
An Examination of Consumer Perceptions Regarding Low-Carbon Products Using the Kano Model

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Abstract

A major challenge facing contemporary society is the impact of global climate change and environmental degradation. The emergence of low-carbon products illustrates sustainable consumption practices, yet a gap exists between corporate initiatives and consumer adoption. This study addresses this gap by integrating the Kano model of quality with planned behavior theories to examine consumer perceptions of low-carbon products. We surveyed 277 Taiwanese consumers online, assessing their knowledge, social influences, attitudes, and perceived behavioral control regarding low-carbon products, along with their purchasing behaviors. Using Kano's classification method, we categorized the psychological factors influencing consumer satisfaction. Most factors (e.g., environmental knowledge, perceived ease of use, social recognition) were identified as one-dimensional attributes, while some were must-be attributes (e.g., actual environmental impact) that cause dissatisfaction if absent. One factor, peer support, was classified as attractive, enhancing satisfaction when present. The research underscores the Kano model's utility in sustainability contexts and emphasizes prioritizing essential attributes and improving performance attributes to promote low-carbon product adoption. These findings contribute to understanding consumer perception and sustainable behavior, providing theoretical insights and practical implications.

Keywords: Low-carbon products, Consumer perceptions, Kano model

1. Introduction

Climate change and sustainability are critical global issues. Low-carbon products, designed to reduce carbon emissions, are promoted to mitigate environmental impact and encourage sustainable consumption. However, despite corporate investments in eco-friendly practices, consumer adoption of these products remains low. A gap exists between the availability of low-carbon options and actual purchasing decisions, indicating that understanding consumer perceptions and motivations is essential. Prior research on low-carbon products in Taiwan and elsewhere has mainly focused on technological development, policy design, and corporate environmental responsibility, with limited exploration of consumer behavior. While some studies have examined the impact of carbon footprint labels on purchase intentions, they often analyze isolated variables or rely on descriptive statistics, overlooking the complex psychological and

social factors that influence consumer decisions. Specifically, social norms, peer opinions, and personal values significantly shape consumer behavior regarding sustainable products, yet many studies neglect constructs like subjective norms and perceived behavioral control. This gap limits our understanding of consumer decision-making in the low-carbon context, highlighting the need for an integrated theoretical framework to capture the cognitive, social, and attitudinal determinants of low-carbon product adoption.

This study integrates the Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), and the Kano model of customer satisfaction to address existing gaps. TAM and TPB explain how attitudes, social influence, and perceived control shape consumer behavior (Ajzen, 1991). The Kano model categorizes product attributes into must-be, one-dimensional, and attractive qualities (Kano et al., 1984). By examining psychological factors like consumer knowledge and social support, we can determine which elements are essential and which can elevate satisfaction or willingness to adopt low-carbon products, clarifying perceptions that drive consumer acceptance. This research investigates consumer perception and acceptance of low-carbon products using an integrated Kano model to classify key psychological determinants. We aim to determine: (1) How do consumer knowledge, social influence, personal attitudes, and perceived ease of use relate to willingness to purchase low-carbon products? (2) Which factors serve as must-be prerequisites, provide one-dimensional performance impacts, and act as attractive motivators affecting consumer satisfaction and behavior? Our study contributes to theory by extending the Kano model to sustainable consumer behavior and to practice by guiding businesses and policymakers in developing strategies that meet basic expectations and enhance consumer delight, promoting broader acceptance of low-carbon products.

2. Literature Review

2.1 Kano Model and Customer Satisfaction

The Kano model, introduced by Noriaki Kano and colleagues in 1984, is a framework for understanding how product or service attributes influence customer satisfaction. Unlike traditional linear models, Kano's model suggests that the impact of an attribute can be asymmetric. Kano et al. (1984) identified three main categories of quality attributes: must-be, one-dimensional, and attractive. Must-be attributes, or basic needs, are expected by customers; their absence leads to dissatisfaction, while their fulfillment only brings satisfaction to a neutral level. One-dimensional attributes have a proportional relationship with satisfaction and dissatisfaction, reflecting what customers explicitly deem important. Attractive attributes are unexpected features that delight customers; they do not cause dissatisfaction when absent but significantly enhance satisfaction when present. This model is widely used to prioritize product development and service

improvements based on customer needs. For instance, Matzler and Hinterhuber (1998) integrated the Kano model into quality function deployment to enhance product development decisions, showing that addressing attractive and one-dimensional attributes can delight customers and create a competitive advantage. Numerous studies have applied Kano analysis across various industries, from hospitality and tourism to healthcare and education, to classify attributes and guide resource allocation (Shahin et al., 2013; Witell et al., 2011). A comprehensive literature review by Luor et al. (2015) identified over a decade of Kano model applications, underscoring its versatility in evaluating customer satisfaction drivers in both products and services. Researchers have also proposed refined or hybrid models, such as integrating Kano with Importance-Performance Analysis or SERVQUAL, to assess service quality attributes (Kuo et al., 2012; Basfirinci & Mitra, 2015). Overall, the Kano model effectively distinguishes between factors that prevent dissatisfaction and those that actively enhance satisfaction.

Likert scales in customer surveys assess perceptions and attitudes toward businesses. The 7-point scale is often used to gauge feelings on specific topics but must be recoded into a 5-point scale to align with the Kano model's five psychological response categories. Research shows minimal impact on validity and reliability between the two scales in regression analyses (Joshi et al., 2015; Revilla, Saris, & Krosnick, 2014). The recoding is as follows: score 1 remains 1 (strongly disagree), scores 2-3 become 2 (disagree), score 4 becomes 3 (neutral), scores 5-6 become 4 (agree), and score 7 becomes 5 (strongly agree). This process preserves clarity and enables consistent modeling of satisfaction and dissatisfaction in the Kano regression.

2.2 Consumer Perceptions of Low-Carbon Products

Understanding consumer perceptions and attitudes toward low-carbon products is essential for promoting their adoption. Previous studies indicate that several factors influence consumers' willingness to buy eco-friendly products. For example, environmental knowledge and awareness significantly impact purchasing intentions; consumers who can interpret environmental labels, such as carbon footprint labels, are more likely to buy green products (Chan, 2001). However, price and convenience pose practical barriers—if low-carbon products are perceived as too expensive or difficult to find, many consumers hesitate to purchase them (Thøgersen & Zhou, 2012). Social influence also plays a crucial role; social norms and peer pressure can either encourage or discourage sustainable consumption. Li, Long, and Chen (2017) found that the credibility and clarity of carbon labels significantly affect Chinese consumers' willingness to buy low-carbon products. When consumers trust the information on these labels and find them easy to understand, they are more likely to include such products in their purchasing decisions.

Overexposure to promotional messages can backfire. Excessive or insincere marketing may lead to consumer skepticism or fatigue, similar to a boomerang effect where social pressure triggers resistance instead of compliance. While peer and media mentions can raise awareness, their influence on behavior is complex; some consumers respond positively to social encouragement, while others may react negatively if they feel overwhelmed. Thus, examining consumer perceptions of low-carbon products requires a multidimensional approach, considering cognitive factors (knowledge, label understanding), affective factors (environmental concern, personal values), social factors (normative beliefs, peer support), and practical factors (price sensitivity, convenience). However, integrating these aspects in a single study is challenging. The Kano model, which categorizes factors by their impact on satisfaction, serves as a useful tool to distinguish between motivators in low-carbon product adoption. Recent sustainability marketing research has begun to adopt such approaches. For instance, Dominici et al. (2016) used an integrated Kano model to analyze consumer attitudes in the automotive industry's shift toward eco-friendly vehicles, showing how certain innovative features were perceived as attractive quality elements that could enhance consumer acceptance. Similarly, Yin et al. (2016) applied a combined Importance-Performance and Kano analysis to residential environment satisfaction, demonstrating that environmental attributes can be classified to better understand resident perceptions. Building on these insights, our study positions consumer perception factors of low-carbon products within the Kano framework, allowing for clearer identification of their roles in driving consumer satisfaction and behavior.

3. Research Method

Sample and Data Collection. We conducted an online questionnaire among Taiwanese consumers aged 18 and older using convenience sampling, yielding 277 valid responses from 300 collected. A pilot test (n=50) confirmed the survey's clarity and reliability (Cronbach's $\alpha > 0.7$), resulting in minor refinements before final deployment.

Measures and Questionnaire Design. The survey evaluated four perception dimensions: (1) product cognition (knowledge of low-carbon products); (2) perceived environmental benefit (beliefs about environmental effectiveness and trust in policies); (3) perceived ease of use and feasibility (convenience, affordability, and self-efficacy); and (4) social influence and attitudes (impact of media, peer support, personal attitude, and willingness to recommend). Dependent variables included self-reported low-carbon product purchases in the past six months, ongoing usage, and behavioral intentions. The questionnaire was developed in Chinese, validated by experts. Factor analysis confirmed construct validity, with high reliability for each construct (composite reliability > 0.8).

Kano Regression Classification Method. We applied Kano's regression-based method to assess the impact of perception factors (Chen, 2012). For each factor, we derived two regression coefficients: β_1 for dissatisfaction (low or absent factor level) and β_2 for satisfaction (high factor level). Factors were categorized as must-be (β_1 significant, β_2 not significant), one-dimensional (both significant, β_1 negative, β_2 positive), or attractive (β_2 significant, β_1 not significant). Factors with no significant effects were classified as "Indifferent" (no impact) or "Reverse" (negative impact). This analysis was conducted for two dependent variables: (1) actual purchase behavior in the past six months and (2) ongoing usage behavior. We recorded β_1 , β_2 , significance levels (p-values), and the coefficient of determination (R^2) for each factor. R^2 indicates the variance explained by the factor's presence or absence. All analyses were performed using SPSS and Python, with a significance threshold of 0.05.

4. Finding and Discussion

4. 1. Descriptive Statistics and Preliminary Analysis

Among the 277 respondents, 62.5% were female, primarily aged 18-34, and over 94% were college-educated. Attitudes toward low-carbon products were positive (mean $\sim 4.1/5$), and environmental concern was high (mean $\sim 4.3/5$). A factor analysis validated the four perception constructs, with item loadings above 0.7 and Cronbach's α between 0.85 and 0.92.

Multiple regression analysis indicated that personal attitude, perceived ease/feasibility, and knowledge significantly predicted recent purchases and continuous use of low-carbon products ($p < 0.01$). In contrast, frequent exposure to low-carbon product information had a small negative effect ($p < 0.05$). The regression models for purchase and continuous use were significant (F-tests, $p < 0.001$), explaining about 48% and 52% of the variance in behavior, respectively.

4. 2. Kano Classification of Perception Factors (Purchase Behavior)

As shown in Table 1, most perception factors were classified as one-dimensional attributes, with both β_1 and β_2 significant- β_1 negative and β_2 positive. Enhancing factors like knowledge, ease of use, social support, and positive attitude increases satisfaction and purchase likelihood, while their absence leads to dissatisfaction. Two factors, perceived pollution reduction and tangible product benefits, were must-be meaning consumers expect actual environmental benefits as a basic benefits. If deliver on them, fails to deliver, them occurs; meeting these expectations results in influence satisfaction. The influence as an attractive attribute opinion was identified only; positive attractive endorsement can pleasantly surprise consumers and boost their enhance not cause but dissatisfaction.

Table 1. Kano classification results for consumer perception factors (Dependent Variable: Low-Carbon Product Purchase in Past 6 Months)

Item (Perception Factor)	linear regression					Kano Category
	β 1	Sig.	β 2	Sig.	R ²	
1. Able to distinguish low-carbon products	-.300	***	.415	***	.339	One-dimensional
2. Understand eco-labels	-.359	***	.256	***	.259	One-dimensional
3. Know design can reduce carbon	-.243	***	.220	***	.150	One-dimensional
4. Can evaluate environmental benefits	-.274	***	.448	***	.390	One-dimensional
5. Information comes from media	-.178	***	.416	***	.237	One-dimensional
6. Marketing influences my perception	-.190	***	.343	***	.188	One-dimensional
7. Government policies increase my trust	-.197	***	.393	***	.244	One-dimensional
8. Friends' opinions influence my view	-.091	.120	.402	***	.191	Attractive
9. Using product can reduce pollution	-.340	***	-.007	.913	.108	Must-be
10. Product has tangible benefits	-.319	***	.100	.092	.125	Must-be
11. Product improves quality of life	-.373	***	.293	***	.302	One-dimensional
12. Understand product labels (carbon footprint, etc.)	-.343	***	.348	***	.305	One-dimensional

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13. Using it is not troublesome (easy to use)	-.340	***	.202	***	.205	One-dimensional
14. Purchase is very convenient (easy to obtain)	-.279	***	.405	***	.355	One-dimensional
15. I have a positive attitude toward using it	-.301	***	.229	***	.200	One-dimensional
16. I feel using it is responsible (ethical duty)	-.252	***	.328	***	.236	One-dimensional
17. Friends/Family will support me using it	-.257	***	.390	***	.273	One-dimensional
18. Society encourages people to use it	-.169	**	.440	***	.256	One-dimensional
19. People around me have positive opinions about it	-.301	***	.372	***	.291	One-dimensional
20. It is affordable (I can afford it)	-.326	***	.317	***	.278	One-dimensional
21. Habit is easy to maintain (easy to keep using)	-.282	***	.219	***	.181	One-dimensional
22. Willing to continue using it in future	-.348	***	.473	***	.448	One-dimensional
23. Willing to recommend it to others	-.259	***	.483	***	.391	One-dimensional
24. Would purchase if price is reasonable	-.272	***	.306	***	.231	One-dimensional

*: Sig. < .05; **: Sig. < .01; ***: Sig. < .001

4. 3. Kano Classification (Continuous Usage Behavior)

The pattern observed in continuous usage exhibited similarities across various factors as illustrated in Table 2. The majority of these factors retained a one-dimensional nature, particularly those related to practical feasibility, such as affordability and ease of maintenance, which emerged as significant one-dimensional drivers of sustained usage. Must-be attributes remained consistent, as users anticipated that low-carbon products would effectively mitigate pollution and provide tangible benefits to encourage ongoing use. Peer influence was found to be somewhat less significant in relation to continued usage compared to its impact on initial purchase decisions; while it remained a positive factor, its effect was diminished. Importantly, the combined influence of frequent mentions in media and among friends demonstrated a negative β_1 and an absence of a positive β_2 , indicating that overexposure or excessive reminders may lead to a decrease in sustained usage, suggesting a potential “Reverse” effect.

Table 2. Kano classification results for consumer perception factors (Dependent Variable: Continuous Use of Low-Carbon Products)

Item (Perception Factor)	linear regression					Kano Category
	β_1	Sig.	β_2	Sig.	R ²	
1. Able to distinguish low-carbon products	-.167	**	.421	***	.245	One-dimensional
2. Understand eco-labels	-2.56	***	.256	***	.175	One-dimensional
3. Know design can reduce carbon	-.230	***	.214	***	.137	One-dimensional
4. Can evaluate environmental benefits	-.115	*	.462	***	.272	One-dimensional
5. Information comes from media	-.194	***	.392	***	.225	One-dimensional
6. Marketing influences my perception	-.249	***	.341	***	.226	One-dimensional
7. Government policies increase my trust	-.227	***	.364	***	.239	One-dimensional

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8. Friends' opinions influence my view	-.041	.489	.416	***	.132	One-dimensional
9. Using product can reduce pollution	-.445	***	.022	.387	.199	Must-be
10. Product has tangible benefits	-.368	***	.110	.057	.166	Must-be
11. Product improves quality of life	-.344	***	.280	***	.264	One-dimensional
12. Understand product labels (carbon footprint, etc.)	-.251	***	.326	***	.213	One-dimensional
13. Using it is not troublesome (easy to use)	-.377	***	.189	**	.229	One-dimensional
14. Purchase is very convenient (easy to obtain)	-.217	***	.387	***	.279	One-dimensional
15. I have a positive attitude toward using it	-.316	***	.234	***	.216	One-dimensional
16. I feel using it is responsible (ethical duty)	-.218	***	.370	***	.248	One-dimensional
17. Friends/Family will support me using it	-.135	*	.413	***	.217	One-dimensional
18. Society encourages people to use it	-.193	***	.405	***	.238	One-dimensional
19. People around me have positive opinions about it	-.270	***	.323	***	.224	One-dimensional
20. It is affordable (I can afford it)	-.319	***	.225	***	.199	One-dimensional
21. Habit is easy to maintain (easy to keep using)	-.264	***	.221	***	.168	One-dimensional

22. Willing to continue using it in future	-.301	***	.441	***	.367	One-dimensional
23. Willing to recommend it to others	-.181	***	.458	***	.300	One-dimensional
24. Would purchase if price is reasonable	-.184	**	.340	***	.195	One-dimensional

*: Sig. < .05; **: Sig. < .01; ***: Sig. < .001

5. Conclusion

5.1 Key Findings and Theoretical Implications

This study explores consumer perceptions of low-carbon products by categorizing psychological drivers using the Kano model. A key finding is that most perception factors act as one-dimensional attributes. Knowledge-related factors (identifying low-carbon products, understanding labels), attitudinal factors (personal attitudes, perceived responsibility), and social normative factors (support from friends and family, societal encouragement) symmetrically influence satisfaction and behavior. This aligns with the Theory of Planned Behavior, which states that attitudes and social norms linearly affect intentions (Ajzen, 1991). Our contribution is demonstrating this in the context of low-carbon products with Kano classification. The one-dimensional nature of these factors suggests that improving them will enhance consumer satisfaction and adoption. For example, increasing knowledge about low-carbon product benefits will boost purchasing likelihood, while a lack of knowledge will hinder adoption. This supports prior research on the role of environmental knowledge in green consumer behavior (Chan, 2001)-informed consumers are more likely to act eco-friendly. Furthermore, the strong one-dimensional nature of perceived feasibility (affordability, ease of use) underscores the importance of perceived behavioral control in the TPB, indicating that consumers prioritize practical convenience in their decisions.

Another key finding is the identification of essential attributes in the low-carbon product context. Consumers expect these products to deliver genuine environmental benefits, such as pollution reduction. While the presence of these attributes does not enhance satisfaction, their absence leads to dissatisfaction and reduced adoption. This highlights that a sustainable product's credibility is crucial; consumer trust relies on its effectiveness in eco-friendly claims. This aligns with sustainability marketing literature, which emphasizes that authenticity and performance are vital for consumer acceptance. It also reflects Herzbergs' two-factor theory (Herzberg, Mausner, & Snyderman, 1959), indicating that certain aspects do not motivate when fulfilled

but demotivate when missing. Future absent of green consumer behavior should account for consider these expectations; green attributes must clear a meet a legitimacy factors even come are relevant. The presence of peer opinion influence illustrates how unexpected social endorsement can enhance consumer enthusiasm. This suggests that, beyond established factors like attitudes or perceived control, subtle influences exist. For example, when friends positively discuss a low-carbon product, it boosts confidence or interest, which traditional models like the Theory of Planned Behavior (TPB) may overlook. This indicates a need to expand consumer behavior models to include social motivators that do not follow linear patterns.

Excessive media and friend mentions during sustained use reveal a boundary condition in social influence, aligning with message fatigue and boomerang effects from social psychology (where too much persuasion leads to resistance). This finding shows that social influence can become negative beyond a certain point. The Kano framework highlights attributes that do not fit positive categories, prompting further investigation. Thus, any model of sustainable behavior adoption should consider potential curvilinear or inhibitory effects of over-communication and design engagement strategies accordingly. In summary, our research utilizes the Kano model to enhance the discussion on sustainable consumer behavior. It shows that consumer perceptions of low-carbon products are complex, with varying impacts on satisfaction and adoption. Some factors are foundational, while others can delight or backfire. This approach can be applied to other green behaviors, such as electric vehicle adoption and renewable energy usage, to identify key motivators and refine behavior change theories.

5.2 Managerial Implications

Our findings offer actionable insights for businesses and policymakers promoting low-carbon products. Companies must ensure the fundamental performance of these products by verifying and communicating their actual environmental benefits, such as carbon emission reductions. Any sign of or underperformance will lead to consumer dissatisfaction and distrust. Certifications or transparent carbon footprint reporting can help assure consumers that the product meets these expectations. Stakeholders should enhance one-dimensional attributes to boost consumer satisfaction. Educational campaigns and clear labeling can improve awareness of low-carbon products, promoting adoption. Convenience-through wider availability, competitive pricing, and user-friendly design-is crucial, as these factors significantly influence consumer decisions. For example, subsidies that make low-carbon products more affordable can increase market uptake. Additionally, ensuring ease of use compared to conventional alternatives, along with support and training, will help maintain usage. Marketers can use peer endorsement to boost acceptance. While not everyone is influenced by peers, positive word-of-mouth greatly affects many consumers. Companies can create communities or referral programs for satisfied users to share experiences.

Social marketing campaigns that highlight testimonials or encourage recommendations can attract new adopters. However, authenticity is essential; orchestrated referrals must be transparent to avoid skepticism.

Our results warn against aggressive marketing saturation. Excessive media and friend mentions negatively affect sustained usage, highlighting the need for moderation. Policymakers and advocacy groups should avoid communications that provide new information or emotional resonance. For instance, campaigns connecting low-carbon product use to community benefits or personal values can keep the message engaging, rather than relying on constant reminders to be green. In addition, companies could invest in enhancing perceived self-efficacy among consumers. Since feeling capable of continuous use was important, providing resources like how-to guides, customer support, or even gamified challenges can empower users and reinforce their confidence in using low-carbon products over the long term. Governments and organizations might also implement programs that integrate low-carbon product usage into everyday life (for example, integrating energy-saving appliances into public incentive programs or community initiatives) so that these behaviors become normalized and easier to maintain.

5.3 Limitations and Future Research

Several limitations of this study should be acknowledged. First, the use of convenience sampling and self-reported survey data may limit the generalizability of our findings. Our sample was skewed toward educated, environmentally aware individuals and may not fully represent the broader consumer population, particularly those less familiar with sustainability issues. Future research could employ random or stratified sampling to capture a more representative consumer profile or conduct studies in different cultural contexts for comparison. Second, the cross-sectional design of our survey captures perceptions and behaviors at a single point in time, limiting causal inferences. While we interpret certain factors as influencing satisfaction or behavior, these relationships could also be reciprocal (e.g., purchasing a product may enhance knowledge or alter attitudes). Longitudinal studies or experiments, such as tracking consumers over time as they adopt low-carbon products or manipulating information exposure in a controlled setting, would strengthen causal claims and reveal how these perceptions and satisfaction relationships evolve. Additionally, we primarily focused on positive satisfaction drivers; exploring the “reverse” and “indifferent” categories in depth, especially regarding overexposure effects, could be a valuable extension, potentially combining Kano analysis with other frameworks like Prospect Theory to understand negative reactions.

Despite its limitations, this study provides a foundation for further research. Future inquiries could explore other sustainable behaviors, such as recycling and public transit, through a Kano lens or

use segmentation analysis to see if different consumer groups (e.g., green enthusiasts vs. skeptics) have distinct Kano classifications. Investigating effective educational initiatives to enhance knowledge, a crucial factor, is also worthwhile. Furthermore, how can businesses convert specific attributes into attractive delights? Addressing these questions will build on current findings and promote sustainable consumption.

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