IIAI Open Conference Publication Series
IIAI Letters on Business and Decision Science
Vol. 004, LBDS254
DOI: https://doi.org/10.52731/lbds.v004.254

Analysis of Consumers' Willingness to Pay for Eco-Friendly Insulation Tape and Its Influencing Factors

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Abstract

The incineration of traditional PVC insulation tape can generate pollutants such as hydrogen chloride, dioxins, and furans, which are significant environmental and ecological damage sources. According to the Stockholm Convention, emissions of pollutants like dioxins and furans should be reduced, and their elimination should be sought wherever feasible. Therefore, developing eco-friendly PVC that is acceptable to consumers is an important issue. This study focuses on a newly developed eco-friendly self-amalgamating insulation tape, exploring factors affecting consumers' willingness to pay through questionnaire design and data analysis. A total of 304 valid questionnaires were collected randomly. The results show a positive correlation between consumers' environmental knowledge, green consumption attitude, and green consumption behavior. Regarding willingness to pay, 60% of respondents will spend an additional 60 NTD to purchase eco-friendly self-amalgamating insulation tape. The findings of this study can provide manufacturers with an assessment of quality costs and suggest that the government should promote environmental knowledge among the public, as well as provide necessary subsidies to manufacturers to create a home with ecological quality jointly.
Keywords: Green consumption behavior, Questionnaire design, Data analysis, Willingness to pay, Quality cost.

1 Introduction

Since the Industrial Revolution, the rapid growth of population and economy has led to the neglect of industrial pollution control, resulting in severe environmental issues. Recent global ecological problems, such as global warming, ozone layer depletion, and the impact of pollutants like dioxins and PM2.5 on human health, have drawn significant attention from governments worldwide. This has led to international environmental conventions such as the 1987 Montreal Protocol, the 1989 Basel Convention, the 1992 Rio Declaration, the 1998 Rotterdam Convention, and the 2001 Stockholm Convention. Businesses are reducing environmental impacts through technological transformations, process improvements, and management efficiency enhancement [1,2]. The Stockholm Convention highlights the need to minimize emissions of hazardous substances like dioxins and furans generated by waste incineration and industrial processes [3, 4]. Environmental degradation is caused not only by natural disasters and wars but also by human consumption behavior. Kates (2000) and Monbiot emphasize that population growth and consumption are major reasons for environmental degradation, with the wealthiest populations contributing disproportionately to carbon emissions [5, 6].

Consumer behavior plays a crucial role in environmental protection. When consumers prioritize environmental considerations, they tend to purchase products with lower environmental impacts

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[7]. Research by Andika and Bidayati (2024) in the Indonesian organic food market shows that increased health and environmental awareness lead to a higher willingness to pay for organic products [8]. Understanding consumers' willingness to pay is essential for producers to set appropriate prices and for policymakers to ensure access to organic products [9, 10]. Studies by Kim and Damhorst (1998) and Stern & Ander (2008) indicate that green-conscious consumers are willing to pay more for environmentally friendly products [11, 12]. Laroche et al. (2001) found that while consumers are generally aware of environmental issues, their willingness to pay more for green products varies [13]. Lin, Nayga Jr, and Yang (2024) observed that consumers prefer organic bread and are willing to pay a premium for environmentally certified products [14].

In Taiwan, many insulation tapes are made of polyvinyl chloride (PVC), which can produce harmful substances like dioxins under poor combustion conditions. This study focuses on an eco-friendly self-amalgamating insulation tape developed by a cooperative manufacturer. The research aims to analyze whether consumers' environmental knowledge, green consumption attitude, and behavior influence their purchase of eco-friendly products and how much they are willing to pay. The findings will serve as a reference for manufacturers and suppliers to promote green products.

2 Methodology

This study's research subject is eco-friendly self-amalgamating insulation tape, which has excellent insulating properties, extensibility, and waterproofing. It can be flexibly coiled, stretched, and extended, providing adequate adhesion and filling properties for irregularly covered surfaces. It also offers excellent sealing properties in humid environments. It can be widely used in electrical operations such as wrapping, jointing, and insulating and sealing wires at 380V voltage. Figure 1 shows the product. It is easy to install and use and resistant to corrosion and extreme temperatures. It is also non-toxic and free of hazardous materials.

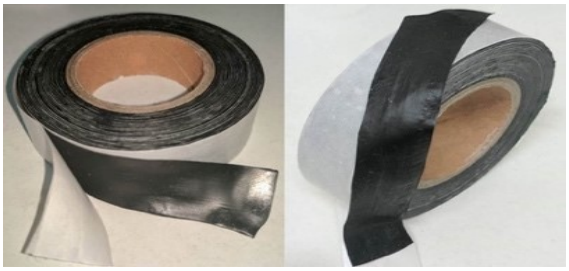

Figure 1: Product image of eco-friendly self-amalgamating insulation tape

Figure 2 shows the manufacturing process. The mixing process involves putting two different types of synthetic rubber (butyl rubber and ethylene-propylene rubber), fillers (carbon black and calcium carbonate), activators (zinc oxide), antioxidants, adhesives, and eco-friendly processing accelerators into a sealed batch mixer. The mixing effect is achieved by the high heat generated by the counter-rotating rotors with raised wing-like structures in the mixing chamber and the solid shearing effect between the rotors and the chamber walls. The calendaring process involves plastic flow deformation under the extrusion force of the calendar rolls. The shear force generated between the rolls increases the plasticity of the material through multiple compressions and shearing, further plasticizing and extending it into a thin base material. The base material then becomes

a semi-finished product through winding equipment. Finally, the semi-finished product is rolled and cut or slit to form the completed tape product.

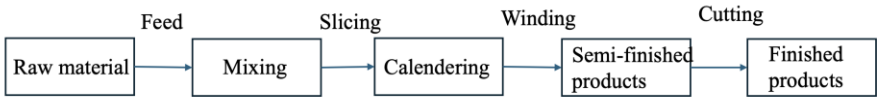

Figure 2: Manufacturing process flow chart of eco-friendly self-amalgamating insulation tape

This study adopts the Engel, Blackwell, and Miniard (EBM) consumer behavior model revised in 1993 as the theoretical foundation. Considering the consumer background, consumer characteristics (including environmental knowledge, green consumption attitude, and green consumption behavior), and willingness to pay, seven hypotheses are proposed for testing, as shown in Figure 3. The operational definitions given to each primary variable are explained as follows:

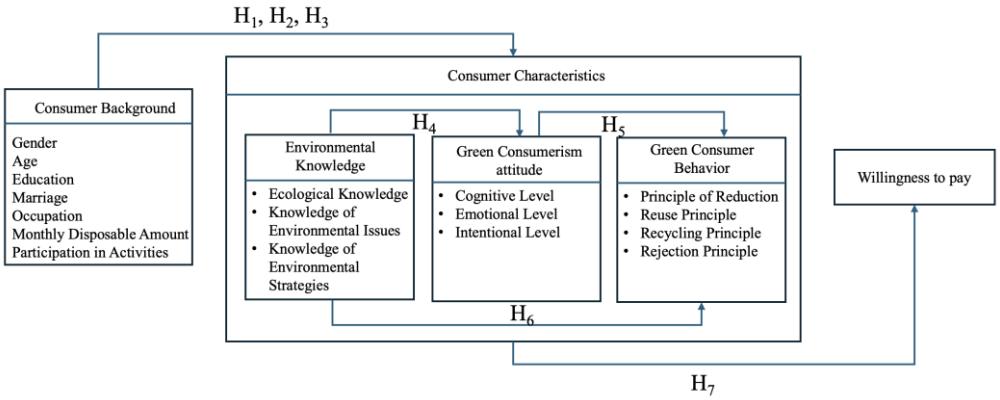

Figure 3: Hypothesis testing framework for the questions to be explored in this study

- Consumer Background: Seven variables, based on past literature and the research framework, are adopted: gender, age, education level, marital status, occupation, average monthly disposable income, and participation in environmental activities.
- Environmental Knowledge: Consider the understanding of consumers' knowledge and concepts related to environmental matters, including natural ecological knowledge, environmental issue knowledge, and environmental strategy knowledge.
- Green Consumption Attitude: Consider and understand consumers' concern for green consumption, including cognitive, affective, and intentional aspects.
- Green Consumption Behavior: Consider measuring consumers' consumption patterns when they become aware of the environmental crisis and realize their consumption behavior can cause ecological damage. Adopting environmentally friendly consumption behaviors, including the principles of reduction, reuse, recycling, and refusal.
- Willingness to Pay: Consider the amount consumers are willing to pay for environmental protection compared to similar products on the market. Based on the scholars' proposals, redesign the research questions.

This study employs scenario design and market assessment methods to construct the questionnaire, distributed through random sampling. The Likert five-point scale is used for scoring based on respondents' subjective judgments. Each dimension in the questionnaire includes one reverse-scored item to ensure consistency and eliminate invalid responses. The willingness to pay is estimated using the market assessment method, focusing on the additional price consumers will pay for eco-friendly self-amalgamating insulation tape. The analysis procedure involves organizing the questionnaire results and conducting reliability and validity analysis to confirm the data's representativeness. Descriptive statistical analysis is then performed on the primary questionnaire data to provide an overview and identify patterns. T-tests and analysis of variance are used to compare group means and assess the relationship between variables and the dependent variable, respectively. T-tests and analysis of variance are used to determine the statistical significance of differences between the dependent and independent variables. This allows researchers to identify any statistically significant correlations or relationships between the variables and to determine if any changes in one variable will affect the other.

3 Case Study and Discussion

This study used a random paper-based questionnaire method, which included ten reverse-scored items to check for consistency in respondents' answers and eliminate invalid samples with contradictory responses. After excluding incomplete and incomplete data samples, 304 valid samples were obtained, with a valid sample rate of 96.82%. These samples used Cronbach's α to test the reliability of environmental knowledge, green consumption attitude, green consumption behavior, and willingness to pay. This is shown in Table 1. The reliability α values for all dimensions reached above 0.7. This indicates that the questions were reliable and the results were accurate. Furthermore, the results can be used to conclude the overall environmental knowledge, green consumption attitude, green consumption behavior, and willingness to pay off the surveyed population. This means that the survey questions were straightforward and easy to understand and that the respondents could provide meaningful responses. Furthermore, the α values for all dimensions above 0.7 indicate that the responses were consistent and valid, providing a reliable basis for the conclusions.

Table 1: Reliability Analysis of the Formal Questionnaire

Measurement Variable	Number of Items	Cronbach's α Value
Environmental Knowledge	15	0.711
Green Consumption Attitude	15	0.760
Green Consumption Behavior	20	0.879
Willingness to Pay	2	0.836
Total	52	0.917

The analysis of valid samples found that most were female (62.2%) and male (37.8%). In terms of age, the most significant proportion was consumers aged 30-39 (41.4%), the target group of general consumers. In terms of education level, the most common was university/junior college (55.6%), followed by graduate school (including above) (28.9%), indicating a high level of education among general consumers. Marital status was almost evenly split between unmarried (48%) and married (52%). The most common occupation was laborer (38.2%). The average monthly disposable income was between NT$20,001 and NT$40,000 (39.1%). Only 22.7% of consumers participated in environmental protection activities in the past three years. This indicates that most

consumers rarely participate in such activities organized by the government or non-governmental organizations. Regarding willingness to pay, 59.9% were willing to pay an additional NT$60 for the product. When comparing the willingness to pay between different demographic groups, it was found that consumers aged 30-39 had the highest percentage (65.2%) of willingness to pay an additional NT$60 for the product, followed by consumers with a graduate school education level (61.8%). In contrast, the lowest percentage of willingness to pay was among laborers (52.3%) and unmarried individuals (56.8%).

Next, under the background of consumers, consumer characteristics (including environmental knowledge, green consumption attitude, and green consumption behavior), and willingness to pay, seven hypotheses were tested, and the results are summarized in Table 2.

Table 2: Reliability Analysis of the Formal Questionnaire

Research Hypothesis Content	Result
Hypothesis 1: There are significant differences in environmental knowledge among consumers with different backgrounds - Partially significant	Partially significant
1-1: There are significant differences in environmental knowledge between genders	Partially significant
1-2: There are significant differences in environmental knowledge among different age groups	Not significant
1-3: There are significant differences in environmental knowledge among different education levels	Partially significant
1-4: There are significant differences in environmental knowledge between different marital statuses	Partially significant
1-5: There are significant differences in environmental knowledge among different occupations	Significant
1-6: There are significant differences in environmental knowledge among consumers with different monthly disposable incomes	Not significant
1-7: There are significant differences in environmental knowledge among consumers who participate in environmental protection activities and those who do not	Partially significant
Hypothesis 2: There are significant differences in green consumption attitude among consumers with different backgrounds	Partially significant
2-1: There are significant differences in green consumption attitudes between genders	Not significant
2-2: There are significant differences in green consumption attitudes among different age groups	Significant
2-3: There are significant differences in green consumption attitudes among different education levels	Not significant
2-4: There are significant differences in green consumption attitudes between different marital statuses	Significant
2-5: There are significant differences in green consumption attitudes among different occupations	Significant
2-6: There are significant differences in green consumption attitudes among consumers with different monthly disposable incomes	Not significant
2-7: There are significant differences in green consumption attitudes among consumers who participate in environmental protection activities and those who do not	Significant

Hypothesis 3: There are significant differences in green consumption behavior among consumers with different backgrounds	Partially significant
3-1: There are significant differences in green consumption behaviors between genders	Not significant
3-2: There are significant differences in green consumption behaviors among different age groups	Partially significant
3-3: There are significant differences in green consumption behaviors among different education levels	Not significant
3-4: There are significant differences in green consumption behaviors between different marital statuses	Significant
3-5: There are significant differences in green consumption behaviors among different occupations	Significant
3-6: There are significant differences in green consumption behaviors among consumers with different monthly disposable incomes	Partially significant
3-7: There are significant differences in green consumption behaviors among consumers who participate in environmental protection activities and those who do not	Significant
Hypothesis 4: There is a correlation between environmental knowledge and green consumption attitude	Positive correlation
Hypothesis 5: There is a correlation between green consumption attitude and green consumption behavior	Positive correlation
Hypothesis 6: There is a correlation between environmental knowledge and green consumption behavior	Positive correlation
Hypothesis 7: There is a correlation between consumer characteristics and willingness to pay	Positive correlation

This study used the scores on the scales of environmental knowledge, green consumption attitude, green consumption behavior, and willingness to pay as variables for correlation analysis to understand the relationship between consumers' ecological knowledge, green consumption attitude, green consumption behavior, and willingness to pay, with the results shown in Table 3.

Table 3: Correlation Coefficients Between Variables

Variable	Environmental Knowledge	Green Consumption Attitude	Green Consumption Behavior	Willingness to Pay
Environmental Knowledge	1	0.616**	0.499**	
Green Consumption Attitude	0.616**	1	0.763**	
Green Consumption Behavior	0.499**	0.763**	1	

Note: **p<0.01 (two-tailed)

From Table 3, it can be seen that there is a statistically significant correlation between environmental knowledge and green consumption attitude (r=0.616, p<0.01**), indicating a moderate positive correlation. A statistically significant correlation exists between green consumption attitude and behavior (r=0.763, p<0.01**), indicating a high positive correlation. Additionally, a statistically significant correlation exists between environmental knowledge and green consumption behavior (r=0.499, p<0.01**), indicating a moderate positive correlation. Lastly, a statistically

significant correlation between consumer characteristics and willingness to pay ($r=0.484$, $p<0.01^{**}$) indicates a moderate positive correlation. These results demonstrate that demographic factors like occupation, participation in environmental activities, and age can significantly influence a person's ecological knowledge, attitudes toward green consumption, and actual green consumption behaviors. Not all factors were significant for each aspect studied, indicating that some demographics may not influence specific environmental or green consumption-related knowledge and behaviors. Additionally, the study found positive correlations between knowledge, attitudes, and behaviors related to environmental consciousness and green consumption, as well as between consumer characteristics and their willingness to pay, suggesting that a higher degree of ecological awareness tends to correlate with a greater willingness to pay for environmentally friendly products.

4 Conclusion

According to the analysis and summary of this study, environmental knowledge shows significant differences based on gender (males superior to females), occupation (government employees and other professions superior to laborers and students), and participation in environmental protection activities (participants superior to non-participants). Green consumption attitude and green consumption behavior mutually influence each other and show significant differences based on age (over 40 superior to under 39), marital status (married superior to unmarried), occupation (attitude: government employees and other professions superior to laborers and students; behavior: government employees, laborers, homemakers, and other professions superior to students), and participation in environmental protection activities (participants superior to non-participants). The relationship between green consumption attitude and behavior is complex and influenced by various factors. While age, marital status, occupation, and participation in environmental protection activities can impact attitude and behavior, it is important to note that individuals with a positive attitude toward green consumption are more likely to engage in sustainable purchasing and consumption practices. However, further research is needed to understand this relationship's underlying motivations and mechanisms.

The popularization of higher education can enhance consumers' knowledge, skills, attitudes, and values regarding environmental protection, encouraging them to value the environment, take action, and achieve sustainable development. Willingness to pay scored the lowest in this study, with 39.1% of consumers having a monthly disposable income between NT$20,001 and NT$40,000. Since green products are priced to include environmental protection costs, they are relatively higher. However, many consumers are open to environmental issues; relatively, their purchasing decisions are constrained by limited income, with practical value and economic conditions being the top priorities. One potential solution to address the limited income constraint is providing financial incentives or subsidies for consumers purchasing green products. The could help offset the higher price of environmentally friendly items and make them more accessible to consumers. Raising awareness about the long-term cost savings associated with green products and emphasizing their durability and quality could also help shift consumer priorities toward sustainable purchasing decisions.

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