Environmental consciousness and choice of bulb for lighting in a developing country

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Abstract

Background: Most countries in the world especially those in Asia and Africa have been undertaking policies meant to help promote science, technology and innovation towards meeting some provisions of the Sustainable Development Goals. However, there is still a sizable number of households who have not yet fully embraced energy-saving technologies. This study provides highlights on the economic and environmental benefits for investing in energy-saving light bulbs.

Methods: Using a survey and a multistage random sampling approach, we administered questionnaires to 1650 households in Ghana. The relevant diagnostic tests associated with cross-sectional data were undertaken. We estimated a maximum-likelihood probit model with its associated marginal effects to find out how the choice of energy-saving light bulb (behaviour) is influenced by environmental consciousness (both local knowledge and global knowledge) and other demographic factors.

Results: Our results are consistent with economic theory as well as what earlier empirical evidence found in literature. That is, environmental consciousness, education, income, etc. are very important in explaining the choice of buying energy-saving light bulbs in Ghana.

Conclusions: Besides advocating for information that will make society more environmentally conscious, we further recommend the use of fiscal policies (i.e. subsidies) to support lower income brackets who are predominant in developing countries.

Keywords: Environmental consciousness, Environmental attitude, Light bulbs, CFLs, Electricity, Developing countries

Background

Emissions from the energy sector is a key driver of greenhouse gas emissions; howbeit, this is not without its associated impact on climate change. As a result, environmental management and promotion of energy efficiency have gained significant interest in global discourse. For example, in the Sustainable Development Goal (SDG) framework, science, technology and innovation (STI) have been recommended to promote efficient use of resources such as energy. Aside from the environmental impact, efficient utilization of energy (particularly electricity) is important in developing countries, where the sector is characterized by supply shortfalls resulting in intense outages.

In Ghana, for instance, a National Compact Fluorescent Exchange Programme was implemented in 2009 under the auspices of the Ministry of Energy. The primary objective of this programme was to save the nation of about 200–220 MW of electricity which hitherto would have been wasted. This was to be achieved through replacing six million incandescent lamps at zero opportunity cost. An evaluation of this policy in 2008 has shown some level of success. This includes peak load savings of 124 MW or 172.8 GWh/annum (equivalent of US$ 1,179,360), CO_2 savings of about 112,320 tons per annum, mean household income savings of about GH¢31.00 in 25 districts nationwide over 6 months, a reduction of 148,000 barrels of light crude oil for thermal electricity generation, etc. However, this policy was not without its fallouts. A key setback to the implementation of the programme was "inadequate awareness creation on Compact Florescent Lamps (CFLs) technology for household beneficiaries" ([1], p.5). For this and other reasons, some households rejected the CFLs irrespective of the enormous benefits associated

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with it.[1] Given the setbacks, it goes without saying that not all households have adopted this efficient technology hence not using energy-saving light bulbs. Coupled with the economic growth potential of Ghana which was about 14.0% in 2011, one would expect residential lighting consumption to rise in the coming years. We find this as a huge setback which calls for a research that borders on the extent to which environmental consciousness (awareness) can influence consumers' behaviour towards efficient energy use.

The purpose of the study is to find out whether there is still much room to reduce waste as a result of households' behaviour. Thus, our key research question is, "will an environmentally conscious household make a rational choice by buying CFLs that will help reduce waste instead of incandescent bulbs?" This is against the background assumption that consumers are likely to choose wrongly as a result of lack of awareness (see [2]). We posit that enhancing consumers' awareness and consciousness about the environment can help achieve 0% use of alternatives to clean energy-saving light bulbs. So, we hypothesize that environmental consciousness/ awareness through education has a statistically significant positive effect on the consumer's behaviour regarding the choice of electricity light bulbs. The main contribution of this study is to highlight the relevance of environmental consciousness in implementing sustainable energy programmes in developing countries.

First, we would like to acknowledge that there is paucity of literature on environmental consciousness/awareness and the choice of energy-saving light bulbs especially in developing countries. In the case of developed countries, Di Maria et al. [3] used the Urban Institute of Ireland's data to analyze attitudes and perception in their quest to shed light on the light bulb puzzle. In their paper, they first presented the theoretical propositions underlying the subject and further subjected it to empirical testing. They showed the relevance of CFLs by estimating the annual external cost associated with lighting to be about €45–50 billion. They argued further that low energy efficiency of the residential sector makes them responsible for about one third of this cost. Their work showed the relevance of environmental consciousness in adoption decision.

Another study by Ellen [4] asked a simple question: "do we know what we need to know?" In her study, she mainly sought to explore objective and subjective knowledge effects on pro-ecological behaviours and related attitudes. Her study used focus interviews which included 37 area citizens, university employees and students. Two-stage random sampling technique was used for respondents who were at least 18 years. Her results showed that for consumers who are environmentally concerned, their objective knowledge regarding environmental issues is relatively low.

Asilsoy [5] acknowledges that urban residents who are environmentally conscious are expected to exhibit attitudes and behaviours that promote sustainable urbanism. Similarly, Kaynak and Ekşi [6] explored environmental consciousness and its associated effects on attitudes using a sample size of 504. They employed a structural equation model and concluded that environmental consciousness has a positive and significant impact on attitudes.

A more recent study by Sánchez et al. [7] on the topic "Improving Pro-environmental Behaviours in Spain. The Role of Attitudes and Socio-demographic and Political Factors" sought to determine by means of the structural equation model the extent to which socio-demographic, economic and political factors influence people's environmental attitudes vis a vis consumption and purchase behaviour of Spaniards. The authors made use of a survey data in 2007. As part of their findings, they had evidence that factors not limited to the level of environmental information/concern, age and education explain positively variation in pro-environmental-related behaviours.

Schlegelmilch et al. [8] have pointed out that there exist a variety of studies that cut across different disciplines such as psychology, sociology, political science, education,[2] environmental studies and business research that have tried over four decades now to conceptualize and operationalize the construct of "environmental consciousness". So far, the literature has not been able to provide any cast-in-stone definition or measurement that is all encompassing in explaining environmental consciousness. Although Schlegelmilch et al. [8] have summarized the views as expressed by some authors as relatively comprehensive, however, they were quick to have cited Van Liere and Dunlap ([9]: p.653) who have pointed out that none of the "issues [or constructs] reflect equally the broader concept…" In sum, most of the approaches used in the literature have tried to conceptualize environmental consciousness; however, they are subjective and in a way are subjected to criticisms. That notwithstanding, in this paper, we define environmental consciousness as the degree of local or global environmental knowledge acquired by an individual, household or society that informs their environmental behaviour (external) or attitude (internal). Schlegelmilch et al. ([8]: p.4) provides some components of the construct of environmental consciousness to include (1) environmental attitudes [is described by Buttel [10], as "individuals' levels of concern/interest about specific or general aspects of environmental, ecological, or energy-saving phenomena"] and (2) environmentally sensitive behaviour [is described by Brooker [11], as "individuals' past, current and intentional commitment to activities that aim to ameliorate society's negative impact on the natural environment"]. Against this background, we argue that households that are environmentally conscious are likely to

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exhibit some of these components. For example, if a household is environmentally conscious, that household will be more likely to buy an energy-saving light bulb. However, we do not expect a similar behaviour from a household that is not environmentally conscious. Following our conservative definition of environmental consciousness, we acknowledge that in this study the term environmental consciousness is used interchangeably with environmental awareness.

Methods
Data
Household-level data from the Greater Accra Region (GAR) was used for the study. This region (made up of ten districts)[3] is chosen because apart from it being the capital city with high access to electricity, it also dominates the other regions regarding the percentage increase in the share of households. With a total number of 766,955 urban households, we used the Yamane sample size formula as used by Amoah [12] to compute our sample size. Nonetheless, we oversampled in order to harness the benefits associated with large samples. The data was obtained with a standard questionnaire to a multistage random sampling technique of 1650 households with access to electricity from the national grid. This was achieved by dividing the region into ten strata (districts). We further sub-divided each stratum into their respective communities. These communities were listed given the Town and Country Planning list of communities. At the final stage, households in the listed communities were randomly selected and interviewed. One hundred four (104) communities from all the ten districts were used in the survey. The face-to-face survey yielded approximately 99% total response rate. In cases where the household was not willing to participate or absent at the time of visit, the next available household was interviewed.

Before the final drafting of the questionnaire, it was made available for survey experts and some relevant stakeholders to provide some reviews before the final draft. The final draft was presented at a seminar for further comments and inputs. The questionnaire was categorized into sections. Similar to Ghana's standard national survey questionnaire, we began with information to identify the respondent and his/her socio-economic characteristics. Unlike other geographical areas where this method is challenged, this sits well with the people of Ghana. We had another section on general questions about the environment which also included the environmental consciousness questions. The penultimate section asked residential characteristics and choice or preference for attributes of the residence which included the choice of light bulbs used in residence. The last section included questions which allowed us to evaluate our instruments used for the survey. Using 25 field administrators in

2014, the survey lasted for about 3 months (March–May) which included training, pilot survey and data entry. We do not expect the period of the survey to have any influence on the behaviour of households regarding their choice of light bulbs.

Econometric technique
Our dependent variable was obtained from households responding to a survey question: "What type of electricity bulb is your household currently using?" This captures past purchase and current use behaviours as discussed by Brooker [11]. The authors reduced the categories (similar to [13])[4] into households who reported to be using *energy-saving/efficient light bulbs* or *incandescent (energy-inefficient light bulbs)*. The former and latter were coded as 1 and 0, respectively. Given that the region has peak household electricity consumption periods to be mornings (6–10 am) and evenings (6–10 pm), one would expect majority of households to behave rationally and use lights within this period. We admit that our design excludes lights that are switched on occasionally as it may not be consistent with observed rational behaviour. Indeed, the binary series provided the opportunity to use a probit model given the binary nature of the dependent variable. In line with Di Maria et al. [3], we specify our probit model (as Eq. 1) which indicates the probability of choosing a light bulb which could either be an energy-saving light bulb or an energy-inefficient light bulb as a function of environmental consciousness (i.e. a vector) and controls. These controls include logarithm of income, gender (male), logarithm of rent per month, education and district dummies.

$$P(Bulb\ Choice[y] = 1|X) \\ = f\left(\beta_0 + \beta_1 Env.Cosciousness + \beta_2\ Controls\right) \quad (1)$$

The log-likelihood function of our probit model is also specified as:

$$LogL = \left[\sum_{i=1}^{n}\left[y_i\ \ln\left(\Phi(\beta_0 + \beta_0 X_i)\right) + (1-y_i)\right]\right. \\ \left. \ln\left(1-\Phi(\beta_0 + \beta_1 X_i)\right)\right] \quad (2)$$

Given that the index of the coefficient of the probit model is different from the marginal effects, we present the marginal effect of our probit model as Eq. 3:

$$\frac{\partial E(y_i|x_i)}{\partial x_i} = \left\{\frac{dF[\beta' x_i]}{d(\beta' x_i)}\right\}\beta_i \quad (3)$$

Our variable of interest which is environmental consciousness was disaggregated into two categories, namely *international (inter.)/global knowledge* and *local knowledge*. Regarding the former, the question asked was "[w]hich of

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the following international environmental issues do you know of?" The main options available to the respondent included global warming/greenhouse gases, climate change, Kyoto Protocol... Respondents were to choose YES if they had knowledge of the option provided and NO if otherwise. For the latter, the question asked was "[m]ention any National/District/Local environmental law/policy/practice you know of?" Respondents who were able to mention any were deemed to have knowledge (YES) and the reverse is true. Thereafter, the principal component analysis (see Appendix) was used to select which of the variables to use as the proxy. Further, we conducted a parametric test (see Tables 4 and 5 in Appendix) of household choice of light bulb by our variables of interest (i.e. local and international). In both cases, we found a statistically significant difference between the choices and environmental knowledge. We acknowledge that the binary option is to a larger extent limited relative to ordinal series. Nonetheless, it does not erode the validity of our conclusion. These variables of interest and other controls used in the model are descriptively presented in Table 1.

From Table 1, the average number of people using energy-saving light bulbs is about 86%, a figure that confirms the significant impact of the light bulb exchange programme as reported by the Ministry of Energy in 2011. To buttress our finding, the United Nations Environment Programme (UNEP) [14] has reported a survey conducted on Ghana in 2009 that penetration of energy-saving light bulbs has increased from 3 to 79%. Sixty-one percent and 56% had knowledge about climate change and domestic environmental policy respectively. This suggests that although a greater fraction of the respondents have knowledge about the environment, quite a good number are also ignorant which requires more education on environmental or green-related matters. The reported households' average monthly income of GHS 636.37 is quite close to the GHS5 44 reported for GAR by the Ghana Statistical Service (GSS) in 2008. Household decision making in Ghana is mainly the responsibility of men. It is therefore not surprising that 89% of the respondents are males. Also, the average rent paid by respondents is GHS 140.39 per month. Lastly, we observed that 59% of the respondents were educated.

Diagnostic tests

Table 2 shows the pairwise correlation matrix for all variables used in the econometric model for our estimation. The test shows the correlation coefficient, the associated *p* values (to determine the level of significance) and the total number of observations used for the estimation. Using a *p* value of 1%, we have evidence of no high pair of variables in our model. Stated differently, as given by our evidence, there is no severe multi-collinearity in the model that can affect our variances and co-variances which can also affect the precision of our estimation. However, we acknowledge that the correlation between rent and income reports the highest correlation coefficient of 0.47, yet this is not high enough to inflate our estimates.

Arguably, environmental knowledge (consciousness/awareness) is endogenous as it is likely to be correlated with unobserved and observable determinants of household's behaviour. However, finding a good instrument for environmental knowledge is an empirical challenge due to data constraints. This poses a challenge to the causal identification of the impact of the environmental knowledge on the households' behaviour. Hence, our estimates should be interpreted as association/correlation rather than causal (see [15]).

Additional diagnostic tests were conducted on the model. Thus, the probit model was estimated with robust standard errors which control for possible heteroscedasticity in the model. Furthermore, we included all district dummies (with district 10 as the reference category) to cater for possible differences or unobserved heterogeneity amongst the districts (see [16, 17]). Against this background, we are confident of our estimates as presented in Table 3.

Table 1 Descriptive statistics

Variables	Description	Obs.	Mean [%]	Std. dev.	Min	Max
*Choice of light bulbs (choice)	Energy-saving light bulbs only=1, otherwise=0	1604	0.87 [87%]	0.34	0	1
*Inter. knowledge	Yes=1, no=0	1604	0.61 [61%]	0.49	0	1
*Dom. env. knowledge	Yes=1, no=0	1604	0.56 [56%]	0.50	0	1
Household income	Amount in Ghana Cedis (GHS)	1604	636.37	581.35	160	4400
Household income (log)	Amount in Ghana Cedis (GHS)	1604	6.13	0.78	5.08	8.39
Male	Male=1, female=0	1604	0.89 [89%]	0.32	0	1
Rent per month	Amount in Ghana Cedis (GHS)	1604	140.39	176.00	10	1000
Rent per month (log)	Amount in Ghana Cedis (GHS)	1604	4.41	0.98	2.30	6.91
Education	Educated=1, not educated=0	1604	0.59 [59%]	0.49	0	1

Obs. observations
*More description of these key variables are provided in the "Econometric technique" section

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Table 2 Pairwise correlation matrix

	Choice	Int. knowl	Loc. knowl	HH income	Male	Rent	Education
Choice	1.0000						
p values	–						
Obs	1604						
Int. knowl	0.1098*	1.0000					
p values	0.0000						
Obs	1604	1604					
Loc. knowl	0.0550	0.2283*	1.0000				
p values	0.0277	0.0000	–				
Obs	1604	1604	1604				
HH income (log)	0.1182*	0.0423	− 0.0034	1.0000			
p values	0.0000	0.0900	0.8931	–			
Obs	1604	1604	1604	1604			
Male	0.0461	− 0.0983*	− 0.1624*	− 0.0218	1.0000		
p values	0.0648	0.0000	0.0000	0.3819	–		
Obs	1604	1604	1604	1604	1604		
Rent (log)	0.1349*	0.1781*	0.0767*	0.4739*	− 0.1276*	1.0000	
p values	0.0000	0.0000	0.0021	0.0000	0.0000	–	
Obs	1604	1604	1604	1604	1604	1604	
Education	0.0969*	0.1490*	0.0647*	0.2557*	− 0.0231	0.2458*	1.0000
p values	0.0001	0.0000	0.0095	0.0000	0.3558	0.0000	–
Obs	1604	1604	1604	1604	1604	1604	1604

*$p < 0.01$

Table 3 Regression results

	(1) Probit regression	(2) Probit regression
VARIABLES	Coefficients	Marginal effects
Environmental consciousness/knowledge		
International env. knowledge (dummy)	0.27*** (0.089)	0.06*** (0.019)
Local/domestic env. knowledge (dummy)	0.15* (0.090)	0.03* (0.018)
Controls		
HH income (log)	0.15** (0.059)	0.03** (0.012)
Male	0.37*** (0.128)	0.09** (0.034)
Rent per month (log)	0.14*** (0.054)	0.03*** (0.010)
Education (dummy)	0.14* (0.084)	0.03* (0.016)
Constant	−1.34*** (0.405)	
District dummies	Yes	Yes
Wald chi^2 (15)	73***	
Log pseudolikelihood	− 584.03	
AIC (df = 16)		1200.051
BIC (df = 16)		1286.135
Observations	1604[1]	1604

Dependent variable is the choice of bulb for lighting responses. Robust standard errors are in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

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Results and discussion

From Table 3, we sought to explore the extent to which households' consciousness of the environment will influence their behaviour regarding the choice of bulb for lighting. To achieve this, we created a dummy variable which was coded as 1 for those households who as of the time of the interview were using only energy-saving bulbs in their residence and 0 for those who were either combining incandescent bulbs with energy-saving bulbs or using only incandescent bulbs. This binary variable representing responses of the choice of bulb for lighting in residences by the household was used as the dependent variable. Given that the dependent variable is binary, we used both the *probit and dprobit* commands in STATA 14 to estimate the probit and marginal effect models, respectively. In this study, we explained environmental consciousness which is our variable of interest with knowledge of the environment. This is represented in two forms, namely local (domestic) environmental consciousness and international (global) environmental consciousness. We proxy the former with knowledge of domestic environmental issues (i.e. laws) and the latter with knowledge of climate change. In line with a priori expectation, we find environmental consciousness variables to be positive and statistically significant in explaining changes in the choice of light bulbs. Basing our analysis on the marginal effects in order to explore possible marginal effects, we observe that the parameter estimate for knowledge of climate change is 0.06, suggesting that if knowledge of climate change rises from zero to one, the probability of choosing an energy-efficient bulb for lighting will rise by 6%. Also, the parameter estimate for domestic environmental knowledge is 0.03, implying that the probability of choosing an energy-efficient bulb for lighting will rise by 3% if knowledge of domestic environmental laws (or issues) rises from zero to one. This suggests that towards achieving efficient energy choices, one way by which households' behaviour can be in line with energy efficient choices somewhat depends on the extent to which they are environmentally conscious or informed.

In order to deal with biases associated with misspecification of our model, we introduced several control variables. These include income, male (gender), rent, education and district dummies. Except for district dummies, all other control variables were found to be positive and statistically significant.

In line with the consumer demand theory, income of the household was introduced in the model to capture the wealth of the household. With this, we expected that wealthy households will be willing to spend a fraction of their wealth to promote efficient energy choice. Consistent with our expectation vis-a-vis sign and significance, the marginal effect of 0.03 suggests that if income of the household rises by 1%, the probability of the household willing to choose an energy-saving light bulb will increase by 3%. This implies that consumers' choice for energy-saving light bulbs is also influenced by income levels. Thus, higher income households are more likely to purchase energy-saving light bulbs, relative to lower income households. This is in line with studies such as Bertoldi and Atanasiu [18] and Di Maria et al. [3] that have shown that financial constraints and affordability counts in choosing energy-saving light bulbs.

Also, we expected that different physiological characteristics may influence consumer behaviour. So, we introduced gender into our model to evaluate the extent to which it will determine the choice of light bulbs. We found that males have a higher probability of choosing energy-saving light bulbs relative to females. Specifically, being a male compared to a female is associated with a 9% chance of choosing an energy-saving light bulb. This could be justified by the fact that in most African countries men are predominantly responsible for paying utility bills such as electricity and water among others. By this, one would expect the man to greatly influence the choice of light bulbs in their residence.

In the literature (see [19]), the size of residence has been used as a control variable. Similarly, in this study, we use the value of the residence rather than the size, as the value presents a broader picture of the residence than just the size. Generally, one would expect a good and energy-friendly environment to attract higher rent. That is, a residence with energy-saving facilities should be expected to attract higher property or rental value. Given that majority of people in the study area are renters, we included rental value to see its associated effect on consumer behaviour. With a marginal effect of 0.03, we argue that if rental value should increase by 1% the probability that the household will choose an energy-saving light bulb is 3%. Indeed, we have evidence that higher rental value properties are more likely to buy energy-saving light bulbs.

Education is considered in literature (see [3, 20][5]) as an important variable that explains consumers' adoption decision. This helps consumers to predict almost correctly if not correctly the cost associated with using either an incandescent bulb or an energy-saving light bulb. Our results show a positive and statistically significant relationship between education and choosing to use energy-saving light bulbs in residences. Thus, we report a marginal effect coefficient of 0.03 suggesting that the probability of an educated household choosing an energy-efficient light bulb for lighting is 3% higher than an uneducated household. This finding is in line with construct validity.

Conclusions

This study provides highlights that the economic and environmental benefits for investing in energy-saving

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light bulbs cannot be overemphasized. It is an undoubted fact that much is expected from developing countries especially those in Africa and Asia. Amoah et al. [21] have substantiated this claim by arguing that Africa and Asia consist of 95% of the 1.4 billion people lacking access to electricity. However, we acknowledge that, indeed, some developing countries (e.g. Cuba, Venezuela, China, Thailand, Philippines, India, Egypt, Senegal, Ghana, etc.) have embarked on several policy measures towards expanding access to and adoption of efficient and sustainable clean energy use. A regional report on "Efficient Lighting in Sub-Saharan African [SSA] Countries" has shown that several countries have demonstrated high social acceptance for energy-efficient lighting technologies. For example, the report mentions that "[in] the survey conducted in Senegal, 95% of users were willing to adopt efficient technology" ([14], pg. 58). This follows a legislation in 2011, promoting energy-saving lighting. Also, Mexico is reported to have achieved energy efficiency, and one major reason underlying this achievement is attributed to the adoption of energy-saving light bulbs (see [22]). This is in line with the 86% shown by this study and the 79% reported by UNEP [14] on Ghana.

However, some of these developing countries, particularly Ghana, have not been able to expand its adoption to a hundred percent coverage in spite of conscious policy initiatives. This is observed to be the case because low income is a challenge to the adoption of new technology.

We hypothesize that environmental consciousness, awareness through education and subsidies to lower income groups can help expand use of energy-saving light bulbs in Ghana.

In this study, we used a representative sample of 1650 households. First, we undertook a series of diagnostic tests that are relevant in cross-sectional data analysis. Evidence from our empirical model estimation which is consistent with theoretical and existing empirical evidence suggests that environmental consciousness is one of the determinants in explaining the choice of light bulbs by households. In addition, we find demographic control variables such as education, income, rent and gender (male) having a positive and significant effect on choice.

By way of comparison, we acknowledge that the initial cost of buying energy-saving light bulbs is higher relative to its alternative. This has been a discouraging factor to majority of the people in developing countries whose income levels are generally very low. We propose to policy makers that given the fact that environmental consciousness and education are both relevant to consumers' behaviour, we recommend the use of these instruments to better inform households about the economic and environmental gains associated with energy-saving technologies. As advocated by Di Maria et al. [3] for developed countries, so do we advocate for developing countries. That is, "[t]he

introduction of clearer energy labels, educational campaigns aimed at teaching consumers how to read them, or simply agreements with supermarkets and other retailers to clearly indicate the average cost *per lumen* of different types of light-bulbs, as commonly done for other products, would all speed the adoption of CFL's" (p.12). What needs to be stressed is the fact that the energy-saving technologies may be associated with higher initial costs but with time it is more cost efficient compared to energy costly technologies. Also, given that income is very sensitive to consumers' choice, we recommend governments' continual intervention through subsidies in making energy-saving technologies cheaper for adopters.

Endnotes

[1]See Bertoldi and Atanasiu [18] and Di Maria et al. [3] for benefits of CFLs.

[2]Education is not part of the disciplines mentioned in Schlegelmilch et al. [8]

[3]After the data collection, the districts have now been expanded to 16. Note: All ten districts were used.

[4]This study adopted only the second step used by Scott and Willits [13]. In their approach, they first used Dunlap and Van Liere's [23] approach with 12 items and further reduced the categories into three for easiness of analysis and descriptive purposes.

[5]This article was originally printed in 1978 by the Journal of Environmental Education. Therefore, the original reference has been used.

Appendix

Table 4 Principal component analysis/correlation

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	*1.75838*	0.946621	0.5861	0.5861
Comp2	0.811754	0.381883	0.2706	0.8567
Comp3	0.429871	.	0.1433	1.0000

No. of observations 1641, number of components = 3, trace = 3, rho = 1

Table 5 Principal component (eigenvectors)

Variable	Comp1	Comp2	Comp3
Knowledge of climate change	*0.6052*	− 0.4676	0.6442
Knowledge of Kyoto Protocol	0.4626	0.8652	0.1934
Knowledge of global warming	0.6049	− 0.1809	− 0.6399

*The other category was excluded as it basically repeated any of the items in the description

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Table 6 *T* test of choice of light bulb responses by international knowledge

Group (knowledge of climate change)	Obs.	Mean	Std. err.	Std. dev.	[95% conf. interval]	
No	620	.8209677	.0154093	.3836889	.7907069	.8512286
Yes	984	.8973577	.0096799	.3036454	.8783622	.9163533
Combined	1604	.8678304	.0084589	.3387807	.8512387	.8844222
Difference		− .07639	.0172714		− .1102669	− .0425131
diff = mean(0) − mean(1)					*t* = − 4.4229	
Ho: diff = 0					Degrees of freedom = 1602	
Ha: diff < 0		Ha: diff! = 0			Ha: diff > 0	
Pr(*T* < *t*) = 0.0000		Pr(|*T*| > |*t*|) = 0.0000			Pr(*T* > *t*) = 1.0000	

Table 7 *T* test of choice of light bulb responses by local knowledge

Group (local knowledge)	Obs.	Mean	Std. err.	Std. dev.	[95% conf. interval]	
No	705	.8468085	.0135745	.3604277	.8201572	.8734598
Yes	899	.8843159	.0106734	.3200238	.8633682	.9052636
Combined	1604	.8678304	.0084589	.3387807	.8512387	.8844222
Difference		− .0375074	.0170226		− .0708962	− .0041186
diff = mean(0) − mean(1)					*t* = − 2.2034	
Ho: diff = 0					Degrees of freedom = 1602	
Ha: diff < 0		Ha: diff! = 0			Ha: diff > 0	
Pr(*T* < *t*) = 0.0139		Pr(|*T*| > |*t*|) = 0.0277			Pr(*T* > *t*) = 0.9861	

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