ANALYSIS OF HOUSEHOLD ENERGY CONSUMPTION IN NIGERIA

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Abstract:

Energy plays a vital role in the development of any country. In the context of the developing economies, the growth in energy consumption is associated with urbanisation and economic development through the transfer of mobile factors of production from rural to urban areas, and by the transition of the economy from a dominantly agricultural based economy to a relatively more industrialised type.

Nigeria as one of the key economies in the African continent faces many challenges in this transitionary path; population growth and the growing movement of population from rural to urban areas creates a challenge for policy makers in terms of planning energy and other infrastructure needs. Planning for future may involve accurate estimation of energy needs and while there are some attempts made at understanding the patterns of demand for energy in industrial sectors, there are scant amount of research into the patterns of consumption by households. Sources of energy for households are numerous and many traditional sources of energy are commonly used for their availability, low or no cost. However, such energy sources can be harmful for the environment and are gradually being replaced by the use of electricity due to its convenience and compatibility with the modern style of living in cities.

Following an initial literature review of the most commonly used estimation modelling techniques in the field of energy consumption this paper will report on the outcomes of a model of energy consumption for the residential sector, followed by a large survey of the household behaviour in selected parts of Nigeria. The research reported here challenges the use of traditional models used for estimation of energy consumption in developed countries for countries such as Nigeria. The existence and size of the black economy as relating to the use and abuse of electricity is highlighted and various hypotheses of this research reject the Energy Ladder theory which assumes a step wise transition into more sophisticated types of energy (i.e. electricity). The paper makes a number of contributions which are important in the debate on planning for energy in developing countries.

KEYWORDS: ENERGY MODELLING, BLACK ECONOMY, HOUSEHOLDS, GROWTH THEORY, NIGERIA

1. INTRODUCTION

Energy is essential to all human activities and, indeed is critical to social and economic development. Energy is only one of the many important inputs for production,

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conversion, processing and commercialisation in all sectors (FAO, 1992). It is generally recognised that energy, including electricity, plays a significant role in the economic development of a country as it enhances the productivity of the nation when inputs such as capital and labour are considered. In addition, the increased consumption is an indication of increase in economic activities, and by inference, an improvement in economic development of energy signifies that a country has high economic ranking.

Energy demand is important as it affects the economy which in turn affects people's lives (i.e. their income, health, happiness), and their ability to meet basic needs such as the need for infrastructure, education and so on. Access to electricity is particularly crucial to human development as electricity, in practice, is indispensable for certain basic household activities, such as lighting, refrigeration and the running of household appliances, and cannot easily be replaced by other forms of energy (IEA, 2002).

Energy demand unlike other consumption goods is a derived demand as it is not valued for itself but for what can be done with it, i.e. it is not wanted for its own sake but rather for the light and heat which it can provide. Energy consumption is also linked to urbanisation as any increase in urbanisation normally brings about changes to land use, causes increase in transportation, industry, infrastructure and the use of domestic appliances. It can be argued that an increase in urbanisation leads to an increase in energy consumption as the demand for goods and services may increase in due course. According to Medlock (2009), the exceptional economic growth and major improvements in standards of living in general over the last few decades have mainly come about because of the replacement of the work force with mechanical power through technological progress. Given the gap in socio-economic development in Africa, and in order to improve such standards in the Continent, better use of technology via electricity may need to be at the centre of long term planning.

The demand for energy (i.e. electricity) in a developing country raises some important issues due to the existence of the black economy and the growing rate of urbanisation, which exists in such nations. Many developing countries are still faced with the challenge of providing adequate and modern energy services to their communities, and the lack of such services may deter the improvements to the standard of living through increased income and employment opportunities.

Due to the nature of most developing countries, and because of the lack of understanding of household dynamics and other factors influencing its dynamics, it is difficult to fully identify the impact of insufficient energy consumption on the development of the various regions in the country and on the standard of living of people. There is difficulty in designing or evaluating policies and programmes intended to address the impact of the use of energy within households. The aim of this study is to be able to provide an appropriate analysis of the different factors that contribute to household energy demand with the objectives as follows:

Investigating the dynamics of demand of energy over time in Nigeria

Identifying the effects of the different factors on household energy demand

Finding out the ultimate impact of such factors on energy demand

The rest of the paper will reveal steps taken to establish various factors that contribute specifically to the consumption of energy by households in Nigeria.

2. LITERATURE REVIEW

The importance of energy to development can be noted at the beginning of the industrial revolution (circa. 1771), when there was a sharp increase in demand for energy (i.e. coal). Coal was used to power the steam engines that changed the world. Such engines, which powered the manufacturing industries in the eighteenth century, were replaced by electricity powered engines in the nineteenth and twentieth centuries. The birth of the industrial revolution helped change the living standards in Europe and North America; higher standards of living helped improve income, health, life expectancy and population growth which in turn led to further increase in the demand for and use of natural and man-made resources and energy.

For the countries which did not follow the same path of growth as in Europe and North America, the question of economic growth and the role that energy consumption plays in it is critical. For policy makers it is important to understand the direction of the causality; does economic growth lead to the growth in energy consumption, or it is the energy consumption that generates the economic growth? Studies show that the lack of viable sources of energy is a contributing factor to the level of poverty experienced among individuals, communities, nations and regions. Various studies also show that there is a strong relationship between energy demand and economic growth (Ebohon, 1996; Masih and Masih, 1996; Asafu-Adjaye, 2000; Jumbe, 2004; Oh and Lee, 2004; Wolfe-Rufael, 2006; Akinlo, 2008, Odularu and Okonkwo, 2009 and Ozturk et al., 2010). However, most studies examining the causality between GDP (economic growth) and energy consumption on a general level show inconclusive results. Some theories also hold that rates of energy consumption and energy efficiency are linked causally to economic growth. The literature on energy also reveals other factors that may affect the economic growth of a country. These are productivity levels, demographic changes, political institutions and the degree of income equality.

In terms of causality methodology, this study identified four different hypotheses that can be used to describe the relationship between Gross Domestic Product (GDP) and energy consumption (EC), namely a) Conservation hypothesis (where Gross Domestic Product causes energy consumption), b) Growth hypothesis (where energy consumption causes Gross Domestic Product), c) Neutrality hypothesis (a case where there is no causal relationship between energy and economic development), and d) Feedback hypothesis (where there is a bi-directional causality between energy and economic development). The variances in these results have been attributed to the fact that economic activities and the human basic activities that take place differ from one country to another (Khanna and Rao, 2009) and the efficiency with which energy is used is also different. Wolde-Rufael (2006) also argued that there are possibly a number of factors, which may influence the

demand for electricity, which differ significantly across countries and therefore cause the different directions of causality. The variations in results are generally known to be due to the differences in data sets, time lines, methodologies and variables used. According to Apergins and Tang (2013), the inconclusive evidence is potentially attributed to model specifications and the stage of economic development of the countries under investigation. Omri and Kahouli, (2014) who recently conducted an extensive review of the nexus between economic growth and different types of energy consumption, observed that the results from the studies were generally sensitive to methodology and type of energy considered. He concluded that the mixture and the non-conclusiveness of the results from previous studies are due to the different countries' characteristics, different datasets, and alternative econometric methodology. Apart from the cases of establishing the causality relationship between GDP and energy consumption, other research have identified different variables such as price (Haris and Liu, 1993, Beenstock et al.,1999; Amusa et al., 2009), temperature (Fatai et al, 2008; Hondrayiannis, 2004; De Vita et al, 2005), population (Liu et al, 1991; Rajan and Jain, 1999; and Mohamed and Bodger, 2005), rate of urbanisation (Adom et al, 2011), and education (Heltberg, 2004 and Khattak et al, 2010).

Although the causality of the relationship between GDP and energy consumption is inconclusive, many of the studies reviewed show that the energy demand in any country is expected to be driven by various factors including the state of development of the country in question and both economic and non-economic factors. Based on the above findings this study focused on exploring different methodologies for estimating and analysing demand for energy in Nigeria.

Modelling energy consumption

Energy modelling involves understanding the energy world or process in a simpler way. The main intent of modelling is to help explain or predict some of the events in the energy world. Although there are a number of approaches to modelling energy demand, many studies have used the econometric modelling approach as this is thought to have a significant advantage in terms of identifying price responsiveness of energy demand and forecasting (Dilaver, 2012). Urban et al. (2007) in their work on developing Asian countries, discovered that the models used for estimating energy in industrialised countries find very little application in developing nations. They advised the need for energy systems and economies of developing countries to be modelled taking account of such factors as supply shortages, the poor performance of the power sector, electrification and the growing trend in urbanisation.

Modelling techniques

The main modelling techniques reviewed in this paper includes: a) Regression- whereby the relationship between a dependent variable and a number of independent variables is determined; b) Auto Regressive Distributed Lag–where the dependent variable is assumed to be dependent on its past value and the current and past values of some other variables. ARDL is used to capture the dynamic process of adjustment within the variables which may not be flexible to adjust to a new equilibrium in the short run; c)

Error Correction model/Vector Error correction Model-Error Correction Models (ECMs) identify a long-run relationship between variables, while allowing for short-run deviations from this relationship. In other words, ECMs estimate how quickly a dependent variable returns to equilibrium after there has been a change to an independent variable. ECM is useful in estimating both long term and short term effects of the independent variable on the dependent variable and is an effective way of characterising the dynamic multivariate interactions of economic data. The use of ECM is to determine if there is a long run relationship between variables.

Our study showed that among research on modelling energy, different regression approaches have been used; for example: Liu et al. (1993) for Singapore; Rajan and Jain (1999) for India, Harlvosen and Larsen (2001) for Norway; Mohammed and Bodger (2005) for New Zealand; Tien and Pao (2005) for Taiwan, Louw et al., (2008) for South Africa; Egelioglu, (2001) for Northern Cyprus; Bianco, (2009) for Italy and Kankal et al. (2011) for Turkey. Whilst some used regression solely e.g. Rajan and Jain (1999), Egelioglu (2001), Louw et al. (2008), others like Liu et al. (1993), Tso and Yau (2007) and Kankal et al. (2011) compared regression to Artificial Neural Networks.

In forecasting the electricity consumption in Italy, Vincenzo et al. (2009) used multiple regression on annual data from 1970 to 2007. They included GDP, price of electricity, GDP per capita and population as independent variables on electricity consumption. They found that price elasticity was limited and therefore pricing policy could not be used to promote the efficient use of electricity in Italy. On the other hand, changes to GDP and GDP per capita had an effect on electricity consumption.

Narayan and Smyth (2005) analysed the residential demand for electricity in Australia. They carried this out using the ARDL bounds testing cointegration approach. They included annual data for 31 years from 1969 to 2000 for income, temperature, price of electricity and price of natural gas in the modelling and found income and price of electricity the most important factors in the long-run. Temperature was found to be significant to a small degree but gas price was not significant in the long-run. Amusa et al. (2009) also applied ARDL approach on data for the period between 1960 and 2007 in their work on South Africa and discovered that the price of electricity had an insignificant effect on aggregate electricity demand but changes in income had an impact. They however advised of the need for pricing policies that ensure electricity prices are cost reflective and that such policies should also enhance efficiency of electricity supply and use.

In an attempt to understand the electricity consumption in Taiwan, Holtedahl and Joutz, (2004) used ECM and included price of electricity as a determinant of its consumption, urbanisation (as a proxy variable to capture economic development characteristics and electricity-using capital stocks that are not explained by income), population, income, price of oil and weather. They found that there was an increase in the consumption of electricity as households in towns and cities were more likely to be connected to the grid than those in the rural areas and the result suggested that short- and long-term effects are separated through the use of an error correction model. Babatunde and Shaibu (2009), in

examining the residential electricity demand in Nigeria, used annual data from 1970 to 2006 for income, price of electricity, price of substitute and population. As in the case of Narayan and Smyth (2005), income was found to be very significant in the long-run. The price of substitute and population were also very significant in the determination of the demand for electricity, but Babatunde and Shaibu (2009) found that, contrary to Narayan and Smyth's findings, the price of electricity was insignificant.

Reviewing the studies above showed consistency and confirmed income as being a very important determinant of consumption of energy but the price of energy may not necessarily have a significant effect on the aggregate demand for energy. This caused Ziramba (2008) in his study of residential electricity demand in South Africa to conclude that price increase alone will not discourage increases in residential electricity consumption.

It must be noted though that the different approaches to energy use and modelling, are all underlined by one or more different theories. They include sociological theory, psychological theory, educational theory and economic theory.

Variables in energy modelling

Some energy models have found different variables such as price and Gross Domestic Product significant in determining the demand for electricity (Atakhanova, 2007; Narayan et al., 2007). Others have included population (Liu et al., 1993; Mohamed and Bodger, 2005) and domestic exports and population (Fung and Tummala, 1995) while yet other studies have included climatic variables (Yan 1998, Rajan and Jain; 1999, Haris and Liu; 1993). Other variables that have also been used in modelling electricity consumption include income, price of substitute, and length of grid connection, appliances and size of household (Louw et al., 2008). Studies by Holtedahl and Joutz (2004) for Taiwan included urbanisation as a proxy for electricity-using equipment and Azam (2015) in his study on factors that affect energy consumption for ASEAN countries included urbanisation, foreign direct investment, human development index and real growth rate. Heltberg (2004) included education, size and composition of household, income, distance to suppliers and availability of natural resources as factors that influence the choice of fuels for households. Prasad (2006) on the other hand included the cost and availability of suitable appliances while Adom et al. (2012) considered real per capita GDP, industry efficiency, degree of urbanisation and structural changes in the economy as other important factors that influence decisions on the use of energy). Generally, the variables that have been used in energy modelling can be grouped into two main categories- endogenous and exogenous as seen in Table 1.

Table 1: Summary of factors determining household energy choice

Factors determining household energy choice	
Categories	Factors
Endogenous factors (household characteristics)	
Economic characteristics	Income, expenditure
Non-economic characteristics	Household size, gender, age, household composition, education, labour
Behavioural and cultural characteristics	Preferences (e.g. food taste), practices, lifestyle, social status, ethnicity
Exogenous factors(external conditions)	
Physical environment	Geographical location, climatic condition,
Policies	Public policy, energy policy, subsidies, market and trade policies
Energy supply factors	Affordability, availability, accessibility, reliability of energy supplies
Energy device characteristics	Conversion efficiency, cost and payment method, complexity of operation

Source: Authors' compilation

Theory in energy demand estimation

The shortcomings of the above econometric models enticed this study to adopt an approach that goes beyond the assumptions of neoclassical economic theory by examining the wider socio-economic context of energy demand in a developing country. The need for such an approach was also driven by the lack of reliable and continuous data which is instrumental in conventional modelling techniques. Obtaining such data may not be easy as identified in the case of Nigeria. More so, there is no doubt that econometrics is subject to important limitations, which stem largely from the incompleteness of the economic theory and the non-experimental nature of economic data. Among developmental approaches to energy consumption, the 'energy ladder' and 'energy mix' models are found to be influential. These helped us study electricity as one part of the household energy mix which in turn is influenced by different factors such as the size of the household, the household income levels, the price of different fuels, and their availability to name a few.

The Energy Ladder model

The energy ladder is a concept used to describe the way in which households will move to more sophisticated fuels as their economic status improves. According to Leach (1992), the energy ladder model (ELM) process is strongly dependent on urban size and, within cities, on household income, since the main constraints on the transition are poor access to modern fuels and the high cost of appliances for using them.

Understanding household energy consumption, fuel choice and fuel switching behaviour is of vital importance in search for policies to support a transition process. In developing a conceptual framework, attention was given to the characteristics of households and models of energy consumption in developing countries. The framework in this study uses Energy Ladder hypothesis as a starting point. With this hypothesis comes the view that

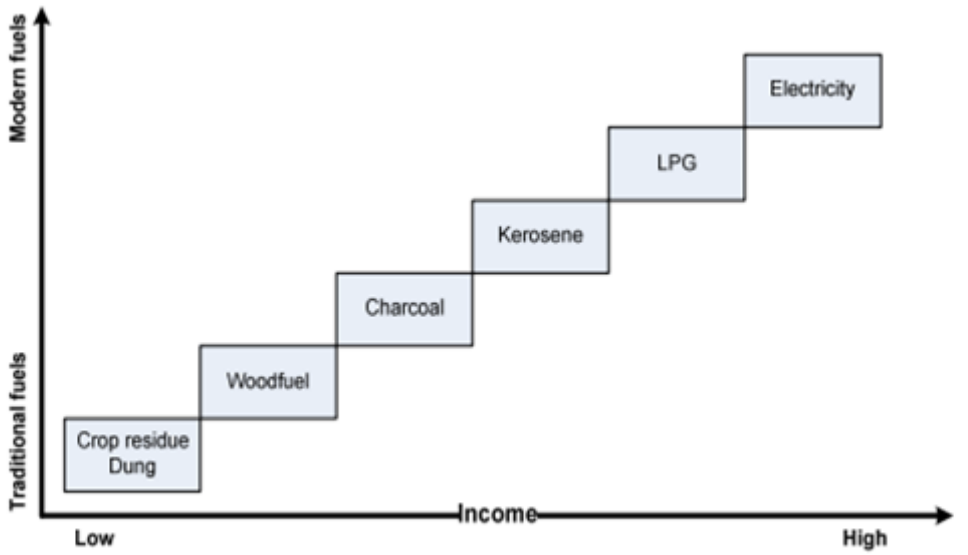
fuel substitution takes place in households. The framework facilitates the estimation of households' demand for energy.

Energy demand in households in developing countries is generally based on the concept of energy ladder or fuel substitution. Essentially, there are three steps in the energy ladder model (Heltberg, 2004):

1. There is universal reliance on biomass in the form of wood, dung and agricultural residues;
2. There is the use of transition fuels such as switch to fuels such as kerosene and coal;
3. The third and final phase is the adoption of fuels such as LPG, natural gas, electricity or other 'clean' sources of energy.

At the top of the list is electricity, while at the low-end of the range are fuel wood, dung and crop wastes. Figure 1 shows the relationship between income level and energy type. There is also the assumption that the energy ladder model operates both at the micro and macro levels. According to Hosier and Dowd, households at lower levels of income and development tend to be at the bottom of the energy ladder, using fuel that is cheap and locally available but not very clean nor efficient while at the macro level, energy consumption increases with development and accompany higher reliance on modern fuels (cited in van der Kroon et al, 2013).

Figure 1 Schematic illustration of energy ladder hypothesis



Source: Adopted from Holdren and Smith (2000)

However, Maun, Botswana, Hiemstra-van der Horst and Hovorka (2008) study examined the energy ladder for household energy use, and found that consumers do not follow the predictions of the energy ladder model; i.e. they do not simply switch from one fuel to

another as their income improves; instead they found that households use multiple energy sources because the different fuels that they use are not entirely inter–substitutable. In fact, the results of the survey indicate that despite nearly universal use of commercial alternatives, fuel wood was chosen by households across the income spectrum as a strategic energy source important for particular applications.

Figure 2. Household energy transition in developing countries: Two alternative frameworks for analysis 2013 International Energy Workshop (IEW)

Source: Treiber, M. (IEA, Paris, 19 - 21 June) International Energy Agency

Energy ladder model and energy mix

The energy ladder model although noted mainly for its ability to explain the income dependency of fuel choices, has been criticised as being insufficient to represent actual energy consumption dynamics (Foster, 2000). This is due to the complexities of switching process as economic aspects are linked with social and cultural issues.

The framework of the energy mix model shows that households will therefore always allocate their disposable income among the different goods or combination of goods that will maximise utility (i.e. an assumption of neoclassical economic theory). A household expenditure may consist of three main categories namely: Food expenditure, clothing expenditure and energy expenditure. The energy expenditure is further broken into the expenditures associated with the different forms of energy: kerosene, Liquefied petroleum gas (LPG) and electricity. The characteristics of the energy ladder model and

the energy mix model provide us with a basis by which we conceptualise our framework for household energy consumption in Nigeria – the energy mix model in this study is used as a framework to analyse and estimate the demand for electricity in Nigeria.

The use of energy ladder/energy mix allows us to include alternative variables to the widely used econometric modelling rooted in the neoclassical tradition, by considering variables such as the rate of urbanisation and the existence of informal economy. The shortcomings of such econometric models have been seen in the weakness of their predictions and therefore not being suitable as effective policy tools for developing countries. Urbanisation is a major contributor to energy consumption and as O'Neil et al. (2012) found urbanisation can influence economic growth and lead to a rapid transition away from traditional fuel use in developing countries. In sub-Saharan Africa only 46 per cent of the urban population uses electricity, compared to 85 per cent of the world urban population which has access to electricity (IEA, 2010). Furthermore, about 70 per cent of the population in developing countries use liquid fuels such as kerosene or bottled gas for cooking and heating (UNDP/WHO 2009).

The improvements in energy consumption may in turn lead to a growing population and growth of urbanisation and therefore it is important that developing countries have accurate information on the patterns of utilisation and factors driving consumption of urban household energy (Adegbulugbe and Akinbami, 2009). Between 1970 and 1980 the rate of urbanisation growth in Nigeria was between 16 and 20 per cent but by 2011, about 49.6 per cent of the total population was estimated as living in urban areas while the rate of urbanisation was given as 3.75per cent (2010-15 est., Index mundi, 2011). Although there has been tremendous increase in urbanisation over the years, the proportion of urban residents without electricity has also increased. Between 1970 and 1990, the number of urban inhabitants without electricity in Africa increased from less than 40 million to 100 million as reported by Karekezi and Majoro (2002). Although energy use patterns in developed and developing countries differ considerably, the evidence on urban energy use in developing countries suggests that it is common practice for poor urban households to use a mix of fuels for different end uses and to switch when fuel prices or household incomes change (Pachauri and Jiang 2008).

Informal economy and energy

Owing to the limited information available it is difficult to have an accurate estimate of the economic impact of the informal sector on the economy. In developing countries, some 60 per cent of the potential working population earn their living in the informal sector. Usually the income generated by the informal economy is not included in Gross Domestic Product calculation as the income is not often recorded for taxation purposes.

The fact that Nigeria has the largest informal sector in Africa stems from its stupendous population and decades of high unemployment rate. An attribute of the informal sector in Nigeria is the fact that the sector has a broad spectrum of activities that cuts across the entire segment of the economy. Such activities include manufacturing, construction, repair of cars and cycles, transportation, wholesale and retail among others. As reported

by Nwaka (2005), information on the size and employment structure in the informal sector is hard to obtain, but estimates suggest that the sector accounts for between 45per cent and 60 per cent of the urban labour force with job creation in the informal sector averaging to 25,000 to 35,000 a year (Fapohunda, 2001). The informal economy contributes to over 35 per cent of the country's GDP and almost 60 per cent of the urban labour force. Studies have also shown that income effects on urban and rural household consumption patterns are crucial to understanding the evolution of household energy demand, and demand for other goods.

3. RESEARCH METHODOLOGY

The initial stage of this study was concerned with a considerable review of various theoretical and econometric modelling approaches to energy demand. The econometric models tend to explore a statistical relationship between various factors that determine energy. In our study we considered a mixed methodology including an econometric analysis using secondary data (40 years of data observations) and a survey based approach using a questionnaire survey (501 survey participants. By using triangulation in our study, we were able to offer a better understanding of what happens in the real world. Such knowledge and understanding can then be used for energy planning and setting up of policies that will help to improve the quality of life of the consumers and enhance the overall development.

We explored the relationship between demand for electricity and a number of economic and social factors based on lessons learnt from our review of literature on modelling studies. The survey of households adopted a door-to-door, semi-structured self-administered questionnaire. These were used to collect data on socio-economic, demographic and housing characteristics. Questions such as household size, type of fuel, amount of fuel used, expenditure on energy, usage of electrical appliances, etc. enabled us to test some key hypotheses rooted in the energy mix/energy ladder as well as alternative ones.

Energy Analysis

Regression analysis

The first part of our study explored the use of the multiple regression in terms of modelling electricity, estimating the elasticities, and forecasting future electricity consumption In order to achieve this, the electricity demand function for the residential sector was estimated using secondary annual data for the period 1971-2011. Energy was considered as a commodity whereby its price act as a key determinant for energy consumption. This approach is quite common in models which use orthodox economy theory. Specifically, the demand for energy is supported by the consumer theory which is concerned with the rational behaviour of consumer with regard to their consumption decisions. This is because the consumer's choice sets are assumed to be defined by certain prices and the consumer's income or wealth. The consumers will therefore choose the set of goods that maximises their utility. In essence, individuals tend to make choices

under income constraints while taking into account the value placed on the consumption of energy. The model tested is as follows:[4]

$$LREC = -14.75 + 0.51LREC_{(-1)} + 0.53LGDP + 0.41LEDU + 0.83LPE - 1.03LCON + \varepsilon t$$

Where REC is the residential electricity consumption level (MW)

GDP - Gross Domestic Product (constant 2005 US $)

EDU - Secondary enrolment level (per cent gross population)

Pe - Price of electricity (Kobo)

Con - Rate of connectivity to the grid (per cent)

All data are transformed to log.

Linear regression analysis shows that there is a statistically significant linear relationship between logged lagged values of residential electricity consumption and lagged values of GDP, price of electricity, education and rate of connectivity to the grid. While this model found some statistically significant results the predictions were not considered widely useful due to the limited number of observations (i.e. 40 years in total).

Survey results

One of the contributions of this study was in offering a better understanding of how the different sectors of the country use energy. Generally, rural consumption tends to rely strongly on fuel wood; charcoal, although there is increasing pressure to adopt electricity because of appliances like, fridges, washing machines as well as phones. Urban areas in contrast may use kerosene, fuel wood, electricity from the grid, gas and diesel generators. Therefore, in the context of a developing economy, the issue of urbanisation and transformation from rural to urban areas and the requirements of energy were rigorously explored. In other words, our survey results help revealed the economics of urbanisation and the demand for energy; which can help generate policies that will aid the development of both sectors.

By using the concept of energy ladder, we examined the differences in the pattern of energy use in households based on the economic status of the households. We also explored other factors that contribute to the consumption of energy by the residential sector in Nigeria. The interview/survey investigated the choice of energy for households and the ways of consumption, factors that affect people's behaviour plus collection of additional data which helped us fill the gap in secondary data.

Sample size and characteristics

A survey was carried out in the Ibadan metropolis in Nigeria in 2014-15. Questionnaires were issued at different locations within Ibadan to gather information. The questionnaire sought information from householders on the type of housing, housing demographics,

[4] L denotes natural log

energy sources, energy appliances and the ownership of household appliances. The studies were conducted in a total of 560 residential buildings within five of the local government areas in Ibadan. There were, however, only a total of 501 respondents.

A general statistics of the subjects involved in the survey is indicated in Table 2.

Table 2 Summary statistics of variables used (N=501)

Stratum	Sub-Stratum	Household	Cumulative per cent
Gender	Male	272	54.6
	Female	226	45.4
Age	18-25	102	20.5
	26-35	165	33.2
	36-45	117	23.5
	46-55	73	14.6
	56-65	38	7.6
	>66	2	0.4
Education level	PhD	56	11.9
	MSc	88	18.7
	BSc	177	37.7
	Secondary	84	17.9
	Primary	9	1.8
	No Formal education	13	2.8
	Other	43	9.1
Income level (per annum)	Low (0-29999)	141	36.6
	Medium (30000-99999)	160	41.5
	High (100000 and above)	84	21.8
Number of people living as a family	Average	4	_
	Minimum	1	_
	Maximum	14	_
	Number of children	2	-
Type of house	Bungalow	102	22.4
	Duplex	77	16.9
	Flat	277	55.3
Electricity connection	Yes	287	78

	No	81	22

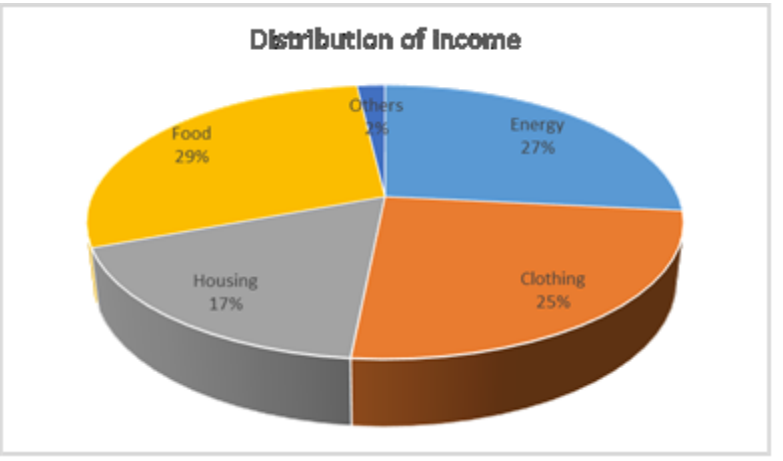
Source: survey result

Further analysis of the households indicated that most of the respondents were married (about 46.7 per cent). The sample area has people whose form of employment is mainly in the Civil service sector – 214 people employed with another 107 people being self-employed. Of the civil servants, almost 38 per cent had first degrees whilst 17.3 per cent have PhDs. The level of education of the household was known to have an impact on the income level and, subsequently (according to the energy ladder hypothesis) an increase in energy consumption.

Survey results: household income and expenditure

Household income and expenditure are very important as many studies done have attributed energy demand to the income of the household. The energy ladder theory implies that people will only move up the energy ladder when there is an increase in their income. Obtaining data on such is therefore helped this study to test this hypotheis. However, it is important to note that issues centred on household finances are usually viewed with suspicion in Nigeria and it is therefore worth noting that some of the income declared by householders may be inaccurate. The chances, of course, are that the figures are more likely to be underestimated than overestimated, possibly for fear of tax implications.

Figure 2 Distribution of income



Source: Survey results

Figure 2 shows that the highest proportion of the households' income is spent on food (29 per cent). This is followed by energy (27 per cent) and clothing (25 per cent). Further, over 30 per cent of those who are classified as low income earners (N0-29,999) and majority of those who earn over N150, 000 live in duplex houses. It is interesting to note that less than 20 per cent of the sampled size lived in flats. A correlation analysis on these

two factors (household income and type of property) showed that there was no correlation between the two while the median household income level across the types of property is N50, 000-99,000.

Analysis of the data collected from the survey indicates that most households did not use just one form of energy but rather a combination of different types of energy for different purposes. For instance, a household may use electricity for lighting and cooling but use kerosene or gas mainly for cooking. The survey also revealed that the issue of availability was the most important factor to be considered when it comes to deciding whether to change from one energy type to another. This factor ranked highest with about 72 per cent followed by the issue of convenience (69 per cent). Other factors considered in making such decision include: efficiency (58 per cent), cost (52 per cent and marketing (29 per cent) in order for the respondents to switch from one energy type to another. In terms of deciding on a choice of fuel, respondents indicated that the following factors would be considered: the availability of the fuel, the efficiency, convenience and the cost.

4. RESULTS AND DISCUSSIONS

The analysis of the data collected did not show any statistically significant difference between the consumption of any of the energy fuels among the high-income earners and certainly there was not an abandonment of one form of energy in preference to another due to income. When asked about the factors that consumers consider important in choosing a fuel type or what would motivate them in switching fuels, only 10 per cent of the high income earners considered cost as important in choosing a fuel but the biggest motivating factor for them to change is the efficiency of the fuel type. Interestingly, too, the issue of cost was not paramount as a factor for those on low or medium income when choosing a fuel type; rather it is the availability, efficiency and convenience of the fuel that motivates them. The research results show that income is not the sole determining factor for household energy choice and so does not support the energy ladder theory which suggests that energy demand depends entirely on income as people move to more sophisticated form of energy as their income increases.

Use of Ordinal logistic regression

An ordinal regression model was evaluated to identify the determinants of energy choice; that is factors explaining the decision to consume a particular fuel. The ordinal regression was conducted as each of the fuel- kerosene, electricity and gas had three different levels of consumption.

It was discovered that the notion of the energy ladder did not hold in this instance as the increase in income which may have resulted in spending more on electrical appliances leading to increase in energy did not result in any significant corresponding effect. This is contrary to the perception that an increase in income may result into increase in the demand for a particular form of energy or abandoning one fuel for another. In the urban areas, more people tended to consume more electricity than gas or kerosene. Males consumed a higher level of electricity than females but within the sample population,

there were more males that were heads of their households. The analysis also showed that education plays a major role in energy consumption and this study suggested that higher levels of education can be associated with a greater probability of the household using modern fuels. More of those with post-secondary education used more gas than electricity or kerosene. Although the increase in the proportion of income spent on any form of energy did not result in an increase in the number of consumers, the final model generated met the assumptions of the ordinal regression and statistically predicted the dependent variable over and above the intercept-only model. The results, however, did not indicate the use of one form of fuel type to satisfy households' energy needs.

5. CONCLUSION

This study aimed to investigate the importance of factors that contribute to the consumption of energy in households in Nigeria and in so doing, broaden the understanding of the concept of modelling energy consumption in general. The review of causality relationship between energy consumption and economic growth was the first step. A critical review of the literature on the energy modelling showed that econometric approach using orthodox economic theory may not be able to provide satisfactory explanation of the factors that affect the demand or consumption of energy in households in Nigeria as some other important factors are not usually considered with the econometric approach. The characteristics of the energy ladder model and the energy mix model provided the basis for a framework for household energy consumption in Nigeria. Under the assumptions of economic theory, households utilise the concepts of separability and multi-stage budgeting in maximising their utility. As disposable income is a constraint for most households in developing countries, many are inclined to firstly determine how much of their income will be spent on energy and in addition then determine the amount to be spent on the different types of the fuels and the quantity of such fuels.

Although, it had always been possible to forecast the use of energy using an econometric approach, the use of ordinal regression was beneficial as it was possible to analyse the data whilst taking into account that people consume energy at different levels. The strengths of the ordinal regression model lies in its ability to be able to identify significant independent variables that influence the ordinal response analysis for all levels of the ordinal outcome and subsequently evaluate and predict validity of the regression model. The impact of the factors on household energy consumption using data obtained from 501 households confirmed a positive and significant association between the locality of the property, ownership status, age, education status, the expenditure on electricity and consumption of energy.

This research highlighted the importance of the various socio-cultural factors that affects the consumption of energy within the household, and in the same vein, it was able to show that contrary to the hypotheses suggested in the energy ladder model, economic contribution is not the sole determinant in the choice of fuel energy. In addition, that movement to different forms of energy is not necessarily unidirectional and linear in

progression and that movement on the energy ladder does not depend solely on the income of the household. However, only one of the hypotheses was supported suggesting that energy consumption depends on the preferences for particular fuel type. It will also be beneficial if the study is repeated for urban areas separately from peri-urban and rural regions and the results from the different areas compared. Future studies are also required to fully understand the main determinants of energy across the urban and rural regions as this will contribute to assisting the formation of relevant energy policies. It will also be interesting to compare the results of modelling the household energy consumption using different packages and methods in order to be able to establish whether the choice of modelling technique has an impact on results generated from analysis of primary data.

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