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Determinants of investment in energy efficient light bulbs in Lagos residential buildings

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ABSTRACT
Household Investment into energy efficient light bulbs is low in Nigeria despite its proven benefits. This paper seeks to examine the factors determining the decision of households to invest in Compact Fluorescent Lamps (CFLs) and Incandescent bulbs. A multinomial logit model was used to estimate these determinants among 1,253 households in Kosofe and Ikorodu Local Government Areas of Lagos State. The model shows that household decision to invest in energy efficient CFLs is determined by factors such as household income, education level of the household head, presence of a technically skilled person in the household, use of prepaid meter, formally employed household head and male household head. Households that reside in tenement buildings are found to be less likely to invest in CFLs for lighting and number of bulbs in apartment was also found to reduce the odd in favour of investment in energy efficient bulbs. Awareness of energy saving benefits as a factor predicting investment was though found to increase the likelihood of investment in CFLs but not statistically significant. The paper recommends the promotion of energy efficient light bulbs in old buildings as recently built houses have been observed to be using them.

Introduction

Several factors have been identified in literatures as being responsible for household's choice of investment in energy efficiency. These factors include tenure type (Black et al., 1985; Costanzo et al., 1986; Rehdanz, 2007, Nair et al. 2010), age of house (Nair et al. 2010, Gustavsson and Joelsson, 2007), energy cost (Black et.al 1985), previous investment in energy efficiency (Costanzo et al., 1986), geographical location (Nair et al. 2010, Nilsson and Martensson, 2003), socio-demographic factors such as education (Held, 1983; Olsen, 1983; Urge-Vorsatz and Hauff, 2001),household income (Barr et al., 2005; Ruderman et al., 1987;Urge-Vorsatz and Hauff, 2001,Barr et al., 2005; Ruderman et al., 1987), homeowners age (Carlsson-Kanyama et al.,2005; Mahapatra and Gustavsson, 2008), the presence of technically skilled person in the home (Costanzo et al., 1986; Darley and Beninger, 1981) and awareness level of homeowners as regards energy efficiency (Rogers, 2003).

Such investment at household level through retrofitting of residential buildings with compact fluorescent lamps in place of incandescent bulbs has been identified as one of the solutions to the present power crisis in Nigeria (Johnson et al. 2012, Garba, 2009; Community Research and Development Centre, 2009; Adaramola and Oyewola, 2011). With the residential sector accounting for 65% of total consumption of electricity, and lighting being one of the major use, Nigeria stands to make a lot of energy savings from the use of energy saving bulbs. This savings has been estimated to be around 1480MW if the 36 states of the federation and the Federal Capital Territory, Abuja can retrofit 1 million light bulbs each (Johnson et.al 2012). A lot of savings would equally be made by households through substantial reduction in the use of electricity for lighting and consequently lower electricity bills as replacing incandescent bulbs with compact fluorescent lamps can reduce electricity consumption by 67% (Community Research and Development Centre, 2009).

This form of investment into energy efficient lighting in Nigeria is however low despite its huge benefits to households. Majority of residential buildings are currently being lit by incandescent bulbs with very few by CFLs while there are some other buildings using incandescent bulbs and CFLs simultaneously. So many factors could be responsible for this low level of use in residential buildings. Johnson et al. (2012) discovered that the inability of consumers to measure the benefits of CFLs ranks the first among set of factors responsible for its low usage. The study also identified the lack of affordability and high initial cost as the second and third critical factors resulting in low usage of CFLs. The cost of CFLs in the Nigerian market goes for between ₦800 *($5.16) and ₦1300 ($8.39) for a 15 watt bulb (while a 60 watt incandescent bulb is sold for ₦50 ($0.32). Most Nigerians see the bulbs as just a means of getting a variety of "white illumination" instead of using the traditional incandescent bulbs. Some households, most especially living in newly constructed buildings have been observed to use more of CFLs than the incandescent bulbs in recent times. It is however not clear if these households are using CFLs because they are aware of their energy saving potentials or just because they are the latest form of illumination in new residential buildings. The Nigerian household just like any other household as a decision making unit that seeks to maximize its utility from available market options can therefore be said to make its choice from three alternatives. Some

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household use exclusive CFL for lighting, some other rely on exclusive incandescent and so many use a hybrid of CFL and incandescent bulbs. In other words, some household use energy efficient light bulbs only, some others solely use energy inefficient light bulbs while there are others using a mix of energy efficient and energy inefficient light bulbs in their homes.

Recent studies (such as Carlsson-Kanyama and Linden, 2007; Raty and Carlsson-Kanyama, 2010; Barr et. al, 2005; Rehdanz, 2007) that have examined the determinants of investment in energy efficiency in homes are from the temperate climate focusing more on building envelope than on lighting. The settings of these studies have also been in temperate and developed economies with very few in tropical climates and third world countries. This paper seeks to analyse the factors that explain households' decision to invest in energy efficient light bulbs over incandescent bulbs through choice modeling technique. To the best of our knowledge, no known studies have tried to examine these factors as most of the studies that address issues relating to energy efficient lighting in Nigeria have been concentrated on raising awareness about their benefits in terms of cost savings and environmental benefits (Community Research and Development Centre, 2009; Global Environment Facility 2010; Garba, 2009; Adaramola and Oyewola, 2011, Ohunakin, Adaramola and Oyewola, 2011;Unachukwu,2010).

*$1(USD) = ₦155

The next section looks into the determinants of investment in energy efficiency, section two addresses methodology and four deals with the discussion of findings as section 5 presents the conclusion.

Factors Determining Investment in Energy Efficiency

Measures to improve energy efficiency by households have been broadly divided into Investment and non-investment measures. The non-investment measures are typically habitual measures such as switching off lights or appliances when not needed, while investment measures are infrequent or one time measures (Nair et al, 2010). The choice of compact fluorescent lamps (CFLs) for residential lighting is an investment measure due to its infrequent nature and the need to finance it by household. The factors determining household decision to invest in energy efficiency has been identified as personal and contextual factors (Nair et al. 2010; Black et al. 1985).

Personal factors may include homeowner's age, level of education, household income, the presence of technically skilled person in the home and homeowner's awareness of energy efficiency. Contextual factors could be building age, perceived energy cost, past investment in energy efficiency and location. These factors in respect of investment into energy efficiency with regards to compact fluorescent lamp in a developing country like Nigeria are quite peculiar. The contextual factors here could be utility bill per month, type of metering system (pre-paid metering or post-paid metering), apartment type, recency of construction, number of light bulbs in apartment, neighbourhood type (high income or low income) and source of electricity. The personal factors are a range of socio-demographic factors along with other factors such as availability of technically skilled person in the household and level of awareness of energy efficient lighting.

Table 1. Factors that may influence the adoption of CFL in Nigerian homes

Personal factors
-Household income
-Education level of household
-Type of employment
-Gender of household head
-Availability of technically skilled person in the home
-Awareness of energy savings
-Household size
Contextual factors
-Utility bill per month
-Type of metering system
-Apartment type
-Recency of construction
-Number of light bulbs in the house
-Type of neighbourhood
-Source of electricity

Methodology

Questionnaires were self administered to 1500 households in two different areas of Ikorodu and Kosofe Local Government areas of Lagos state. These Local governments were selected because of their characteristics of having a mix of old and recently constructed residential buildings. Ikorodu is an area that has experienced rapid growth in the past ten years due to high influx of population from the metropolitan areas of Lagos. This invasion is characterized by the development of residential buildings on a massive scale by low income earners on incremental basis due to the lack of financial capability to start and finish construction within a short period of time. Most of these buildings are either 2 and 3 bedroom bungalows or tenement buildings with very few detached houses and duplexes. Magodo, a highbrow area in Kosofe Local Government is characterized with tastefully finished residential apartments for the high income class of Mainland Lagos.

750 households with their buildings were expected to be surveyed in each of the two selected areas with the household heads targeted as respondents. A combination of questionnaires and interviews were used in this study. The interviews were conducted on respondents with no formal education most of whom were found in the Ikorodu area. Random sampling technique was employed in selecting the respondents in the two areas. This survey was conducted between the months of February and June 2011, with 584 and 673 questionnaires retrieved from Ikorodu and Magodo respectively. 4 of the returned questionnaires from Ikorodu were found invalid due to partial completion. A total of 1253 questionnaires (580 from Ikorodu and 673 from Magodo) i.e. a response rate of 83.53% were therefore found usable for the estimation of the Multinomial Logit model.

Results and Findings

A total of 703 respondents which is 56.10% of the total number of respondents employ a mixture of CFLs and Incandescent bulbs for lighting in their homes. 14.21% of the respondents use CFL light bulbs exclusively in their homes and this result goes to show the low level of its use in residential buildings in Lagos state and this outcome is similar to Johnson et al (2012) that had 9.6% of its respondents across 5 local governments of Lagos state using CFLs for lighting. A greater majority of this small proportion of respondents using CFLs are located in Magodo (159 respondents) while only few (19 respondents) reside in Ikorodu. This high level of use in Magodo

could be as a result of the affordability of the residents for CFLs due to their high income earning status. Apart from the high affordability of the respondents of this area, most of the buildings in the area have been observed to be designed with energy saving light bulb fittings though it is not clear if this is as a result of the deliberate intention of the residents to be energy efficient.

Table 2. Respondents by the type of bulb used in Ikorodu and Magodo

Ikorodu and Magodo		
Light bulb type	**Frequency**	**Percent**
CFL	178	14.21
Incandescent	372	29.69
CFL and Incandescent	703	56.10
Total	**1253**	**100.00**
Ikorodu		
CFL	19	3.27
Incandescent	336	57.84
CFL and Incandescent	226	38.89
Total	**581**	**100.00**
Magodo		
Light bulb type	**Frequency**	**Percent**
CFL	159	23.66
Incandescent	36	5.36
CFL and Incandescent	477	70.98
Total	**672**	**100.00**

Authors, 2012

This survey also found out that 29.69% of the respondents employ the use of Incandescent bulbs exclusively. Majority of these users are in the Ikorodu sample where they constitute 57.84% of the sample drawn compared to 5.36% of the sample drawn from Magodo. Affordability and high initial cost could also be the major factors here as most of the residents in Ikorodu area are low income earners who spend not less than 15 years in completing their buildings. It is an apriori expectation that households with less economic resources are more eager to save on energy expenditures (Martinsson et. al, 2011), but the situation in the low income area of Ikorodu is such that this group use more of the energy inefficient light bulbs. Greater percentage (56.10%) of the respondents uses combinations of CFLs and Incandescent bulbs for lighting in their homes. This proportion is about 70.98% in Magodo and 38.89% of the respondents in the Ikorodu area. The next section explores the use of discrete choice modeling in determining the factors that predicts the choice of investment in different light bulbs in the two areas.

Model

The decision to invest in the use of energy efficient light bulbs by households can be said to be a choice made between CFLs, incandescent light bulbs and a combination of CFLs and incandescent bulbs. To properly determine the influence of the personal and contextual factors on the choice made between CFLs and Incandescent bulbs, we decided to employ choice modeling in terms of Multinomial Logit model. The Multinomial Logit Model (MLM) is one of the diverse forms of the discrete choice models. It statistically relates the choice made by an individual to the attributes of that person and the attributes of the alternatives available to the choice maker. The alternatives in the Multinomial Logit model go beyond the dichotomous set of alternatives in the Binomial Logit model. If P_i is the probability that a household will choose a type of light bulb and $(1\text{-}P_i)$ is the probability of not choosing it. The odds ratio in favour of choosing a light bulb is therefore

$P_i / 1\text{-}P_{i=} e^z$

Where $z = \beta_1 + \beta_2 X_1$

Log of the odds i.e Log of e^z will therefore give z

$Log\ (Pi/1\text{-}Pi) = z$

$Z = \beta_o + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} \ldots\ldots\ldots\ldots\ldots\ldots \beta_n x_{ni}$

Where P_i = the probability of choosing a light bulb type by household i,

β = coefficient of the covariates (i.e. personal and contextual factors) and slope intercept

The dependent categories in this model include;

1. CFLs only
2. 2.Incandescent only
3. 3.Mixed use of CFLs and incandescent lamps

Table 3. Regressors and their definitions

S/NO	VARIABLE	DEFINITION	EXPECTED SIGNS*
1.	INCMHSLD	Income of household head	+
2.	HSLDSIZE	Household size	+
3.	FORMEMP	Dummy variable 1 if the respondent is formally employed	+
4.	OWNER	Dummy variable 1 if the respondent is a building owner	?
5.	EDULEVEL	Number of years spent in school	+
6.	ELECBILL	Electricity cost per month (Monthly bill)	+
7.	METER	Dummy variable 1 if the respondent uses prepaid meter	+
8.	TENEMENT	Dummy variable 1 if the respondent live in tenement building	?
9.	RECENCY	Dummy variable 1 if the respondent lives in a building less than 5 years old	+
10.	BULBNUM	Number of bulbs in building	+
11.	GENDER	Dummy variable 1 if the respondent is male	+
12.	SKILL	Dummy variable 1 if there is a technically skilled person within the household	+
13.	AWARENESS	Dummy variable 1 if the respondent is aware of the energy saving potential of CFLs	+

* The expected signs are a priori expectations as gleaned from literatures

The estimated Logit model used the third choice of mixed use of incandescent and CFLs as the reference category. The category has the highest frequency and it is the default category which will be used to estimate the determinants of choice for the energy saving CFLs and the Incandescent bulbs. With a Likelihood ratio of 258.563, all the variables are collectively significant. The impacts of the selected personal and contextual factors predicting the choice of CFLs among households in the two study areas are presented on Table 4. Their impacts on the choice of incandescent bulbs are also presented on Table 5.

The choice of Compact fluorescent bulbs (CFLs) is found to be influenced positively by all the variables tested except TENEMENT and BULBNUM as they negatively affected the choice of CFLs. Residence in tenement building reduces the odds in favour of investing in energy saving bulbs by a factor of -2.996. This result is statistically significant with a Wald statistics of 2.655.

Respondents living in tenement houses are therefore less likely to invest in CFLs and this could be due to the high cost of CFLS as most of the households living in tenement buildings in Lagos are low income earners. This group constitutes 80.6 % of urban residential dwellers in Lagos (National Bureau of Statistics, 2009). Most of them live on less than 1 dollar per day and would find it difficult purchasing the energy saving CFLs because of the price of the product. About 70.8% of Nigerians live below the international poverty line of $1 per day (United Nations Development Program, 2007). Inferior CFLs are in the range of ₦100 - ₦150 for 15 watts and standard 60 watts CFLs are in the range of ₦1, 000-₦1, 500. Thus, significant proportion of the household in tenement buildings is not able to afford the cost of purchase and installation of good quality or standard CFLs.

Table 4. Estimation results of the Multinomial Logit of Light bulb choice

Bulb Type CFL	B	Std Error	Wald	exp(B)
Intercept	16.348	5.406	9.146	
INCMHSLD	3.754	2.571	2.132	42.691
HSLDSIZE	0.214	0.987	0.047	1.239
FORMEMP	2.504	1.675	2.234	12.230
OWNER	0.076	1.654	0.002	1.079
EDULEVEL	2.765	1.796	2.371	15.879
ELECTCOST	0.310	0.148	4.387	1.363
METER	0.431	0.208	4.293	1.539
TENEMENT	-2.996	1.839	2.655	0.049
RECENT	1.210	0.640	3.564	3.353
BULBNUM	- 0.771	0.545	2.001	0.463
GENDER	2.541	1.350	3.543	12.692
SKILL	1.765	0.872	4.098	5.842
AWARENESS	0.098	0.085	1.332	1.103

Income of households (INCMHSLD) appears to be one of the major factors predicting the choice of investment in energy efficient light bulbs over the other options among households. An increase in household income by ₦1 increases the odd in favour of choosing the energy saving CFLs by 3.754. This means that high income earners are more likely to use energy efficient light bulbs. The high cost of the light bulbs is apparently not a barrier to the high income group. This result supports the findings of Urge-Vorstaz and Hauff (2001) that argues that ownership of CFLs is higher in households with higher level of income. The highbrow residential areas of Lagos in recent times have been observed to make use of most of these energy efficient bulbs as most of the buildings are designed with luminaries for CFLs. Number of years spent in school by the household head (EDULEVEL) also increases the odd in favour of investment in CFLs by a factor of 2.765. This result is also statistically significant with a Wald statistics of 2.371 and it also supports the argument of Urge-Vorstaz and Hauff (2001). The cost incurred by households from electricity consumption (ELECTCOST) was found to increase the odds in favour of investment in CFLs by a factor of 0.310. This result is also statistically significant and it matches the a priori expectation of the study. This result shows that the higher the monthly electricity bill from the power utility the higher the odds in favour of investment in CFLs. There has been increasing awareness of late most especially among the users of prepaid electricity meters to try and make savings by adopting CFLs for lighting. Detached houses in highbrow areas of Lagos often get higher electricity bills and are more likely to adopt the energy efficient CFLs. Usage of prepaid meter for billing (METER) also increases the odds in favour of investment in Energy efficient light bulbs by 0.431 with a Wald statistics of 4.293. This could be as a result of the tendency for the users of prepaid meters to always want to reduce their consumption as they are more aware of the need to save energy than post paid customers. Recency of construction (RECENT) also increases the odds in favour of investment in CFLs by 1.210 with a Wald statistics of 3.654. Recent buildings in Lagos have been noticed to employ the use of CFLs as the buildings most especially in the highbrow areas are delivered with luminaires for CFLs. Number of bulbs (BULBNUM) in residential buildings was discovered to reduce the odds in favour of investment in energy saving bulbs. This could be due to the high cost of energy saving bulbs which can be prohibitive to most households that use higher bulb numbers. These households particularly the poor ones will not see the rationality behind the purchase of expensive CFLs when the Incandescent bulbs can provide the needed illumination in their homes. The Households where the household head has a higher level of education are more likely to adopt energy efficient bulbs. The low level of CFL use for residential lighting could be associated to the low level of education of the people living in the low income areas. Type of employment of the household head i.e. whether formal or informal also has significant influence on the choice of energy efficient light bulbs. Household heads that are formally employed are more likely to use energy efficient bulbs. The odd in favour of investing in CFLs is increased with Households where the head is male. The odd increases by 2.541 with a wald statistics of 3.543 and the presence of a skilled person within the household increases this odd by 1.765 with a wald of 4.098. The increase in the odd of investing in energy efficient lighting through awareness of energy saving potential is however not significant with a Wald of 1.332.

Table 5. Estimation results of the Multinomial Logit of Light bulb choice

Bulb Type Incandescent	B	Std Error	Wald	exp(B)
Intercept	16.348	5.406	9.146	
INCMHSLD	-0.754	0.532	2.009	0.470
HSLDSIZE	1.214	0.832	2.129	3.037
FORMEMP	0.604	1.002	0.363	1.829
OWNER	0.032	0.015	2.133	1.033
EDULEVEL	-0.715	0.231	9.580	0.489
ELECTCOST	0.121	0.145	0.696	1.129
METER	-0.324	0.153	4.484	0.723
TENEMENT	4.712	1.839	6.565	111.274
RECENT	-1.766	0.640	7.614	0.171
BULBNUM	1.886	1.545	1.490	6.593
GENDER	1.541	1.350	1.303	4.669
SKILL	-1.005	0.572	3.087	0.366
AWARENESS	- 0.021	0.012	3.063	0.979

The odds in favour of investment in incandescent bulbs appear to be reduced with an increase in household income, higher level of education, use of prepaid meter system and presence of technically skilled person within the household as well as awareness of saving potential all reduce to an extent the odds in favour of investment in Incandescent bulbs. Residents of recently constructed buildings also appear less likely to invest in incandescent bulbs.

Conclusion

This study has presented the findings from a questionnaire survey conducted in two different locations in Lagos. It was discovered that the residents of the low income neighbourhood surveyed employed more of the use of energy inefficient incandescent bulbs than the high income neighbourhoods. The multinomial Logit model employed estimated the determinants of household investment in CFLs and Incandescent bulbs. The model shows that household decision to invest in energy efficient CFLs is determined by factors such as household income, education level of the household head, presence of a technically skilled person in the household, use of prepaid meter, formally employed household head and male household head. Households that reside in tenement buildings are found to be less likely to invest in CFLs for lighting and number of bulbs in apartment was also found to reduce the odd in favour of investment in energy efficient bulbs. Awareness of energy saving benefits as a factor predicting investment was though found to increase the likelihood of investment in CFLs but not statistically significant. The results revealed in this study are of great benefit to the three tiers of government in Nigeria. Nigeria governments could use the outcome of the study as a sound platform towards promoting the usage of CFLs in the study areas and in Nigeria as whole. The results also help deepen governments' understandings about the major barriers they

would encounter in promoting the usage of CFLs, so that significant attention and efforts can be devoted to solving them.

Based on the findings, the following recommendations will definitely improve the usage of energy efficient bulbs in the study area and Nigeria as a whole.

Campaigns at promoting energy efficient light bulbs should target low income earners most of whom reside in tenement buildings as shown in the study area. Single room housing of which tenement buildings constitute a major part represents 66.3% of the total number of housing in Nigeria (National Bureau of Statistics, 2009). Substantial energy savings will be made if these households can be encouraged to use more of energy saving bulbs.

The government of Nigeria should encourage the local production of energy saving bulbs as the market is presently dominated by imported CFLs from China. Local production of the product should be subsidized. This subsidy could be in terms of tax holidays for the early years after commencement of production. Nigeria has a viable market for lighting with an estimated population of 154 million and a strong workforce that can support the industry. When these companies are sited here, the cost of the light bulbs will go down considerably to the extent that many poor households can afford to pay the initial cost which in most cases deters them.

This study discovers that new buildings are making use of energy efficient light bulbs which means the older buildings should be targeted for the promotion of investment in energy efficient light bulbs. For a significant reduction in the emission of CO_2 from residential buildings, existing buildings should be targeted (Urge-Vorsatz et al, 2007, Gupta and Chandiwala, 2009). There is need for governments in Nigeria to promote the use of energy efficiency lighting in existing residential building stock as this study has shown that the use is of the bulbs is more prevalent in new buildings.

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