ELECTRICITY CONSUMPTION IN DEVELOPING COUNTRIES

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ABSTRACT

Developing countries are rapidly increasing electricity energy consumption since they foster their economic growth currently. High technological electrical appliances in daily activities demand high consumption in the energy. People demand for higher living standards and rapid population growth are among determinants in the increase of electricity consumption. This paper portrays electricity consumption in 32 developing countries as dependent variable and independent variables are GDP per capita, price of oil (proxy variable) and lagged electricity consumption. The findings are similar and correspond with expectations in the relationship between variables.

Keywords: Electricity, consumption, developing countries, GMM estimator, electricity demand

INTRODUCTION

Having access to electricity energy in this modern world brings a significant impact in our life especially when we need a source of energy for lighting, heating, power, machines, generator and many more. Without electricity, people are faced with lots of problems in their daily activities and for large companies an electricity shutdown means loss of millions of Dollar due to failure in sustaining operations and other activities. At present, about 1.6 billion people in developing countries still do not have access to electricity in their life. Investment in electricity energy involves massive research and costly investment. It reflects the country's capabilities in providing economic and social development for the population. Lack of access to electricity supply may limit the population's activities in many areas such as transportation, medical, employment, education and many more. These activities consume a tremendous amount of electricity every year. Various studies including Chang and Chen (1981), Peter and Matthew (2005), Halicioglu (2007) and Zachariadis and Pashoutidou (2007) have been undertaken in countries on the demand for electricity using various econometric models besides socioeconomic variables.

People require energy since various economic activities are dependent on electricity and lifestyle change has resulted in people using more electrical appliances such as computer, washing machine, and vacuum cleaner. Increases in income also result in increases in electricity demand since they will use more electrical appliances especially air conditioners, heaters, and refrigerators which consume more energy. A rapid growth in population is causing changes in electricity energy demand from time to time. High consumption of electricity has been attributed to many determinants. A rise in electricity prices ceteris paribus will lead to a fall in consumption. It suggests that if price increase, the consumption will decrease. They reveal a negative relationship between each other. The most important variable that can reduce consumption of electricity in any advanced country among the three consuming sectors (Residential, Commercial and Industrial) in Nigeria is an increase in price

of electricity (Ubogu, 1985). Income elasticity is the degree to which demand for a good will change relative to a change in the spending power of the consumer. Romero, Sandez and Morales (2001), suggest that there is a correlation between energy consumption and income level that is demonstrated in the situation of high income levels with high income energy consumption in Mexico. Economic theory suggests that electricity purchases will depend on the prices of its substitutes such as natural gas and distillate fuel oil. On the other hand, they also have a close relationship with each other. Reviewing the results of the case study in Taiwan, Holtedahl and Frederick (2000) maintain that electricity price responds to a change in price of oil.

Questions are still arising, such as what are the factors which are affecting the electricity consumption level in the world. While such factors can provide a general indication of the reasons for the high consumption, more important issue is which factors are most dominant in characterizing the consumption of electricity in the world. This study may explain in what capacity the factors are contributing to the consumption level in electricity energy in developing countries. This paper aims at analyzing the demand for electricity for 32 selected developing countries using panel data spanning the 1999 to 2004 period. This paper comprises three main sections. In the first section, it demonstrates the introduction and previous studies regarding to electricity consumption. In the second section, it portrays research methodology and description of variables in the model. In the third section, it presents the analysis and empirical results of the study and in the final section, it exhibits conclusion and limitation of the study.

METHODOLOGY

This study provides a model by referring to models proposed by Ubogu (1985), Houthaker and Taylor (1970), and Iwayemi (1981). The electricity demand model can be expressed as follows:

$$ln\ Q_{it} = b_0 + b_1\ ln\ Y_{it} + b_2\ ln\ P_{it} + b_3\ ln\ Q_{i,t-1} + \varepsilon_{it} \qquad (1)$$

where;

i   =   32 selected developing countries.

t   =   1999, 2000, … , 2004.

Q_{it} =   electricity consumed in the developing countries, i and at time t, expressed in billion kilowatt-hours.

Y_{it} =   per capita real income in the developing countries (GDP at time t, expressed in US Dollar/ population at time t).

P_{it} =   price of oil (as an alternative variable).

$Q_{i,t-1}$ =   One period lagged electricity consumption in billion kilowatt hours.

Variables are converted into a natural logarithmic form since log-linear specification is convenient and it can be estimated directly. The equation is known as auto regression because one of the explanatory variables consists of lagged value of the dependent variable. The dependent variable for this paper is the consumption of electric energy in the developing countries from 1999 to 2004. The independent variables are income per capita, price of oil, and previous electricity consumption. Higher income is expected to increase electricity consumption through greater economic activities and purchases of electrical-using appliances. The higher the electricity price is, the less should be the quantity demanded by consumers; given also that electricity is a normal good. Economic theory suggests that

electricity purchases will depend on the price of its substitutes such as natural gas and distillate fuel oil. Because of the difficulties to get data and information regarding the price of electricity across from 1990s, 'price of oil' is the best solution since electricity price increases when the price of fuel increases. The electricity energy price depends on the price of oil respectively. Moreover, current consumer electricity consumption is positively related to previous year's consumption also, there will be a positive relationship between the consumer sector's current electricity consumption and its previous year's level of electric energy needs.

This study aims to make maximum use of both the time and cross country dimensions of available data sets, by using data on an annual basis rate. Data spanning a period of 6 years from developing countries were collected from various sources. A list of 32 developing countries was retrieved from American Mathemathical Society (AMS) Website. The period covered from 1999 to 2004 is acceptable due to data availability of other variables. The data for this study are obtained from secondary sources such as from various websites. Electricity consumption in billion kilowatt hours and price of oil in US Dollars per barrel are obtained from Energy Information Administration (EIA) website, while the GDP per capita is sourced from World Development Indicators (WDI).

RESULTS AND DISCUSSION

The determinants of electricity consumption level in the developing countries are analysed using econometrics panel data. Our procedure starts with descriptive statistics, correlation and normality test. Then it proceeds with Generalised Method of Moments (GMM) and presents the one-step and two-step results respectively. Finally, it includes robustness check by putting a new determinant in the equation. Table 1 is the descriptive statistics of electricity consumption, price of oil and real GDP.

Table 1. Electricity Consumption in 32 Developing Countries, annual data (1999-2004 Observations = 192)

Variables	Mean	Median	Maximum	Minimum	St. Deviation	Skewness
Electricity Consumption	2.997659	2.697327	6.124749	-0.094311	1.488512	2.188053
Price of Oil	3.194915	3.218876	3.748091	2.140066	0.268567	-1.729688
Real GDP	7.176034	7.333077	8.788444	4.950096	1.012146	-0.263652

Panel Data Econometric Results

Software package *Eviews* Version 6 program is used to estimate the data. The preferred estimator in this study is Generalised Method of Moments (GMM) by Arellano-Bond in *E-views 6*. This study uses Arellano-Bond GMM estimator because of the presence of the lagged variable $Q_{i,t-1}$ which gives rise to autocorrelation. The first differenced lagged dependent variable is also instrumental with its past levels. In addition, the panel data set has a short time dimension (T = 6) and a larger country dimension (N = 32). The Arellano-Bond estimator was designed for small T and large N panels. In large T panels, a shock to the country's fixed effect, which shows in the error term, will decline with time (Mileva, 2007). Table 2 demonstrates Arellano-Bond GMM estimator results for one step and two step tests for each variable.

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<div align="center">**Table 2. Arellano-Bond GMM Estimator Results**</div>

Variables	One Step		Two Step	
	Coefficient	Std. Error	Coefficient	Std. Error
LELECCN(-1)	0.660479**	0.204858	0.692495**	0.079498
LRGDPC	0.249963	0.186353	0.243187**	0.074860
LPO	-0.091594	0.078237	-0.036700	0.033515
AR(1)	-4.282008***		-4.558940**	
AR(2)	-0.816778		-1.146302	
Sargan Test (P-Value)	0.2046400		0.386942	

Note: ** significant at 5% level.

By comparing the estimated coefficients in one step and two-step, it illustrates that they are quite similar in all cases. The asymptotic standard errors in two-step estimates are much lower than those associated with the one-step estimation. Both models are well decided and have sensible long run properties for an electricity demand equation. In this study, we use two-step estimator since it improves the efficiency of the one-step GMM considerably.

$$ln\text{Q}it = 0.243^{***} \, ln\text{Y}_{it} - 0.036 \, ln\text{P}_{it} + 0.692^{***} \, ln\text{Q}_{i,t-1} \qquad (2)$$

$$(0.07) \qquad\qquad (0.03) \qquad\quad (0.07)$$

The estimated coefficient for per capita real income is 0.243 and it is significant at 5% level. It shows a positive relationship between per capita real income and consumption of electricity in developing countries. When incomes of consumers increase, they tend to consume more electricity energy in their daily life. They utilize more high technological goods which are powered by electricity such as computer, vacuum cleaner, and washing machine. But, they still consume it within their budget constraints. The consequence of higher demand will lead to an increase in price of electricity in the future.

The price of oil is insignificant at 5% level but right in sign. The estimated coefficient is at -0.036. It is expected to have a negative relationship between dependent and independent variables. The price is sticky since it responds to electricity consumption level in small amounts. This study uses price of oil as a proxy since the electricity price depends on the price of oil. Economic theory states that a rise in prices ceteris paribus will lead to a fall in the quantity demanded. However, for electricity if the price is increased, the consumption of is unchanged. Electricity is assumed to be a necessity good (service) since the electric energy is demanded in every aspect of life. The demand for a necessity good is relatively inelastic where the quantity demanded does not change much when the price changes. Inelastic demand is commonly associated with "necessities," although there are many more reasons a good or service may have inelastic demand other than the fact that consumers may need it.

Lagged electricity consumption variable in both estimation are positive and highly significant at 5% level. For this variable, a positive relationship is expected. It is a significant variable that influences the level of current electricity consumption. It means that the higher the previous level of electricity consumption, the higher is the level of current demand for electricity by consumers. This is due to a rapid growth in their welfare and lifestyle. There are

a lot of changes in every aspect of the environment. People tend to have better standard of living compared to the previous year. Besides, more advanced technologies electrical appliances are designed to satisfy consumer needs resulting in higher electricity energy consumption.

Our results are similar and correspond with theoretical expectations of this study. The determinants LRGDPC, LELECCN (-1), and LPO maintain the causal relationship in terms of sign. The results are quite similar to the previous studies. Reviewing a study in Taiwan, Holtedahl and Frederick (2000) maintain that the electricity price responds to a change in price of oil. Ibitoye and Adenikinju (2007) reported in their study on future demand for electricity in Nigeria that there was an increase in electricity consumption since consumer income also increased. They demonstrated a strong correlation between electricity consumption and economic development.

Sensitivity Analysis

In this study only one variable, lagged GDP is added to the more conventional previous studies. This paper does not follow fixed effects estimator since they are biased with a presence of lagged dependent variable. The new equation with additional variable is as follows;

$$ln Q_{it} = b_0 + b_1 ln Y_{it} + b_2 ln P_{it} + b_3 ln Q_{i,t-1} + b_4 ln Y_{i,t-1} + \varepsilon_{it} \qquad (3)$$

Table 3. Arellano-Bond GMM Estimator Results with Additional Variable

Variables	One Step		Two Step	
	Coefficient	Std. Error	Coefficient	Std. Error
LELECCN(-1)	0.635046**	0.210305	0.685767**	0.091032
LRGDPC	0.635046	0.169866	0.233447**	0.082224
LRGDPC(-1)	0.066011	0.124337	-0.052110	0.058323
LPO	-0.087625	0.074631	-0.028770	0.032776
AR(1)	-4.146821**		-4.543215**	
AR(2)	-0.780576		-1.120301	
Sargan Test (P-Value)	0.203172		0.368232	

Note: ** significant at 5% level.

$$ln Q_{it} = 0.233^{***} ln Y_{it} - 0.028\ ln P_{it} + 0.685^{***}\ ln Q_{i,t-1} - 0.052\ ln Y_{i,t-1} \quad (4)$$

Based on estimation in Table 3, the determinants of lagged electricity consumption, real GDP per capita and price of oil are similar to previous studies in terms of the signs and significance. Thus, it proves that by adding a new variable, the determinants of electricity consumption in developing countries are still in a similar direction and do not change at all. However, by adding an alternative variable (LRGDPC (-1)), it demonstrates a negative sign and it is totally insignificant with smaller estimated coefficient. Lagged RGDPC suggests that the level of economic development is not an important determinant of the magnitude of electricity consumption in the developing countries. Thus, this variable should be dropped

and should not be included in the equation because of its insignificance towards the dependent variable.

CONCLUSION

Our findings indicate that the most dominant parameter is the previous level of electricity consumption. It signifies that the higher the previous level of electricity consumption, even by assuming the same state of electrical equipment, the higher is the level of current electricity demanded by consumers. The use of electricity is indispensable to modern life. Lifestyles have been changing very quickly and they tend to force consumers to demand more electric energy sources in order to satisfy their needs.

Real GDP per capita is significant at 5% level in affecting electricity consumption. It is because when income increases, people tend to consume more advanced electrical appliance since it reflects their standard of living. When income increases, the consumer's purchasing power also will increase. The level of economic development in developing countries also influences electricity consumption.

The price of oil variable though insignificant, is rightly signed indicating probably the impact of electricity as necessity goods (services). As oil price is expected to continue to be high in the foreseeable future the price of electricity is expected to follow since it is linked to oil price in international oil markets. Electricity, an essential source of energy for many activities, is one of the important catalysts for socioeconomic development in developing countries. The demand for it is relatively inelastic as the quantity demanded does not change much when the price changes. Goods and services for which no substitutes exist are generally inelastic since they are necessities. Besides, government regulatory action in controlling the price of electricity in the economy may possibly affect the price of electricity.

Implications and Caveats of the Study

The findings of this study tend to agree with the previous studies about electricity demand in the developing countries. However, the results depend on the situation in each country. Government plays a role in order to maintain or improve the energy efficiency constantly. It sets some limits and barriers so that it can achieve its aims and targets in planning future policies. Electricity suppliers' are responsible for providing more efficient electric energy for every level of consumers. The service must be improved constantly so that consumers can trust the supplier. Moreover, electricity is a normal good and it is a necessity for everyone. People may feel frustrated if the suppliers provide bad services with lots of power failures. People depend on this energy since in the modern world electricity plays a significant impact in our daily activities since everybody is catching up with high technological appliances.

This study is limited to electricity consumption by Residential, Commercial and Industrial sectors in 32 selected developing countries. There are still many practical problems that make it difficult to compare data from one country to another or data from one period of time to those from another. This study uses single equation demand function to estimate the parameters. There are many ways of building a system of equations but it needs more time and information which involves a huge amount of cost.

This study uses a proxy for the price of electricity and the results will be more accurate and appropriate if the actual price of electricity is used. If price of electricity is used it can explain precisely the electricity consumption level in the countries and can realistically measure how consumers respond and react to a change in price. An impact of this study is that government regulatory bodies can use the findings to take actions by controlling the price of electricity.

This study can be improved by dividing the consumers into classes, so that it may be able to determine what are the important determinants that mostly influence the three classes? The outcomes can become more accurate. Besides, it may also show which class has the highest electricity consumption level in the countries.

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