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Interaction among Energy Consumption, Growth and Environment in Ethiopian Economy

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Abstract

Energy consumption in Ethiopia has been the lowest compared to several developing countries. The country needs to diversify its energy sector and develop other energy sources such as wind, geothermal and solar. The present energy mix greatly increases vulnerability to climate change and the poorest segment of the population is the most vulnerable. Recognizing that formulation of sound economic development and environmental sustainability policy needs knowing the relationship among energy use, economic growth and environmental quality. This paper provides a comprehensive review of "Interaction among Energy Consumption, Growth and Environment in Ethiopian Economy". Finally, this paper helps the researchers as well as the government officials to find pin point unforeseen issues that need to be considered while planning development policy regarding energy along with proposing recommendations.

Keywords: Energy consumption • Geothermal • Environment • Ethiopian economy

Introduction

The increasing threat of global warming and climate change has attracted attention on the relationship among economic growth, energy consumption and environmental pollution. There are a number of studies which have examined the relationship between energy consumption and economic growth and given the policy implications empirical findings at global level. This line of inquiry stems basically, from the earlier oil shocks in 1970s to the more recent interest on energy prices and the impact of Kyoto protocol agreement by a number of industrialized and developing countries to conserve energy and reduce greenhouse gas emissions in face of achieving high growth rate of the economies. The high economic growth rates experienced by developing countries are achievable only with the consumption of larger quantity of commercial energy, which is one of the key factors of production, though it leads to environmental degradation. There is still dispute on whether energy consumption is a stimulating factor for, or result of, economic growth. However, when more commercial energy, particularly oil and coal are used, carbon dioxide (CO_2) emissions rise accordingly. The increased share of CO_2 in the atmosphere which is a product of the unbridled use of fossil fuel has negative impact on natural systems and it is also a key factor contributing to climate change. In this context, the modern economies are trying to replace coal and oil with renewable alternatives such as wind,solar,and hydropower which do not emit CO_2.

Despite, Africa is a small contributor to global emissions; there are some groups which advocate environmental concerns while LDCs growth and development is being planned. In 2009, continental Africa accounted for 3.2% of global CO_2 fossil fuel emissions and Sub-Saha--ran Africa for less than 1% of global emissions (IEA 2010). Emissions are low because economic activity is smaller than in other regions and most of the population still lacks accessto electricity and clean-burning fuels [1]. Currently, Africa produces only 4% of global Gross Domestic Product (GDP) and it uses only 5.9% of the global final energy [2,3].

Sub-Saharan Africa has lagged far behind the rest of the world in providing its population with access to electricity (only 14% of rural and 63% of urban residents were electrified in 2010) and modern fuels (over 80% still rely on traditional solid fuels for cooking) [4]. Evidence of the pivotal catalytic role of access to adequate, affordable, reliable and suitable energy types for lifting people out of poverty and enhancing their welfare is irrefutable [5].

In Particular, in Ethiopia Within the traditional biomass fuels fire wood and charcoal contribute for about 87% while agricultural residues such as dung and crop residues met an estimated amount of about 11% [6]. As far as the sectoral energy consumption in the country is concerned, the largest share, over 90%, is attributed to household consumption, followed by the transport sector amounting to 6% and the industrial and service sectors respectively consuming about 1% each [7]. Though agriculture is the main stay and the dominant sector for the Ethiopian economy, it consumes the lowest

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energy proportion amounting to 0.1% of the total energy consumption.

Consequently, the country faces serious energy deficits due to poor investment in energy infrastructure. The inadequate provision of energy services in Sub Saharan Africa has been cited by the United Nations Economic Commission for Africa as a limiting factor to economic growth and poverty alleviation efforts. To meet daily energy needs, majority of the population relies on traditional biomass sources such as wood, agricultural residues, and animal dung and thus exacerbating the problems of environmental and land degradation [8].

The causality relationship between energy consumption and economic growth has attracted the interest of many economists. Some of the findings indicate that there is a strong relationship between energy consumption and economic growth. For instance, a unidirectional Granger causality running from energy consumption to economic growth entails that the country's economy is energy dependent and, hence, more energy consumption is compulsory for sustained economic growth [9]. Despite the growing volume of literature on the causal relationship between energy consumption and economic growth including for Sub-Saharan African countries, the evidences are mixed and there is no consensus yet. The review will add in various ways to the body of knowledge on the important subject of the work done on the interaction among energy consumption, economic growth, and environment in Ethiopia.

Materials and Methods

This Article is based on review of latest scientific literature presented in journals, books related on energy consumption, Growth and Environment, Internet sources and country data obtained from various ministries of the governments of Ethiopia to collect qualitative and quantitative information. Based on data collected a comprehensive literature review is carried out on Ethiopia the nexus between Energy Consumption, Growth and Environment in Ethiopian Economy. The article is divided in to five sections: in section 1 introduction, in section 2 methodology parts is discussed. Section 3 discusses energy prospects of Ethiopia, Theoretical and conceptual considerations. Finally, section 4 summarizes this article with intensive conclusion.

Results

Literature review

Energy prospects of Ethiopia: The total final energy consumption of Ethiopia was estimated at 745 Peta joules or about 51 million tons of wood equivalents during the year 1998/99G.C [10]. Energy consumption in Ethiopia is characterized by a high dependence on biomass fuels. Out of the total final energy consumption of the country, traditional biomass fuels account for more than 90% and the contribution of the modern source of energy like petroleum and electricity did not exceeding 10% [7]. Within the traditional biomass fuels fire wood and charcoal contribute for about 87% while agricultural residues such as dung and crop residues met an estimated amount of about 11% [6]. For the majority of the population, particularly dwelling in the rural areas of the country and poor urban residents, traditional biomass fuels are the sole sources of energy implying high dependence on biomass fuels. As far as the sectoral energy consumption in the country is concerned, the largest share, over 90%, is attributed to household consumption, followed by the transport sector amounting to 6% and the industrial and service sectors respectively consuming about 1% each [7,11]. Though agriculture is the main stay and the dominant sector for the Ethiopian economy, it consumes the lowest energy proportion amounting to 0.1% of the total energy consumption.

Energy consumption in Ethiopia is among the lowest in the world. The total energy consumption per capita his reported to be 0.40 toe (tons of oil equivalent), which is far below the average sub-Saharan energy consumption of which is about 0.80 toe. In fact, Ethiopia is one of the countries of Africa with abundant sources of primary energy capable of producing electricity. However, the country is dependent excessively on traditional sources of energy such as fuel wood, crop residues, and animal waste (dung).

Ethiopia is also endowed with huge potential of hydroelectric power from its numerous rivers and the potential is estimated to be up to 45,000 MW. Some statistical evidences also indicated that there exists a substantial potential to market (export) hydroelectric power to the neighboring countries of Africa. With a total of installed capacity about 2000 MW, power generated by the plants supply most of the country's electricity needs [12]. Similarly, the statistical evidences indicate that only about 3% of the potential is currently being used for electricity generation and the potential is not properly exploited. Although, more than 95% of the total electricity generation comes from hydropower, the government is currently undertaking efforts to incorporate other renewable energy sources such as solar and wind energy in the production of electricity. Apart from the existing power sources, some projects are currently underway to augment the electrical power supply of the country which is believed to contribute to the economic growth of the nation. But, more importantly Ethiopia envisages being a net exporter of clean renewable energy. Nowadays a number of grand projects like Kaysha and Great Ethiopian Renaissance Dam (GERD) are under construction to increase the country's energy production and strength a country to be a major producer and exporter of renewable energy to eastern Africa (Table 1) (Figure 1).

	Share in Year			
	1991/92	2000/01	2011/12	1991/92-2011/12
Export	42.0	52.0	40.9	51.0
Import	31.8	35.5	11.6	28.5
GDP	0.6	3.7	3.7	3.1

Table 1. Share of fuel imports (%).

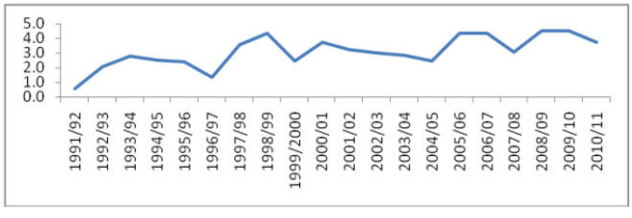

Figure 1. Trends in the share of fuel imports in GDP (%).

Theoretical and conceptual consideration

The relationship between energy consumption and economic growth: Since the late 1970s, the causal relationship between energy use and economic growth remained empirically elusive. The central issue concerning the two variables economic growth and energy use is: "Does economic growth takes precedence over energy use, or can energy use itself be stimulus for economic growth the indirect channels of effective aggregate demand and human capital, improved efficiency and technological progress?" [13].

Based on the methodology used, the literature on the relationship between energy use and economic growth can be divided into three generations of "energy-use-economic-growth relationship studies." First generation studies are based on a traditional VAR methodology and Granger's causality testing, which assumed that these data series were stationary [14]. Second and third generation studies are based on the understanding that the variables in question are nonstationary and, hence, that cointegration is the appropriate tool for investigating these relationships. Second generation studies tested pairs of variables for cointegration relationships and estimated error correction models to test for Granger causality. This approach is, as suggested in the introduction, problematic for several reasons. What we call third-generation energy-use-economic-growth relationship literature has implemented multivariate estimators, which facilitated estimation of systems where restrictions on cointegration relation can be tested, and information on short-run adjustment were investigated. The multivariate approach also allows for more than two variables in the cointegration relationship.

Influence of traditional energy source on environment: Various theoretical studies consider mainly policy tools that emphasize on emissions trading and conservation and pollution taxes. Any effective policy, as mentioned in the theoretical studies, should take the dynamic nature of the relationship between growth, energy use and environment into consideration and should have a long-term vision. Hence, in deriving (generating) effective policies in individual countries, it is essential to understand the inter-temporal relationship between energy use, economic growth and emissions.

Economic growth, energy consumption and environment interact over time. There exists a great disparity between energy consumption across countries at international level and between relatively poor and rich within a given country. Disparities in household energy use exist between rural and urban populations, between high-income and low-income groups within a nation and among countries [15]. Moreover, a large number of studies have focused on the existence of the huge gap in energy consumption across the world and have argued that the richer nations are continuing to use both more and more advanced energy while the poor are confined to the consumption of inefficient fuel as a source of energy. A recent work supported this view and argued that the poorer half of the world's populace has long relied on fuel wood for their energy needs [16].

Deforestation is an important issue in the discussion of fuel consumption of rural households. Various studies have focused on this subject. Firewood gathered from common forests is the major source of domestic energy in rural areas of many poor countries [17]. Demand for fuel wood by subsistence agricultural households may be the leading cause of the world's deforestation. For example, noted that Ethiopia is the third largest user in the world of traditional fuels for household energy consumption, with 96 percent of the population dependent on traditional biomass (e.g., fuel wood and dung) to meet their energy needs [18].

The energy crisis of rural households is rooted in their dependence on few and low-grade energy sources. To mitigate the problem, fuel diversification and inter fuel substitution can help to discourage the use of traditional sources and to optimize fuel mix in the energy portfolio. In fact, a study by the International Energy Agency argued that the major goal of fuel diversification is to reduce dependence on traditional fuel and promote the switch to modern sources as well as to increase fuel efficiency as an alternative or to complement use [19]. It also is noted that energy efficiency improvements enhance both energy security and environmental protection. In addition to energy security, environmental concerns may provide a large part of the impetus for the introduction of alternative fuels in rural household energy consumption. Fuel choices therefore need to be understood in terms of relative household resource scarcities. Although the use of low-grade fuels (such as dung and residue) may be less detrimental to forests, there is a trade-off between using them as agricultural inputs and burning them as fuel.

However, recent studies of household energy use in developing countries show that the energy ladder theory is too simplistic and that there are many additional factors other than income that determine household fuel choice [20]. The household sector is the major consumer of rural energy. Household energy often has been understood through the concept of the energy ladder. The energy ladder model has been shown to be strong in its emphasis on the determining fuel choices. It states that households switch their fuel use from biomass to modern energy sources as a country develops and incomes increase, implying that firewood is an inferior good [21]. Similarly, other studies by the energy Sector Management Assistance Program (ESMAP) and G. Leach envision the energy ladder model as a three-stage fuel-switching process. The first stage is marked by universal reliance on biomass. In the second stage, household move to "transition" or intermediate fuel such as kerosene, coal, and charcoal in response to higher incomes and factors such as deforestation and urbanization. In the third phase, household switch to liquefied petroleum gas (LPG) and electricity once their income is sufficient.

Empirical literature

Economic growth and environmental pollution: There have been two parallel literatures on the relationship between economic growth and environmental pollution. The first set of studies have focused on the economic growth-environmental pollutants nexus and closely allied to testing the Environmental Kuznets Curve (EKC) hypothesis. The EKC hypothesis states that as income increases, emissions increase as well until some threshold level of income is reached after which emissions begin to decline. The EKC hypothesis specifies emissions as a function of income, which presumes that unidirectional causality runs from economic growth to emissions. However, it is conceivable that causation could run from emissions to economic growth whereby emissions occur in the production process and, as a consequence, income increases.

A second set of studies on the relationship between economic growth and environmental pollution have focused on the economic

growth-energy consumption nexus, as emissions are primarily generated by burning fossil fuels. Since the seminal work, many studies have investigated the causal relationship between energy consumption and economic growth [22]. They have emphasized on the substitutability or complementarity between energy and factors of production and its interplay with technical progress and productivity within the neoclassical theory of economic growth [23, 24].

Energy consumption and economic growth: Energy and its contribution as a separate factor input in the production process have been neglected until recently because the cost of energy accounts only for small proportion to Gross Domestic Product. Recent studies, however, have attempted to highlight the importance of energy in the production process like capital and labor [25]. Energy is a vital input for economic and social development of any nation because it improves productivity and enhances the living standard. The significant energy use is related to the nature of energy services in different sectors in an economy, environmental constraint as well as the economic situation [26].

There are two approaches through which the causal relationship among the endogenous variables can be analyzed. First is multivariate approach and second is bivariate approach. After who used four variable vectors autoregressive (VAR) model- a multivariate model for USA in the post-war period, among others too employ the multivariate model. These studies investigated the relationship between GDP and energy within a production function model; hence a multivariate model naturally includes GDP, energy, labor and/or capital, as well as technological change [27-30].

On the other hand, several studies used a bivariate model in detecting the causality between GDP and energy. Among others have focused just on the direction of causality [31-33].

We can classify the studies to date into four groups on the basis of their findings. First, a large number of studies find unidirectional causality running from electricity or energy consumption (both aggregate and disaggregate level) to GDP. Studies worthy of mention include those of Turkey, which find strong evidence for the period 1950-2000, for Taiwan for the period 1954-2003, for China for the period 1971-2000, for Turkey, France, Germany and Japan [32-35].

Second, are those studies that find unidirectional causality running from economic growth or gross domestic product to electricity or energy consumption. These include for India for the period 1950-1997, for New Zealand and Australia for the period 1960-1999, and for Sweden for the period 1965-2000, for Singapore for the period 1975-1995 [36-39].

The third group comprises of studies that find bi-directional causality. This includes for Argentina, for Korea for the period 1970-2002, and for Malawi for the period 1970-1999 [9, 31, 32].

And the last group comprises of studies that find no causal linkages between energy or electricity consumption and economic growth, such as fir US for the period 1947-1990, and for USA for the period 1947-1990, for Us for the period 1950-1970 [27, 40, 41].

A study which incorporates more than hundred counties found that the causal relationship between energy consumption and economic growth is more likely marked in developed than in developing countries. In his study, he obtained that causality running from energy consumption to economic growth was found in only 35%, 42% and 69% of the poorest nations, of the middle-income nations and of the high-income countries respectively [42]. In his bivariate relationship between energy consumption and economic growth in African countries also found an evidence which is conflicting with the neutrality hypothesis in a substantial number of countries and gave support for the hypothesis that energy causes economic growth [43]. They found for some countries a bi-directional causality while a uni-directional causality running from energy consumption to economic growth was found in other countries. Also found a long run causality of 16 Asian countries running from energy consumption to economic growth. Evidence from 11 sub-Sahara African countries on energy consumption and economic growth using the Autoregressive Distributed Lag (ARDL) bounds test found that energy consumption is co-integrated with economic growth in Cameroon, Cote D'Ivoire, Gambia, Ghana, Senegal, Sudan and Zimbabwe [44]. Moreover, this test suggests that energy consumption has a significant positive long run impact on economic growth in Ghana, Kenya, Senegal and the Sudan. Bi-directional relationship between energy consumption and economic growth for Gambia, Ghana and Senegal was observed with the help of Granger causality test based on vector error correction model (VECM). The results of the study conducted revealed that a high level of economic growth leads to high level of energy demand and vice versa.

Asserts that while energy appears to be an essential contributing factor to the growth of output in an economy in many developed and some developing Asian countries, his variance decomposition analysis reveals that the majority of the African countries under consideration, the contribution of energy as a factor of production is less or is not the most important factor compared to labor and capital [43]. The shocks to Gross Domestic Product due to shocks of energy were very negligible for many African countries and in seven out of the 17 countries considered, energy consumption shocks accounted for only less than 10% of the forecast error variance of GDP and in 4 countries between 10% and 15%.

Discussion

According to The Johansen test for co-integration test is employed and found that energy consumption and economic growth are co-integrated series (process). The causality or direction of causality between them is also identified using the Engle-Granger causality test within the vector error correction model framework. The Granger causality test between energy consumption and economic growth shows a uni-directional relationship running from energy consumption to economic growth in Ethiopia.

A combination of these two literatures whereby the relationship between economic growth, energy consumption and pollution emissions are considered by examining Granger-causality within a multivariate framework is relatively new area of research. There are a limited number of studies in this direction either for developed countries, such as France and United States, or for developing countries, such as China and Malaysia [35, 45-47].

For example, Unidirectional Granger-causality running from energy consumption to pollution emissions in the long run, while reported bidirectional Granger-causality in the long run and short run between economic growth and pollution emissions [48]. Documented unidirectional Granger-causality running from economic growth to

energy consumption to pollution emissions in the long run, while mentioned unidirectional Granger causality running from economic growth to energy consumption and pollution emissions in the long run [49-51]. In case of Pakistan and Portugal, investigated the existence of environmental Kuznets curve using ARDL bounds testing approach to cointegration. Their result showed cointegration and validated the reality of EKC for both countries. In case of Portugal, energy consumption and urbanization played a significant role in degrading environment both in long and short run while trade openness had adverse effect on environmental degradation in Pakistan. Granger causality analysis also confirmed the existence of EKC for both countries for short as well as long span of time [52-54].

It is important to note that most of the studies have found either unidirectional or bidirectional Granger-causality among electricity or energy consumption, CO_2 emissions and economic growth for develo--ping countries andno Granger-causalityin caseof developed countries. This impliesthat the unidirectionalGranger-causality between electricity consumption and economic growth seems to be more consistent for developing countries. It can be concluded that increasing electricity supply is required to meet growing electricity consumption, to sustain economic growth [55, 56].

Conclusion

Ethiopia has a growing economy with very limited indigenous energy sources. However, its economy is highly dependent on fuel import. Responding to the increasing environmental concerns at the domestic and global levels, Ethiopia has aggressively incorporated environmental issues into overall energy policy framework. The ongoing shift in the energy supply pattern toward much greater reliance on renewable energy sources such as hydropower, wind geothermal, and biofuels will help the country to ensure environmental sustainability. Ethiopia is planning to liberalize its energy industry to overcome power shortage and stabilize energy supply. One of the justifications for encouraging the expansion renewable energy supply in Ethiopia is the possibility of saving scarce foreign currency that is used to import fossil fuels and shifting from high-cost fossil oil to cost-effective energy sources. The value of the country's oil imports has increased substantially over time. For instance, the value of oil imports relative to export earnings of the country has increased from 52.7% percent in 2000/1 to 66.9% in 2010/11.The high cost of oil imports has aggravated the country's balance of payments problem, and has serious repercussions on the macroeconomic stability of the country. Besides, effective implementation of energy conservation and demand-side management measures as well as strengthening research and development will also be carried out to ensure the continued energy growth is compatible with environmental objectives. However, even with the above-mentioned efforts, the country's contribution to global warming will still increase mainly due to its greater energy need even though it low enough as compared to with that of the industrialized nation.

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