Household's Level Fuel Switching in Nigeria

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Abstract
This paper examines the household level fuel switching in Nigeria in the light of energy transition theories. The study used a survey panel data wave 3 based on the General household survey by NBS (2016). The descriptive results show that there is prevalence of different fuel, energy expenditure share and multiple-fuel use patterns among all the income groups. Hence, it is concluded that there is evidence of multiple fuel use in Nigeria in both rural and urban households largely driven by income. Also, Households tend to move towards the use of LPG use as incomes increase. Whereas electrified households tend to use more of alternative fuel (petrol) and also diesel for urban high income. Increase in income leads to increase in LPG use while the opposite trend is observed for electricity expenditure/use. The study therefore, recommends that in terms of household energy demand policy, fuel stacking model should be the appropriate theory to be adopted for Nigeria.

Keywords: *Household Level Fuel Switching*

1 Introduction

Energy consumption is a necessity; it plays an important role in the progress of any nation. Moreover, the growth in energy consumption is associated with various factors such as urbanization, the transfer of mobile factors of production from rural to urban areas, and by the transition of the economy from the consumption of primitive and dirty energy sources to modern and clean sources (Babatunde & Shauaibu, 2009).

The household sector in Nigeria just like other developing economics uses numerous fuel sources mostly traditional whose consumption are induced by their availability, familiarity, effectiveness low or no cost and reliability hence exhibits several patterns (Yaqub, Olateju & Aina, 2005). In rural households, majority of the household rely heavily on traditional energy (fuelwood) as their major source of energy (Busola & Olaniyi, 2012). Although there is prevalence of the other energy sources such as LPG and electricity but at a very low rate while kerosene and charcoal are also used for cooking (Babatunde & Shauaibu, 2009).

Similarly, income is found to be the major determinant of fuel choices among the urban households. Thus, the more it increases the more the households tend to switch to more suitable and cleaner fuels (Bello, 2011). Also, just like the case with the rural households' fuel wood is found to be the most used by the urban households for cooking and food processing/preservation (Onoja & Emodi, 2012). On the contrary, kerosene is reported as the most used fuel for cooking while petrol for lighting homes in the urban areas. This is because majority of the houses are electrified but due to the acute shortage of power supply, about 99% of the households have resorted to use power generating plants in their homes (Olaleye & Akinbode, 2012; & Maina, Dantama & Kyari, 2017).

There are a lot of studies conducted on pattern of energy use as shown by literatures on either rural or urban households. However, to the best knowledge of the present study, very few research was conducted on pattern of energy use in Nigeria, i.e. the study of Maina et al. (2017) covered only Northeast in Nigeria and was silent on the possibility of using multiple fuel among income groups. Hence, in an attempt to find out which energy consumption theory is applicable to Nigeria, this study considers the entire households and to achieve the main aim, two objectives are considered to examine whether there is I) the prevalence of different fuel types in rural and urban households and II) the prevalence of multiple-fuel use among income groups in Nigeria.

2 Literature Review

The major theories underpinning domestic fuels consumption pattern are energy ladder and fuel stacking models. The energy ladder of fuel preferences posits that income level plays an important role in fuel transition from primitive fuel such as biomass to more convenient and modern energy sources such as kerosene, LPG and electricity. Moreover, the model assumes a complete switch from one fuel to another as income changes (Leach, 1992).

Various empirical studies have revealed that households' adoption of modern fuels most times is accompanied by multiple fuel use and a greater total energy demand. This results in households using a group of fuels at a time (Davis, 1998 & Maina, Dantama and Kyari, 2017). Thus, given birth to the second model of energy transition known as the "Fuel Stacking" (Arnold, Kohlin & Persson, 2006). The model further shows that, households do not completely switch to other fuels as the energy ladder posits but choose to consume a portfolio of energy options at different points representing the various combinations of fuels from both lower and upper levels of the ladder depending on availability, convenience and affordability. Moreover, even the promotion of petroleum energy sources doesn't result to the phase out of the traditional fuels. (Maina, *et al*, 2017).

The pattern of fuel use among households in Nigeria shows that fuelwood is the most used for food processing/preservation and ironing cloth (Ojo & Chuffor, 2013; Bello, 2011; Busola & Olaniy, 2012; Onoja & Emodi, 2012). Howevr, Yaqub, Olateju and Aina, and Olalaeye and Akinbode, (2012) reported that the Kerosene is the most used fuel for cooking Similarly, majority of the urban dwellers use a portfolio of fuels at a time while solid fuels are mainly used in rural areas (Tolutope & Ayodele, 2012). Moreover, income is the major factor that determines the types of fuels to be used (Bello, 2011; Onyekuru and Eboh, 2011; Maina, 2018).

With regards to the fuel use among different income groups, kerosene LPG and electricity are found to be the major energy sources of high income households, for middle income households are charcoal, kerosene and LPG while low income households are characterized by wood charcoal and kerosene (Yaqub, Olateju & Aina, 2005). Similarly, fuel wood use tends to decline among employed household heads with higher income while the use for kerosene tends to increase among such households (Onyekuru & Eboh, 2011).

3 Methodology

3.1 Study Area

The study area is Nigeria, it lies between latitudes 4º 12′ 40.37″ N to 13º51′ 36.50 ″ N of the equator and longitudes 2º 45′ 47.735″ E to 14º42′ 55.123″ E of the Greenwich meridian. Located at the extreme inner corner of the Gulf of Guinea on the west coast of Africa, Nigeria occupies an area of 923,768 sq. km (356,669 sq mi), extending 1,127 km (700 mi) East to West and 1,046 km (650 mi) North to South. The country is made up of 36 states and had a combined projected population of 214, 312, 387 as at the end of 2018 (NPC, 2006).

3.2 Data Type and Variables

This study utilized a secondary data set obtained from the database of the National Bureau of Statistics (NBS) on General Household Survey, Panel 2015-2016, drawn from 3530 households, 1389 from the urban and 2149 from the rural households across the country. This study classifies income groups into three Low (earing ₦30, 000 or less), middle (₦ 30001 – ₦ 50000) and high (earning ₦ 50001 or more). The result presented for fuel wood represent wood-users that purchase it because the data used for the study did not include those that fetch from nearby bushes.

3.3 Model Specification and Method of Estimation

3.3.1 Descriptive statistics

The secondary data utilized for this study was large, thus for clarity and precision, descriptive statistics was used to present the results in tables and bar charts. In addition, the two energy transition theories are examined based on the descriptive results obtained.

For a normal distribution, the standard deviation is a very appropriate measure of variability (or spread) of the distribution. If you know a distribution is normal, then knowing its mean and standard deviation tells you exactly which normal distribution you have. However, when the distribution of the continuous variable is not normal, it is recommended to report the median rather than the mean, as median is not affected by extreme values.

Furthermore, because for skewed distribution, the standard deviation gives no information on the asymmetry, interquartile range is a better major spread. Thus, considering a population of over 3000 with poorest, poor, middle, richer and richest households we cannot really assume they are normally distributed and that their pattern would surely revolve around the mean values. Thus the median will be reported here since it is not affected by the extreme values. While the interquartile instead of standard deviation.

4 Results and Analysis

4.1 Prevalence of Different Fuels

The results' presentations are divided into two sections. Firstly, the prevalence of different fuel types among households is examined. This includes the extent to which various fuels are used, including charcoal, grid electricity, fuel wood, diesel, kerosene, LPG and petrol. This is achieved through the percentage of household expenditure on different fuel types. Secondly, the patterns of multiple-fuel usage are explored, given an indication of the extent to which all these fuels are combined in both rural and urban households and among income groups. Table 4.1 and figure 4.1 shows the prevalence fuel used between rural and urban households.

Table 4.1 Prevalence of Different Fuels Among the Urban and Rural Households

Charcoal	4	1
Diesel	1	0
Electricity	21	16
Fuelwood	10	22
Kerosene	37	43
LPG	4	1
Petrol	23	17
Mean	12	12
STDev	13	16
Median	10	16
Interquartile	18	18.5

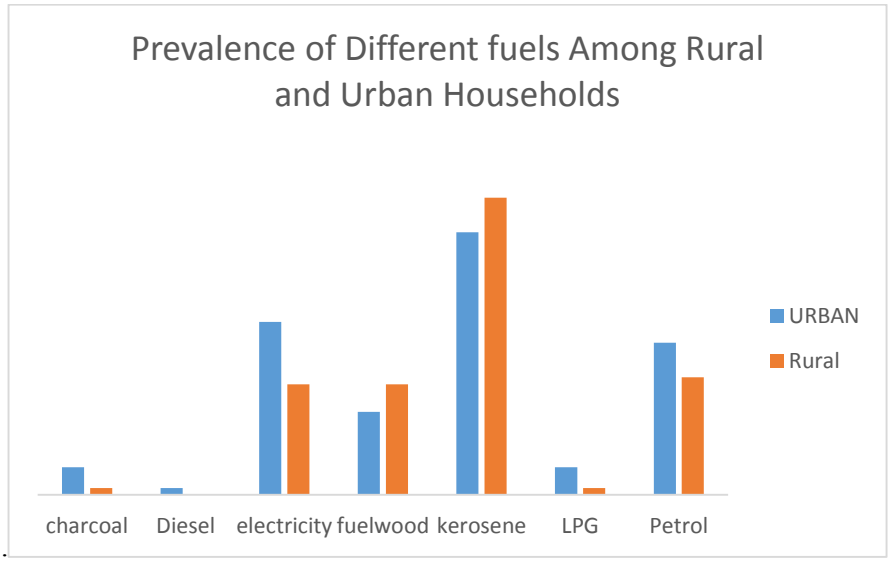
Source: GHG 2016 (NBS Data)

Looking at table 4.1 it can be observed that the two means are the same 12, while their standard deviation vary, with that of urban households been less dispersed compared to that of rural area. This shows the effect of extreme values on the mean. Thus, for better clarification the median is considered which showed different values and different interquartile. Indicating that the rural households' fuels used is more spread out than the urban.

Also it can be observed that the most used fuel in the urban area is kerosene for cooking with 37%, followed by petrol for lighting homes with 23% then electricity with 21%. Fuel wood use on the other hand was low with only 10% while charcoal and LPG were even lower at 4% each and finally diesel use accounted for only 1%.

With regard to the rural households, the pattern of fuel use as presented in table 4.1 for rural households shows that kerosene is also the most used with 43%, followed by fuel wood with 21% of the total energy used by the rural households then petrol for lighting homes accounted for 17%. Electricity use on the other hand was slightly lower than petrol use with 16%. However, there was no record for diesel use among the rural households while LPG and Charcoal recorded only 1% usage respectively. For more visualization of the results figure 4.1 is considered.

Figure 4.1 Prevalence of Different Fuels in Nigeria



Source: GHG 2016 (NBS Data)

Prevalence of different fuels for cooking

The prevalence of a fuel is expressed as the percentage of households using it. However, this indicator does not describe the extent to which households are dependent on a fuel. Hence, in the absence of information to describe the quantities of fuel used, the analysis relies on expenditure on each fuel. Also the explanations of the results are given based on each fuel used.

Kerosene: is one of the most widely used fuels in both rural and urban households with a total of forty-three (43) and thirty-seven (37) (%) respectively of homes reported using it based on their percentage expenditure. This is in line with the findings of (Olaleye and Akinbode, 2012) and contrary to the findings of (Bello, 2011). Although there are some differences in relation to area of residence, it is apparent that the fuel is widely used in all areas. This could be because it is the most acceptable, suitable and convenient fuel for the Nigerian household. Moreover, Kerosene is obviously the safest fuel and has been in existence since time immemorial. Another, implication of the result is with regards to its supply to some extent is efficient that is why is it the most used in both areas.

Fuel-wood: Is found to be the second most used fuel in both rural and urban areas with 22% and 10% respectively based on their expenditure shares. This agrees with the findings of (Maina *et.al*, 2017). It is however, apparent that based on fuel wood expenditure it is also among the top most used fuel for cooking. Thus, this implies that fuel-wood has an important implication for the amount of money that households spend on it.

LPG: The use of LPG was found to be the lowest in both rural and urban households. This finding is in line with previous works such as (Bello, 2011 and Maina *et al*, 2017). Moreover, there is no much difference in terms of use for both the two areas. In contrast, it is contrary to the findings of (Busola and Olaniyi, 2012) that showed higher demand/use for urban area. A lot of factors could be responsible for its low demand. LPG has high installation cost and most Nigerians are living in an extreme poverty. Therefore, they would prefer to use cheaper and convenient fuels.

Charcoal: is also one of the least used cooking fuels in Nigeria with the same percentage as LPG of 4% and 1% for urban and rural households respectively. The low expenditure share agrees with the findings of (Maina *et al*, 2017). Although, charcoal is smokeless, convenient and more affordable than LPG however, a kg of fuel wood produces only 0.25kg, thus making it an expensive fuel.

Prevalence of different fuels for Lighting Homes

Petrol: Is found to be the most used energy source for lighting homes in Nigeria for both urban and rural households with 23% and 17% of their total budget shares for energy respectively. This corresponds with the results for the households in north east region of

Nigeria by (Maina *et.al.* 2017) and for urban households of Lagos state Nigeria by (Olaleye & Akinbode, 2012). The reason for been the highest above any other fuel for lighting homes could be because Nigerian households have been experiencing acute shortage of power supply for years, hence they have been forced to resort to the use of generators for lighting and most of which uses petrol to power their homes.

Electricity: From table 4.1 it can be seen that electricity use accounts for 21% and 16% for urban and rural households respectively. Although electricity is used for both cooking and lighting homes but it usage fell below that of Kerosene, Fuel-wood and petrol. This could be due to the epileptic nature of power supply to households. Therefore, the consumers have lost confidence and they no longer rely on it for domestic uses. This is in line with the findings of (Olaleye & Akinbode, 2012).

Diesel: Although it has been reported by some respondents that they used diesel as their household fuel for lighting homes and also there was an expenditure share recorded against it but it usage appeared to be the least with just1% for urban and non for rural households. This is in line with the result of (Maina, *et al*, 2017). Hence, only the households that actually own big power generating plants that use such fuel allocated an expenditure share for it. However, such type of power generating plant is not very common thus the low usage of diesel as a domestic fuel for lighting.

4.2 The Prevalence of Single or Multiple Fuel use in both Rural and Urban Households and among Income Groups

This section examines the number of fuels used by households at a time whether single or multiple in both rural and urban areas and among the three different income groups categorized by the study. Out of the 1381urban and 2149 rural households studied,1296 and 2112 urban and rural households respectively fell under the category of low income households earning less than or equals to ₦30, 000 monthly. Then 55 and 20 earning between ₦30001 to ₦50000 monthly represented the middle income group in the urban and rural areas respectively while 30 and 17 households represented the high income category earning ₦50, 001 and above. Hence, these classifications were used to assess whether the fuel usage pattern in Nigerian household comply with either the energy ladder or fuel stacking theory. Hence, the results are presented in table 4.2 and figure 4.2.

Table 4.2.1 Frequency (%) of Multiple Fuel Use Among Household

Income Groups	One	Two	Three	More
Low (Urban)	29	40	25	6
Low (Rural)	60	31	8	1
Middle(Urban)	8	34	37	21
Middle (Rural)	25	45	5	25
High (Urban)	3	17	43	37
High (Rural)	44	25	13	19
Mean	28	32	22	18
Median	27	33	19	20
STDev	21	10	16	13
Interquartile	28	7	24	15

Source: GHG 2016 (NBS Data)

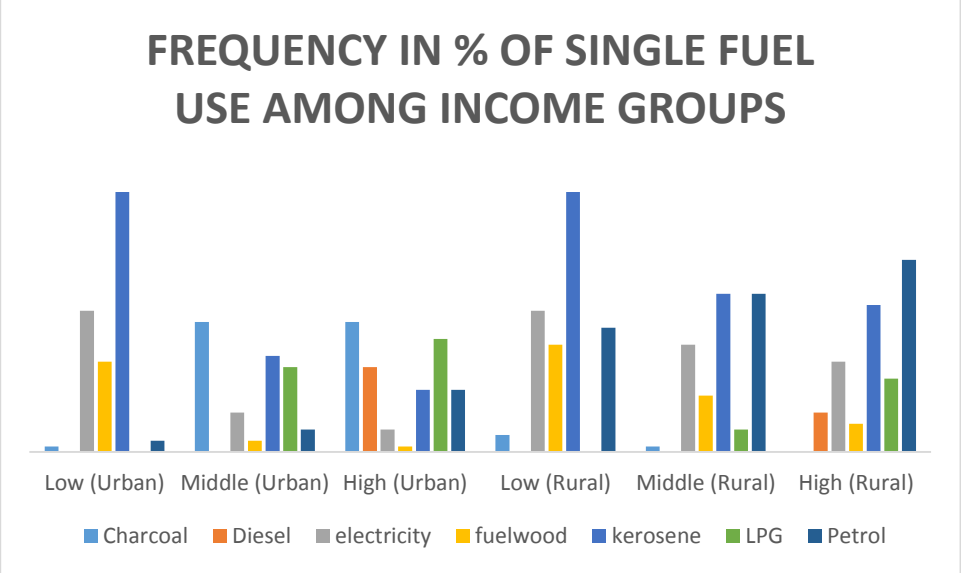
Table 4.2 presents entirely different means, standard deviations medians and interquartile values that vary completely. Thus, these imply that the value that represents households that uses two fuels is less spread out followed by those that use more than three fuels. As for the ones that use one and three fuels at a time are more spread out.

From table 4.2 it can still be observed that about 60% of the low income rural households used only one (single fuel), 31% used double fuels, 8% used triple fuels while only 1% used more than three fuels at a time. Although

majority of them relied heavily on using one fuel but still there is the prevalence of fuel stacking because in total about 40% use two or more fuels at a time. Similarly, about 45% of the middle income in the same residence area used double fuels, 25% used more than three fuels and another 25% used only one fuel. While only 5% used three fuels at a time. Surprisingly a higher share of the high income rural households (44%) used single fuel more than the middle income quartile, while 25% used double fuels, 13% three fuels and 19% used more than three fuels. The trend of fuel usage pattern in the rural area shows the prevalence of fuel stacking among the households in the rural areas of Nigeria. This coincides with the study of (Onyekuru & Eboh, 2011).

The result on the urban households on the other hand shows that he low income urban households are also characterized by multiple fuel use with two fuels users constituting the highest (40%) followed by 29% that used one single fuel, then 25% used three fuel while only 6% used more than three fuel. Similarly, the same trend of multiple fuel use continues in the middle income urban households with about 37% representing those that used three fuels, 34% used two fuels, 21% used three or more while only 8% used one fuel at a time. With regards to high income urban households, the rate of multiple fuel usage increased with those that used three fuels 43% constituting the majority followed by those that used more than three fuels with 37% and a declined share of 17% for double fuel and even with a much lower share of 3% for those that used only a single. Hence, the implication of these results is that the urban households just like the rural exhibited multiple fuel use among all the income groups. To confirm whether the energy transition by fuel type is complied with by the Nigerian households' figure 4.2 is presented.

Table 4.2 Prevalence of Different Fuels among Different Income groups



Source: GHG 2016 (NBS Data)

Figure 4.2 presents the energy transition among income groups. Two major issues are being observed by this figure, Firstly the prevalence of different fuel usage among different income groups and secondly the trend of energy transition.

Prevalence of Fuels among Income Groups: As it can be observed, except for diesel in low and middle income rural and urban households, LPG in low income households of both rural and urban areas as well as Charcoal in the high income urban households all the other energy sources have been used by all the income groups in the two areas of residence. These show that all the households in Nigeria are engaged in fuel stacking for domestic uses. The reason for the usage of diesel by only the high income households irrespective of area of residence relies on the fact the type of the power generating plant that works on diesel is mostly affordable by high income households and therefore it non-use. With regards to the absence of LPG use in the low income households in the two areas could still be attributed to affordability. LPG attracts high installation cost and gas refill. Moreover, charcoal was not used by the high income households. The reason could be because there are other multiple fuels available, affordable and convenient to them hence, it low expenditure share.

Energy Transition: From figure 4.2, there is some interesting transition processes observed. Firstly, all the fuel sources for cooking kerosene, fuelwood and charcoal were found to be declining with increase in income except for LPG which is seen to be increasing with increase in income level. Although the increase in usage is more visible in urban households but in general there is an appreciable rise in the usage as income increases. This shows that as income level of households in Nigeria increases the preferences for LPG also rises.

Secondly on fuels for lighting home, electricity use was found to be higher in low than high income group while the use of petrol is observed to be increasing as income increases. This trend could be linked to the epileptic nature of electricity supply in the country. Most low income household are forced to rely on electricity use despite its epileptic supply state because they cannot afford power generating that use petrol. Thus, the electricity expenditure keeps declining as income increases for higher income urban households because they have been forced to resort to the alternative fuels such as petrol and diesel for only higher income urban households as alternatives.

5 Conclusion and Recommendation

The study examines the household level fuel transition in Nigeria. The results revealed that there is prevalence of seven fuels for domestic energy uses. Also, there is an evidence of multiple fuel use among all the income groups in both urban and rural households but pre dominantly uses single fuel in the rural low income households. Moreover, despite the prevalence of fuel stacking there is evidence of an energy transition largely driven by income. Hence, the study area is characterized by fuel stacking theory not energy ladder as earlier postulated.

Although, it does not involve fuel switch completely but an appreciable change in consumption pattern has been noticed. Households tend to move towards LPG use as incomes increase. Whereas electrified households tend to use more of alternative fuel (petrol) and also diesel for urban high income homes. The results indicated that an increase in income results to increase in LPG use and an opposite effect for electricity.

This study, therefore recommends that in case of household energy demand policy, fuel stacking model should be the appropriate theory to be adopted.

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