Unraveling the Paradigm of Household Energy Consumption: Environmental Impacts and the Transition to Energy Efficiency

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Abstract. Amidst global climate change and natural resource degradation challenges, adopting energy-efficient home appliances is becoming increasingly crucial, especially in developing countries like Indonesia. Java Island is the country's economic and industrial center with the highest domestic energy consumption. This study aims to analyze the influence of knowledge about eco-labels and environmental consciousness, mediated by self-efficacy, on the willingness of consumers in Java to adopt energy-efficient household appliances. This study utilizes the Information-Motivation-Behavioral Skills (IMB) theoretical framework. Data were collected from 210 respondents through a survey disseminated through social media, and analysis was conducted using the Partial Least Squares (PLS) method within the Structural Equation Modeling (SEM) framework. Results show that eco-label knowledge and environmental consciousness significantly contribute to willingness to purchase energy-efficient appliances, with self-efficacy as an essential mediator. The findings present new insights into sustainable consumer behavior and provide practical recommendations for policymakers and practitioners in formulating effective promotional strategies to increase the adoption of energy-efficient home appliances in Indonesia. As such, this study extends the green consumer behavior literature by exploring the mediating role of self-efficacy in a developing country context.

1 Introduction

Home appliances in Indonesia have transformed into one of the dominant factors in energy consumption and carbon emission production at the household level. This phenomenon is confirmed through 2022 data, which states that per capita electrical energy consumption in the household sector reached 1,173 kWh, showing an increase of 4% compared to the previous year [1]. Regarding carbon emissions, household energy in Indonesia has experienced a significant increase, amounting to 14.97% from 2017 to 2021 [2]. Furthermore, the contribution of carbon emissions from households to total national carbon emissions is quite significant, with 3.8% directly and 20.7% indirectly [3]. The main factor behind this phenomenon is the use of household appliances, which are responsible for about 70% of household carbon emissions [4]. These improvements result in various modern facilities that benefit society, including air conditioning devices, heaters, electronics, and other household appliances, all contributing to comfort, well-being, and flexibility in domestic life [5].

Unfortunately, the ever-increasing behavior of household energy consumption provides only short-term enjoyment. This is because it is predicted to trigger an environmental crisis and degradation of natural resources if alternative solutions are not immediately found [6]. Therefore, concrete steps are needed to raise public consciousness about the importance of using efficient and sustainable household appliances to escape this dilemma. This step is essential because it can contribute to climate change mitigation and natural resource conservation. Proven in 2017, using energy-efficient household appliances (EEHA) has resulted in annual electricity savings of around 10 billion kWh and reduced carbon emissions by 6.5 million tons. This result is equivalent to a reduction of 14,000 tons of sulfur emissions, 14,000 tons of nitrogen oxide emissions, and 11,000 tons of particulate matter emissions [7]. On this basis, a deeper understanding of people's willingness to purchase (WTP) energy-efficient and sustainable home appliances is needed.

Researchers have previously studied WTP household appliances by adopting a variety of diverse variables based on the theory of planned behavior (TPB). This includes subsidy policies [4], Norm ethics [8], price [9], Environmental consciousness, and knowledge of eco-labels [7,10]. Research Wang et al. [4] shows that subsidies do not have a significant influence on purchasing desirability, mainly due to limited subsidy policies and the difficulty of changing consumer habits in the short term. Unlike ethical norms that affect purchasing tendencies, such changes require government education, promotion, and considerable time [8]. Price significantly influences purchase desirability, but the market and consumer preferences influence the change and are difficult to control [9]. On
the other hand, environmental consciousness and knowledge of eco-labels significantly influence purchasing decisions [7,11]. It concerns the education level, publicity popularity, and education. Therefore, to increase this consciousness and knowledge, an increase in social publicity and environmental education is needed, which can be done quickly [7].

Previous research has explored the mechanisms and impacts of environmental consciousness and knowledge about eco-labels on WTP energy-efficient home appliances. Nonetheless, there is still room for clarification and further exploration. Research on the factors influencing WTP needs to be more consistent. Several studies have shown significant positive impacts [7,11–13], while others found no significant association [8,14]. This discrepancy is due primarily to model construction differences and study area variations. Previous research models used TPB Theory to focus on direct influences, while the indirect impact of environmental consciousness and eco-label knowledge was often overlooked. The literature has called for more in-depth research to explore the factors influencing purchase willingness using diverse theoretical frameworks and different population samples [15]. In addition, the role of self-efficacy (SE) as a mediating variable has not received enough attention. Environmental consciousness and knowledge of eco-labels can influence purchase desirability through consumer SE. Therefore, this influence should not be ignored in further research. In conclusion, there needs to be a more holistic and diverse approach to understanding the relationship between environmental consciousness, eco-label knowledge, SE, and WTP.

Based on the gap assessment that has been highlighted, our research adopts the Information-Motivation-Behavioral Skills (IMB) model as a basic framework to understand the factors that influence the WTP EEHA in Indonesia. Model IMB [16] integrates three main components: information, motivation, and behavioral skills. 'Information' refers to the consumer's knowledge of energy-efficient equipment labels; 'Motivation' involves environmental consciousness, whereas 'behavioral skills' include an individual's ability to translate information and motivation into purchasing decisions. The IMB model states that information and motivation directly influence behavior, with behavioral skills mediating. The IMB model was adopted because it could analyze and categorize critical elements that influence consumer decisions. With this approach, this study aims to explore how information and motivation influence purchasing willingness, as well as the role of SE in linking knowledge and motivation with sustainable home appliance purchase willingness. The results of this study are expected to provide valuable insights into the energy-efficient home appliances industry and enable the development of marketing strategies that are more targeted and follow consumer needs.

2 Materials and Method

2.1 Materials

This study used survey techniques to collect respondent data in Java, Indonesia. The choice of Java Island as the location for data collection is significant, considering that this island has the highest electricity consumption in Indonesia, with a percentage reaching 73.5% [17]. This is unsurprising, as Java has a high population density and is Indonesia's economic and industrial center [18]. With a large population, Java not only experiences higher household energy consumption but also influences national energy consumption trends significantly, making it a critical region for understanding the dynamics of energy consumption at the household level in a broader context [18]. Using EEHA can help mitigate climate change and conserve natural resources [19]. The data collection method utilized purposive sampling and involved a digital questionnaire created with Google Forms. The questionnaire was distributed through social media platforms, such as WhatsApp and Instagram, specifically targeting individuals who were at least 17 years old and had purchased energy-efficient appliances for home use. The survey tool comprised 16 questions, with responses measured on a four-point Likert scale, from 'strongly disagree' to 'strongly agree.' The design of the questionnaire was based on various sources cited in the existing literature [12,20–23]. A total of 210 participants completed the questionnaire. Their responses were then analyzed using the Partial Least Squares (PLS) method within the Structural Equation Modeling (SEM) framework.

2.2 Method

2.2.1 Hypotheses Development.

Eco-label is increasingly used as a marketing tool to spread consciousness about eco-friendly products [24]. The significance of this label is further increased due to the ineffectiveness of environmental knowledge in general in encouraging environmentally friendly behavior [25]. Researchers argue that more than a superficial understanding of environmental issues is needed for evaluating and predicting consumer pro-environmental behavior [11]. Therefore, Taufique et al. [25] revealed that a deeper understanding of eco-friendly labels is more relevant to buying eco-friendly products. From an environmental marketing perspective, eco-labels are a communication or promotional tool informing consumers about products and their environmental impact [26].

Effective consumer response is seen when information on eco-friendly labels leads to purchasing eco-friendly products [19]. The consumption of these products relies on information provided through various channels, such as product packaging or eco-labels, advertising, and programs aimed at raising environmental consciousness [27–29]. However, the researchers note that while the eco-labels' impact on consumer behavior is positive, the effect is still relatively weak [30]. Given eco-labels' ineffectiveness in encouraging consumer behavior, further investigations have been conducted into eco-labels...
effectiveness in consumer decision-making regarding energy-efficient home appliances, confirming a positive and significant relationship between knowledge of eco-labels and consumer behavior [10,19]. From a theoretical perspective, the IMB model states that eco-friendly purchasing decisions by consumers are determined by their consciousness of the consequences of their actions. This is mainly related to knowledge of eco-labels. On this basis, we devised the following hypothesis:

H1: Eco-label knowledge has a significant effect on the WTP of EEHA

Consciousness of environmental issues relates to how individuals recognize and support solutions to ecological problems [31]. This responsibility is not only psychological but also involves the desire to participate in protecting the environment [32]. Studies have shown that this environmental consciousness significantly influences consumers' purchasing decisions. For example, Andika et al. [33] found that consumers more sensitive to environmental issues tend to be more open to purchasing green cosmetics. Jaciow et al. [34] also show that someone who cares more about the environment tends to be more active in energy conservation efforts and applying energy efficiency. This is also true when purchasing energy-efficient equipment, where environmental consciousness plays an important role [7]. Based on the IMB model, we understand that environmental consciousness, as a motivating factor in purchasing, particularly sustainable products such as energy-efficient home appliances, can influence purchasing decisions. Thus, we propose the following hypothesis:

H2: Environmental consciousness has a significant effect on the WTP of EEHA

Several previous studies have consistently found a positive correlation between a person's level of knowledge and consciousness of environmental issues, which contribute to their behavioral competence. These relationships play a crucial role in shaping a person's tendency to follow different types of behavior. For example, research conducted by Ameri et al. [35] highlights the significant impact of information and motivation on behavioral skills, culminating in impacts on medication adherence, dietary adherence, and physical activity in HIV/AIDS patients. Likewise, Iqbal et al. [36] found that SE is an intermediary between information accumulation and personal motivation in financial data security behavior. In the context of environmentally friendly behavior, the literature presents evidence supporting the role of behavioral skills as intermediaries. For example, research by Liu and Yang [37] found that a person's recycling behavior ability partially intermediates between motivation and information about recycling and their recycling practices. Based on the IMB Model, behavioral skills are required for a person to perform specific actions [38]. This suggests that those with better behavioral skills are more driven to carry out particular actions. The IMB model also states that a person's actions reflect their information, motivation, and belief in the skills to act in various situations [39]. Regarding the existing literature and the IMB Model, this study proposes that SE, defined as a person's belief in his abilities, can mediate the relationship between various elements and the WTP of EEHA. Therefore, we hypothesize the following:

H3: SE mediates the effect of eco-label knowledge on WTP EEHA
H4: SE mediates the impact of environmental consciousness on WTP EEHA

Fig 1. Proposed research model
3 Results and Discussion

3.1 Descriptive Statistics

In this study, the demographic profile of respondents was classified based on several aspects. Of the 210 total respondents, 42% were male and 58% were female. The age of the majority of respondents ranged from 17-26 years, covering 72% of the total. Regarding family income, most respondents, i.e., 57%, have an income of less than 1,500,000 IDR. Based on education level, respondents were divided into three groups: high school, undergraduate, and graduate, with 53% having an undergraduate education background. In addition, about 50% of respondents stated using EEHA, such as LED lights.

3.2 Measurement Model Testing

Tests on measurement models are carried out to assess validity and reliability based on established standards. These standards include convergent validity assessed through outer loading weights, discriminant validity examined using Average Variance Extracted (AVE), and composite reliability measured through Composite Reliability. The analysis results showed that the outer loading weight for each indicator crossed the threshold of 0.6, which confirms its validity based on a significant relationship with the respective construct. In addition, the discriminant validity for each variable is considered adequate, with an AVE value greater than 0.50. Regarding composite reliability, all constructs show significant strength with values above 0.70, indicating high consistency and stability. Thus, the measuring tools in this study have proven effective and reliable in measuring the variables studied, with validity that has been comprehensively verified.

3.3 Structural Model Evaluating

The main objective of PLS analysis is to assess the validity of a conceptual model with a particular focus on its predictive capabilities. To perform this validation, we used several evaluation metrics, including R square, Q square, SRMR, and PLS Predict, following the guidelines recommended by Hair et al. [41]. The results of the R Square analysis showed that the variables of eco-label knowledge and environmental consciousness had a minimal impact on SE, with an R Square value of 0.423. Meanwhile, WTP energy-efficient home appliances showed a moderate impact with an R Square of 0.695 [42]. Further, the Q square value for the SE variable was 0.341, indicating a moderate degree of prediction. The same pattern is also seen in the WTP energy-efficient home appliances, with a Q square value of 0.479 [41]. SRMR is an essential metric for assessing model fit in the context of PLS-SEM. Our analysis yielded an SRMR value of 0.06, which indicates a good fit for the model [43]. Lastly, it is essential to emphasize the predictive power of PLS compared to linear regression (LM) models. Our analysis shows that all components in PLS produce lower RMSE and MAE values compared to LM, indicating the high predictive potential of the PLS model [41].

3.4 Hypothesis Testing

This study put forward four hypotheses regarding causal relationships. All such hypotheses were verified using statistical analysis. This hypothesis testing method utilizes SmartPLS 3.3, which involves bootstrapping techniques and focuses on T-statistic and P-value values. The evaluation standards include criteria where the T-statistic value must be more than 1.96, the P value must be less than 0.05 (5%), and the beta coefficient must be positive [44]. Detailed information on the results of testing this hypothesis is outlined in Table 1.

Table 1. Hypothesis test results

| Hypothesis | Effect | Original Sample (O) | T Statistics (|O/STDEV|) | P Values | Conclusion |
|------------|--------|---------------------|--------------------------|----------|------------|
| H1 ELK -> WTP | Direct | 0.312 | 3.995 | 0.00 | Accepted |
| H2 EC -> WTP | Direct | 0.22 | 2.964 | 0.003 | Accepted |
| H3 ELK -> SE -> WTP | Indirect | 0.173 | 3.695 | 0.00 | Accepted |
| H4 EC -> SE -> WTP | Indirect | 0.11 | 2.535 | 0.011 | Accepted |

Based on the results of hypothesis testing in Table 1, it can be explained as follows:

The results of the hypothesis 1 test show that the t-statistic value is above 1.96 (3.995), the P-value is below 0.05 (0.00), and the original sample value shows positive results. This proves that knowledge about eco-labels positively and significantly affects WTP energy-efficient home appliances. This finding aligns with the study of Hossain et al. [10] and Taufique et al. [25], which shows that knowledge of eco-labels is the most significant variable in determining the WTP energy-efficient home appliances. These findings align with IMB theory, suggesting that adequate information about eco-labels can increase willingness to behave in an environmentally friendly manner, particularly when purchasing energy-efficient home appliances. It also emphasizes the importance of education and consciousness to promote sustainable behavior.

The results of hypothesis 2 testing showed that the t-statistic value is above 1.96 (2.964), the P-value is below 0.05 (0.003), and the original sample value is positive. This proves that environmental consciousness significantly affects the availability of EEHA. This finding aligns with Li et al. [45] in China and Jaciow et al. [34] in Poland, which revealed that environmental consciousness is significantly positively correlated with people's availability to buy EEHA. From the perspective of IMB theory, these findings suggest that increased
environmental consciousness (information and motivation) significantly influences consumer purchasing behavior. It also affirms the importance of education and consciousness campaigns to inform the public about the benefits of energy-efficient home appliance products and their environmental impact. Moreover, these findings suggest that this is not just a local or cultural phenomenon but a global trend reflecting shifting values and priorities among consumers worldwide.

The results of hypothesis 3 testing showed that the t-statistic value was above 1.96 (3.695), the P-value was below 0.05 (0.00), and the original sample gave positive results. This proves that SE can significantly mediate the effect of eco-label knowledge on WTP energy-efficient home appliances. This finding is in line with the results of the study by Andika et al. [46], which revealed that SE significantly mediated the relationship between consumers' knowledge of pro-environmental products and their WTP. These findings confirm that when a person has a good understanding of eco-labeling, this not only directly influences their purchasing decision but also indirectly through increased SE. In other words, knowledge of eco-labels makes them feel more capable and confident in making environmentally friendly choices, ultimately encouraging purchasing energy-efficient home appliances. This aligns with IMB theory, which emphasizes that information, motivation, and behavior are interrelated and essential elements in understanding and influencing human behavior. In the context of research and marketing, these findings are significant because they show that consumer education about eco-labels should be followed by efforts to improve their SE. This can be done through campaigns showing how easy it is to make eco-friendly choices or by providing more information about the long-term benefits of purchasing energy-efficient appliances for the environment and personal cost savings.

Likewise, the results of hypothesis 4 testing showed that the t-statistic value is above 1.96 (2.535), the P-value is below 0.05 (0.011), and the original sample value is positive. This suggests that SE significantly mediates the relationship between environmental consciousness and readiness to purchase energy-efficient home appliances. This finding is in line with the results of Limbu et al. [47], which reveals that the combination of high environmental consciousness and strong SE can encourage individuals to choose eco-friendly products. The findings have important implications for marketers and policymakers. To promote the purchase of energy-efficient products, communication and marketing strategies not only need to increase environmental consciousness but must also be designed to strengthen consumer SE. This can be achieved by providing clear information on how individuals can contribute to environmental sustainability through their product choices and affirming that individual actions have an impact.

4 Conclusion

Based on the application of IMB theory, this study uncovers significant relationships between knowledge of eco-labeling, environmental consciousness, SE, and predisposition to purchasing EEHA. Statistical analysis shows that each variable contributes positively and significantly to buy intent, with self-efficacy as a critical mediator. It emphasizes the need for a match between in-depth knowledge and environmental consciousness with consumers' confidence in their ability to act sustainably. These results reinforce the findings of previous studies that highlight the importance of psychological factors in influencing sustainable consumer behavior, providing new insights that emphasize synergies between environmental consciousness, knowledge of eco-labels, and SE in promoting more sustainable choices.

Based on these findings, we suggest the importance of structured interventions to increase consumers' consciousness and knowledge of eco-labeling and environmental consciousness. This can be achieved by developing and implementing comprehensive educational programs, which not only increase understanding of the economic and environmental benefits of energy-efficient products but also improve consumer SE. The program should provide practical and accessible information on selecting and using equipment effectively. The importance of collaboration between government, industry, and educational institutions in ensuring messages about the importance of choosing environmentally responsible products can reach a wider audience and encourage sustainable behavior change. The practical implications of this research provide strategic direction for designing consciousness campaigns that not only increase knowledge of eco-labeling but also support the transition to more environmentally friendly consumption practices.

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