What Factors Drive Energy Consumption in Ghana?

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Abstract

Whilst most countries have drafted energy policies**,** the desired goals of these policies are not met. One reason may be the failure to distinguish between renewable and non-energy. The purpose of this study is to estimate the impact of economic and non-economic factors on renewable and non-renewable energy demand. The Structural Time Series Model is applied to renewable studies for the first time. The findings indicate that productivity growth and income are the major drivers of renewable and non-renewable energy consumption in Ghana. It is recommended that there should be more investments in productivity to help control non-renewable energy demand.

Key words: Renewable energy, non-renewable energy, productivity, energy consumption

1. Background

The world faces a development challenge. That challenge is due to the quest to use energy resources for production without harming the environment. On the one hand, energy consumption has been found to contribute immensely to carbon emissions (1). On the other hand, (2) finds that in two out of four hypotheses, energy consumption either Granger causes growth or has a bidirectional relation with growth. (2) therefore surveys the literature on studies relating to the energy demand-economic growth nexus and finds four main hypotheses. The growth hypothesis posits that energy consumption leads to economic growth which implies that energy is a vital production input and therefore energy conservation policies can constrain growth. On the other hand, the conservation hypothesis postulates that economic growth leads to energy consumption, and hence, increases in income allows consumers to buy energy consuming gadgets such as refrigerators, cars and home theatre. The bidirectional hypothesis explains that there is a feedback relation between energy consumption and growth whilst the neutrality hypothesis propounds that there is no relation at all between the two. The neutral hypothesis supports the neoclassical economics assertion that energy is an intermediate input in the production process which can be substituted by other factors of production. Energy is therefore not relatively significant as compared to capital. This assertion is challenged by ecological economists who consider energy as essential. They posit that energy and capital are complements and not substitutes (3).

Problems with energy supply and use are related not only to global warming, but also to such environmental concerns as air pollution, acid precipitation, ozone depletion, forest destruction, and emission of radioactive substances. These issues must be taken into consideration simultaneously if humanity is to achieve a bright energy future with minimal environmental impacts. Much evidence exists, which suggests that the future will be negatively impacted if humans keep degrading the environment (4). Other environmental considerations have been given increasing attention by energy industries and the public. The concept that consumers share responsibility for pollution and its cost has been increasingly accepted. In some jurisdictions, the prices of many energy resources have increased over the last one to two decades, in part to account for environmental costs. (5) suggests that the most promising means of reducing the effect of energy consumption on the environment in the short-run is through energy conservation which calls for a change in the energy-using behaviour of consumers. In the long run however, a permanent and reliable solution should be designed to mitigate the effect of energy consumption on the environment. Renewable energy becomes the ultimate choice since its consumption reduces the effect of energy consumption on the environment, the fast depletion of non-renewable energy and its availability, especially in rural areas (6).

The main sources of renewable energy in Ghana are biofuels and waste and are predominantly used in the residential sector (7). However, there is a potential for renewable energy in the power sector. For instance, (8) estimate that Ghana's electricity demand has been estimated to be growing at a high rate of about 7% per annum over the last ten years. This is due to the relatively high population growth, economic aspiration of the country and the extension of electricity to rural areas. Electricity supply, on the contrary, has been unable to meet the demand due to high dependency on rain-fed hydropower plants, which started operating in

1965 and currently account for about 68% of the total installed capacity. Within the last 28 years, climatic changes and draughts have caused the nation to experience three major power crises.

These climate changes resulted in low inflows and thus reduced power generation from hydropower systems. To complement the hydropower systems, the Government in 1997 installed thermal plants based on light crude oil. However, the high crude oil prices on the international market in recent times have made the operation of these plants very expensive. With Ghana's current oil production, it is possible for the country to boost its energy supply when the oil exploration begins somewhere in 2010. For rural cooking, domestic biomass is employed. Ghana has no domestic coal resources. The Government of Ghana is concerned with: limited further growth potential of domestic hydro; high cost of imported oil and gas and environmental issues associated with use of imported coal.

The high cost of oil coupled with intermittent rainfall pattern makes the potential for large scale investment in solar, wind and geothermal an optimal policy choice. But since these investments require huge funding and possible long time lags, there is the need to examine the factors that influence renewable energy demand in Ghana. Whilst studies on non-renewable energy such as oil and gas abound in energy demand literature, few studies have estimated the factors that affect renewable energy demand. Most of these studies test the causality between renewable energy consumption in bivariate or multivariate framework and are usually carried out in Europe or America or developed Asia. For instance, (9) presents and estimates an empirical model of renewable energy consumption for the G7 countries. Panel cointegration estimates show that in the long term, increases in real GDP per capita and carbon dioxide (CO_2) per capita are found to be major drivers behind per capita renewable energy consumption. These results are robust across two different panel cointegration estimators. Oil price increases have a smaller although negative impact on renewable energy consumption. Deviations from equilibrium are driven mostly by the error correction term as opposed to short-term shocks. (10) study the causality between residential consumption of renewable energy and growth in the US from 1946 to 2006 and find a unidirectional causal relation from residential renewable energy consumption to growth. (11) find bidirectional causality in both the short- and long-run between renewable and growth. In Ghana, (12) find technological diffusion to be an important driver of energy efficiency.

According to Sadorsky (9) research into renewable energy is important because of the increased concerns over energy security and global warming. This makes renewable energy a fuel of choice. According to the (13), renewable energy is projected to be the fastest growing energy source between 2010 and 2030. In addition, understanding renewable energy demand will help guide investment decisions in the sector and enhance renewable energy policy design. This study moves studies on renewable energy further by applying Harvey's Structural Time Series Model to examine both the exogenous (technology, lifestyle, regulations) and the endogenous (price, income, household final expenditure) on renewable energy demand. In addition, the causal relation between renewable energy and growth in a multivariate framework is examined.

2. Methodology

(14), (15) and (16) argue that energy saving technical progress and a range of other exogenous factors (distinct from income and price) can have potential impact on energy demand. These factors include environmental pressures and regulations, lifestyle, taste and preferences of energy consumers, substitution between types of energy. Hence there is a need for a broader concept to capture not only energy saving technical progress in an energy demand function but also other unobservable factors that might produce energy efficiency. (17) therefore introduced the concept of the underlying energy demand trend (UEDT) to capture the impact of these exogenous factors. The Structural Time Series Model (STSM) developed by (18) for example, allows for the UEDT to be modelled in a stochastic fashion hence it may vary over time (both positively and negatively) if supported by the data and is therefore a particularly useful and convenient tool in these circumstances. The UEDT/STSM has been found to be a superior approach to one that uses a deterministic trend to try and capture technical progress and moreover the elasticity estimates and the shapes of the UEDTs are robust to different lengths and frequencies of data (19). To achieve this, the STSM is utilized given that it allows for the impact of unobserved components in a time series model to be captured by a stochastic trend (18). The STSM decomposes time series into explanatory variables, a stochastic trend and an irregular component. Since additional observations are included, the parameters and unobserved components of the model are estimated by using the recursive filtering smoothing process and maximum likelihood.

A framework similar to the methodology of (20) is used to estimate to estimate both renewable and non-renewable energy demand in Ghana.

$$eo_{tt} = \theta^{o}_{y} y_{tt} + \theta^{o}_{p} K_{tt} + \theta^{o}_{wtt} tfp + \theta^{o}_{htt} m + \mu^{o}_{tt} + \varepsilon_{tt} \qquad 1$$

Where eo_{tt} is the natural log of energy demand (non-renewable or renewable), y_{tt} is the natural log of income, K is the natural log of investment, TFP is the natural log of total factor productivity, m is the natural log of manufacturing, and ε_t is the error term

$$\mu_{t}{}^{o}{}_{t} = \mu_{t}{}^{o}{}_{t-1} + \gamma_{t}{}^{o}{}_{t-1} + \eta_{t}{}^{o}{}_{t} \qquad 2$$

$$\gamma_{t}{}^{o}{}_{t} = \gamma_{t}{}^{o}{}_{t-1} + \xi_{t}{}^{o}{}_{t} \qquad 3$$

Where ε_{tt} $NID(0, \sigma^2_{eo})$, η^o_{tt} $NID(0, \sigma^2_{o\eta})$ and ξ^o_{tt} $NID(0, \sigma^2_{o\xi})$. Equation (2) and (3) represent the UEDT for energy demand. μ^o_{tt} is made up of level and slope components. This is a stochastic trend dependent on $\sigma^2_{o\xi}$ and $\sigma^2_{o\eta}$. Following the work of Broadstock and Hunt (2010), the initial model is estimated as the Autoregressive Distribution Lag version with 4 lags. Statistically insignificant variables are eliminated and normality, auxiliary residuals and diagnostic tests are carried out to obtain the preferred equation. Equations (1) to (3) are estimated with the software package STAMP (21). If the estimated trend slopes downwards, then the trend depicts energy-saving behaviour whilst an upward trend depicts energy-using behaviour. Data on fixed capital formation used as a proxy for investment, income and manufacturing are obtained from the World Bank indicators. Data on renewable and non-renewable are obtained are from the IEA whilst TFP is obtained from the UNIDO.

3. Results and Discussion

Table 1.0. Estimated Coefficients

Non - Renewables		Renewables	
Ghe_1	0.53***	y	0.08**
Y_4	3.23***	tfp_2	-0.10**
Tfp_4	-3.51**	Investments_4	-0.01**
Manufacturing	1.44***		
Investments	-0.86***		

Table 1. estimated results

Total factor productivity is the most significant determinant of both renewable and non-renewable energy consumption in Ghana in the short-run. In the short-run, any 1% increase in total factor productivity growth leads to 3.51% reduction in non-renewable energy consumption whilst the same growth in TFP reduces renewable energy consumption by 0.10%. This is an opportunity to invest in productivity and efficiency since it will curb the increase in emissions through reduction in non-renewable energy consumption. In the short-run, income drives the consumption of non-renewable energy more than renewable. This may be because increase in income allows consumers to buy cars, gas cookers and other devices that use non-renewable energy than renewable. The short-run income elasticity for non-renewable energy is 3.23 whilst for renewable, it is 0.08. Another important factor that drives non-renewable energy demand is manufacturing output. Owing to intermittent power supply, most companies buy generators that uses light crude oil.

As output increases, more energy is required. This confirms the assertion of (22) that energy is an important input in the production process. In the short-run, the estimated elasticity for manufacturing output is 1.44. Investments have an inverse relationship with both renewable and non-renewable demand. Since investments are usually made by the private sector or external investors, cost of input including the cost of energy is usually considered important. As investment increases, cost-efficient means of production are usually explored and implemented. In the long-run, the most important impact on non-renewable energy consumption are TFP and income with elasticities of -6.62 and 6.09 respectively. The long-run elasticity for manufacturing output is 2.72 whilst investment is -1.62.

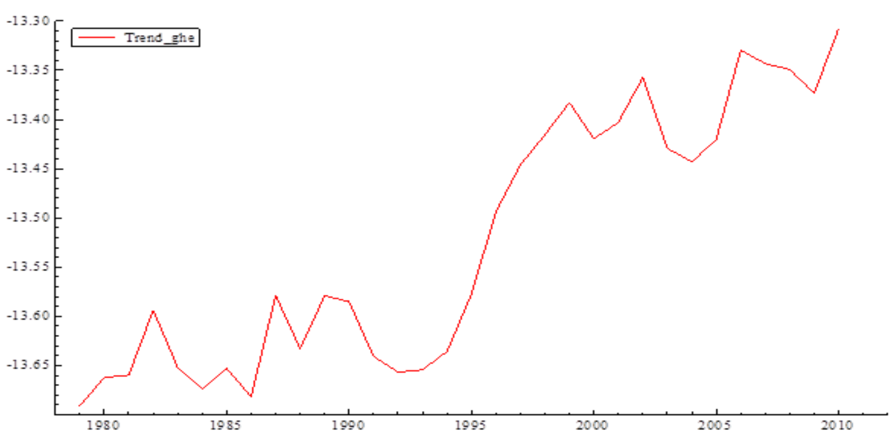

Figure 1.0 UEDT for non-renewable energy

The UEDT for the non-renewable energy sector shows a gradual increasing trend for non-renewable energy consumption. Whilst the trend decreased slightly from 1983 to 1987, and also from 1990 to 1993, it increases sharply between 1994 and 2000. This sharp increase can be attributed to the first load shedding which made both companies and individuals rely more on generators.

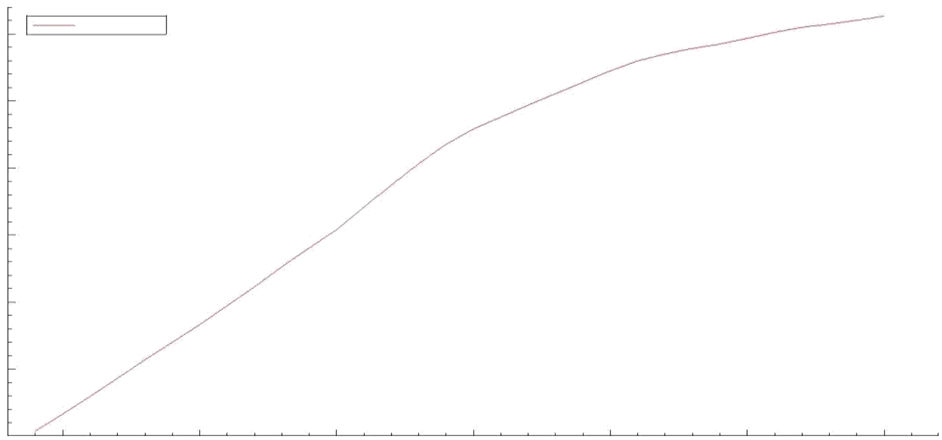

Figure **2.0 UEDT for renewable energy**

Fig. 2.0 shows the renewable energy consumption trend of Ghana from 1971 to 2010 estimated through the Structural Time Series Model which can be described as “energy using”.

The trend rises upward though gently decreasing indicating inefficient use of renewable energy. This may be due to several factors including cheaper price of renewable energy, and availability of biofuels and waste, which are the main sources of renewable energy in Ghana.

4. Conclusion

This study seeks to estimate the impact of economic and non-economic factors on renewable and non-renewable energy demand in Ghana. The Structural Time Series Model is used since it has the ability to capture exogenous non-economic factors. The findings indicate that TFP and income are the most important drivers of non-renewable energy demand in the short- and the long-run. Additionally, investment has an inverse relationship with the demand both types of energy. The trend of the UEDT shows inefficient consumption especially of renewable energy. The study recommends that in order to control the consumption of non-renewable energy, there should be more investments and policies that enhance productivity growth.

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