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HOUSEHOLD PREFERENCES TOWARDS ENERGY LABELS IN MALAYSIA: A PATHWAY TO SUSTAINABILITY

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Abstract: Using energy labels helps households save on electricity bills and positively impact the environment by guiding informed purchasing decisions and promoting energy-efficient products. This study employs a hypothetical Choice Experiment (CE) to examine how energy efficiency labels influence Malaysian consumer preferences for refrigerators. Using Multinomial logit (MNL) and Mixed logit (ML) models, it analyses key attributes considered by households: Energy star ratings, energy consumption, energy savings (non-monetary attributes), and price (the monetary attribute). Findings reveal that consumers are willing to pay more for refrigerators with high energy-saving attributes, underscoring the significance of energy-efficient choices in reducing monthly energy costs and supporting long-term sustainability. The study highlights the critical role of energy efficiency labels in shaping consumer preferences towards environmentally friendly appliances, contributing to sustainable development. It demonstrates that energy labels are pivotal in promoting energy-efficient products and practices in Malaysia, strongly supporting Goal 7 of the United Nations Sustainable Development Goals (UN SDGs), which emphasises the importance of clean energy, energy efficiency, and sustainable energy access. These findings affirm the value of energy efficiency labels in encouraging sustainable consumer behaviour and fostering an environmentally sustainable and socially inclusive energy landscape.

Keywords: Choice experiment, energy label, energy efficiency, refrigerator, sustainability.

Introduction

The energy-efficient (EE) label is an indispensable tool in promoting energy-efficient technology and is an essential component of energy efficiency policies. The information contained on the label is crucial in communicating the message to different audiences (Ward *et al*., 2011). In addition, the label provides critical information to end consumers, enabling them to make informed decisions when purchasing products. A focus on energy label behaviour is of public interest, as labels can communicate to consumers the sustainability of products, given the growing concern about environmental protection (Zhang & Tao, 2020). Choosing products with an EE label helps consumers reduce energy consumption and utility bills and stops the country from becoming a dumping ground for inefficient electrical appliances (Energy Commission of Malaysia, 2020). The EE label significantly impacts overall energy consumption by electrical appliances.

The pioneering efforts of the United States Environmental Protection Agency (USEPA) and the United States Department of Energy (USDOE) in conducting environmental information programmes have contributed immensely to the success of the EE label. With the increase in awareness of environmental issues, the EE label has become even more critical in ensuring that consumers make energy-efficient choices, reducing energy consumption and greenhouse gas emissions. Since the early 1960s, the EE standard and label have been established in Europe to regulate energy consumption for electrical appliances. However,

the implementation of the EE standard and label could have been more robust. In 2013, this changed when 80 countries adopted the EE standard and label and it has become the most prevalent, straightforward, and effective way of helping consumers purchase household appliances. Displaying operating costs on the EU energy label significantly impacts consumer decision-making (Andor *et al*., 2019). It helps people notice how much they will spend on energy, making the difference between efficiency classes less important; thus, encouraging consumers to choose energy-efficient appliances.

Additionally, consumers' information-seeking and decision-making behaviours are influenced by the information provided on the energy label, especially regarding energy efficiency and savings (Waechter *et al*., 2015). There has been a growing trend toward sustainable consumption in recent years and the importance of energy-efficient appliances has increased significantly. Therefore, the EE label has become even more critical in promoting sustainable consumption and reducing greenhouse gas emissions (International Energy Agency, 2020). As such, policymakers are continuously updating and improving EE standards and label to encourage energy-efficient choices by consumers. The adoption of EE supports various Sustainable Development Goals (SDGs) that are centred on sustainability and climate action. These include Goal 7 which highlights the importance of accessible and clean energy, Goal 12 which prioritises responsible consumption and production, Goal 13 which advocates for climate action, and Goal 17 which underscores the need for partnerships among manufacturers, governments, and consumers to attain these goals.

The objective of this study is to observe household preferences for energy efficiency labels on refrigerators among consumers in Malaysia. By employing the Choice Experiment (CE) method, this study aims to determine the Marginal Willingness to Pay (MWTP) to derive implicit prices for each attribute of the energy label. This method will allow this study to gauge public awareness and valuation of energy labels, offering a novel economic perspective that will add to the existing literature on energy efficiency. The uniqueness of the study lies in its dual focus; that evaluates both the economic value of energy efficiency labels and consumer preferences. This is particularly crucial in Malaysia, where such an in-depth analysis is unprecedented.

This research article findings will equip policymakers with valuable insights to enhance the effectiveness of the national energy efficiency programme. By understanding households' preferences, policymakers can make informed long-term decisions to improve energy labels, aligning them with national policies and ensuring sustainable energy consumption. This study's innovative approach and its context-specific insights offer a significant contribution compared to previous studies, which have largely overlooked the economic value and consumer preference aspects of energy labels in Malaysia. This research article not only fills this gap but also provides actionable data that can drive policy improvements and ultimately help the country achieve its energy efficiency goals.

Literature Review

Research shows that displaying energy labels on household devices like refrigerators, vacuum cleaners, and tumble dryers significantly boosts the purchase of energy-efficient products compared to not having any label (Stadelmann & Schubert, 2018). This shows that energy-efficient labels are an effective tool for encouraging consumers to choose energy-efficient technology. Providing comparable energy consumption and additional energy-related information can increase consumers' willingness to pay (WTP) for energy-efficient technology (Zhou & Bukenya, 2016). When the potential energy savings are small, the effect of disclosing information on consumers' WTP is only moderate. However, if the potential energy savings are substantial, providing information to customers can significantly increase their WTP. The energy label plays a vital role in

assisting consumers in determining the operating expenses of an appliance and selecting the most suitable model based on their budget. It conveys valuable insights into the energy efficiency of appliances.

The label is legally required in many countries and manufacturers must display it prominently on their products (European Union, 2017). This information allows consumers to make informed decisions when purchasing appliances, helping them to save money on energy bills over their lifetime and reduce their carbon footprint. Moreover, this helps reduce incomplete information and limited attention to energy use, significant barriers to purchase energy-efficient appliances (Allcott & Greenstone, 2012; Gillingham & Palmery, 2014; Gerarden *et al*., 2017; Stadelmann & Schubert, 2018). In recent years, there has been a shift towards sustainable consumption and consumers are increasingly interested in the environmental impact of their purchases. The energy label is essential in encouraging sustainable consumption by providing consumers with the necessary information to make informed decisions when purchasing appliances. We must continue to use and enhance the energy label for a more sustainable future.

People are willing to pay more for appliances if they save money on overall energy bills (Aliyu *et al*., 2015). Therefore, the EE label offers numerous benefits, including helping consumers to choose products that use less energy and save their money. Applying the EE label to washing machines can encourage manufacturers to produce more energy-efficient appliances and increase competition in both domestic and international markets (Ahmed *et al*., 2011). Furthermore, the EE label can also catalyse manufacturers into investing in energy-efficient product designs (Ward *et al*., 2011). However, Wang *et al*. (2021) demonstrated that the labelling policy for energy efficiency failed to motivate consumers to adopt environmentally friendly consumption habits in China. Despite the potential 24.47% increase in refrigerator sales due to a higher energy efficiency rating, the product's price can impede the connection between energy efficiency rating and sales.

In recent years, there has been a growing demand for sustainable and energy-efficient products. For instance, the global market for energy-efficient appliances has seen significant growth, with sales increasing by approximately 8% annually between 2015 and 2020 (International Energy Agency, 2021). Manufacturers have made significant advancements in energy-efficient appliances via diligent research and development efforts. Such dedication has led to the creation of new technologies and innovative solutions. One noteworthy example is the emergence of smart appliances that can adapt their energy usage according to usage patterns and tariffs, elevating the market's energy efficiency standards. The EE label plays a crucial role considering the global concern over climate change and the push for environmentally friendly practices. It empowers consumers by providing the necessary information to make informed choices when buying appliances and motivating manufacturers to create more energy-efficient products. The ongoing implementation and enhancement of the EE label is vital for achieving a sustainable future for everyone.

Improvements of Energy-efficient Label in Malaysia

Recently, there has been an increased focus on appliances that are energy-efficient, meaning that they use less energy while still performing well. The Energy Commission (EC) Malaysia oversees evaluating and rating products with the STAR system, which shows their level of compliance with energy efficiency standards as part of the energy efficiency and labelling programme. The EC has been enforcing the Minimum Energy Performance Standards (MEPS) and Electricity Regulations (Amendment, 2012) for various household appliances like refrigerators, televisions, air conditioners, lamps, and fans since May 2014. To be sold in the market, these appliances must meet the MEPS requirements and have at least a

2-star rating, as indicated in Figure 1 (the most recent version with three components, namely QR code, Certificate of Approval (CoA), and year of the rating given or revise). Information in Figure 1 offers the most energy-efficient models when buying appliances.

The 11th Malaysia Plan strengthens improvements and appropriate methods to guarantee efficient energy use in buildings, industries, and homes and supports the MEPS for household appliances (Ministry of Economy, 2015). While the 12th Malaysia Plan details a five-year strategy for the country that focuses on sustainability and economic goals to be executed between 2021 and 2025. The government has implemented various initiatives under its third theme to promote green growth and energy sustainability (Ministry of Economy, 2020). Encouraging households to adopt energy-efficient technologies is one of the aims of appliance standards (Qiu & Kahn, 2019). The labelling provides information about the energy-saving characteristics of appliances and to encourage consumers to purchase more energy-efficient household appliances by disclosing several types of energy information. The effectiveness of energy labels in promoting energy efficiency has been widely studied (Sanchez *et al*., 2008; Andor *et al*., 2019). New labelling schemes have resulted in a considerable increase in the sales of energy-efficient appliances in the Danish market (Bjerregaard, n.d.). Two-thirds of participants are willing to pay at least €30 for a better efficiency class, despite only marginal improvements in energy efficiency (Andor *et al*., 2019).

Stated Preference Method on Energy Label

Studies on stated preferences need to pay more attention to the effect of energy-efficient labels on consumers' willingness to pay. Most of the research articles on consumers' willingness to pay for energy-efficient products have used methods like the Choice Experiment (CE) and the Contingent Valuation method (CVM) that rely on stated preferences. On the other hand, the impact of labelling on consumer decision making has been widely studied in econometric models, discrete choice analysis, and questionnaire-based studies. In questionnaire-based studies, people are asked about their WTP for labelling and higher efficiency (Jain *et al*., 2018).

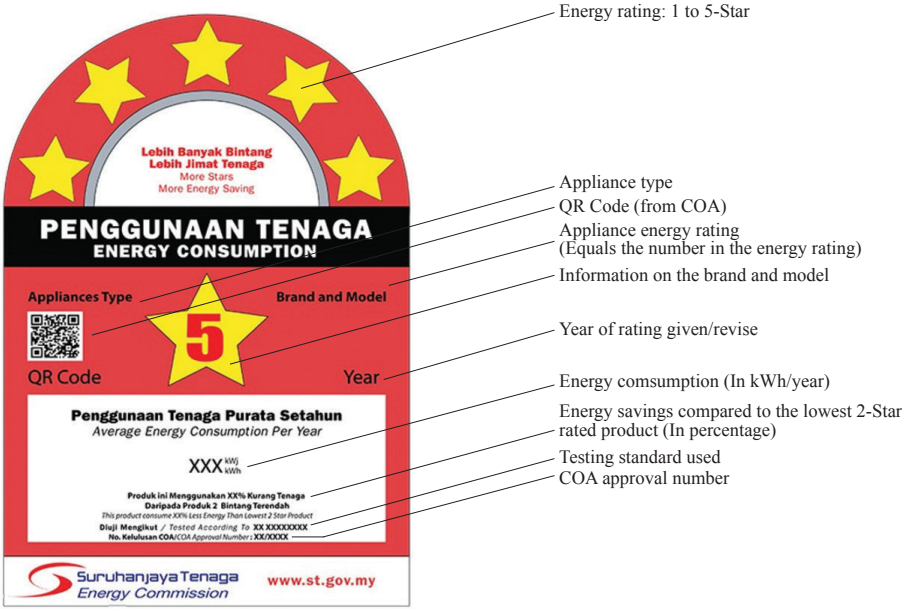

Figure 1: Energy efficiency label in Malaysia

Few studies have used the stated preference in the CVM to assess the impact of the different elements of the energy guide label on consumer choices and household welfare benefits (Newell & Siikamäki, 2014; Davis & Metcalf, 2016). Studies found that specific labelling leads to wiser choices. In addition, consumers prefer to spend about the same overall amount on energy-efficient products. A survey was conducted on consumers' willingness to pay for energy-efficient labels of air conditioners in China, which included collecting data on the brand, purchase price, and energy grade attributes through a discrete choice experiment (Zhou & Bukenya, 2016). The study found that consumers' WTP increased significantly when energy use information was comparable and additional energy-related information was provided. A discrete choice experiment conducted in South Korea found that the implementation of EE labels on household appliances has a significant impact. The study revealed that households favour labelled appliances and are willing to pay a premium price for appliances with EE labels (Jeong & Kim, 2015).

Energy efficiency labels can promote environmentally friendly products. Attitude functions can enhance their influence on air conditioners in countries with moderate income such as Ghana and the Philippines (Kuhn *et al*., 2022). Though these reviews have addressed some significant views of the EE label, there is still little information available in the literature about how Malaysian households perceive the label, which is important in mitigating the effect of climate change and reducing electricity costs.

Research Methodology

This paper conducted a stated preference approach to assess household preferences on energy efficiency (EE) labels on refrigerators. The refrigerators were selected for its prevalence and as it is the most-owned household appliance, it contributed approximately 96% of households in Malaysia (Sentral *et al*., 2014). This study assessed how the EE label that implies the relative efficiency of appliances, affects household preferences by estimating the marginal WTP for each of the attributes on the label. This paper outlines the steps for conducting the CE method: Selecting attributes, designing attribute levels, creating an experimental design, presenting choice set infographic cards to respondents, and analysing the data using a Choice Model. The CE depends on the Random Utility Theory (RUT) which asserts that a consumer's utility is established from the attributes of a product (Lancaster, 1966). Respondents will decide wisely and select for best case scenario, which is utility maximisation. In this study, consumers are expected to make trade-offs between the attributes of the energy label. Thus, the utility of a household is as below:

$$U_{ij} = \beta X_{ijk} + \varepsilon_{ij} \quad (1)$$

where U_{ij} signifies the household's utility from EE label j, X_{ijk} presents the attribute of the EE label j for household i, β is a vector of coefficients which is homogenous among households, and ε_{ij} is a type I extreme value distributed error term. The household's utility related with alternative j is as below:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (2)$$

where V_{ij} is the utility obtained from the EE label attributes and $\boldsymbol{\varepsilon}_{ij}$ is a stochastic component. The following equation represents the likelihood of household i selecting alternative j:

$$P_{ij} = \text{Prob}\,(V_{ij} + \varepsilon_{ij} > V_{is} + \varepsilon_{is}) \quad (3)$$

The probability of household i choosing alternative j can be demonstrated using the multinomial logit (MNL) model as follows:

$$Probij = \frac{e^{vij}}{\sum_{i=1}^{J} e^{vij}} \quad (4)$$

The MNL is described to assess the product attributes that households look for when selecting refrigerators in this study. Respondents have similar preferences and this can be identified (Hensher *et al*., 2005). This hypothesis is related to the random parameter logit model (RPL) which permits heterogeneous preferences among respondents.

Calculation of Marginal Willingness to Pay (MWTP)

Discrete CE generally assesses individuals' preferences with an estimation of marginal willingness to pay according to the amount of money that respondents are willing to pay for a particular product or attribute. The marginal willingness to pay is calculated by dividing the attribute coefficient by the attribute coefficient price, resulting in mathematically marginal rates of substitution (MRS). Hence, it offers the trade-offs individuals are willing to make when choosing between the attributes of the EE label.

$$MWTP_j = V_j/V_p \quad (5)$$

The $MWTP_j$ presents marginal willingness to pay of attribute j, V_j as the coefficient value of EE label's attributes, and V_p presents the coefficient value of the price (monetary) attribute. Respondents prefer the baseline attribute when a negative MWTP value is obtained.

Experimental Design

A suitable selection of number of attributes is vital when conducting the CE. Too many attributes will cause exhaustion and cognitive stress in respondents, whereas it will create a tricky situation in the questionnaire (J. Wang *et al*., 2018). This study offers four attributes with three non-monetary attributes such as energy star, energy consumption, and energy saving and one monetary attribute which is the price of a refrigerator (Table 1). All the attributes are reasonable and technically feasible. This study also proposes a framework that outlines the relationships between household preferences for energy-efficiency labels on refrigerators and attributes like energy stars, energy consumption, energy savings, and the price of refrigerator (Figure 2).

The efficiency of the experimental design of the CE is crucial. It is imperative that each level within an attribute has an identical frequency and that every pair of levels is equally frequent in all attribute combinations. Thus, it is possible to reduce confidence intervals for parameters of interest in selection models and the required sample sizes. An efficient experimental design can confidently generate consistent parameter estimates, even with a smaller sample size (Louviere *et al*., 2010). According to experts, efficient choice experimental designs meet strict criteria for statistical efficiency. This paper presents 192 potential combinations of the three attributes (EStar, ECon, and ESav) with four levels and a price attribute (Price) with three levels (4*4*4*3). This study's design is precisely orthogonal and balanced with regression via STATA Version 16 with suggested 16 choice sets with four blocks.

When people are presented with between 15 and 20 sets of choices, they may become

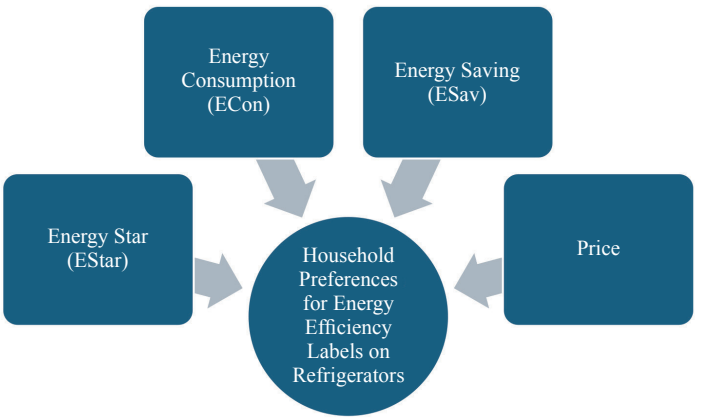

Figure 2: Research framework

Table 1: The energy efficiency label has different attributes and levels

Attributes	Attribute Levels	Descriptions	Regression Coding
Energy Star (EStar)	2-star 3-star 4-star 5-star	Star rating on energy label	EStar1=1; EStar2=0; EStar3=0; EStar4=0 EStar1=0; EStar2=1; EStar3=0; EStar4=0 EStar1=0; EStar2=0; EStar3=1; EStar4=0 EStar1=0; EStar2=0; EStar3=0; EStar4=1
Energy Consumption (ECon)	RM132.70 RM106.20 RM84.92 RM67.98	Average energy consumption cost per year in Ringgit Malaysia (RM)	ECon1=1; ECon2=0; ECon3=0; ECon4=0 ECon1=0; ECon2=1; ECon3=0; ECon4=0 ECon1=0; ECon2=0; ECon3=1; ECon4=0 ECon1=0; ECon2=0; ECon3=0; ECon4=1
Energy Saving (ESav)	No possibility of saving Saved RM26.50 per year Saved RM47.78 per year Saved RM64.72 per year	Total energy savings per year in comparison to the lowest two-star rated products	ESav1=1; ESav2=0; ESav3=0; ESav4=0 ESav1=0; ESav2=1; ESav3=0; ESav4=0 ESav1=0; ESav2=0; ESav3=1; ESav4=0 ESav1=0; ESav2=0; ESav3=0; ESav4=1
Price	RM950 RM1,400 RM2,000	Price of Refrigerator in Ringgit Malaysia (RM)	Price1=1; Price2=0; Price3=0 Price1=0; Price2=1; Price3=0 Price1=0; Price2=0; Price3=1

fatigued and less responsive (Allcott & Greenstone, 2012). In this scenario, three options are available: Choice A, Choice B, and No-option (Table 2). If the condition matches the respondents' actual decision, an opt-out option is added to the choice set based on the RUT (Veldwijk *et al*., 2014). The option to opt-out empowers individuals to choose preferences that align with their true desires without any obligation to select options that do not align with their preferences (Hole, 2007). For instance, as in Table 2, despite the higher price of RM2,000 for Option B compared with RM950 for Option A, respondents prefer Option B, indicating a willingness to pay more for greater energy savings (RM47.78 per year) despite similar energy star ratings and consumption costs. This choice highlights that consumers prioritise long-term energy savings and efficiency over initial costs.

Table 2: An example of a choice set in questionnaire

Attributes	Option A	Option B	
Energy Star	4 Star	4 Star	**No-option**
Energy Consumption	RM106.20	RM106.20	
Energy Saving	Saved RM26.50 per year	Saved RM47.78 per year	
Price	RM950	RM2,000	
Please tick your choice		√	

Sampling Design

The sampling design for this study involved a structured field survey conducted on 799 households in selected rural and urban areas in Malaysia, focusing on the head of households to assess their preferences and awareness of energy efficiency labels on refrigerators. The survey spanned four months from November 2021 to February 2022 and was carried out by five trained enumerators. The survey was administered using a written questionnaire, which the enumerators orally presented to the participants to ensure comprehension and accuracy. Potential biases of this method include a response bias, where respondents might provide socially desirable answers rather than their true preferences and information bias, where the amount and type of information provided to respondents about energy labels and the attributes of refrigerators can affect their choices. Incomplete or overly technical information might lead to misunderstanding or misinterpretation of the attributes.

Additionally, there might be interviewer bias if enumerators administering the survey inadvertently influence respondents through their tone, body language, or explanations and it could bias the results. The enumerators mitigated this by introducing themselves, explaining the research objectives, and seeking informed consent; thereby, fostering a neutral and supportive environment for respondents to provide honest answers. The respondents were deemed adequate as recommended by calculation (Hensher *et al*., 2005). The sample size of 50 respondents and 16 choice sets with fully generic parameter specifications for characteristics without covariate effects was deemed acceptable. The research of this paper have meticulously selected a sample size of 799 respondents, resulting in 3,196 observations. Each respondent was presented with four distinct choice sets, ensuring that the attribute levels, choice cards, and options were suitable for conducting a proper test using the CE method (Johnson & Orme, 2002).

$$N = 500 \text{ x } \frac{L}{AXC} \quad (6)$$

The study used N as the sample size, A for the number of alternatives per choice set excluding the status quo, C presents the number of choice questions, and L presents the maximum number of attribute levels in Equation 6. Equation 6 indicated a minimum requirement of 250 respondents. By including 799 respondents, the study improved its statistical power and reliability. This larger sample size ensures that results are statistically significant and representative of the diverse population preferences.

Results

Table 3 provides a summary of the socio-demographic characteristics of the 799 participants. The data reveals that the survey had a nearly equal distribution of male (45.31%) and female (54.69%) participants. The median age of respondents was 38.24 years, indicating that the survey captured a diverse range of age groups. About 42.93% of the respondents completed intermediate school, while 37.42% of respondents were employed in the private sector. The data also demonstrated that respondents had an average monthly income of RM2,662.00.

Multinomial Logit Model

The multinomial logit model analysis of respondents' choices is presented in Table 4. The model considers coefficients for EStar2, EStar3, EStar4, ECon2, ECon3, ECon4, ESav2, ESav3, and ESav4, indicating positive preferences for energy star, energy consumption, and energy saving characteristics when purchasing refrigerators. These attributes have a high level of significance at 1%. However, as expected, a negative price attribute sign with a 1% significance level indicates that respondents are sensitive to price fluctuations (Ward *et al*., 2011). Respondents exhibit a decreased willingness to pay as the cost of the refrigerator increases, owing to the decrease in their utility. Therefore, it is observed that household preferences decrease as the price of the refrigerator increases. The

Table 3: Profiles of respondents (n = 799)

Characteristics	Number	Percentage (%)
Gender		
Male	362	45.31
Female	437	54.69
Age (years)		
Less than 20	10	1.25
21 – 30	256	32.04
31 – 40	226	28.29
41 – 50	155	19.40
51 – 60	122	15.27
More than 60	30	3.75
Education level		
No education	9	1.13
Elementary school	23	2.88
Intermediate school	343	42.93
Higher school certificate/diploma	214	26.78
Bachelor	189	23.65
Master/PhD	21	2.63
Occupation		
Government employee	183	22.90
Private employee	299	37.42
Business owner	236	29.54
Farmer/fisherman	10	1.25
Retiree/housewife/part-timer	71	8.89
Household earning (RM)		
Less than 2,000	429	53.69
2,001 – 4,000	284	35.54
4,001 – 6,000	44	5.51
6,001 – 8,000	17	2.13
8,001 – 10,000	16	2.00
More than 10,000	9	1.13
Total	**799**	**100**

Note: RM1 is equivalent to USD 0.22, RM denotes Ringgit Malaysia.

significant independent variables at the 1% level indicate strong relationships with the choice outcomes, affirming the model's validity. This discrepancy is common and reflects the complexity and variability in consumer choice data. The log-likelihood improvements further substantiate the model's effectiveness in capturing key influences on consumer decisions.

Table 4 presents EStar2 has a marginal value of 1,863.14 with a positive sign, indicating that an upgrade in the energy star will result in a marginal value of RM1,863.14. EStar3 has a

marginal value of 2,031.34 with a positive sign, indicating that an upgrade in the energy star will result in a marginal value of RM2,031.34. EStar4 has a marginal value of 2,042.15 with a positive sign, indicating that an upgrade in the energy star will result in a marginal value of RM2,042.15. The positive signs were similar to an analysis by Razali *et al*. (2022) that demonstrated preferences among consumers towards the energy labels. ECon2 has marginal value of 1,214.53 with a positive sign, indicating that an upgrade in the energy star will result in the marginal value of RM1,214.53. ECon3 has marginal value of 1,167.46 with a positive sign, indicating that an upgrade in the energy star will result in the marginal value of RM1,167.46. ECon4 has marginal value of 744.532 with a positive sign, indicating that an upgrade in the energy star will result in a marginal value of RM744.532. The finding shows that the energy consumption attribute has a positive relationship with consumer preference for energy labels. This aligns with Kamaludin *et al*. (2021), who found a significant positive relationship for the "energy consumption" attribute, indicating that consumers, including students are more inclined

Table 4: Multinomial logit model (MNL) (Model 1)

Variables	**Coefficient**	**Std. Error**	**z-value**
EStar2	0.61699	0.06859	9.00***
EStar3	0.67269	0.06858	9.81***
EStar4	0.67627	0.06137	11.02***
ECon2	0.40220	0.06532	6.16***
ECon3	0.38661	0.06120	6.32***
ECon4	0.24656	0.06850	3.60***
ESav2	0.98456	0.07004	14.06***
ESav3	1.10927	0.06904	16.07***
ESav4	0.90142	0.05930	15.20***
Price	-0.00033	0.00005153	-6.43***
Marginal values of the attributes: $-\frac{\beta\ attribute}{\beta\ monetary}$			
EStar2	1,863.14	339.6847	5.48***
EStar3	2,031.34	370.4664	5.48***
EStar4	2,042.15	355.6545	5.74***
ECon2	1,214.53	259.0597	4.69***
ECon3	1,167.46	247.5464	4.72***
ECon4	744.532	229.5635	3.24***
ESav2	2,973.10	471.3954	6.31***
ESav3	3,349.69	505.6428	6.62***
ESav4	2,722.05	414.1896	6.57 ***
Number of observations		3,196	
Log-Likelihood		-2,851.33145	
Log-Likelihood, No coefficients		-2,758.1378	
Pseudo R^2		-0.0338	
Adjusted Pseudo R^2		-0.0354	

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

to choose energy-efficient appliances. While, ESav2 has a marginal value of 2,973.10 with a positive sign, indicating that an upgrade in the energy star will result in a marginal value of RM2,973.10. ESav3 has a marginal value of 3,349.69 with a positive sign, indicating that an upgrade in the energy star will result in a marginal value of RM3,349.69. Finally, the marginal value of EStar4 is 2,722.05, with a positive sign indicating that an upgrade in the energy star will result in a marginal value of RM2,722.05. An upgrade in every energy star with a positive sign in the model indicates an increase in utility.

Multinomial Logit Model with Interaction

This study includes socioeconomic attributes to the model as an alternative to improve the model fit and provide heterogeneity in choices (Khan & Zhao, 2019). The recent interactions provide a thorough and accurate examination of household preferences across all levels, supplying a more extensive range of data to aid in making informed decisions. Several socioeconomic and demographic factors can influence the preferences of households (Yusof & Duasa, 2010). Insignificant variables' interactions happened, possibly because the respondents evaluated each attribute separately or the test powers were insufficient to recognise the interactions (Hensher *et al*., 2005; Latinopoulos *et al*., 2018).

Incorporating socio-economic parameters and new interactions improved Model 2's performance. As shown in Table 5, the log-likelihood for Model 2 increased from -2,851.33 to -2,824.61, indicating better performance compared with Model 1. The negative coefficients

Table 5: MNL model with interactions (Model 2)

Variable	Coefficient	p-value
EStar2	0.69644***	0.0000
EStar3	0.57249***	0.0000
EStar4	0.75094***	0.0000
ECon2	0.21360**	0.0107
ECon3	0.24099***	0.0020
ECon4	0.15860**	0.0377
ESav2	1.10877***	0.0002
ESav3	1.12617***	0.0000
ESav4	0.91220***	0.0000
Price	-0.00034***	0.0000
EStar2_Age	-0.01155*	0.0569
EStar3_Male	0.23009**	0.0374
ECon2_Male	0.39954***	0.0004
ECon3_Male	0.30721***	0.0025
Estar2_Job	-0.32321**	0.0128
EStar4_Job	-0.31656***	0.0088
ESav2_HH	0.08268***	0.0070
ECon4_Mar	0.35825***	0.0055
ESav2_Mar	-0.42112**	0.0126

Marginal values of the attributes:: – $\frac{\beta\ attribute}{\beta\ monetary}$

EStar2	2,048.35
EStar3	1,683.79
EStar4	2,208.65
ECon2	628.24
ECon3	708.79
ECon4	466.47
ESav2	3,261.09
ESav3	3,312.26
ESav4	2,682.94
Price	-33.97
EStar2_Age	676.74
EStar3_Male	1,175.12
ECon2_Male	903.56
ECon3_Male	-950.62
EStar2_Job	-931.06
EStar4_Job	243.18
ESav2_HH	1,053.68
ECon4_Mar	-1,238.59
Number of Observations	3,196
Log-likelihood	-2,824.61044
Pseudo R^2	-0.0241
Adjusted Pseudo R^2	-0.0272

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

indicate that households dislike buying refrigerators at high prices, consistent with demand theory, which states that higher prices reduce demand. However, customers tend to prioritise refrigerators with better specifications while being mindful of possible extra costs.

When purchasing a refrigerator, males prioritise energy star ratings and annual energy consumption rates more than females. The positive relationship between male and attribute levels EStar3, ECon2, and ECon3 indicates this. Additionally, EStar2_Job shows a negative relationship with government sector workers having less interest in energy star levels than other sectors. Lastly, respondents with larger households prefer to buy energy-saving refrigerators, as indicated by the positive relationship between household variable ESav2 and ESav2_HH. Married respondents have been found to opt for refrigerators with a lower energy consumption, as per ECon4_Mar. This could be attributed to its ability to help them manage their monthly expenses. However, ESav2_Mar has revealed that married individuals prioritise energy consumption over energy-saving features when choosing a refrigerator. The analysis reveals that socio-demographic factors such as gender, occupation, household size, and marital status significantly influence consumer preferences for energy-efficient refrigerators with each group displaying unique priorities and trade-offs. For instance, young female respondents in China are reported to be more aware of energy savings and knowledgeable about energy labels (Zha *et al*., 2020).

Mixed Logit Model

In Table 6, it states that four variables, namely ESav2, ESav3, ESav4, and Price exhibit a statistical significance of 1% and demonstrate the anticipated directional relationship. The results indicate that ESav3 has a high positive coefficient, indicating that respondents strongly prefer it compared to levels one, two, or four. This shows that the respondents expect an improvement in the energy savings of the refrigerators compared with the current situation but they have low expectations for this attribute. The findings of this study align with Hong *et al*. (2023), who found that consumers prefer higher energy savings and are willing to pay more for appliances with better energy efficiency labels. Furthermore, respondents are less willing to pay a higher price for a refrigerator following the lower utility, as shown by the significant 1% price decrease. This finding demonstrated that respondents are less willing to pay higher prices, supports the findings of Hong *et al*. (2024), which also shows the significant negative impact of price on consumer choices. Both studies highlight that higher prices decrease consumer willingness to pay for energy-efficient products. The pseudo R^2 value improved from -0.0338 (Model 1) to 0.2520 (Model 3) with the ML model, which was higher to the MNL model in terms of log-likelihood and pseudo R^2 values. The pseudo R^2 goodness-of-fit test indicates a well-fitted simple ML model for cross-sectional data with estimates ranging between 0.2 and 0.4 (Louviere *et al*., 2010).

Mixed Logit (ML) Model with Interactions

According to Table 7, the ML model (Model 4) with interactions shows that all interaction variables are significant at every level.

ESav2_Age, younger individuals exhibit greater awareness of the energy-saving features of refrigerators. Furthermore, when Male interact with EStar3, it positively impacts EStar3_Male, ECon2_Male, and ECon3_Male. On the other hand, the correlation between job and energy star attributes suggests unfavourable outcomes. It is not feasible to claim that individuals with permanent jobs are more likely to select refrigerators with high energy star ratings. Zha *et al*. (2020) highlighted that even

Table 6: Mixed logit model (Model 3)

Variables	Coefficient	Std. Error	z-value
EStar2	0.17044	0.08365	0.0416**
EStar3	0.00546	0.08963	0.9514
EStar4	0.11550	0.08329	0.1655
ECon2	-0.20101	0.08300	0.0154**
ECon3	-0.21314	0.08580	0.0130**
ECon4	-0.09739	0.09457	0.3031
ESav2	0.81352	0.10573	0.0000***
ESav3	1.03272	0.11322	0.0000***
ESav4	0.53332	0.08415	0.0000***
Price	-0.00070	0.00008	0.0000***
Number of observations			799
Log-likelihood			-2626.502
Pseudo R^2			0.2520
Adjusted R^2			0.2494

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Final ML model with interactions (Model 4)

Variables	Coefficient	p-value
EStar2	0.24407***	0.0060
EStar3	-0.00100	0.9922
EStar4	0.33701***	0.0004
ECon2	-0.23332**	0.0161
ECon3	-0.22270**	0.0265
ECon4	-0.24634**	0.0222
ESav2	0.71972*	0.0575
ESav3	0.73965***	0.0000
ESav4	0.57258***	0.0000
Price	-0.00064***	0.0000
ESav2_Age	-0.01503*	0.0547
EStar3_Male	0.24116*	0.0642
ECon2_ Male	0.51180***	0.0001
ECon3_ Male	0.39874***	0.0022
EStar2_Job	-0.41832***	0.0061
EStar4_Job	-0.38546**	0.0286
ESav2_HH	0.09923**	0.0118
ECon4_Mar	0.44261**	0.0182
ESav2_Mar	-0.50789**	0.0189
Marginal values of the attributes:: $-\frac{\beta\ attribute}{\beta\ monetary}$		
EStar2	381.36	
EStar3	-1.56	
EStar4	526.58	
ECon2	-364.56	
ECon3	-347.97	
ECon4	-384.91	
ESav2	1124.56	
ESav3	1155.70	
ESav4	894.66	
Price	-23.48	
ESav2_Age	376.81	
EStar3_Male	799.69	
ECon2_ Male	623.03	
ECon3_ Male	-653.63	
EStar2_Job	-602.28	
EStar4_Job	155.05	
ESav2_HH	691.58	

ECon4_Mar	-793.58
Number of observations	3196
Log-likelihood	-2627.5807
Pseudo R^2	0.2516
Adjusted Pseudo R^2	0.2481

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

highly educated individuals with a good income may not prioritise energy consumption levels. Similarly, the findings show that people with stable jobs are not necessarily more inclined to choose refrigerators with high energy star ratings. This suggests that factors such as job security or income do not automatically translate to a preference for higher energy efficiency. By interacting with ESav2, it has been proven that the household member variable is significant at a 5% significance level. People with bigger households will likely be more interested in knowing how much energy the refrigerator can save annually. Lastly, the interaction of marital status, ECon4_Mar, implies that married respondents are more concerned about energy consumption. According to ESav2_Mar, people who were single or divorced showed greater concern for energy saving refrigerators.

The marginal values of energy star level discovered that respondents are willing to pay for three-star-level refrigerators at a price of RM381.36. Based on Table 1, the yearly average cost for energy consumption is RM84.92. Interestingly, some respondents were willing to pay RM347.97 for the Level 3 energy consumption cost. The study revealed a significant inclination among consumers to invest in refrigerators that generate savings of up to RM47.78 per year at RM1,155.70 per unit, emphasising the high value placed on energy conservation. Numerous factors influence consumer decisions. Zhang *et al*. (2020) demonstrated perceived quality, emotional value, and the efficacy of energy efficiency labelling have a substantial influence on consumers' purchase attitudes. Improving the accuracy of information in energy labels can improve the WTP. For example, providing comparable energy consumption data significantly increased the price premium consumers were willing to pay for energy-efficient air conditioners (Zhou & Bukenya, 2016).

Marginal Willingness to Pay (WTP) Analysis

The calculation of the marginal willingness to pay (MWTP) for any non-monetary attribute is using the coefficient $\boldsymbol{\beta}$. The MWTP or marginal substitution rate specifies respondents' willingness to pay based on their choices or preferences. It can be assessed using the ratio of the non-monetary attribute as in Equation 5. The marginal values estimation generated by the Wald test using NLogit 5.0 econometric software is displayed in Table 8. The marginal values interrelated to the energy label are determined in Ringgit Malaysia (RM) currency. Table 8 presents the monetary trade-off between two attributes with the understanding that all other attributes remain unchanged.

The energy-saving attribute in both the MNL and ML models has been improved. On average, the change in savings from "no saving" to "saving of RM26.50" is RM2,130.23, while the change from "saving of RM26.50" to "saving of RM47.78" is RM193.01. However, the transition from "saving of RM47.78" to "savings of RM64.72" results in a decrease of RM557.86, as shown in Table 9.

Table 9 illustrates that the energy saving attribute at a base level to the first improvement level produces the highest marginal value of [(RM2,973.10 + RM3,261.09 + RM1,162.17 + RM1,124.56) ÷ 4]. A significant number of individuals are willing to invest additional

Table 8: Marginal values for difference in attribute levels

Attribute Levels	MNL Model (RM)		ML Model (RM)	
	Simple (Model 1)	Interaction (Model 2)	Simple (Model 3)	Interaction (Model 4)
Energy Star (EStar)				
EStar1 → EStar2 (2-star to 3-star)	1,863.14	2,048.35	243.49	381.36
EStar2 → EStar3 (3-star to 4-star)	168.20	-364.56	-235.69	-382.92
EStar3 → EStar4 (4-star to 5-star)	10.81	524.86	157.20	528.14
Energy Consumption (ECon)				
ECon1 → ECon2 (RM132.70 to RM106.20)	1,214.53	628.24	-287.16	-364.56
ECon2 → ECon3 (RM106.20 to RM84.92)	-47.07	80.55	-17.30	16.59
ECon3 → ECon4 (RM84.92 to RM67.98)	-422.93	-242.32	165.33	-36.94
Energy Saving (ESav)				
ESav1 → ESav2 (No saving to RM26.50)	2,973.10	3,261.09	1,162.17	1,124.56
ESav2 → ESav3 (RM26.50 to RM47.78)	376.59	51.17	313.14	31.14
ESav3 → ESav4 (RM47.78 to RM64.72)	-627.64	-629.32	-713.42	-261.04

funds in refrigerators that come equipped with energy saving features. Furthermore, integrating energy-efficient features in all domestic appliances can effectively decrease the monthly bills for the respondents. These findings are consistent with those of studies in Kenya, where consumers are willing to pay 28,708.5 Kenyan shillings for refrigerators with an Energy Star Rating (Kabingu, 2023). Customers in the United States showed a willingness to pay between US$249.82 and US$349.30 more for refrigerators bearing the Energy Star Rating labels. This willingness was driven by the desire to achieve both financial savings and environmental benefits (Ward *et al*., 2011). This underscores the strong influence of energy saving features on purchasing decisions globally.

Conclusions

This study examines the effect of the Energy Efficiency (EE) label on household purchasing behaviour and preferences using the CE method to assess their preferences. The refrigerator was chosen as an appliance for the analysis using Multinomial logit (MNL) and Mixed logit (ML) models to observe household preferences for EE labels and examine the effects of labels on the purchase of appliances. This study contributes to the understanding and implementation of an economic valuation on energy labels via studies on households' willingness to pay. This study calculates the household preferences for the highest level of energy efficiency and their distribution.

Table 9: Average of marginal values

Attribute Levels	Average of Marginal Values
Energy Star (EStar)	
EStar1 → EStar2 (2-star to 3-star)	RM1,134.09
EStar2 → EStar3 (3-star to 4-star)	–RM203.74
EStar3 → EStar4 (4-star to 5-star)	RM305.25
Energy Consumption (ECon)	
ECon1 → ECon2 (RM132.70 to RM106.20)	RM297.76
ECon2 → ECon3 (RM106.20 to RM84.92)	RM8.19
ECon3 → ECon4 (RM84.92 to RM67.98)	–RM536.86
Energy Saving (ESav)	
ESav1 → ESav2 (No saving to RM26.50)	RM2,130.23
ESav2 → ESav3 (RM26.50 to RM47.78)	RM193.01
ESav3 → ESav4 (RM47.78 to RM64.72)	–RM557.86

The findings of the study have significant implications for both marketing and policy objectives in Malaysia's energy efficiency labelling initiatives. The calculation of MWTP values in Table 8 shows that WTP varies greatly between the four models. For the simple MNL model, the variables EStar2, EStar3, EStar4, ECon2, ECon3, ECon4, ESav2, ESav3, and ESav4 showed a strong positive preference with high significance at a confidence level of 99%. However, this article found that the variables ESav2, ESav3, and ESav4 had a significant positive preference with a confidence level of 99% for the simple ML model.

This study also found that the respondents were more concerned with energy saving information on the label because it revealed in monetary terms how much energy in kWh per year the appliance saves. The "energy saving" attribute presents the highest marginal value of RM2,130.23, reflecting the significant importance consumers place on reducing energy consumption, cost, and household expenses. Suggesting that individuals are willing to invest more in energy-efficient appliances that can effectively lower their monthly electricity expenses. Policymakers can leverage these insights to refine energy efficiency labels, ensuring they effectively communicate the benefits of energy savings in monetary terms. This will likely enhance consumer understanding and drive more sustainable consumption patterns. For instance, the findings have proven that households are aware of how much energy they could have used or could have been saved annually if they understand the functions of energy efficiency labels in terms of currency rather than energy units. Implementing energy efficiency labelling in household appliances tries to address mitigation and adaptation to support sustainable development.

Moreover, energy efficiency labels play a pivotal role in advancing sustainable consumption patterns by informing and guiding consumer choices. By investing in appliances with high energy efficiency ratings, consumers can significantly reduce their energy usage and bills, contributing to environmental sustainability. This aligns with Goal 7 of the SDGs, which aim to ensure access to affordable, reliable, sustainable, and modern energy for all. Moreover, by promoting the use of energy-efficient appliances, EE labels contribute to Goal 12 of the SDGs, which focus on ensuring sustainable consumption and production patterns. Moreover, the implementation of energy efficiency labelling in Malaysia is consistent with the National Energy Policy (2022 to 2040), which prioritises energy efficiency to reduce consumption, support sustainable development, and achieve national goals for reducing carbon emissions and enhancing energy sustainability.

Sustainable consumption entails choosing products that are not just reduce resource depletion and have little or no environmental impact. The findings support the idea that consumers are increasingly aware of and responsive to the benefits of energy efficiency, which is crucial for achieving sustainable development. Implementing effective EE and promoting energy-efficient appliances that can significantly impact efforts to combat climate change by reducing CO_2 emissions and conserving resources. The connection between EE labelling, sustainable consumption, and SDGs is evident in the way energy-efficient products can drive both economic and environmental benefits.

Implementing an economic valuation study has the potential to provide many beneficial programs, for instance, investment programmes for the benefit of the public. Many alternative programmes such as seminars, workshops, or even conventions can be conducted to educate the public about how important it is to use efficient appliances at home. By joining these initiatives, people will be more aware of the need to use energy-efficient appliances and it will encourage positive behaviour towards good household energy management. One of the ways to make energy efficiency labelling more effective is by conducting campaigns to maximise its impact (Kuhn *et al*., 2022). Energy saving campaigns should prioritise highlighting the multitude of social benefits that come with reducing energy consumption from a policy standpoint (Skourtos *et al*., 2021). Besides, the manufacturers should consider that consumers have their specific preference for an efficient appliance; hence, they would try to produce the best quality of efficient products according to the consumers' preferences. The manufacturers usually do their best efforts to improve the EE performance of their products by competing against one another. This is because they recognise that more consumers will choose products with a higher efficiency performance. In this case, studies on energy efficiency labelling may be essential to household appliance manufacturers for information on what attributes to focus on (Zhang & Tao, 2020). This study recommends that the manufacturers should concentrate on technical aspects, which contribute more to annual energy savings. Companies are incentivised to invest in energy-efficient product design through energy labels. For instance, the power saving feature reduces the appliance's power by stopping the fridge compartment from functioning. Certain sophisticated refrigerators are equipped with temperature sensors within the unit that detect any changes in temperature and automatically adjust the cooling process. These sensors guarantee that the refrigerator only cools to the extent required, conserving energy.

Although the study provides valuable perspectives, it also has limitations that should be acknowledged. First, the study concentrates on household preferences in Peninsular Malaysia, which may limit the generalisability of the findings to other regions or countries with different socio-economic characteristics and energy consumption patterns. Furthermore, the study depends on hypothetical approach, which may not always accurately depict real

purchasing behaviour. Future research could mitigate these limitations by incorporating a broader geographic scope and employing revealed preference methods to validate the findings.

Future studies could also expand the scope of the research by investigating the impact of energy efficiency labels on a wider range of household appliances. Besides, investigating the effectiveness of different types of energy-efficient labels such as comparative versus endorsement labels could offer a more comprehensive understanding of consumer behaviour. Further research could also investigate the long-term effects of energy-efficient labelling on consumer behaviour and energy consumption; thereby, supporting the ongoing efforts to promote sustainable consumption and production.

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Conflict of Interest Statement

The authors agree that this research was conducted in the absence of any self-benefits, commercial, or financial conflicts and declare absence of conflicting interests with the funders.

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