

Original Research Article

CONSUMER WILLINGNESS TO PAY FOR ENERGY EFFICIENT REFRIGERATORS IN NAIROBI CITY COUNTY, KENYA

ABSTRACT

In Kenya, consumer choice of home energy appliances such as refrigerators can offer significant contributions to achieving energy efficiency and environmental conservation. The Kenya Energy Star Rating Label provides consumer with the energy usage information of an appliance in kWh/year. This study examined how the Kenya Energy Star rating label affected consumer choices for refrigerators. Stratified random sampling was used to select 330 respondents across five constituencies Nairobi County, Kenya. The study used a combination of two conditional and mixed logit models. There was a significant positive relationship at $P = .05$ between the Kenyan Energy Star Rating label and consumer preference for energy-efficient refrigerators across all models. The results show that consumers are willing to pay an average premium of 28, 708.5 Kenyan shillings for refrigerators that have been the Kenyan Energy Star Rating label. Additionally, the results provide evidence that consumers preference for energy-saving appliances has a positive effect on consumer preference for energy-labelled appliances. The results of this study have policy implication towards educating Kenyan consumers on the environmental benefits of energy-efficient appliances.

Comment [CNC1]: More insight need to be made on the methodology. From which population was the 330 respondents chosen. Why did you make use of stratified sampling method

Keywords: Energy-Efficiency; Household Appliance Efficiency; Consumer Willingness to Pay; Discrete Choices; Environmental Concern

1 INTRODUCTION

Old and inefficient refrigerators pose a significant financial burden on households across Kenya. These outdated appliances not only consume electricity driving up monthly utility bills but also strain the power grids and conversely lead to increased emission of greenhouse gases. On average, residential appliances account for up to 19 % of the global primary residential energy use and are listed among the top six CO₂ emitting end uses contributing an estimated 6 % in global CO₂ emission [1]. The wide-spread adoption of energy efficient appliances and equipment's can help manage its energy demand and reduce greenhouse gas emission in a cost-effective way. Energy efficiency is regarded as one of the most affordable ways countries can reduce capital investment in new power supply, expand electricity access and reduce environmental pollution [2]. In this regard, the energy efficiency of household appliances is critical towards helping Kenyan consumers reduce their electricity cost. Additionally, the adoption and use of energy efficient appliances across Kenyan household is an effective way to manage the growing energy demand and reduce the strain on the power grids (Government of Kenya 2020).

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Energy policies such as Standards and Labelling programmes have proven to be impactful towards enhancing the purchase of energy efficient appliances. As of 2021, up to 120 countries had implemented National Energy Efficiency Standards and Labelling programmes for appliances. Currently, S&L programmes globally cover more than 100 types of appliances in the commercial, industrial and residential sectors (Bennich, et al. 2022)

In 2016, Kenya's Energy and Petroleum Regulatory Authority (EPRA) developed the Kenyan Standards and Labelling programme for appliances as a policy response tool towards the country's growing energy demand. Kenya's appliance S&L requires importers and suppliers to ensure their

products meet the required minimum energy performance before availing them for sale in the Kenyan market. Currently, ¹the Kenyan Standards and Labelling program covers refrigerators, air-conditioners, motors and lightings.

Kenya's S & L programme is part of a continuing global process that aims at changing consumer behaviour towards sustainable energy use (Pollitt & Shaorshadze, 2013; European Environmental Agency, 2013; Abbotts, 2019). The Kenyan energy label works on influencing consumers by providing them with information on the energy use of an appliance in kWh/year. Notwithstanding their benefits, Africa and largely sub-Saharan Africa is still experiencing a slow uptake of energy efficient technologies (USAID, 2022; Murshed et al., 2022). Since the implementation of the Kenyan Standards and Labelling programme EPRA has been enforcing compliance with the energy-star rating process (EPRA 2020). However, studies have yet to be carried out to examine the degree to which the Kenyan energy-star label has succeeded in influencing consumer preference towards adopting and using energy-efficient refrigerators in urban households in Kenya. Using stated preference method this study sought to understand relations between energy efficiency and consumer willingness to pay for refrigerators and explore consequences that result from residential consumers reception and response to the Kenyan Energy star-rating label.

Consumer preference for household appliances particularly refrigerators have been a popular subject of energy efficiency related research. Revelt and Train (1998) in their study of consumer choices for refrigerators in South Carolina found that customers were willing to part with between USD 2.26 – 2.12 for a 1 USD in energy savings. Similarly, Moxnes (2004) while studying the effects of energy standards on the utility of recent refrigerator owners found that energy efficiency standards increase customers utility. Ward et al. (2011) studied Factors influencing willingness-to-pay for the ENERGY STAR label. The authors found that consumers were on average willing to pay an additional 249.82 – 349.30 for refrigerators that had been awarded the ENERGY STAR label. In Switzerland, Sammer and Wustenhagen (2006) conducted a stated preference experiment via face-to-face interviews with consumers at major retail stores purchasing or in the process of shopping for washing machines. The authors found that consumers were willing to pay 30 % more for products that were A labelled as compared to C labelled products. Likewise, Shen & Saijo (2009) concluded that the Chinese energy label significantly influenced Chinese consumers' purchase decisions for appliances. Their results revealed a WTP of USD 76-89 for a single-step upgrade in a refrigerator's energy efficiency. In summary, these studies show that consumers indicate a high willingness to pay for energy-efficient appliances. According to Wang et al. (2019), consumers that refer to energy labels as a purchase attribute are more likely to buy energy-efficient products. However, there research on the influence of the Kenyan energy star rating label on consumer preference for appliances is piecemeal.

Environmental concern refers to the depth of people's willingness to recognize and actively engage in addressing problems that impact the environment. Several studies highlight environmental concern as a positive factor influencing individuals' willingness to pay for products that make a positive environmental contribution (Albayrak et al., 2013; Chen & Tung, 2014; Chan et al., 2014). General environmental concern and attitudes are found to have a low to moderate association with pro-environmental behaviour in many empirical studies (Bamberg, 2003). For example, Urban and Scancy (2012) argue that establishing environmental policies is likely to enhance investment in energy efficiency. Contrary to the studies mentioned above, Ramayah et al. (2010) and Tan et al. (2017) argue that although consumers may show concern for the environment, this may not necessarily elicit their purchase of energy-efficient appliances. To sum up, there is no consensus on the role of environmental information on energy labels for energy-efficiency decisions. More importantly, evidence of the relationship between environmental concern and consumer preference for energy-efficient appliances is still lacking. This study aims to contribute to these gaps and provide insights for the better designs of energy-efficiency labels for household appliances.

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2 MATERIALS AND METHODS

of a particular appliances and that consumers are motivated to purchase appliances that comparatively consume less energy. Given these, we hypothesized that energy labels positively influence consumer preferences for energy-efficient appliances

H_{a1}: The Kenyan Energy Label has a positive influence on consumer willingness to purchase energy-efficient refrigerators.

2.1 Next, we consider Hypothesis

According to the above literature review, consumers are willing to pay extra amounts for appliances that are energy labeled. Energy labels provide consumer with information on the technical performance the influence of environmental concern on consumer preference for energy-efficient refrigerators. Overall, we expect that consumer environmental concern will have a positive influence on consumer preference for energy-efficient appliances

H_{a2}: Consumer self-rated environmental concern is positively related to willingness to purchase energy-efficient refrigerators.

2.2 Sampling

The sample size of the respondents was 399 households. Stratified random sampling was employed in selecting households for the study. Each of the constituencies provided samples for collection. The following equation was used to calculate the sample size for each sub county:

$$n_i = \frac{n}{N} \times 399$$

Where:

n_i = the sample size in the sub county

n = population of households with refrigerators in the constituency (stratum)

N = total number of households with refrigerators in the 5 constituencies

List 1 : the sample distribution.

Serial No.	Constituency	Population of Households with refrigerators	Representative fraction
1	Embakasi	79,339	123
2	Roysambu	64,466	100
3	Westlands	43,465	68
4	Langata	29,792	46
5	Kasarani	39,671	62
Total		256,733	399

2.3 Data collection

Data was collected across five constituencies in Nairobi County broadly representing the upper-middle and middle-income groups. According to Boucher et al. (2021), refrigerator ownership is common among middle- and high-income earners. Data was collected through an online survey. Respondents were provided with a link to the survey via a personalized email or text. The survey introduction detailed the criteria respondents required to qualify for the study. The researcher visited households in the area and engaged with community organizations and community members to identify eligible households for the survey. Broadly, respondents were required to be above 18 years old, residents of the specified study target areas, own a refrigerator and currently act as household heads. Questionnaires were administered at random in the corresponding constituencies. A total of

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Comment [CNC5]: what is your reason for stratified sampling method. We should also have the population of the study before sampling

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Comment [CNC7]: Out of how many constituencies did you sample 5

330 responses were considered complete and valid for analysis. In our analysis of incomplete surveys in this study, we compared the characteristics of respondents and non-respondents, and we found no significant differences between the two groups. This result suggests that our sample of 330 respondents is representative of the larger population of eligible households within the selected constituencies in Nairobi County.

2.4 Survey design

Questionnaires were designed using the Survey King choice platform. Respondents were presented with questionnaires on the Survey King choice platform, containing six choice sets, each comprising three refrigerators with distinct combinations of attributes: Configuration, Brand, Energy Star Rating, Price, Technology, and Capacity. A no-choice option allowed participants to opt-out if none of the choices matched their preference. To ensure relevance, respondents were instructed to assume compatibility with their current refrigerator space, preferred colour, and design. Prior to questionnaire completion, participants received detailed information about the refrigerator attributes surveyed. Additionally, data on consumer socioeconomic and demographic factors were collected

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2.5 Discrete choice model

The theoretical basis of Discrete Choice Experiments (DCE's) can be attributed to Lancaster's (1966) consumer theory (Ndunda and Mungatana 2013, Hoyos 2010). According to Lancaster (1966), given several options consumers will choose the option with features that satisfy their utility. Consumer n is presented with J alternatives. The utility of consumer n from alternative j can be expressed as:

$$(1) U_{nj} = \beta_n X_{nj} + \varepsilon_{nj}$$

In the context where n represents the decision maker, and i and j denote the available choice options, with U representing utility, x representing explanatory variables or covariates, β representing parameters, and ε denoting the error term, McFadden (1973) states that when estimating equation 1 through a conditional logit model, the likelihood of person n selecting alternative j can be expressed as:

$$(2) \Pi_{nj} = \frac{\exp(\beta' X_{nj})}{\sum_{j=1}^n \exp(\beta' X_{nj})}$$

WTP for the k attribute is expressed as:

$$(1) WTP_k = -\frac{\beta_k}{\beta_p}$$

Where p is price, and k is a non-price attribute.

The conditional logit model is subject to several limitations. It presupposes homogeneous individual preferences (Train, 2003). Moreover, a critical assumption of the model is that unobserved factors are uncorrelated across alternatives and possess identical variances for all options. The current model can be modified by employing a mixed logit. Thus, the equation can be expressed as:

$$(1) U_{nj} = \beta' X_{nj} + \sigma' X_{nj} + \varepsilon_{nj}$$

Where the random coefficient β is decomposed to its mean $\hat{\beta}$ and standard deviation σ , an estimate of WTP for attribute k is expressed as:

$$(2) WTP_k = -\frac{\hat{\beta}_k}{\hat{\beta}_p}$$

The study incorporated conditional and mixed logit models. The conditional logit models included one version with refrigerator attributes exclusively and another version integrating interactions between refrigerator attributes and attitudinal and sociodemographic variables. Likewise, the mixed model encompassed a variant with only refrigerator attributes and another variant incorporating interactions

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between refrigerator attributes and attitudinal and socio demographic variables. Consumers environmental concern was captured using seven questions adopted from Li (2011). We conducted a factor analysis and applied VARIMAX method which revealed three factors. The factors defined three variables

- Consumer perceived efficacy in affecting product design and manufacturing and the ambient environment (PCE)
- Consumer perceived efficacy towards tackling global climate change (TGCC)
- Consumer need for intervening on environmental matters (IEM)

Table1 shows the results of the factor analysis score

Table 1: Rotated factor loadings with reliability score

Factor Index	Factor Weight
perceived efficacy in affecting product design and PCE (Cronbach = 0.68) By selecting appliances that are less harmful to the environment, I communicate to manufacturers the type of appliances they should be producing	0.68 0.77
Consumer perceived efficacy towards tackling global climate change (TGCC) (Cronbach = 0.65) Global climate change is expected to have a discernible negative effect on the environment in which my family and I reside	0.78 0.61
Consumer need for intervening on environmental matters (IEM) (Cronbach = 0.60) We do not need to urgently combat climate change Utilizing electricity generated from renewable sources, such as solar power, represents a constructive approach to mitigating climate change Reducing electricity consumption is the most effective way of countering climate change	0.6 0.73

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Model inputs

The four models featured a varying combination of different variables. In the extended logit models the sociodemographic and attitudinal variables were interacted with the energy label variable. Table 2 shows the variables used across the four models.

Table 2: Model inputs

Variables	Description	Hypothesized sign
Dependent variable Choice	1 if the refrigerator option is chosen, 0 otherwise	NA
Independent Variables Price	70,00 KES, 80,000 KES, 90,00 KES	+
EnergyStarRating(Label)	1 if appliance is energy-star rated, 0 if not	+

Capacity	150 Liters, 250 Liters, 350 Liters, 450 Liters	+
FrenchDoor	1 if French door configuration, 0 if side-by-side	NA
LG	1 if LG, 0 if otherwise	NA
Samsung	1 if Samsung, 0 if otherwise	
WiFi	1 if Wi-Fi enabled, 0 if otherwise	+
ASC	1 if "None" option, 0 if otherwise	NA
Demographic, attitudinal and explanatory Variables		
Age	Respondents' age in years	-
Income	Annual household income in '000' KES	+
ElectricityBill	Average monthly electricity Bill in '000' KES	
PCE	Factor score for perceived consumer efficacy to influence product design	+
TGCC	Factor score for perceived efficacy to tackle climate change	+
IEM	Factor score for Need for intervening on environmental matters	+

3 RESULTS

Respondents age ranged from 18 to 65 and above with an average age of 41. Approximately, 52 % of the respondents were female and 48 were male and up to 56 % had a bachelor degree or higher. Up to 27 % of respondents had average net monthly household incomes of 100, 000 KES or more and up to 32 % had incomes between 60, 000 – 99, 999 KES. Up to 77 % of the respondents had bought their refrigerators first hand and 73 % were involved in the purchase decision. Respondents were requested to indicate if they had previously seen the Kenyan Energy Star Rating label. Approximately 67 % of the respondents had seen the energy label prior to filling the questionnaire with 46 % indicating they had seen the label on an appliance in a retail store. Table 3 to 6 Table represent the results of running the four models

Table 3: Basic conditional logit model

Choice	Coefficient	Std. err.	z	P> z	[95% conf. interval]
Price	-.0000417	3.84e-06	-10.86	0.000	-.0000492 -.0000342
ASC	.174008	.0256508	6.78	0.000	.1237334 .2242826
EnergyStarRating	1.011554	.0802969	12.60	0.000	.8541746 1.168933
FrenchDoor	-.2390061	.0617518	-3.87	0.000	-.3600374 -.1179748

LG	.3791085	.0762647	4.97	0.000	.2296325	.5285845
Samsung	.4349766	.0763768	5.70	0.000	.2852807	.5846725
WiFi	.1159642	.0619423	1.87	0.061	-.0054404	.2373689
Capacity	.1574925	.0277989	5.67	0.000	.1030077	.2119773

Table 4: Extended conditional logit model

Choice	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
Price	-.0000419	3.85e-06	-10.88	0.000	-.0000495	-.0000344
ASC	.1711829	.0257181	6.66	0.000	.1207764	.2215894
EnergyStarRating	1.431976	.3714605	3.85	0.000	.7039268	2.160025
Samsung	.4304326	.0765616	5.62	0.000	.2803746	.5804905
LG	.3798935	.0765077	4.97	0.000	.2299413	.5298458
Capacity	.1585337	.0279145	5.68	0.000	.1038222	.2132452
WiFi	.1101916	.0621502	1.77	0.076	-.0116205	.2320037
FrenchDoor	-.2442451	.0619109	-3.95	0.000	-.3655883	-.1229019
LabelAwareness	-.0637747	.1728195	-0.37	0.712	-.4024946	.2749452
LabelIncome	-.000214	.0002719	-0.79	0.431	-.0007469	.0003188
LabelAge	.0000413	.008557	0.00	0.996	-.0167302	.0168127
LabelIHS	-.0311367	.0343877	-0.91	0.365	-.0985354	.0362619
LabelPCE	-.0238877	.0902527	-0.26	0.791	-.2007798	.1530044
LabelIEM	.0289634	.092786	0.31	0.755	-.1528939	.2108207
LabelTGCC	.2046589	.1051132	1.95	0.052	-.0013593	.410677
LabelEBill	-.0183378	.0724009	-0.25	0.800	-.1602409	.1235653

Table 5: Basic mixed logit model

Choice	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
Mean						
Price	-.0000507	4.65e-06	-10.91	0.000	-.0000599	-.0000416
ASC	.2086794	.0304672	6.85	0.000	.1489648	.268394
EnergyStarRating	1.349849	.1267648	10.65	0.000	1.101394	1.598303
FrenchDoor	-.2561915	.0776925	-3.30	0.001	-.4084661	-.103917
LG	.4139097	.093917	4.41	0.000	.2298358	.5979835
Samsung	.4696941	.1066628	4.40	0.000	.2606389	.6787494
WiFi	.1091217	.0754648	1.45	0.148	-.0387866	.25703
Capacity	.1914177	.0376196	5.09	0.000	.1176846	.2651508
SD						
EnergyStarRating	.9531823	.18787	5.07	0.000	.5849639	1.321401
FrenchDoor	.5135813	.1660114	3.09	0.002	.188205	.8389577
LG	.5516476	.1584803	3.48	0.000	.2410318	.8622633
Samsung	1.006937	.1387303	7.26	0.000	.7350306	1.278844
WiFi	.4036123	.170093	2.37	0.018	.0702361	.7369886
Capacity	.3151125	.0634897	4.96	0.000	.190675	.4395501

Table 6: Extended mixed logit model

Choice	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
Mean						
Price	-.0000512	4.67e-06	-10.96	0.000	-.0000603	-.000042
ASC	.2075041	.0305506	6.79	0.000	.147626	.2673821
LabelAwareness	-.0572659	.2348037	-0.24	0.807	-.5174728	.402941

LabelIncome	-.0010894	.0006843	-1.59	0.111	-.0024307	.0002518
LabelAge	.001938	.0115474	0.17	0.867	-.0206945	.0245706
LabelIHS	-.0423455	.046501	-0.91	0.362	-.1334857	.0487947
LabelPCE	-.0369253	.1212585	-0.30	0.761	-.2745877	.200737
LabelIEM	.0015775	.1249346	0.01	0.990	-.2432899	.2464448
LabelTGCC	.2710561	.1441944	1.88	0.060	-.0115597	.5536719
LabelEBill	-.0552908	.0977514	-0.57	0.572	-.2468801	.1362985
EnergyStarRating	2.100022	.5556945	3.78	0.000	1.010881	3.189163
FrenchDoor	-.2585136	.0778724	-3.32	0.001	-.4111406	-.1058866
LG	.4203613	.0937854	4.48	0.000	.2365452	.6041773
Samsung	.4674695	.1068983	4.37	0.000	.2579528	.6769863
WiFi	.1093266	.0759571	1.44	0.150	-.0395466	.2581997
Capacity	.1909472	.0380322	5.02	0.000	.1164054	.265489
SD						
EnergyStarRating	.9009163	.1943082	4.64	0.000	.5200792	1.281753
FrenchDoor	.512093	.169218	3.03	0.002	.1804318	.8437542
LG	.5345872	.1605409	3.33	0.001	.2199327	.8492416
Samsung	1.010267	.1389981	7.27	0.000	.7378357	1.282698
WiFi	.4185452	.164066	2.55	0.011	.0969818	.7401087
Capacity	.3271436	.0614338	5.33	0.000	.2067356	.4475516

The coefficient for price is negative and significant across all four models suggesting that respondents were sensitive to price changes. The coefficient for the Kenyan Energy Star Rating Label is positive and significant across all four models, suggesting that respondents preferred refrigerators that had been awarded the Kenyan Energy Star Rating Label. The coefficient for capacity was positive and significant which shows that respondents preferred larger capacity refrigerators. The coefficient for Samsung and LG was positive and significant showing that respondents preferred these brands over the base brand (Ramtons). The coefficient for French door was negative and significant across all four models suggesting that respondents preferred refrigerators with the base configuration (side-by-side). The Wi-Fi attribute was not significant across all four models.

Comment [CNC11]: What is the implication of this finding. What is the reason for this

In the mixed logit models, the coefficient for the interaction between energy label and socio demographic variables was not significant. These results differ with those of (LI, 2011). The coefficient for the interaction between energy label and environmental concern was not significant suggesting that respondents were not motivated by the environmental benefits associated with the energy label. These results agree with those of (Asinyaka, 2019) who found no significant relationship between environmental concern and consumer preference for energy-labelled appliances in Ghana. The willingness to pay for the energy star rating label was calculated using the Delta method (Hole, 2007). Estimates of WTP for all of the energy star rating attribute across all four models are presented in are presented in Table 7-9.

Comment [CNC12]: why

Table 7: Estimated willingness to pay for the discrete choice models

Model	Estimated WTP in Kenya Shilling
Basic Conditional Logit	24, 267
Extended Conditional Logit	31, 743
Basic Mixed Logit	26, 605
Extended Mixed Logit	32, 220

On average consumers were willing to pay 28, 708.75 extra for refrigerators that were awarded the Kenya Energy Star Rating Label. The WTP for the mixed logit model was the highest across all models.

Comment [CNC13]: Reason

Akaike Information Criteria (AIC) and the Bayesian Information Criterion (BIC), were used in evaluating the models. In the AIC test, the model with the least or smallest AIC is considered the better. Similarly, in the BIC, the test model with the smallest BIC is considered the better model (Mohammed et al., 2015; Akaike, 1974; Claeskens& Jansen, 2015). Table 8 shows the results of employing the AIC and BIC in evaluating the models. Overall, the extended mixed logit model was the best performing justifying the inclusion of the interaction terms. These results agree with (Ward et al., 2011)

Table 8: Basic conditional vs Basic mixed logit

Model	ll(null)	ll(model)	df	AIC	BIC
Conditional logit Basic	-1966.804	-1753.862	10	3527.725	3593.612
Mixed logit Basic	-1753.862	1717.8	10	3455.6	3521.487

Table 9: Extended Conditional vs Extended mixed logit models

Model	ll(null)	ll(model)	df	AIC	BIC
Conditional logit Extended	-1966.804	-1748.143	10	3516.286	3582.174
Mixed logit Extended	1748.143	-1712.908	10	3445.816	3511.704

4 Conclusion

The result from this study shows that there is a positive relationship between consumer preference for energy-efficient refrigerators and the Kenyan energy star rating label. According to the four models' consumers are willing to pay an extra 24, 267 to 32, 220 Kenya shillings depending on the model for refrigerators with the energy label. Further, the results show that there is no significant relationship between consumer preference for energy-labelled appliances and their environmental concern. The coefficient for the interaction between the energy label and the measures of environmental concern were not significant across all four models suggesting that environmental benefits of the energy label did not necessarily result in respondents' preference for energy-labelled refrigerators. These results suggests that consumers of energy-efficient refrigerators in Kenya consider the energy label in their purchase decision. Further, the results show that it is essential for the Kenyan government among other stakeholders to educate the public on the environmental benefits of energy efficient appliances.

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