

On The Demand Dynamics of Electricity in Ghana: Do Exogenous Non-Economic Variables Count?

Ishmael Ackah

Economics and Finance Subject Group, Portsmouth Business School
University of Portsmouth, UK. Email: ackish85@yahoo.com

Frank Adu

Department of Economics, KNUST, Kumasi, Ghana.
Email: Frankadu64@gmail.com

Richard Opoku Takyi

University of Knutsford, Accra, Ghana.
Email: o.takyi@yahoo.com

ABSTRACT: The purpose of this study is to identify and quantify the effect of endogenous and exogenous economic factors on electricity demand in Ghana. The Structural Time Series Model is employed due to its ability to capture exogenous non-economic variables. The findings reveal that education has significant effect on electricity consumption in both the short and the long run. Education has inverse relationship with electricity consumption implying that the more consumers are educated, the less electricity they consume. The study also reveals that price changes have less impact on electricity consumption in the short run and that efficiency in electricity consumption has improved since 1971 and will continue for the next twenty years. The study recommends that more public education should be carried out to enhance energy conservation and also, realistic prices should be charge for electricity consumption to allow private investment into the sector.

Keywords: electricity consumption; efficiency; economic factors

JEL Classifications: Q43; Q49; O40

1. Introduction

The significance of energy in any economy cannot be overemphasised; sectors such as manufacturing, health, construction, entertainment, education and communications significantly depend on the production of power for their activities. This is because both capital and labour requires energy of some form to function well. Onakoya et al. (2013) recognises the significance of energy in developing countries and characterises energy as “the pillar of wealth creation” in many economies. The forgoing statement is evident from the fact that, energy is the nucleus of operation and the fulcrum on which every economy revolves. Medlock (2011) indicates that lack of access to modern energy like electricity is a principal cause of low levels of economic and social development in developing countries. Availability of energy enhances economic activities such as opening of cold store to sell fish, selling chilled water and drinks, night time sewing and hair dressing can be undertaken in rural areas. These activities increase employment, empower women economically, improve living standards and help in achieving the Millennium Development Goals (MDG). Thus, economic activities are consolidated by the output of the energy sector. However, due to the versatility of electricity, it has attracted a lot of academic interest (Adom et al., 2012).

According to the Ghana Shared Growth and Development Agenda (2010-2013), the energy sector will seek to ensure secure and reliable supply of high quality energy products and services for all sectors of the economy as Ghana regains her position as a regional exporter of power and becomes a net exporter of oil. Ghana discovered oil and gas in commercial quantities in 2009. This implies that, the economy is at the verge of attracting local and foreign firms into the oil industry whose operation are usually capital base and relies mostly on electricity to operate. However, Ghana like many African countries, suffers from perennial energy crisis which has culminated in the loss of a significant amount

of output in the country. This loss in output is an accumulation of time lost in production and redundancy created as a result of lack of alternative sources of power to bridge the supply and demand gap (Brammah and Amponsah, 2012). Various governments have tried to tackle the supply side of electricity generation in Ghana to fill the demand and supply gap in Ghana. Yet the security of electricity supply in Ghana remains erratic and inconsistent. According to ISSER (2013) the contribution of the electricity sub sector to GDP in 2011 and 2012 stood at a disappointing level of 0.5% and its share of total industrial GDP in 2012 completely declined to 1.8%.

The significance of the study can be identified in pondering over the question what happens if policy makers accurately have information on the factors that determines the demand for electricity. Determining the factors that influence the demand for electricity and other forms of energy in Ghana can guide policy makers to enact and implement tailor measured policies to manage and bridge the power deficit in the country (Ackah and Adu, 2014). Gyamfi (2007) and Adom et al. (2012) asserts that, the electricity problem in Ghana could be solved easily if attention is given to the demand side of electricity in Ghana and this study therefore pays attention to the demand side to identify factors linked to the demand for electricity in Ghana.

Adom et al. (2012) and Adom and Bekoe (2012) were the only study that tried to estimate the demand dynamics for electricity in Ghana. However the inability of the authors to measure the impact of certain exogenous factors of demand and the price of electricity completely weakens their analysis. This study will therefore fill this research gap and make significant contributions to on-going research on the subject matter. This study is also informed by calls for the government to privatise the electricity sector to attract the needed investment to curb inconsistent power supply. Since investment in the energy sector requires long lead times and huge financial outlays, knowledge of the factors that influence electricity demand will be valuable for investment decisions and policy design.

2. The Model

The purpose of this study is to ascertain the impact of economic and non-economic factors on electricity demand in Ghana. This study is significant since the Ghana Energy Commission and other electricity related bodies have introduced various policy schemes aimed at energy conservation and efficiency. In order to model the impact of the policy on consumption, the Structural Time Series Model is used. The Structural Time Series Model (STSM) developed by Harvey (1989 and 1997) allows for the underlying energy demand trend 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. Furthermore, the more traditional formulations with a linear deterministic time trend (or no trend at all) become limiting cases within this framework; hence the validity of the deterministic restrictions can be tested and only accepted if supported by the data. This UEDT/STSM approach has been applied to the UK and Japan (Hunt et al., 2003), Hunt and Ninomiya (2003) and has been found to be superior approach to other methods because of its ability to capture technical progress. In addition, the elasticity estimates and the shapes of the UEDTs are robust to different lengths and frequencies of data (Hunt et al., 2003; Hunt and Ninomiya, (2003); Dimitropoulos et al., 2005).

The above discussion focused on the conceptual issue of modelling technical progress using a deterministic trend and hence the arguments for using the alternative STSM estimating technique. However, there are also strong statistical arguments for using this STSM as opposed to the more generally accepted technique of unit roots and cointegration. Harvey (1997) heavily criticizes the over reliance on the cointegration methodology as being unnecessary and/or a misleading procedure due, to amongst other things, its poor statistical properties. Due to this and the superior characteristics of the STSM, this study follows Hunts et al. (2003) as follows:

$$el_{it} = \theta_y^o y_{it} + \theta_p^o po_{it} + \theta_h^o hc_{it} + \mu_{it}^o + \varepsilon_{it} \quad (1)$$

Where el_{it} is the natural log of electricity consumption, y_{it} is the natural log of income, po_{it} is the natural log of energy prices, hc_{it} is the natural log of education, and ε_{it} is the error term $\theta_y^o, \theta_p^o, \theta_{hc}^o$ are the elasticity's of income, price, and education respectively

$$\mu_{it}^o = \mu_{it-1}^o + \gamma_{it-1}^o + \eta_{it}^o \quad (2)$$

$$\gamma_u^o = \gamma_{u-1}^o + \xi_u^o \quad (3)$$

Where $\varepsilon_{it} \square NID(0, \sigma_{\varepsilon_o}^2)$, $\eta_u^o \square NID(0, \sigma_{\eta_o}^2)$ and $\xi_u^o \square NID(0, \sigma_{\xi_o}^2)$. Equation (2) and (3) represent the UEDT for energy demand. μ_u^o is made up of level and slope components. This is a stochastic trend dependent on $\sigma_{\varepsilon_o}^2$ and $\sigma_{\eta_o}^2$. Following the work of Broadstock and Hunt (2010), the initial model is estimated as Autoregressive Distribution Lag version with 4 lags. Statistical insignificant variables are eliminated and normality, auxiliary residuals and diagnostic test are carried out to obtain the preferred equation. Equations (1) to (4) are estimated with the software package STAMP (Koopman et al., 2000). Annual data from 1971 to 2011 on aggregate electricity in Kilojoules are obtained from the IEA. Data on education expenditure and GDP in constant US dollars are obtained from the World Bank. The consumer price index obtained from the World Bank is used as a proxy for electricity prices.

3. Discussion

The estimated result shows that, the price elasticity of demand for electrical energy in Ghana is inelastic though significant, in the first and the third lags as shown in Table 1.0. Thus a 1% increase in the price level will reduce the consumption of electrical energy by 0.01% in the first lag and raise electricity consumption by 0.01% in the third (3) lag which is close to perfect inelasticity. This is due to the fact that, electricity usage has become part of the lifestyles of all those that have access to electricity and as such, people are less likely and slow to change their consumption patterns to changes in the price of electricity, perhaps a more reason to look at energy saving policies in Ghana. Another reason may be lack of suitable alternatives especially for the residential sector.

Table 1. Estimated Output

Regressors	coefficients	RMSE	T-ratio	Probability value
$\ln P_{-1}$	-0.012099***	0.0030876	-3.9186	0.0005
$\ln P_{-3}$	0.011973***	0.0039853	3.0044	0.0053
$\ln Y$	0.70144***	0.64600	10.858	0.0000
$\ln Y_{-3}$	1.5324***	0.51320	2.9859	0.0056
$\ln HC$	-3.5587***	1.6195	-2.1975	0.0358
$\ln Elec_{-3}$	0.33242***	0.090454	-3.6749	0.0009
Calculated and generated from stamp ox metrics where; *** denotes the level of significance at the 1%.				

The income elasticity of demand is found to be highly elastic, it assumed a positive effect and it is significant at 1% which implies that, a 1% increase in income in its levels will lead to a 0.70% increase in electricity demand. Education is found to have the most significant impact on electricity consumption in Ghana in the short-run. This may because education makes consumers energy efficiency-sensitive and alter their energy consuming behaviour. Any 1% increase in education leads to 3.6% reduction in electricity consumption. In the long run, price and income elasticity is -3.79 and 6.72 respectively. The reason for the high price elasticity may be in the long run consumers use less electricity due to price hikes. The long run income elasticity is similar to the findings of Wadud et al (2011) who reports a long run income elasticity of 6.3 for natural gas demand in the power sector of Bangladesh. In the long run, consumers tend to acquire and use energy-using gadgets as income incomes.

These findings are different from previous studies on electricity elasticities in Ghana. This could be due to the inclusion of the dynamic stochastic trend and education. For instance, Adom et al. (2012) reports a long run income elasticity of 1.6 and short run of 0.84.

Energy efficiency leads to savings leads to reduction in electricity consumption. For instance, Adom et al. (2012) finds that any 1% improvement in efficiency leads to 0.58% savings annually in electricity consumption in Ghana. Figure 1 shows the underlying electricity demand trend in Ghana from 1971 to 2011.

Figure 1. Underlying Electricity Demand Trend for Ghana



The estimated trend in Figure 1. shows a decreasing path implying that Ghana has been exhibiting electricity saving behaviour over the estimated period. This trend be as a result of factors major factors in the electricity sector of Ghana. First, the Ghana Energy Commission embarked on lighting retrofit which lead to te distribution of six million free compact flourescent filament lamps to consumers to help promote energy efficiency (Ghana Energy Commision, 2013). In addition, all public buildings have been fitted with capacitor to reduce electricity consumption in the public sector. The third has been the continual public education by electricity related institutons to help consumers safe electricity. Lastly, the Energy Commission has intiated efficiency standards for some electrics like air conditioners, refridgerators etc. Electronics that do not meet the standards are not allowed into the country. The trend of the UEDT is decreasing at a decreasing rate suggesting that the various efficiency interventions of policy makers in the energy sector are accruing positive dividends. The trend can be termed as ‘energy saving’ which is similar to the one found by Dimitropoulos et al.,(2004) for the UK gasoline consumption for the whole economy.

4. Conclusion

The purpose of this study is to identify and quantify the effect of endogenous and exogenous economic factors on electricity demand in Ghana. The STSM is employed due to its ability to capture exogenous non-economic variables. The findings reveal that education has significant effect on electricity consumption in the short run. Education has inverse relationship with electricity consumption implying that the more consumers are educated, the less electricity they consume. The study also reveals that price changes have less impact on electricity consumption. Electricity in Ghana is heavily subsidized and run by the state-owned Electricity Company of Ghana (ECG). Due to inefficiencies in supply coupled with low prices and government’s failure to settle its debt to the ECG, there has been general lack of investment in the sector. This finding suggests that gradual removal of subsidy to open the sector to private investment will not harm consumption even if such action should lead to price increases. The UEDT has been downward sloping over the estimated period and the forecast shows the trend will continue for the next 20 years. This suggests that there has been improvement in efficiency in electricity consumption as a response to many efficiency schemes initiated by policy makers. The study recommends that realistic prices should be charged for electricity consumption to allow for improvement and consistency in electricity supply.

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