Research on Willingness to Pay for Cascade Utilization of New Energy Vehicle Battery Products under the "Double Carbon" Goal

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Abstract. With the growing global concern about climate change, China, as the world's largest carbon emitter, faces the great challenge of achieving the carbon peak and carbon neutral goals. This paper explores the factors affecting consumers' willingness to pay for secondary utilization of battery products and, based on the Theory of Planned Behavior (TPB), adds three variables, namely incentive policy, knowledge and perceived risk, and applies interpretative structural modeling (ISM) to analyze how these factors affect consumers' willingness to pay. It was found that knowledge and incentive policy are deep-level factors that affect willingness to pay, while consumers' perceived risk, perceived behavioral control, and subjective norms are mid-level influences that directly affect attitude and willingness to pay. Attitude, as a superficial factor, is a direct determinant of consumers' willingness to pay. Through ISM analysis, the study reveals the interactions and the dynamic circular system between these factors, emphasizing the importance of policy and knowledge dissemination in promoting consumer acceptance of new products, as well as the importance of reducing perceived risk and increasing self-efficacy in forming positive attitudes. Finally, the theoretical and practical implications of the findings are discussed and relevant policy recommendations are made.

Keywords: "Double Carbon" Goal; New Energy; Secondary Utilization; Willingness to pay.

1. Introduction

In recent years, China has emerged as the leading nation globally in terms of total carbon emissions, with mobile source pollution emerging as a significant contributor to air pollution in major and medium-sized Chinese cities. The pressing need to enhance the management of mobile source pollution is becoming increasingly evident[1]. Following the proposal of the "double carbon" goal by General Secretary Xi Jinping, China has rapidly elevated the strategic importance of this objective. The implementation and promotion of the "double-carbon" policy has led to rapid development in the new energy vehicle industry, particularly in 2021, when there was a significant increase. This transition indicates a shift from a "policy-driven" to a "market-driven" approach, which is a notable advancement for the new energy vehicle industry. Exhaust emissions from traditional fuel-powered vehicles have been proven to cause significant levels of pollution to the environment. In contrast, new energy vehicles boast both low fuel consumption and low emissions as a consequence of their design. In an effort to reduce the reliance of the automobile industry on traditional fuels, the government has introduced a series of incentives to promote the development of new energy vehicles [2]. However, the power battery in new energy vehicles has a limited life cycle. Research results from experts in the field demonstrate that, upon reaching an approximate capacity of 80%, the battery is no longer suitable for use as a power source for new energy vehicles. This results in a significant number of decommissioned batteries. As posited by the New Energy Battery Recycling Committee, it is anticipated that by 2027, the quantity of retired batteries from new energy vehicles will amount to 1.14 million tons. In the event of the improper disposal of power batteries from new energy vehicles, there is a risk of significant environmental and safety hazards for individuals and society as a whole. This poses a substantial threat not only to the natural environment, but also to the health of individuals.

In February 2018, the Ministry of Industry and Information Technology promulgated the Interim Measures for the Management of Power Battery Recycling for New Energy Vehicles [3], which

proposed to encourage the development of power battery laddering and recycling, and to promote the innovation of power battery recycling modes. Secondary utilization is defined as the process of re-evaluating and examining retired power storage batteries with a view to re-deploying them in areas characterized by uncomplicated operating conditions and relatively modest performance criteria. These areas include renewable energy systems in buildings, electric vehicle charging stations, portable power units, and electric bicycles [4]. In accordance with the provisions set out in the national policy framework, domestic enterprises and research institutions are undertaking the work of power battery laddering and recycling. Furthermore, these entities are encouraging innovation with regard to power battery recycling methods. It has been predicted by certain experts that the secondary utilization of batteries will be gradually applied to the field of mass consumer products, such as low-speed vehicles and electric bicycles. This suggests that the secondary utilization of retired power batteries has significant market potential in China [5]. The sustainable development of the recycled battery products in China is contingent on the consumers' propensity to purchase such products. The present study focuses on the factors that influence consumers' willingness to pay for recycled battery products. In addition, it explores the hierarchical relationship between these factors, a relationship which is of great theoretical and practical significance.

In the contemporary global context, numerous nations are engaged in the active promotion of research and implementation initiatives pertaining to the utilization of power batteries in a secondary capacity. The primary focus of both domestic and international research endeavors in this domain encompasses the pivotal technological aspects of secondary battery utilization, alongside considerations of national policies and the diverse application areas that have been identified. Wang Kunqiang [6], Huang Zhaixu [7], Liu Qian [8] and others have conducted research on the current state of power battery secondary utilization and the future challenges it faces. They have presented a comprehensive overview of domestic and international power battery secondary utilization application fields. They have also proposed a series of recommendations to facilitate the industrialization of secondary utilization, acknowledging the numerous challenges that must be overcome. These recommendations are informed by the current state of power battery secondary utilization development in the relevant countries. Rautela et al. [9]conducted a technical review of the recovery of metals from retired power batteries. In this review, he discussed in detail the current technologies used for the secondary utilization of retired power batteries. His aim was to promote the development of the industrialization of the secondary utilization of retired power batteries.Garg et al. [10] introduced the treatment methods of retired power batteries. In this paper, they comprehensively elaborated on the performance evaluation methods and classification and restructuring methods of retired power batteries. Ahmadi et al.[11] primarily focused on the life cycle management of lithium-ion battery packs utilized in electric vehicles, underscoring the significance of recycling decommissioned power batteries from an environmental and resource efficiency standpoint. They further proposed the imperative of conducting health assessments and implementing management strategies for these battery packs to ensure their effectiveness and safety during the recycling process.

In summary, there is an absence of empirical research on consumers' propensity to pay for recycled battery products under the objective of "double-carbon". The present study employs the Theory of Planned Behaviour (TPB) to select variables. This approach is then expanded through the incorporation of three additional variables: incentive policy, knowledge, and perceived risk. Utilizing the interpretative structural model (ISM), the hierarchical relationship between each variable is explored, with the objective of providing valuable guidance for the development of new energy automobile power batteries. The hierarchical relationship between the variables is explored using the interpretative structure model (ISM), with a view to providing useful guidance for the development of the secondary utilization of power batteries in new energy vehicles.

2. Theoretical Model

The present study employs the TPB model as the theoretical foundation for the identification of factors that motivate consumers to incur the cost of purchasing power battery laddering products.The TPB model is a widely utilized behavioral model that is regarded as one of the most efficacious frameworks for elucidating and predicting human behaviour [12]. The theoretical framework under scrutiny aims to elucidate the relationship between an individual's behavioral intentions and their actual behaviour in a given situation.The TPB posits that behavioral intentions are the direct antecedents of behaviour, which in turn is influenced by three key factors: namely, attitudes, subjective norms, and perceived behavioral control [13].

Attitude is defined as an individual's positive or negative evaluation of a behaviour. It is an established fact that if an individual holds a positive attitude towards a given behaviour, there is a greater probability that they will engage in that behaviour. Subjective norms are defined as an individual's perceived social pressure, that is to say, the expectations of significant others (e.g., family members, friends, colleagues, etc.) regarding the performance of a particular behaviour. This social pressure exerts influence on an individual's behavioral intentions. Perceived behavioral control is defined as the degree of confidence an individual has in their ability to perform a behaviour. It has been demonstrated that, even in circumstances where attitudes and subjective norms are conducive to a certain behaviour, if the individual perceives themselves to be incapable of engaging in the behaviour, the probability of the behaviour manifesting itself is reduced.

The integration of these three factors enables TPB to provide a systematic framework for explaining and predicting the behavioral patterns of individuals in various contexts. This has resulted in the extensive utilization of TPB in diverse fields, including health behaviour, environmental behaviour, and consumer behaviour, among others. This approach facilitates comprehension of the motivations underpinning behaviors, thereby providing a theoretical foundation for the development of interventions. However, consumers are complex beings, and the factors that influence their payment decisions are similarly intricate and diverse. The three variables of attitude, subjective norms and perceived behavioral control in the TPB model do not fully explain consumers' behavioral intentions. This study therefore explores the main internal and external situational factors faced by consumers by analyzing the three variables of incentive policy, perceived risk and knowledge. The aim is to comprehensively assess the factors that influence consumers' willingness to pay for power battery products and their willingness to pay for products from the laddered utilization of power batteries.

Incentive policies have been identified as a significant external contextual factor for government intervention in consumers' green purchasing behaviour. The implementation of such policies has been shown to exert a positive effect on consumers' green willingness to pay and purchasing behaviour [14]. It is imperative to understand how consumers perceive policies, given that they are often influenced by policy orientation when making purchase decisions.

Perceived risk is defined as the individual's inability to predict the decision-making outcome of their purchase behaviour. This outcome is perceived as good or bad, and is influenced by the existence of uncertainty, which produces an unpleasant feeling in the individual. This in turn has a significant effect on the consumer's purchasing decision[15]. It is evident that consumers are not only concerned about the environmental performance of products, but also attach great importance to the quality and safety of products. This is particularly salient in the context of products involving power battery secondary utilization technology, as the technology is not yet fully mature. Consequently, the perceived risk of consumers for such products cannot be disregarded. The objective of this study is to ascertain the stability of performance and potential risks to health and the environment associated with the products under scrutiny.

The level of knowledge possessed by consumers has been identified as a significant factor influencing their purchasing behaviour. The extent of consumers' awareness regarding the secondary utilization of power battery products directly correlates with their ability to accurately assess the performance and advantages of these products. This, in turn, impacts their propensity to incur costs.

It is imperative for consumers to possess a comprehensive understanding of the product features, technical intricacies, and market intelligence to facilitate confident decision-making during purchase and to ensure effective adaptation to market fluctuations.

In summary, the present study will undertake a comprehensive analysis of the multifarious internal and external situational factors confronted by consumers in their purchasing decisions. This analysis will be informed by a study of three pivotal factors: namely, incentive policy, perceived risk and knowledge. The study's findings will provide valuable insights to inform relevant policy formulation and marketing strategies. The present study provides a detailed analysis and organization of the main factors influencing consumers' willingness to pay for the products of the battery for secondary utilization, as shown in Table l.

Table 1. Factors affecting consumers' willingness to pay for recycled battery products

Indicator number	factors
α_1	Subjective norm
α_2	Perceived risk
α_3	Knowledge
α_4	Incentive policy
α_5	Attitude
α_6	Willingness to pay
α_7	Perceived behavior control

3. Factor analysis based on the Interpretative structural modeling

3.1. Interpretative structural modeling

This section employs the ISM method to construct a recursive structural model, which was developed in 1976 by Professor John N. Warfield in the USA as a methodology for analysing problems related to complex socio-economic systems [16].

The ISM is utilized to construct a hierarchical structural model by decomposing a complex system into multiple subsystem elements, thereby transforming a chaotic system into a clear and concrete model. This facilitates analysis of the structural relationships between key elements and identification of the elements that solve the key problems [17]. The ISM method has been demonstrated to be effective in exploring the mechanism of consumers' influence on the willingness to pay for the secondary utilization of power batteries. It has the capacity to systematically decompose the influencing factors of the willingness to pay for the secondary utilization of power batteries, thereby identifying the intrinsic connection between the various influencing factors. This process enables the preliminary establishment of the structural relationship between the influencing factors and the identification of underlying causes [18].

3.2. Implementation steps

3.2.1 Establishment of initial direct matrix

This study invites six experts in the field of new energy power batteries to use the Delphi method to score the mutual influence relationship between the indicators of willingness to pay for SURB products. The scores range from 1 to 5, indicating five grades of mutual influence relationship: none, weak, weaker, stronger, and strong. α_i denotes the i indicator, i=1~7, where $\alpha_1 \sim \alpha_7$ respectively denote subjective norms, perceived risk, knowledge, incentive policies, attitudes, WTP, and perceived behavioral control. The initial direct matrix, denoted by C^m, is expressed as $C^m = (\beta_{ij}^m)_{n\times n}$, where β_{ij}^m indicates the degree of direct influence evaluation of the indicator α_i on α_j made by the experts. Note that $\alpha_{ij} = 0$ when $i = j$ as it will not influence itself. Let n be the number of experts, and the scores are aggregated using the averaging method according to formula (1) to obtain the initial direct matrix ' C '.

$$\beta_{ij} = \frac{1}{n}\sum_{m=1}^{n} \beta_{ij}^{m}, \quad m = 1,2,\cdots,n. \tag{1}$$

$$C = \begin{pmatrix} 0 & 2.14 & 2.49 & 2.64 & 3.28 & 3.24 & 1.64 \\ 2.44 & 0 & 2.44 & 2.89 & 2.72 & 3.19 & 1.64 \\ 2.95 & 2.99 & 0 & 3.02 & 3.61 & 3.73 & 1.83 \\ 2.67 & 3.21 & 3.02 & 0 & 3.36 & 3.19 & 2.04 \\ 2.48 & 2.68 & 2.93 & 2.73 & 0 & 3.06 & 1.81 \\ 2.55 & 2.89 & 2.68 & 2.82 & 3.13 & 0 & 1.39 \\ 1.58 & 1.28 & 2.03 & 1.60 & 2.94 & 3.06 & 0 \end{pmatrix}$$

3.2.2 Establish the adjacency matrix and reachability matrix

Set the threshold $\lambda = 3.01$ based on the initial direct matrix. Then, establish the adjacency matrix ϕ using equation (2), where 1 indicates a direct influence of indicator α_i on indicator α_j, and 0 indicates no direct influence of indicator α_i on indicator α_j.

$$\phi_{ij} = \begin{cases} 1, & \beta_{ij} \geq \lambda, \\ 0, & \beta\text{ij} < \lambda. \end{cases} \tag{2}$$

$$\phi = \begin{pmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$

After obtaining the adjacency matrix, we find the maximum number of passes K using equation (3) in MATLAB software. The unit matrix I is used to obtain the reachability matrix M, as shown in equation (4).

$$(\phi + I) \neq (\phi + I)^{K-1} \neq (\phi + I)^{K} = (\phi + I)^{K+1} \tag{3}$$

$$M = (\phi + I)^{K} \tag{4}$$

$$M = \begin{pmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 \end{pmatrix}$$

3.2.3 Regional division of reachability matrix

The reachability matrix is regionally divided, i.e., the influencing factors are divided into reaches set $A(\alpha_i)$, prior set $B(\alpha_i)$, and common set $C(\alpha_i)$ to further study the hierarchical relationship among the indicators, as shown in Table 2.

Table 2. Reachable set, prior set, and a common set of impact factor indicator systems

Indicators	Reachable set $A(\alpha_i)$	Prior set $B(\alpha_i)$	Common set $C(\alpha_i)$
α_1	1, 5, 6	1, 2	1
α_2	2, 5, 6	2, 3, 4	2
α_3	2, 3, 4, 5, 6	3, 4	3, 4
α_4	2, 3, 4, 5, 6	3, 4	3, 4
α_5	5, 6	1, 2, 3, 4, 5, 6, 7	5, 6
α_6	5, 6	1, 2, 3, 4, 5, 6, 7	5, 6
α_7	5, 6, 7	7	7

3.2.4 Establishment of an interpretive structural model

Based on the reachable and common sets obtained in Table 2, a hierarchical decomposition of the influencing factors $\alpha_i(i = 1\sim7)$ is performed. The steps are as follows: firstly, identify the factors that correspond to $A(\alpha_i) = C(\alpha_i)$ and consider them as the first layer in the ISM model. Secondly, remove the columns and rows that correspond to the factors in the first layer from the matrix to create a new reachable matrix. Finally, determine the factors that are included in the second layer based on the same principle. And so on, until each factor is categorized into the corresponding level[19]. This paper classifies the seven factors that influence the willingness to pay for SURB products into three levels based on the layering principle. The top-level factors are α_5 WTP and α_6 attitude. The mid-level factors are α_1 subjective norms, α_2 perceived risk, and α_7 perceived behavioral control. The bottom-level factors are α_3 knowledge and α_4 incentive policy. The results are presented in Figure 1.

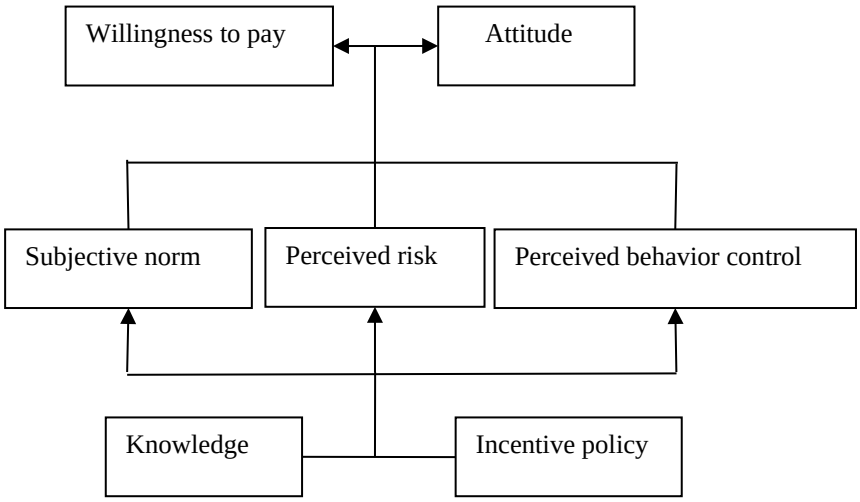

Figure 1. ISM of Factors Influencing Consumers' Willingness to Pay for SURB Product

3.3. Analysis of ISM results

3.3.1Analysis of stratified results

In relation to the findings presented in Figure 1, it can be observed that knowledge and incentive policies emerge as the fundamental factors influencing consumers' propensity to incur costs for power battery secondary utilization products in new energy vehicles. These policies directly impact the three intermediate-level influencing factors of subjective norms, perceived risks and perceived behavioral control. Meanwhile, attitudes represent the surface-level influencing factors that shape consumers'

willingness to pay for power battery secondary utilization products. The following specific analysis is provided. The analysis of results was conducted on a stratified basis.

Firstly, it is evident that the primary constraints influencing consumers' propensity to remunerate for secondary battery products are rooted in their awareness of these products and the prevailing national incentive policies. The significance of this awareness and these policies as fundamental factors in shaping consumers' willingness to pay should not be overlooked. The level of knowledge possessed by consumers has been demonstrated to exert a direct influence on their propensity to accept new products or technologies. When consumers have a more profound understanding of power battery secondary utilization products, they are better able to assess the performance, advantages, and potential environmental benefits of these products. Consequently, they are more likely to generate positive purchasing behaviour. Moreover, government incentives, including tax reductions, subsidies, and preferential policies, have the potential to not only decrease consumers' purchasing costs but also function as signals of quality assurance and policy support. This, in turn, can enhance consumers' confidence, thereby stimulating their propensity to pay.

Secondly, mid-level factors, which serve as a conduit between root and surface factors, play a pivotal role in the formation of consumers' willingness to pay. Subjective norms, which are typically associated with social acceptance and expectations, have the capacity to engender a social drive compelling consumers to contemplate the procurement of laddered utilization products in accordance with social norms and expectations. This social influence may create a cohort effect among consumers, in which individual behaviour is influenced by those around them. This has been shown to contribute in part to the popularity of laddered utilization products. Perceived risk constitutes the natural reaction of consumers when confronted with a novel product or an uncertain situation. In the context of power battery laddering products, consumers may have concerns regarding product safety, performance stability, and potential long-term health effects. Should consumers perceive these risks to be excessive, they may elect to refrain from making a purchase. It is therefore vital to recognize that reducing perceived risk is pivotal to increasing willingness to pay. This can be achieved through transparent communication, user education, and robust quality assurance. Perceived behavioral control has been shown to be related to consumers' self-efficacy, that is to say, their beliefs about their ability to perform specific behaviors. It has been demonstrated that consumers are more likely to make a purchase when they believe they are in control of the buying process and can effectively utilize the product. The provision of comprehensive product information, user guides and excellent customer service has been demonstrated to reinforce this sense of control.

Thirdly, attitude, as a direct determinant of consumers' willingness to pay, is a comprehensive reflection of consumers' evaluation of products. Although attitude is superficially observable, it is the consolidated articulation of consumers' internal evaluations, thereby serving as a pivotal conduit between middle-level factors and the propensity to incur a cost. The attitude of consumers integrates their cognitive, emotional and behavioral tendencies towards the product, forming an overall evaluation of the power battery laddering product. A positive attitude on the part of consumers is indicative of their receptiveness to products, and of their satisfaction and pride in purchasing and using them. This positive evaluation has the potential to influence consumers' purchasing behaviour, as well as the behaviour of other potential consumers through the phenomenon of the word-of-mouth effect. Consequently, this may create a positive cycle in the market. In the context of "double-carbon" goals and power battery recycling products, consumer attitudes may be influenced by personal values, environmental awareness, and support for technological innovation. In order to promote positive purchasing attitudes, companies must emphasize the environmental, economic and social benefits of their products in marketing and product promotion, while ensuring that product quality and performance meet consumer expectations.

3.3.2 Analysis of the relationship between factors

It is posited that the interactions between factors affecting consumers' willingness to pay for the secondary utilization of power batteries form a dynamic circular system, as evidenced by ISM analysis. In this system, knowledge and incentive policies shape consumer attitudes by enhancing

consumer knowledge and confidence, reducing perceived risk, and strengthening perceived behavioral control. This positive attitude, in turn, reinforces consumers' support for the policy and their desire for knowledge, creating a positive feedback mechanism. This cycle has been demonstrated to engender an enhancement of consumers' propensity to pay in accordance with the "double-carbon" objective. Furthermore, it has been shown to provide a sustained impetus for the market development and social acceptance of power battery gradient utilization products.

3.3.3 Comparative analysis of models and theories

The ISM analysis yielded results that were inconsistent with those of the Theory of Planned Behavior, yet they were also somewhat interpretable. Firstly, a fundamental difference exists between the TPB and the ISM model. While the TPB treats attitude as a direct influence on behavioral intentions, the ISM model places attitude at the same level as willingness to pay, thereby emphasizing the juxtaposition of attitude with other factors such as perceived behavioral control, perceived risk, and subjective norms. This discrepancy suggests that, in the ISM model, attitude is the result of a combination of factors rather than a single driver.The ISM model provides a more profound understanding of the process of consumer willingness-to-pay formation through a hierarchical factor decomposition. The study reveals the path of knowledge and incentive policies as root factors that shape consumer attitudes by influencing mid-level factors and subsequently shaping consumer attitudes. The analysis emphasizes the key role of external policies and knowledge levels in shaping consumers' intrinsic attitudes and willingness to pay. Moreover, the ISM model's hierarchical structure elucidates the manner in which mid-level factors collaborate to influence consumer attitudes. Subjective norms, perceived risk, and perceived behavioral control serve as mediators, reflecting the influence of social influence, risk perception, and self-efficacy on consumer decision-making. This finding indicates that consumer attitudes are not formed independently, but rather, they are developed through the interaction of a range of internal and external factors.

Secondly, the interpretability of the Theory of Planned Behaviour is evidenced by numerous studies that have confirmed the impact of subjective norms on attitudes [20-22], a conclusion that is further substantiated by the present study.

When considered as a whole, the ISM model provides a more nuanced perspective on consumer willingness to pay for products that utilize power batteries in the context of the "double-carbon" goal. The study underscores the pivotal role of policy and knowledge dissemination in fostering consumer acceptance of novel products. It further emphasizes the significance of comprehending and mitigating consumers' perceived risks, along with enhancing their self-efficacy in cultivating positive attitudes and amplifying their propensity to pay. This in-depth analysis assists policymakers and marketers in the more precise design of strategies to promote consumer support and adoption of environmentally friendly products.

4. Conclusions and policy recommendations

4.1. Research conclusion

Drawing upon the logical connotation of the Theory of Planned Behavior, this study employs the ISM approach to systematically summarize and analyse each relevant factor, explore in detail the interactions and influencing mechanisms between different factors, and explicitly reveal the intrinsic correlations of these factors in influencing consumers' willingness to pay for power battery laddering products. This study arrives at the following major conclusions through meticulous examination of data and models:

Firstly, it is important to note that the exploration of the influencing factors of consumers' willingness to pay is a systematic work, which will be influenced by a multitude of factors concurrently. This paper identifies seven variables – including attitude, subjective norms and perceived risk – as the key factors affecting consumers' willingness to pay for power battery secondary utilization products. This identification is arrived at through a survey of existing literature

combined with the theory of planned behaviour. Consequently, in the process of promoting the development of power battery secondary utilization under the goal of "double carbon" and policy planning, it is necessary to strengthen the in-depth analysis and research on the causes and mechanisms of these influencing factors.

Secondly, incentive policies and knowledge related to power battery secondary utilization products are deep-level factors affecting willingness to pay. Consumers' perceived risk, perceived behavioral control and subjective norms are mid-level influences that directly affect attitudes and willingness to pay, while attitudes are surface-level influences. This study unveils, for the first time, the multilevel factors affecting willingness to pay. This multilevel analysis contributes to a deeper understanding of the formation mechanism of consumers' willingness to pay.

In conclusion, it is evident that consumer attitude directly influences the willingness to pay. This concept is a comprehensive reflection of product evaluation and is influenced by personal values, environmental awareness and support for technological innovation. Positive marketing and product promotion strategies that emphasize the environmental, economic and social benefits of products can promote the formation of positive consumer attitudes and thus increase willingness to pay.

The conclusions of this paper provide a novel perspective on consumer behaviour, thus offering an essential theoretical foundation for the promotion of power battery recycling products under the overarching objective of achieving "double carbon" targets.

4.2. Policy recommendations

4.2.1 Strengthening policy advocacy and education

The role of government in promoting the development of secondary utilization products for power batteries is indisputably significant. Government policy, as the root influence factor affecting residents' propensity to pay for such products, is the primary issue to be addressed. As demonstrated in the preceding analysis, it can be observed that the government's efforts to promote policies related to the gradual adoption of power batteries, in conjunction with the introduction of pertinent incentive measures, have the potential to enhance public awareness of these policies. This, in turn, can lead to an increased level of consumer awareness regarding power battery products. Furthermore, this awareness can serve to mitigate consumers' perceived risks, thereby fostering a more comprehensive understanding of the products' performance and environmental benefits. Consequently, this heightened awareness can positively impact the willingness to pay for new energy power battery products.

4.2.2 Improving risk management and transparency

In view of the negative impact of perceived risk on consumers' willingness to pay, it is incumbent upon governments and enterprises to improve the transparency of information on products for the secondary utilization of power batteries. This will ensure that consumers can have a clear understanding of the composition of the products, the production process and relevant safety information. Concurrently, the establishment of a reliable quality assurance system is imperative to ensure that products meet the stipulated standards and the guaranteed quality level through rigorous quality control and certification mechanisms. Furthermore, the establishment of a comprehensive risk management system for sound products is imperative. Such a system should be designed to facilitate the identification and prompt response to potential product safety hazards, thereby ensuring the protection of consumers' health and safety. It is imperative to establish a comprehensive and effective consumer complaint and feedback mechanism. Such a mechanism would facilitate the convenient reflection of problems by consumers and ensure the provision of timely solutions, thereby further enhancing consumer trust and satisfaction. It is imperative to mitigate the perceived risks to consumers by enhancing the transparency of product information and ensuring the reliability of quality assurance.

4.2.3 Promoting social consensus and participation

Perceived behavioral control and subjective norms have also been identified as significant factors in the development of power battery recycling under the "double-carbon" goal. The active participation and support of society as a whole is therefore required to improve consumer awareness. It is vital to disseminate environmental concepts and practical benefits of power battery recycling to a wide audience. This can be achieved through extensive media campaigns, regular public lectures, community activities and other means. The objective is to raise public awareness of the concept, deepen the public's understanding of the importance of power battery recycling, and thus establish a broad social atmosphere in support of green consumption. These initiatives will not only help to enhance consumers' awareness and understanding, but also prompt them to change their purchasing and usage behaviour, thus promoting the continuous growth of market demand for technologies and products of gradient utilization.

4.2.4 Improving consumer attitudes

Attitude, as a superficial influencing factor affecting consumers' willingness to pay for the secondary utilization of power batteries, is directly related to the development of the secondary utilization of power batteries for new energy vehicles. Therefore, enterprises should improve consumer attitudes through positive marketing strategies. In the context of the marketing process, enterprises have the opportunity to emphasize the environmental, economic and social benefits of their products, demonstrating how these products align with consumers' personal values and environmental awareness. By ensuring product quality and performance, and meeting consumer expectations, it is possible to promote positive consumer attitudes.

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