic saving has a negative and insignificant effect on real GDP in the long run. And LNGGG has positive and statistically insignificant relationship with real GDP in the long run. A 1% change in LNENU, LNEXP, LNGGG and LNTLF, will result in 8.39%, 0.12%, 0.035%, and 4.41% increase in LNRGDP respectively, on average; LNGDS has a negative sign and statistically not significant. This is due to the fact that, in Ethiopia there is a lack of continuous saving behavior over time, and the existence of low saving rate. According to Abu, (2004), the insignificant level of domestic saving in the economy has necessitated increasing reliance on foreign aid to finance investment requirements of the country. Despite the insignificant effect of saving in economic growth of Ethiopia (both in the short run and long run), energy use has a strong positive impact on economic growth in the long-run in Ethiopia. According to Bencivenga and Smith (1991), economic growth can occur even if savings is reduced because labor force, export and energy use has a significant impact on economic growth. Among the coefficients of variables only two got statistical significance, however measuring the statistical significance of two independent variables jointly would be very important in order to clearly say whether two independent variables at a given lag length are jointly significant or not. Furthermore, this study was applied Wald tests on the various null hypothesis involving sets of regression coefficients. The results are shown in table 5. The P-value indicates that we reject the null hypothesis that regression coefficients of all the variables in the LNRGDP equation are equal to zero. The null hypothesis that regression coefficients in each equation are equal to zero is also rejected as shown by the p-values. Thus, it indicates that all variables are jointly affects RGDP.

Table 5: Wald Coefficient Test

Wald Test:

Test Statistic	Value	Df	Probability
F-statistic	20.96068	(5, 33)	0.0000
Chi-square	104.8034	5	0.0000

Null Hypothesis: C(1)=C(2)=C(3)=C(4)=C(5)=C(6)

Source: Own computation (2017)

4.4.2 Granger Causality Test/Long Run Causality

The dynamic relationship is the simplest technique use to examine the cause and effect relationship between variables in bivariate system and it is applied in the context of the simple linear regression model. However, the simple linear regression model fails to capture the underlying dynamic causality between variables which is efficiently analyzed by Granger (1969) in terms of the Granger causality tests.

To further investigate the dynamic relationship between the variable, we employed Granger causality test using the VAR model. The institution behind of this test is that to find out whether changes in one variable cause the other to change. In order to infer the direction of causation between two variables, the granger causality test analysis must make sense. The following table shows Granger causality test for energy consumption and economic growth in Ethiopia.

Table 6: Pairwise Granger Causality Tests for Multivariate Model

Pairwise Granger Causality Tests
Sample: 1 41
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LNENU does not Granger Cause LNRGDP	40	0.09772	0.7563
LNRGDP does not Granger Cause LNENU		16.4018	0.0003

Source: Own computation, (2017)

As can be seen from the table above, we reject the null hypothesis that LNRGDP does not Granger Cause LNENU, but we fail to reject the null hypothesis that LNENU does not Granger Cause LNRGDP. Therefore, it is shown that granger causality runs one way from LNGDP to LNENU and not vice verse. Thus, in the long run the granger causality is unidirectional from Economic growth to Energy consumption, implies that it not viable to depend on energy consumption alone to promote economic growth and the government can implement stronger energy conservative policy without compromising economic growth in the long run. It suggests that policy on energy consumption have no effect on the economic growth. It may be due to little share of energy in the production function, and economic growth is vital for the energy consumption in Ethiopia in the period of 1974/75 to 2014/15. This is the indicator of developing country. The scenario may different for developed economy, the more the country is developed, the more energy use is essential to fasting economic growth Chontanawat *et al*. (2008). The conservation hypothesis implies that energy conservation policies designed to reduce energy consumption and waste may not reduce real output. Unidirectional Granger-causality from real output to energy consumption would lend support for the conservation hypothesis. This result is in line with the findings of Thoma (2004) and Sari *et al*. (2008), Mehari (2011), and Sheilla *et al*. (2017)support this conservation hypothesis.

Table 7: Pairwise Granger Causality Tests for Trivariate model

Pairwise Granger Causality Tests
Sample: 1 41
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Prob.
LNEPC does not Granger Cause LNRGDP	38	2.42269	0.0846
LNRGDP does not Granger Cause LNEPC		4.64058	0.0086
LNEIMP does not Granger Cause LNRGDP	38	0.32899	0.8044
LNRGDP does not Granger Cause LNEIMP		9.95298	9.E-05

Source: Own computation (2017)

As can be seen from the table 7 above, we reject the null hypothesis that LNRGDP does not Granger Cause LNEPC, but we fail to reject the null hypothesis that LNEPC does not Granger Cause LNRGDP. Therefore, it is shown that granger causality runs one way from LNGDP to LNEPC and not vice verse. This is due to the per capita consumption of electricity in Ethiopia remains relatively low at about 200 kWh per year, due to the heavy reliance on traditional biomass energy sources, such as wood fuels, crop residues, and animal dung (Guta *et al*., 2015,).Thus, in the long run the granger causality running from economic growth to Electricity consumption and not conversely, implies that it not viable to depend on electricity consumption and energy import alone to promote economic growth and the government can implement stronger energy conservative policy without compromising economic growth in the long run.
On the other hand, the import equation we see that economic growth leads to energy import and not vice versa. Some logical inferences could be drawn from the above results. It seems that increased economic activity causes growth in energy consumption and since petroleum products are largely imported, is also affected by growth in GDP. Furthermore, as economic growth is boosting energy consumption. That is this study support conservation hypothesis' which suggests that policy on electricity energy consumption have no effect on the economic growth. It may be due to little share of electricity consumption in the production function, and economic growth is vital for the electricity consumption in Ethiopia in the period of 1974/75 to 2014/15. This indicator of Ethiopia is still developing country. The scenario may different for developed economy, the more the country is developed, the more energy use is essential to fasting economic growth Chontanawat *et al*. (2008). Unidirectional Granger-causality from real output to electricity consumption and energy import would lend support for the conservation hypothesis. The result of causal running from economic growth to energy import is supported by Aqeel (2001) while the causality running from Economic growth to electricity consumption is contradicted with the findings of Aqeel (2001).

4.4.3 Short Run Vector Error Correction Model

The error correction terms lagged one period is shown in table (8).The result from the following table (8) shows that, in the short run only the one year lagged value of Energy consumption and labor force is significant in affecting current growth in real GDP whereas LNEXP, LNGGG and LNGDS are not statistical significance in affecting growth in real GDP.
Like in the long run, total exports of goods and service is not significant in the short run though with positive coefficient, which shows the positive relationship between export and Ethiopian economic growth during the period of investigation. This insignificant result might be related with agricultural primary product; more than 68 percent of export level in the country comes from agricultural primary product, which suffered from international price shock. Furthermore, the insignificant result might be due to huge gap resource balance (17.8% as ratio to real GDP), which indicates that exports of goods and services have insignificant impact on Ethiopian economic growth. This result also confirmed by MoFED particularly during 2011/12 and 2012/13 despite it was expected to play an important role in accelerating the economic growth during the GTP period. Furthermore, this finding is consistent with the study conducted in Ethiopia by Gezehegn (2012), they found that, total exports of goods and service was insignificant on Ethiopian economic growth even though there is positive impact, while there is an inverse relationship between economic growth and export volatility.

The capital is insignificant in both short run and long run, result may be due to the fact that benefits from capital accumulations (both private and public) are not ensured in the short period of time and may have crowding out effect on growth, and it may also due to small capital accumulation in the country. The additional justification may be due to the macro economic instability like inflation and thus no one is willing to invest and thus accumulate the capital as in lined with Belay (2015).Domestic saving has statistically insignificant effect on real GDP in both the long and short-run models. This might be due to lack of continuous saving behavior in Ethiopia over time. According to Abu, (2004), the insignificant level of domestic saving in theeconomy has necessitated increasing dependence on foreign to finance investment project of the country.

In spite of the insignificant effect of saving in economic growth of Ethiopia both in the short run and long run, labor has a strong positive impact on economic growth in the long-run in Ethiopia as in lined with Bencivenga and Smith (1991), and Roman (2012).Thus, the impact on real GDP can be explained on average in the short run as, a 1% growth in LNENU of the lagged one year decreases the current economic growth by 4.96%, on average; this due to the fact that a low level of energy efficiency in Ethiopia. 1% growth in LNTLF of the lagged one year decreases the current economic growth by 3.63%, on average. This is due to labor tends to be abundant and relatively cheaper and thus the existence of hidden unemployment in the sector. Hence, additional labor may reduce the industrial value added. In the long run determinants of value added are found insignificant in all. As seen from the long run time trend the positive sign show that as time passes, the economy of Ethiopia is on good progress.

Table 8: Estimation of Vector Error Correction Model

Dependent Variable: D(LNRGDP)
Method: Least Squares
Sample (adjusted): 3 41

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)= CointEq1	-0.739481	0.282110	-2.621247	0.0136
C(2)= D(LNRGDP(-1))	0.408876	0.257326	1.588940	0.1226
C(3)= D(LNENU(-1))	-4.696662	2.735798	-1.716743	0.0963
C(4)= D(LNGDS(-1))	-0.012933	0.030808	-0.419809	0.6776
C(5)= D(LNEXP(-1))	0.009755	0.039559	0.246584	0.8069
C(6)= D(LNGGG(-1))	0.050448	0.065640	0.768559	0.4482
C(7)= D(LNTLF(-1))	-3.632774	1.649442	-2.202426	0.0355
C(8)= CONISTANT	0.074035	0.043306	1.709580	0.0977
C(9)= @TREND(1)	0.002744	0.000977	2.808287	0.0087

R-squared	0.439692	Mean dependent var	0.050992
Adjusted R-squared	0.290277	S.D. dependent var	0.059229
S.E. of regression	0.049897	Akaike info criterion	-2.958534
Sum squared resid	0.074692	Schwarz criterion	-2.574635
Log likelihood	66.69141	Hannan-Quinn criter.	-2.820794
F-statistic	2.942752	Durbin-Watson stat	2.009267
Prob(F-statistic)	0.014922		

Normality test: Jarque-Bera: 0.575999; probability: 0.749762
Serial correlation test: Obs*R-squared: 0.007493; probability: 0.9310
Heteroskedasticity test: Obs*R-squared: 18.76871; probability: 0.4944

Source: Own computation (2017)

Since Durbin-Watson stat is greater than R-squared we accept the model. Speed of adjustment towards long run equilibrium but it must be significant and the sign must be negative. The coefficient of error correction model depicts that there is long run causality running from independent variables to LNRGDP.

The speed of adjustment or the error correction term (ECT) from the above model is represented by C (1) and come up with the expected sign and level of significance. In an empirical sense, it implies 74% of the disturbance in the short run is corrected each year or it adjusts any disequilibrium towards long run equilibrium state path.The coefficient indicates that there is high correction for divergence of LNRGDP from equilibrium, implying economic agents taking past experience they correct about 74 per cent of errors in one year and the remaining 26% in the next year, and imply a very high speed of adjustment to equilibrium. According to 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.

R^2 is 0.4396 which indicate that the fitted value explain the model well, indicates 43.96% of the growth in real GDP is explained by the variables included in the regression. The F test which shows the jointly significant indicate that the variables are jointly significant at 5 per cent level of significance. Also, in order to strength our analysis, the stability of the estimated parameters in the model is examined using stability test of Recursive residuals. The stability of the model is checked using CUMSUM method and the graph that show the result is presented in appendix. Figure 1 affirms that the coefficients of the model are stable over a sample interval.

4.5 Diagnostic tests

The Diagnostics test was also employed for VECM to detect model misspecification and as a guide for model improvement. All these tests include no serial correlation, homoscedasticity and normality tests are satisfied(seeAppendix).

4.6 Short Run Granger Causality Wald Test: Vector Error Correction Model

As long as, the error correction term has negative sign and got statistical significance that we can test the short run causality between energy consumption (use) and economic growth. To examine the short run causality we use the technique of Wald coefficient restriction. Table 9 shows the result of the tests.

Table 9: VEC Granger causality Wald test result

Dependent Variable: LNRGDP

Test Statistic	Value	Df	Probability
t-statistic	-1.716743	30	0.0963
F-statistic	2.947207	(1, 30)	0.0963
Chi-square	2.947207	1	0.0860

Null Hypothesis: C(3)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	-4.696662	2.735798

Restrictions are linear in coefficients.

Source: Own computation (2017)

There is no short run causality running from Energy use to LNRGDP because the probability of Chi-Square is greater than 5% level of significance, thus we accept the null hypothesis that says there is no short run causality running from Energy consumption /use to LNRGDP.
In the table 9 where RGDP is dependent variable the null hypothesis energy consumption does not Granger cause economic growth and the alterative hypothesis is energy consumption Granger cause economic growth. From the table it shown that the P value is 0.086, which is higher than 5% and based on the "P-value" we tends to accept H0. That is, energy does not granger cause economic growth in the short run.Here also we can induce that there is no short run causality running from LNENU, LNGDS, LNEXP, LNGGG and LNTLF to LNRGDP. The result of table 9 shows whether independent variable jointly has short run causality or not. The short-run causality is determined by the F-statistics on the explanatory variables, based on the Wald Test or the Variable Deletion Test. However, the long-run causality is confirmed by the error-correction term (ECMt-1) in the same function, which is both negative and statistically significant. The results are consistent with the growth-driven energy consumption thesis (see also Ouedraogo, 2013; Stern and Enflo, 2013; Odhiambo, 2014; Sheilla, 2016). These findings imply that in Ethiopia, it is economic growth that drives energy consumption in the long run.

Table 9 where GDP is dependent variable the null hypothesis energy consumption does not Granger cause economic growth and the alterative hypothesis is that energy consumption does Granger cause economic growth. From the table it shown that the joint P value is 0.2331 and thus, we accept H0. That is, energy does not granger cause economic growth. Differently, when energy is dependent variable and with the null hypothesis GDP does not Granger cause energy consumption and the alternative hypothesis that GDP does Granger causes energy consumption. The joint "P-value" is 0.0001 and accordingly we reject the null hypothesis and thus we accept the alterative hypothesis. Hence, the evidence of multivariate analysis is in line with the growth-led energy consumption hypothesis where causality running from economic growth to energy consumption.

The pair wise Granger causality (which is bivariate analysis) and the vector error correction model Granger causality test (which is multivariate analysis including LNGGG, LNTLF, LNEXP and LNGDS) result are not support each other. That is in the long run the result support the growth-led energy consumption hypothesis where causality running from economic growth to energy consumption, indicating that economic development to take first over energy consumption and that economic growth caused high demand for energy. Obviously, the economy of Ethiopia is highly relied on the agricultural sector. As a result, the energy use of agricultural sector is insignificant. Thus, the finding of this study shows that shortage of energy may not adversely affect RGDP growth or cause a fall in the RGDP in the short run. This is due to the fact that Ethiopia the agricultural sector does not depend on energy over the period of investigation, and total energy consumption is very low.

The result of Granger causality running from economic growth to energy consumption in Ethiopia consistent with the findings of Chontanawat et al. (2008), Wolde-Rufael (2005), Wolde-Rufael (2009), Masih (1996) and Akinlo (2008). However, the result contradicts the result of Yohannes (2010) in Ethiopia and the result of Amirat et.al (undated).

The finding of this study, the unidirectional causality from economic growth to energy consumption may be justified by the fact that:
The insinuation of the unidirectional causality running from economic growth to energy consumption result is that, the result may statistically and empirically suggest that energy conservation measures may be taken without endangering /hindering economic development. However, in practice suggest measures that can lead to the reduction of energy consumption to the consumer in order to stop any conservation problem arising out energy consumption may not be a feasible option for Ethiopia. The reason is that given the magnitude of the energy problems and the fact that the current energy infrastructure of the country is still insufficient to answer the quest for rapid economic growth that is required to alleviate poverty and to raise the living standards of the people.

Reducing energy consumption while the devastatingly majority of the population is still denied access to the use of modern type of energy may not be a feasible option. Ethiopia has not yet reached the energy ladder that may guarantee such a suggestion but it can still substantially improve the detrimental consequences of energy consumption (example the loss of natural resource for energy and the subsequent loss of soil fertility and erosion) without reducing its use. By making its energy sector more efficient and by making it available to a larger part of the population (especially electricity) energy used per unit of output can be raised.

4.7 Test of Volatility: Impulse response and Variance decomposition

Table 10 indicates the following results. In response to a one standard deviation disturbance output (LNRGDP) itself future output increase by 0.0494 in the first year and it declines in second year and consequently in third year and it continue increase but it never die out in the long run and reaches 0.040620 at the 10th year.

A one standard deviation disturbance originating from capital results in an approximately 0.022609 percent increase in output in first year and it further increase to 0.019184 in the 3rd year and it did not die out in the time horizon and consequently it reaches 0.021314 at the 10th year. A one standard deviation disturbance originating from labor results in an approximately 0.013797 increase in output in first year and it never dies out in the long run and consequently it reaches 0.023740 at the 10th year. The result shows the impact of capital and labor is permanent.

A one standard deviation disturbance originating from LNENU produces a -0.004 decrease in LNRGDP in the first year. Its effect continues to fall as the forecast horizon is extended and reaches -0.019818 at the 10th year. LNENU has no permanent impact on GDP, and its effect does die out. In other words, energy consumption has no a long- run impact on economic growth which is in line with the above findings. The impact of LNGGG, LNTLF, LNGDS and LNEXP are permanent.

The conspicuous result is the disturbance originating from energy is negative (although it is small in magnitude) suggesting that energy use negatively impacts on economic growth.

The negative relationship between energy consumption and economic growth implies that the low level of energy efficiency[5] in the country. Africa contributes about 4 per cent of total greenhouse gases. Most countries (except for the wealthier and fossil-fuel rich nations) have very low carbon dioxide (CO2) emissions per capita due to low energy intensities, lower GDPs and high levels of biomass energy use (Economic Commission for Africa, 2010).

Though the average African currently uses far less energy than the world average, producing a dollar's worth of GDP uses more energy in Africa on the average than the rest of the world (ECA, 2004).Ethiopia has low level of energy efficiency in Africa, with $2.6 of GDP for one unit of energy use in 2000 compared to the Sub-Saharan Africa average of $2.9 (Mehari, 2008).

Furthermore, Energy consumption in Ethiopia is heavily dependent on biomass energy (fuel wood, charcoal, wood waste wood, crop residues and animal dung, including biogas). The total final energy consumption in 2012 was estimated by IEA at 37,048 ktoe. Biomass fuels consumed during the same period was about 29,889 ktoe. The total petroleum consumption in the 2012 was 2,286 ktoe. Total electricity consumption was about 399 ktoe for the same period (2012), representing only the 1% f the total energy consumption. Electricity transmission and distribution losses were a fifth (20%) of total output in Ethiopia compared to 2.9% for Zambia and the world average of between 10 and 12%. Like many African countries, Ethiopia has to reduce inefficacy in the supply and use of energy.

It can be seen that almost all the biomass, the main energy vector in Ethiopia, is consumed in the residential sector. The real problem Ethiopia faces regarding energy consumption comes from the use of biomass for cooking. It is imperative that this issue is addressed and options analysed to overcome the situation; not just for reducing energy consumption, but also to avoid deforestation and the environmental impact that it carries as a consequence. The use of energy in the industry has to be addressed as well, but always with the goals of the GTP and the CRGE in mind; that is reducing energy consumption but aiming at economic development.

It is very important to develop an Energy consumption baseline study as a starting point to set up Energy Reduction Targets. In terms of electricity, the use of appliances and equipment has to be analysed since the potential for energy reduction comes from them. It has to be pointed out that the transport sector is out of the scope of this document. While the energy efficiency of individual system components, such as motors (85%-96%) and boilers (80%-85%) can be quite high, when viewed as an entire system, their overall efficiency is quite low (European Commission, 2015).

The power shortage due to insufficient hydropower generation during time of drought as hydroelectricity represents the primary source of electricity for Ethiopia could be another factor for the negative relationship between energy and economic growth. These shortages and inefficiencies could hinder industrial sector and decrease to the growth of employment in the country.

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[5] Energy efficiency measures the amount of GDP generated by one unit of energy use. Energy intensities (measured as tons of oil equivalent per unit GDP) vary widely across the region depending on the structure and energy efficiency of the economy. Energy efficiency means here that the energy inputs are reduced for a given level of service or there are increased or enhanced services for a given amount ofenergy inputs.

Table 10: Generalized Impulse Response of VAR model
Table 10.1: Impulse Response of LNRGDP

Period	LNRGDP	LNENU	LNGDS	LNEXP	LNGGGG	LNTLF
1	0.049427	-0.004043	0.024730	0.019656	0.022609	0.013797
2	0.038852	-0.005878	0.008974	0.020139	0.018848	0.013832
3	0.038450	-0.009946	0.005871	0.023185	0.019184	0.015677
4	0.039003	-0.013246	0.004315	0.025593	0.019454	0.017290
5	0.039528	-0.015554	0.003389	0.027325	0.019592	0.018624
6	0.039920	-0.017083	0.002945	0.028605	0.019763	0.019784
7	0.040192	-0.018098	0.002835	0.029611	0.020034	0.020843
8	0.040379	-0.018810	0.002919	0.030452	0.020402	0.021843
9	0.040513	-0.019357	0.003099	0.031193	0.020838	0.022805
10	0.040620	-0.019818	0.003315	0.031868	0.021314	0.023740

Table 10.2: Response of LNEN period

	LNRGDP	LNENU	LNGDS	LNEXP	LNGGGG	LNTLF
1	-0.000234	0.002862	0.000304	-0.001336-	0.000139-	0.000599
2	0.000877	0.001523	0.001231	-0.000182	0.000824	1.53E-05
3	0.001099	0.000620	0.000815	0.000327	0.000930	0.000243
4	0.001231	3.01E-05	0.000408	0.000598	0.000844	0.000358
5	0.001326	-0.000305	0.000164	0.000744	0.000735	0.000425
6	0.001388	-0.000471	5.34E-05	0.000827	0.000658	0.000474
7	0.001423	-0.000545	2.35E-05	0.000882	0.000622	0.000518
8	0.001441	-0.000578	3.07E-05	0.000926	0.000616	0.000560
9	0.001450	-0.000598	4.86E-05	0.000965	0.000629	0.000601
10	0.001454	-0.000617	6.53E-05	0.001001	0.000648	0.000641

Source: Own computation (2017)

Table 10.2 presents the accumulated response of LNENU. In response to one standard deviation shock of LNENU, LNENU itself increases by 0.0028 in the first year and continues to fall in the long-run reaching -0.000500 in 10th period. A one standard deviation disturbance originating from LNRGDP produces a -0.00023 decrease in LNENU in the first year. However, its effect continues to grow and reaches 0.001454 at the 10th year. Hence, LNRGDP has a significant impact on LNENU implying that economic growth has a long-run impact on Energy consumption. In other words, the empirical results indicated that the response of energy consumption to economic growth negatively while the response of economic growth to energy consumption is positively.

4.7.2 Variance Decomposition of VAR model

The impulse response functions trace the effect of a shock to one endogenous variable on the other variables in the VAR whereas variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. The relative importance of each random innovation in affecting the variables in the VAR can be seen by the variance decomposition results. It highlights the proportion of the movements in the dependent variables that are results of their own shocks, against shocks from the other variables.

Table 11.1 reports the results of the variance decomposition of output growth in Ethiopia within a 10-period horizon. We limited our discussion on the relative importance of endogenous variables in explaining the variation in LNRGDP and LNENU; thus, we only decompose the forecast error variance on LNRGDP and LNENU. In table below (table 11.1), the variance estimates indicate that a greater proportion of the variation in LNRGDP is due to its own innovations. The variation due to the other variables is smaller. The other five variables together explain approximately 18.03% of the future variation in GDP growth in Ethiopia. The remaining 81.97% are due to changes in GDP growth itself within the period under investigation. When we look the partial effect of factor inputs, LNGDS (7.49%) as percent of LNGDP has the highest effect on GDP growth followed by LNEXP (4.59%) and LNENU (3.22%). The fourth and fifth, are 2.66 % due to LNGGG and due to 0.05128% LNTLF respectively. 3.22% of future changes in GDP are due to changes in LNENU, showing it has less important impact on future growth rate of output in Ethiopia. Energy has less important compared to GDS and EXP. As it can be seen from the table 11.2 the response of output growth to shockscoming from energy input is slow during the first periods and its full effect on output continues to over time horizon and its has permanent effect. LNGGG, LNGDS, and LNTLF have permanent effects over all period.
The result is in line with Amirat et.al (undated) who found the variance error decomposition of capital high compared to energy and it is also consistent with the result of Sari and Soytas (2007) who found in Singapore, energy to be less important than the other inputs in short run.

The relatively low level contribution of energy to economic growth for Ethiopia may be suggest that the causal relationship between energy consumption and economic growth is relatively weak when compared to either capital or labor, LNGDS, LNEXP. The low economic performance of the country reinforces the limited energy development and consumption. The current energy infrastructure is not enough to promote sustainable economic development (ECA, 2010).The finding evidence shows that GDS, LNEXP, LNENU may be relatively more important input than both labor and capital in Ethiopia in the long run. This may be due to the fact that in Ethiopia, labor tends to be abundant and relatively cheaper, our results suggest that in order to sustain high economic growth rates in the long run, the country need to expand its Gross Domestic saving capacity to encourage investment and thus, economic growth, and export to generate foreign currency.

Table 11: Variance Decomposition position

Table 11.1: Variance Decomposition position of LNRGDP

Period	S.E.	LNRGDP	LNENU	LNGDS	LNEXP	LNGGGG	LNTLF
1	0.049427	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.064962	93.65860	0.173955	3.297758	1.600032	1.264950	0.004704
3	0.078455	88.23246	0.875821	5.670334	3.022204	2.195353	0.003832
4	0.091010	83.93423	1.880049	7.330892	4.092820	2.758324	0.003681
5	0.102793	80.58297	2.920154	8.503760	4.900389	3.083246	0.009485
6	0.113846	77.99043	3.863696	9.311383	5.536210	3.273824	0.024461
7	0.124226	75.96966	4.675936	9.844697	6.063334	3.396201	0.050172
8	0.134009	74.36129	5.366195	10.17759	6.519875	3.487946	0.087109
9	0.143280	73.04448	5.956492	10.36761	6.927596	3.568619	0.135204
10	0.152118	71.93407	6.468311	10.45703	7.298901	3.647518	0.194166

Table 11.2: Variance

Decomposition of LNENU

Period	S.E.	LNRGDP	LNENU	LNGDS	LNEXP	LNGGGG	LNTLF
1	0.002862	0.668961	99.33104	0.000000	0.000000	0.000000	0.000000
2	0.003460	6.883978	89.32057	3.545927	0.001427	0.207481	0.040618
3	0.003736	14.56193	80.23138	3.290294	0.290512	1.459576	0.166315
4	0.003991	22.27618	70.43744	3.327766	0.810372	2.849525	0.298717
5	0.004288	28.86353	61.23091	4.537092	1.334667	3.660319	0.373486
6	0.004607	34.07269	53.63423	6.167305	1.794337	3.941169	0.390274
7	0.004926	38.16302	47.68911	7.608929	2.211340	3.953933	0.373664
8	0.005232	41.42316	43.05519	8.689215	2.614704	3.874080	0.343653
9	0.005523	44.05419	39.38763	9.447808	3.017433	3.781600	0.311337
10	0.005802	46.19132	36.42933	9.971717	3.419646	3.705840	0.282150

Source: Own computation (2017)

Table (11.2) on the other hand shows the variance decomposition result for LNENU. The variance estimate result shows that high variation in LNENU is due to RGDP changes. Hence, economic growth is significantly important as it explains 46.19% of future changes in Energy consumption. This finding is consistent with our previous result. The variation due to the other variables, when compared to GDP is smaller.

5.Conclusions

This study has examined the causal relationship between energy consumption and economic growth using the time-series data from Ethiopia during the period from 1974/75 to 2014/15. The study is basically different from the majority of previous studies on energy-growth causality link in that it has used a multivariate framework – with capital, labor, gross domestic saving, and export as the intermittent variables.

In the long run, the model estimation shows LNENU, LNEXP and LNTLF have positive and statistically significant relationship with real GDP in the long run. However, domestic saving has a negative and insignificant effect on real GDP in the long run. And LNGGG has positive and statistically insignificant relationship with real GDP in the long run. LNEPC has positive and statistically significant relationship with real GDP where as LNEIMP has negative and statistically significant relationship with real GDP. Furthermore, in the long run the granger causality test reveals unidirectional from economic growth to energy consumption. That is this study support conservation hypothesis' which suggests that policy on energy consumption have no effect on the economic growth, implying that reducing energy consumption may be implemented with little or no adverse effect on economic growth. In practice however any conservation measures taken to reduce energy consumption may not be a viable option for Ethiopia particularly given the magnitude of its energy problems and the fact that the current energy infrastructure of the country is still inadequate to support its quest for rapid economic growth and for eradicating poverty. The option therefore might be for Ethiopia to enhance the level of efficiency in the energy sector. Increasing energy efficiency can cut down growth of energy demand that can mitigate conservation and health problem. As noted by IEA (2016), finding ways of expanding the quality and quantity of energy services while simultaneously addressing the environmental impacts associated with energy use represents one of the critical challenges Africa is facing. 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).

Furthermore, the estimated results infer that economic growth causes electricity consumption but not vice verse in the long run; this is due to the fact that, the per capita consumption of electricity in Ethiopia remains relatively low at about 200 kWh per year, due to the heavy reliance on traditional biomass energy sources, such as wood fuels, crop residues, and animal dung (Guta *et al*., 2015,). The study also investigate that economic growth leads to the growth in petroleum consumption (energy import) in the long run.

In the short run, the empirical revels that only the one year lagged value of Energy consumption and labor force is significant in affecting current growth in real GDP. Like in the long run, in the short run, the estimated short run Wald test for causal relationship reveals no short run causality running from Energy use to LNRGDP in Ethiopia for the period under investigation. Contrary to long run, in the short run there is no causality running from economic growth to energy consumption. The short run speed of adjustment coefficient is estimated is significant and have a correct sign. The adjustment coefficient of -0.7394 indicates that 73.94 % of the short run adjustment made within a year, and it is the speed of adjustment is high implying that it takes short time (less than two year) for growth in real GDP to move back to its equilibrium once it drifts away from its long run equilibrium value.

The results of Impulse response and variance decompositions also indicate the energy consumption has no a long- run impact on economic growth which is in line with the above findings. LNRGDP has a significant impact on LNENU implying that economic growth has a long-run impact on Energy consumption.

The strength of this causal relationship, as measured by the variance decomposition analysis, reveals that, energy has high contributing factor to output growth and certainly the most important one when compared to capital and labor. However, it is an important factor in output growth in Ethiopia next to GDS and EXP.

Although this may be due to the fact that in Ethiopia, labor tends to be abundant and relatively cheaper, our results suggest that in order to sustain high economic growth rates in the long run the country need to expand its saving capacity. Energy needs of Ethiopia will not only be affected by rising residential energy demand as a result of income growth, but also by the industrial demand for energy as the economies expand in the long run, and based on promote long-term sustainable economic development of Ethiopia, the following policy recommendation was forwarded.

7. Policy Implications

Based on the empirical result, we can infer the following recommendations:

- The results of this study show, there is a unidirectional causal flow from economic growth to energy consumption in the long run. However, in practice any conservation measures taken to reduce energy consumption may not be a feasible alternative for Ethiopia particularly given the magnitude of its energy problems and the fact that the current energy infrastructure of the country is still insufficient to support its quest for rapid economic growth and for eliminating poverty. Thus, policy makers should consider expanding their energy-mix options, to address the future demand arising from increased economic growth, and adjust the industrial structure, development high value-added industries, promote energy conservation structures, and improving energy efficiency, enhance the level of efficiency in the energy sector. Increasing energy efficiency can cut down growth of energy demand that can mitigate conservation and health problem.

- The increased demand for energy in Ethiopia's economic growth and development process needs that the path must be cleared for clean energy, develop new energy sources and increasing the use of renewable energy sources like, solar power, wind farms, geothermal and natural gas with long-term investments on technology in spite of their grave (huge) economic cost, and for instance, in 2015/16, the Ethiopian Petroleum Enterprise imported about 3 million metric tons of petroleum products worth Birr 30.3 billion which was 20.1 percent lower than last year mainly due to a significant drop in international oil price. The volume of petroleum imports however rose 7.8 percent with higher imports of regular gasoline (25.7 percent), gas oil (11.7 percent) and jet fuel (3.3 percent). As a result, using oil more efficiently and substituting gas for oil wherever possible could be a good policy measure. Thus, the regulations to be arranged and policies to be implemented must aim to minimize our dependency on foreign energy sources and reduce it over time the outflow of domestic currency.

- An energy growth policy in the case of both electricity consumption and energy import, conservation would not lead to any adverse side-effects on economic growth in Ethiopia, growth in these sectors doesn't stimulates economic growth in the long run.

- More, promote energy for sustainable development including the diversification of energy supply, diffusion of environmentally sound technologies, modernized energy systems in agriculture, industries and households, and optimizing energy consumption structure, actively develop the tertiary industry with lower energy consumption, thus the light of the economic structure and energy development.

- Promoting energy efficiency and focusing on decreasing energy intensity may also have positive impacts on economic growth rates without putting considerable pressure on the environment. Developing energy sources that are renewable and that have low or no carbon content seem to be essential for this purpose.

- Besides that, to ensure sustainable economic growth and protect the environment needs building a resource-saving society. It will be helpful for the government to utilize innovative technologies and more intensive management, improve the efficiency of the use of coal, oil, natural gas and other energy and lead aggressive research and development of new technologies, energy use technology so that a resource-saving and environment-friendly society will be built.

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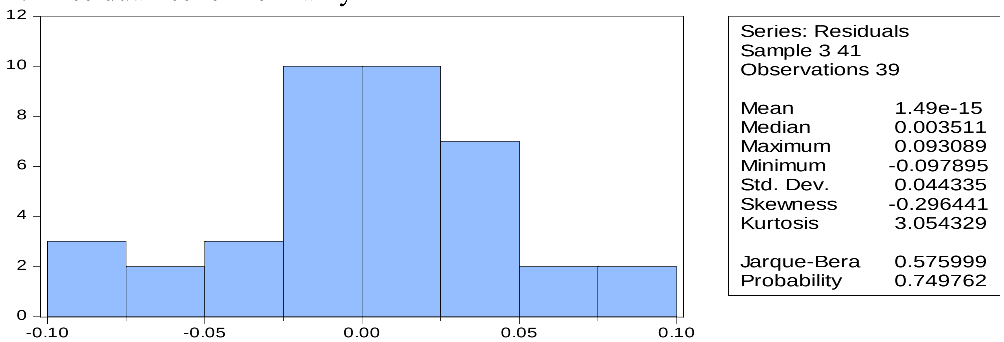
Appendix:

1. Diagnostic tests of VECM

1.1 Residual test of normality



1.2 Serial correlation test

Breusch-Godfrey Serial Correlation LM Test:

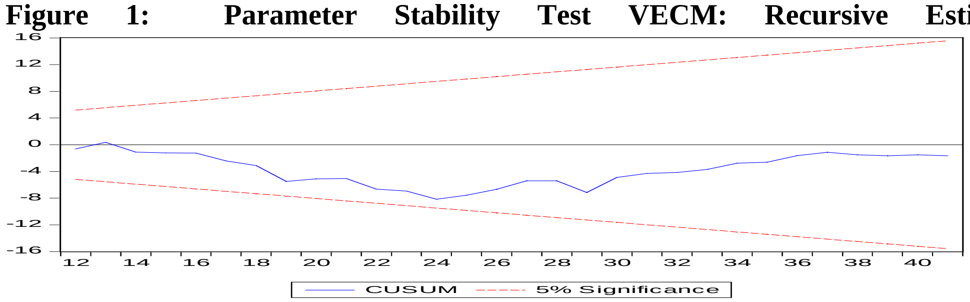
F-statistic	0.005573	Prob. F(1,29)	0.9410
Obs*R-squared	0.007493	Prob. Chi-Square(1)	0.9310

1.3 Heteroskedasticity test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	2.010031	Prob. F(12,26)	0.0663
Obs*R-squared	18.76871	Prob. Chi-Square(12)	0.0943
Scaledexplained SS	11.40743	Prob. Chi-Square(12)	0.4944

Figure 1: Parameter Stability Test VECM: Recursive Estimates (OLS only)



Source: Own drawing (2017), and *EViews version 9 using NBE data.*