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Exploring Factors Influencing Electric Vehicle Purchase Intentions through an Extended Technology Acceptance Model

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Abstract: Recently, with climate deterioration and environmental pollution, consumers are becoming more and more aware of the use of sustainable energy. In particular, the demand for electric vehicles that use sustainable energy is also increasing. In addition, due to the simple driving principle of pure electric vehicles, many electric vehicles developed by electronics companies are continuously being launched. Electric vehicles not only use renewable energy to protect the environment but also save on various usage expenses, so they are expected to become the main products in the mobile travel equipment market in the future. This study aims to explore the impact of product design dimensions on electric vehicle (EV) purchase intentions, provide a theoretical basis for companies' differentiation strategies, and reflect the impact of product design on purchase intention. This study uses Davis's TAM combined with environmental awareness (EA) for analysis; an online survey was conducted on Chinese (n = 468) and Korean (n = 409) consumers, both male and female, aged 20–60 years and above. We found that, for Chinese consumers, the aesthetic and symbolic dimensions do not affect perceived usefulness and perceived ease of use, but they do affect environmental awareness, while the functional dimension affects not only perceived ease of use and usefulness but also environmental awareness. For Korean consumers, the aesthetic, functional, and symbolic dimensions all affect perceived ease of use and environmental awareness, but perceived usefulness is only affected by aesthetics and environmental awareness. Through simulation analysis, the results show that perceived ease of use, usefulness, and environmental awareness all directly affect purchase intentions. Perceived ease of use and environmental awareness are particularly important for Chinese consumers, while Korean consumers pay more attention to the test drive experience and environmental awareness. The results show that electric vehicle manufacturers should develop new technologies for the Chinese market to attract consumers, while in the Korean market, they should improve perceived usefulness through test drives and pay attention to environmental awareness. Specific statistical data show that both Chinese and Korean consumers assign importance to the impact of environmental awareness on purchase intention, proving the importance of environmental awareness. The results of this study will be of great reference value to electric vehicle manufacturers, policymakers, and consumer behavior researchers, helping them to better understand the role of product design in improving the market acceptance of electric vehicles.

Keywords: TAM model; structural equation modeling; product design; electric vehicle purchase intention

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1. Introduction

Electric vehicles are improving the environment and modern people's lives, with various appearances and functions. Modern people's definition of cars is also constantly changing. For example, the electric car released by China's Xiaomi in 2024—a case in which a company that manufactures electronic products successfully transitioned into the automotive industry—has attracted global attention. With people's increasing awareness of environmental protection, electric vehicles, as mobile tools that can reduce pollution and

effectively save nonrenewable energy, have gradually become a new development trend in the automobile industry [1].

According to Statista, a global statistical data and market research platform, global sales of new electric vehicles increased significantly by 55.1% in 2022, with sales exceeding 10.25 million units [2]. Expected trends show that EU countries will push for the implementation of CO_2 emission standards and steadily move toward zero-emission vehicle regulations. This indicates that the development trend of electric vehicles will continue. In other words, more consumers will use electric vehicles in the future, and various demands have been generated for them. In order to meet these consumer needs, electric vehicles with various high-tech technologies and unique shapes have emerged.

In other words, in order to satisfy consumers, the demand for electric vehicles with unique styling, environmental protection symbolism, and advanced technology continues to grow [3,4]. In the future, when the electric vehicle market reaches the saturation stage, product design will become the only competitive advantage of each automobile manufacturer [5].

Therefore, it is of great significance to study consumers' demand and consumption cognition for electric vehicles. However, to date, most of the research on electric vehicles has been about battery and charging technology [6], consumer characteristics [7], supervisory norms with respect to electric vehicles, perceived behavior [8], perception and adoption of new technologies and other studies; that is, research on electric vehicle product design is currently limited to technology or consumer attitudes.

In response to these limitations, some recent studies have tried to explore the appearance of electric vehicles from a design perspective [9–12]. However, research on electric vehicles is still limited to appearance styling or the future trends of electric vehicle styling; there has been no analysis of the relationship between consumer cognition and willingness to buy. In addition, in terms of research methods, research using the technology acceptance model has also been attempted [13], but there are limitations in expanding or improving existing research. Based on these research deficiencies, this study starts from the product design dimensions (i.e., aesthetics, function, and symbolism) in electric vehicle purchase intention, establishes an empirical analysis model, and analyzes the variables that affect electric vehicle purchase intentions. To this end, we develop an extended technology acceptance model (TAM) to explain the relationship between product design and technology acceptance based on new technologies, and to provide prediction results for electric vehicles through the identified predictors and estimation results. Development provides implications, and in terms of measurement, the impact of environmental awareness is added along with product design and cognitive acceptance in order to apply the extended model.

Finally, when studying the willingness to purchase electric vehicles (EVs), it is important to choose Chinese and Korean consumers as comparison objects. The Chinese market is growing rapidly, with strong policy support and subsidies, and local brands such as BYD and Xiaopeng are actively promoting market development. Although the Korean market is relatively small, the government is also actively promoting the popularization of EVs, and brands such as Hyundai and Kia have performed well in the global market. Comparing these two markets can reveal the impact of different policy environments on consumer purchase intentions, as well as reflecting differences in culture, economic level, and consumer behavior. In addition, the development of charging infrastructure, market size, and the influence of local brands are different in the two countries. Studying these differences can provide in-depth understanding of the complexity of the EV market, along with valuable insights for relevant policymakers and companies.

For companies, cross-cultural surveys can help them to better understand the needs and preferences of different cultural markets, so as to develop more effective marketing strategies and product designs. Cross-cultural differences in design tastes are common. Cultural background is one of the important determinants of consumers' perceptions of product design [14]. In order to explore consumers' purchase intentions and provide a basis for the differentiation strategies of enterprises, this study uses Chinese and Korean

consumers as samples, explores the impact of product design dimensions on the purchase intentions of consumers in the two countries, and analyzes the differences in their purchase intentions for electric vehicles. Such research helps electric vehicle manufacturers in various countries to understand the characteristics of consumers in various countries, and it can also serve as a reference for other studies in the future.

2. Literature Review

2.1. Concept of Product Design

As one of the four Ps of marketing (product, price, place, and promotion), the importance of product design was proven long ago (e.g., Bloch,1995 [14]; Davis,(1989) [15]). Nussbaum's research (1988) [16] shows that when consumers can choose between two products with the same price and function, they will buy the product that they think is more attractive. Han (2021) [17] believes that product design trends should be understood from the perspective of social trends, consumer lifestyles, and work. The elements of product design are defined differently depending on the purpose of the research. For example, Kellaris (1993) [18] and Bloch, P.H (1995) [14] divide product design into elements such as shape, proportion, rhythm, proportion, material, color, reflectivity, decorativeness, and texture based on the consumer's product image; and in Sascha Mahlke's research (2007) [19], the user experience research was conducted by combining aesthetics, symbolism, and emotional user response with a user interaction experience method. Lee (2017) [20] studied consumers' purchase intentions through form (appearance) and feature design. Srinivasan et al. (2012) [21] proposed a customer-based product design framework based on customer experience design—the total product design concept (TPDC), which they defined as three elements of a product—function, aesthetics, and meaning—in order to understand the role and impact of the product.

However, the existing research has shortcomings in several respects. First, most studies have only focused on a specific field or design element, lacking a comprehensive perspective. Second, the mechanism of how product design specifically affects consumers' willingness to buy is still unclear. To make up for these shortcomings, Homburg et al. (2015) [22] and others have developed and validated a new scale to measure product design from three dimensions: aesthetics, function, and symbolism. In addition, they also studied the impact of these design dimensions on purchase intention, word of mouth, and willingness to pay. In summary, this study finally adopted the product design dimensions of aesthetics, function, and symbolism, as described by Homburg et al. (2015) [22], as measurement variables for our research.

2.2. Technology Acceptance Model

The technology acceptance model (TAM) is based on the model proposed by Davis (1989) [15]. It is a modified and developed model based on the causal relationship between attitude and intention to use, as proposed by Ajzen and Fishbein (1980) [23]—the theory of rational action (TRA).

Davis (1989) [15] pointed out through research that the "perceived usefulness (PU)" and "perceived ease of use (PEU)" of a particular technology affect the acceptance of new technologies. PU refers to the individual's belief that using a particular technology will improve their performance, while PEU refers to the individual's belief that using a particular technology is trouble-free. By studying the impact of a particular technology (external variable) on PU and PEU, one can understand the individual's acceptance of new technologies.

Later scholars established an extended TAM based on this model by adding external variables and other factors. For example, Venkatesh and Davis (2000) [24] added relevant external variables such as social influence and cognitive process to the TAM and proposed TAM2. Venkatesh and Bala (2008) [25] further refined perceived ease of use and perceived usefulness on the basis of TAM2, explored how intervention measures affect

these factors, and proposed a more comprehensive model for user acceptance and use of technology: TAM3.

Subsequent studies introduced factors such as social influence and perceived risk when expanding the TAM. For example, Wang et al. (2013) [26] applied the TAM to study the influencing factors of new-energy vehicle purchase intentions; Hu et al. (2015) [27] combined the TAM with the perceived risk theory to study the willingness to purchase new-energy vehicles; Yin et al. (2019) [1] combined the TAM and perceived risk theory to analyze the impact of consumers' personality traits on their willingness to purchase new-energy vehicles when facing uncertainty. These studies verify that environmental awareness is an important variable affecting the acceptance of EVs.

In addition, Wang (2018) [28] explored the relationships between variables based on PEU, PU, and attitudes toward the intention to use electric motorcycles; Yuan et al. (2018) [29] confirmed through the TAM and rational behavior theory that users' environmental awareness (EA) has a significant positive impact on their attitude and willingness to use shared cars; Zhang (2022) [30] used the TAM as a theoretical framework based on variables such as PU and PEU, introduced extended variables such as social influence and environmental awareness, and established a willingness analysis model for the Mobility as a Service (MaaS) platform; He et al. (2018) [31] also showed that personality types such as personal innovation and environmental concern directly affect the willingness to purchase electric vehicles. Therefore, these previous studies can confirm that EA is an important variable in consumer acceptance of EVs.

However, the TAM also faces some challenges. First, the TAM focuses on the initial acceptance of technology's use, but there is less research on long-term usage intentions. Second, the model rarely considers the impact of social, cultural, and emotional factors on technology's acceptance.

2.3. Electric Vehicles (EVs)

Electric vehicles (EVs) can be divided into battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell electric vehicles (FCEVs), hybrid electric vehicles (HEVs), etc., according to the driving system (see Figure 1) [12,13,32–35].

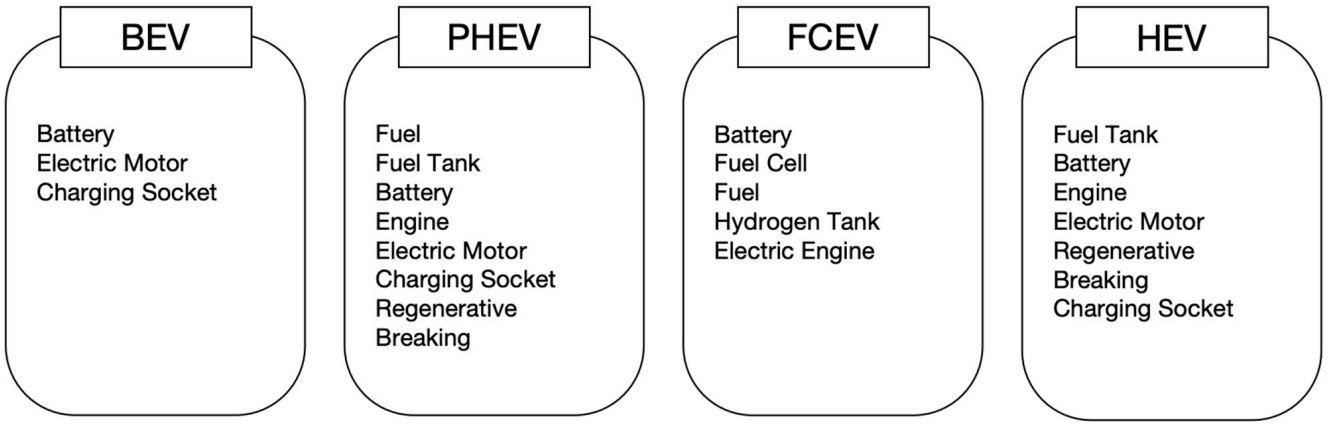


Figure 1. Electric vehicle classification.

1. Battery electric vehicle (BEV): Refers to a car that uses electricity to drive the motor and does not use any fuel, such as gasoline. The battery provides electricity to drive the motor, which drives the vehicle. A BEV is a vehicle that only needs a battery to drive the electric motor, and it requires fewer parts than an internal combustion engine vehicle (e.g., Tesla Model S; Nissan Leaf; Audi Bolt EV; BYD tang EV).
2. Plug-in hybrid electric vehicle (PHEV): A vehicle that can be charged and run on gasoline. The battery capacity is larger than that of ordinary hybrid vehicles. A PHEV is usually driven by electricity, but when the battery is exhausted, it switches to a

conventional internal combustion engine (e.g., Toyota Prius Prime; Chevrolet Volt; Mitsubishi Outlander PHEV; Hyundai oniq Plug-in Hybrid).

3. Fuel cell electric vehicle (FCEV): Uses environmentally friendly energy such as methanol and hydrogen to generate electricity, and relies on the converted electricity to drive the car, so it does not pollute the environment. However, the power system is driven by the chemical combination of hydrogen in the vehicle tank and oxygen in the air to generate electricity—not batteries (e.g., Toyota Mirai; Honda Clarity Fuel Cell; BMW i Hydrogen NEXT; Mercedes-Benz GLC F-CELL).
4. Hybrid electric vehicle (HEV): Does not support external charging. An HEV is a vehicle that combines an internal combustion engine and an electric motor, using an electric motor or a generator to run. It is equipped with two or more energy storage systems and energy conversion to allow the car to charge the electric motor while driving, and it rotates the transmission at the same time to make the gasoline engine and electric motor work (e.g., Toyota Prius; Honda Accord Hybrid).

2.4. Willingness to Buy (WTB)

Willingness to buy (WTB) refers to an individual's thoughts or plans for a specific action—that is, the consumer's intention to purchase a certain product [36]. Excellent design can differentiate products by creating and conveying value to customers, thereby improving customers' acquisition and retention of products [37,38].

Song et al. (2018) [7] studied the WTB and satisfaction of early adopters of electric vehicles based on satisfaction and anxiety about mileage, subjective knowledge, and important attributes. Lieven et al. (2011) [39] weighed personal priorities with social preferences and determined the WTB of individuals who were considered to be potential EV buyers through empirical research on German consumers. Kim et al. (2019) [40] studied the WTB of Chinese consumers for EVs based on the theory of planned behavior. Based on the above, Table 1 (Ashraf et al., 2020) [41] was compiled.

Table 1. Literature review.

No.	Research	Key Findings	Weaknesses	Suggested Solutions
1	Bloch (1995) [14]; Davis (1989) [15]	Importance of product design	Lack of comprehensive perspective	Introduce multi-dimensional design elements and comprehensive evaluation
2	Nussbaum (1988) [16]	Attractiveness affects purchase decisions	Research limited to specific conditions	Expand to different product categories and markets
3	Han (2021) [17]	Design should be understood from a lifestyle perspective	Lack of empirical research	Combine with empirical data verification
4	Homburg et al. (2015) [22]	Developed a new scale to measure product design	No involvement in electric vehicles	Apply to the electric vehicle field
5	Davis (1989) [15]	TAM explains technology acceptance	Ignoring long-term usage intentions	Introduce long-term use variables
6	Venkatesh and Davis (2000) [24]; Venkatesh and Bala (2008) [25]	Extended TAM	Lack of emotional factors	Add emotional and socio-cultural factors
7	Wang et al. (2013) [26]; Hu et al. (2015) [27];	Combining TAM with perceived risk to study new-energy vehicles	Mainly focused on initial acceptance	Study long-term use and market maturity
8	Song et al. (2018) [7]; Lieven et al. (2011) [39]; Kim et al. (2019) [40]	Factors affecting purchase intention	Immature market, insufficient research	Conduct more market and consumer perception research

Although existing studies have shown that the electric vehicle market continues to grow, the research and market are still not fully mature. There are currently few studies on consumer perceptions of electric vehicles, and there have not been many cases that studied the appearance design of electric vehicles in detail. Therefore, this study aims to explore the relationship between product design and consumer perceptions, in order to fill this research gap.

Through reviewing and analyzing the existing literature, this study explores the impact of product design on electric vehicle purchase intentions from a multi-dimensional perspective in order to make up for the shortcomings of existing research.

3. Conceptual Framework and Hypotheses

3.1. The Impact of Product Design on Technical Models and Environmental Awareness

3.1.1. The Impact of Aesthetics (Aes) on Technical Models and Environmental Awareness

Veryzer Jr, R. W. (1993) [42] believes that the aes response refers to a person's reaction to an object (e.g., based on their perception of the object). Aes is sometimes more important than technical features and is important in ensuring the success of a new product. Kotlw and Raih(1984) [43] also believe that good design can be transformed into high-quality product perceptions, bringing greater market share and higher profits. The connection between aes and technology acceptance is very important because aes design directly affects users' experience and acceptance. Elegant and intuitive interfaces not only improve perceived ease of use and make users feel that the operation is simple, they also enhance perceived usefulness and increase trust in the technology's function. In addition, aesthetic design can stimulate positive emotional responses, increasing users' satisfaction with the technology and long-term willingness to use it. An attractive visual and interactive design can also strengthen the brand image, further affecting users' acceptance of the technology. Therefore, aes not only affects the appearance of technology but also profoundly affects users' acceptance and use of technology, which merits further exploration in technology acceptance research [44,45].

Therefore, based on the above theoretical background, this study makes the following assumptions:

Hypothesis 1. *The higher the aesthetics dimension of product design, the greater the impact on PEU, PU, and EA.*

H1-1. *The aes dimension of product design has a significant positive impact on the PEU of EVs.*

H1-2. *The aes dimension of product design has a significant positive impact on the PU of EVs.*

H1-3. *The aes dimension of product design has a significant positive impact on the EA of EVs.*

3.1.2. The Impact of Function (Func) on Technical Models and Environmental Awareness

Functional design of products, in terms of practicality and functionality, involves product performance, reliability, and whether the product meets the basic needs of users. Fu et al. (2008) [46] proved through research on the functional requirements and intrinsic quality of automobiles that automobile technology plays a key role in automobile styling design. Chakrabarti and Bligh (2001) [47] believe that an ideal functional reasoning environment should have the following characteristics: able to support a variety of design tasks, whether routine or innovative; able to handle designs at any level of detail; and able to provide support between designs at different levels of detail. The functions of EVs have attracted much attention from researchers and users in the EV design process. Lv et al. (2014) [48] and Agarwal and Prasad (1998) [49] pointed out that the novelty of technology will affect practicality and ease of use, thereby affecting usage intention.

In addition, Agawal and Karhanna (2000) [50] showed that cognitive absorption significantly affects individuals' PU and PEU with respect to information technology, thereby affecting their intention to use it. Therefore, an individual's perceived technological innovativeness can be explained by cognitive absorption. Based on the discussion of these previous studies, this study proposes the following hypotheses on the role of func dimensions of product design in EV acceptance:

Hypothesis 2. *The higher the function (func) dimension of product design, the greater the impact on PEU, PU, and EA.*

H2-1. *The func dimension of product design has a significant positive impact on the PEU of EVs.*

H2-2. *The func dimension of product design has a significant positive impact on the PU of EVs.*

H2-3. *The func dimension of product design has a significant positive impact on the EA of EVs.*

3.1.3. The Impact of Symbolism (Sym) on Technical Models and Environmental Awareness

Symbolism (sym) refers to the symbolic meaning and cultural value of a product; it involves how products express the user's identity, status, and personal taste [42,51–54].

Xing (2022) [55] in order to promote the spread of Macao culture and the development of the tourist souvenir industry, took the symbolic meaning of cultural symbols as the starting point and explored effective methods for the design of Macao tourist souvenirs; Zhang et al. (2001) [56] pointed out that this is related to functional indicator symbols. Compared with packaging, the design and recognition of symbols on packaging are more complex. However, the connotative meaning conveyed by a symbol is usually broader and deeper than the denotative meaning of the symbol. Belk et al. (1989) [57] and Verganti (2008) [58] believe that sym is as important as func because consumers have a strong desire for meaning. In fact, sym can become the basis for consumers to experience personal value. Based on the above research, this study proposes the following hypotheses:

Hypothesis 3. *The higher the symbolism (sym) dimension of product design, the greater the impact on PEU, PU, and EA.*

H3-1. *The sym dimension of product design has a significant positive impact on the PEU of EVs.*

H3-2. *The sym dimension of product design has a significant positive impact on the PU of EVs.*

H3-3. *The sym dimension of product design has a significant positive impact on the EA of EVs.*

3.2. The Impact of the Technology Acceptance Model and Environmental Awareness on Willingness to Buy (WTB)

The technology acceptance model (TAM) has been widely used by many scholars at home and abroad to study the use of innovative technologies from different perspectives. The model proposes using PU and PEU as the main indicators for measuring technology acceptance behavior. PU refers to the individual's belief that using a specific application system can improve their work performance—i.e., users feel that using this innovative technology can bring convenience to their work or life—while PEU refers to the individual's belief that it is relatively easy to use or master a system or innovative technology [20].

The study of Jamal and Sharifuddin (2015) [59] shows that PU can positively promote the willingness to purchase products. Chitra (2007) [60] pointed out that consumers' EA has become an important factor affecting their willingness to pay. The stronger the consumer's EA, the higher the price that they are willing to pay for environmentally friendly products. Li (2001) [61] believes that efforts should be made to cultivate people's EA, so that they can clearly understand the interdependence between humanity and nature and humanity and the environment, and consciously pay attention to and actively participate in environmental

protection. He et al. (2015) [62] demonstrated that consumers' PU and PEU with respect to innovative technologies of new-energy vehicles can significantly and positively affect their willingness to purchase such vehicles [1].

Based on these previous studies, we believe that PU, ease of use, and EA affect the WTB for EVs. Therefore, this paper proposes the following hypotheses and verifies them through empirical analysis:

Hypothesis 4. *The higher the PU, PEU, and EA, the greater the impact on the WTB.*

H4-1. *PEU has a significant positive impact on the WTB for EVs.*

H4-2. *PU has a significant positive impact on the WTB for EVs.*

H4-3. *EA has a significant positive impact on the WTB for EVs.*

3.3. Measurement Model

As mentioned above, this study is based on the extended TAM. The scale of the TAM is affected by multiple factors. Model complexity increases with the increase in the number of variables. More variables (such as user characteristics and environmental factors) will make the model larger, thereby increasing the amount of calculation and the analytical complexity. The size of the dataset is also critical. Large-scale datasets require more complex models to capture subtle differences, while simultaneously posing computing and storage challenges. Variable selection is equally important. Adding more external variables (such as social influences and personal characteristics) will make the model more complex, thereby affecting the effectiveness and efficiency of the model.

For the external variables, we selected Aes, Func, and Sym as product design variables, with PU, PEU, and EA as mediators and WTB as the dependent variable, to study EVs. In measuring perceived acceptance, this study not only included the influence of usefulness and ease of use on WTB, but also EA, because as people's awareness of environmental protection increases, it becomes necessary to confirm the difference between EA and perception in WTB. This study established the following research model by reviewing previous studies (see Figure 2).

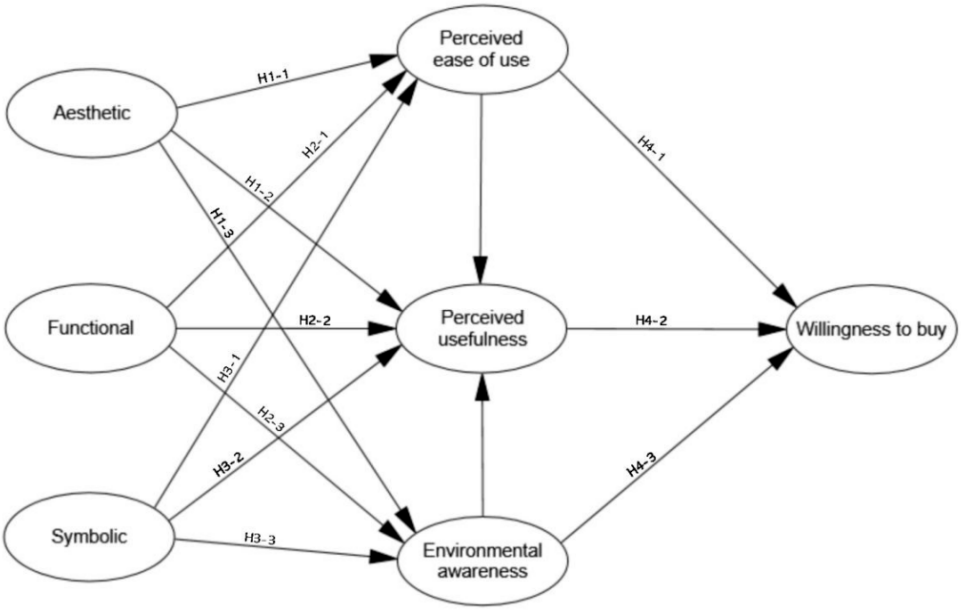


Figure 2. Structural equation modeling.

Based on the above assumptions, the expanded TAM model was established and used to analyze the purchase intentions of Chinese and Korean consumers toward EVs.

4. Research Methodology

Measures

The questionnaire survey of this study is designed to be divided into five parts. The first part is the demographic statistics (seven questions); in addition to the basic gender, age, and education level, it also includes the four user types classified by Lee (2017) [37] in the identification characteristics of the attractiveness of car appearance design (A: car enthusiasts, B: users who value car sym, C: users who value car functions, and D: users who are not interested in cars), in order to confirm the potential awareness of most consumers about cars. The second part measures the participants' attitudes toward the aes (four questions; question codes Q1, Q2, Q3, and Q4), func (three questions; Q5, Q6, and Q7), and sym (four questions; Q8, Q9, Q10, and Q11) of EV design. The questions are adapted from the works of Bloch, P. H. (1995) [14], Srinivasan et al., 2012 [21], Homburg et al., 2015 [22] and Gilal et al., 2018 [44]. The third part measures the participants' PEU (three; Q12, Q13, and Q14) and PU (three questions; Q15, Q16, and Q17) of EVs. The questions are adapted from the works of Davis [15,24,63–65] and Venkatesh et al. [24,25,64]. The fourth part measures the participants' attitudes toward EA (five questions; Q18, Q19, Q20, Q21, and Q22); the items are adapted from the works of Van et al. (2023) [66], Carley et al. (2013) [67], and Bunce et al. (2014) [68]. The fifth part measures the participants' willingness to purchase EVs (three questions; Q23, Q24, and Q25); the items are adapted from the works of Agarwal et al. (2000) [50], Zhang et al. (2011) [69], Park et al. (2020) [70], and Patara and Monroe (2008) [71] (see Table 2).

The second to fifth parts of the scale are measured by 7-point Likert scales, from high to low: 7 points = strongly agree; 6 points = somewhat agree; 5 points = agree; 4 points = neutral; 3 points = somewhat disagree; 2 points = disagree; 1 point = strongly disagree. After the scale design was completed, it was first reviewed by relevant experts and scholars, and then appropriately modified. Then, in order to distribute the questionnaire to Chinese and Korean consumers at the same time, the English questionnaire was translated.

Finally, in order to ensure measurement invariance, the final questionnaire was translated in two stages. First, all items of the questionnaire were translated from English to Chinese by two Chinese professors who were fluent in English, and from English to Korean by two Korean professors who were fluent in English. In the second stage, according to the double translation procedure, five other independent professional translators conducted back-translation checks on the Chinese and Korean questionnaires. After comparing the original English version and the translated versions of the questionnaire, and adding some minor changes to the Chinese version, the Chinese and Korean questionnaires were finalized.

To determine the validity of the questionnaire, a small-scale pre-survey was conducted in a group chat on a Korean software platform (KakaoTalk version 10.8) 42 people, with ages ranging from 20 to 65). The questionnaire was revised for the second time based on the survey results, and the final version of the questionnaire was determined. Before the final questionnaire data were collected, all participants, including Chinese and Korean consumers, were informed of the purpose of the study, the benefits and risks of participating in the study, and how their data would be used. All tests were conducted after obtaining the consent of the participants, and the questionnaires were completed anonymously and voluntarily.

Although the overall population bases of China and South Korea are very different, the representativeness of the samples can be ensured through appropriate sample selection and analysis methods. If the sample sizes from China and South Korea are more than 400 each, they may still be statistically valid. The key is to ensure the representativeness of the samples in terms of key characteristics such as gender, age, and income. Stratified sampling and weighted adjustment methods can be used to reflect the overall characteristics, and the

representativeness of the samples can be confirmed through validation data and sensitivity analysis. Appropriate sample selection, weighted adjustment, and data verification can improve the reliability and validity of the research results.

Table 2. Measurement scales for variables.

No.	Variable Name	Code	Measurement Question	Reference Source
1	Aes	Q1	I think electric cars look good	Bloch, P. H. (1995); [14] Srinivasan, R et al. (2012) [21]; Homburg, C et al. (2015) [22]; Gilal, N. G et al. (2018) [44];
		Q2	I think electric car designs are attractive	
		Q3	I think electric car designs are eye-catching	
		Q4	I think electric car designs are impressive	
2	Func	Q5	I think electric car functionality is important	
		Q6	I think electric car designs are safe	
		Q7	I think electric cars are very functional	
3	Sym	Q8	I think electric cars can show my social status	
		Q9	I think electric cars can show that I value environmental awareness	
		Q10	I portray part of my lifestyle through electric cars	
		Q11	I want to define myself through electric cars	
4	PEU	Q12	I think it is easy to use electric cars	Davis, F. D. (1987); (1989 [15]); (1992) [63]; (2000) [24], Venkatesh et al. (2003) [64]; (2008) [25];
		Q13	I think electric cars are easy to learn to use	
		Q14	I find it easy to do what I want to do with electric cars	
5	PU	Q15	I think using electric cars will improve my life	
		Q16	I think using electric cars will be useful	
		Q17	I think using electric cars is effective	
6	EA	Q18	I think environmental issues are important	Bunce et al. (2014) [68]; Song et al. (2018) [7]; Van et al. (2023) [66]; Carley et al. (2013) [67];
		Q19	I usually take practical actions to protect the environment (such as garbage sorting)	
		Q20	I usually use environmentally friendly products as much as possible	
		Q21	I think we should use environmentally friendly products	
		Q22	If it is an environmentally friendly product, I will buy it even if it is expensive	
7	WTB	Q23	I plan to buy an electric car in the future	Wang et al. (2013) [26]; Agarwal et al. (2000) [50]; Zhang et al. (2011) [69]; Park et al. (2020) [70]; Patara and Monroe (2008) [71]
		Q24	Next time I buy a new car, I will buy an electric car	
		Q25	I will recommend buying an electric car to people around me	

5. Study

5.1. Chinese Consumers

5.1.1. Chinese Participants and Measures

This study used convenience sampling and conducted an online survey using the Chinese market research company "wjx.cn" from 11 April 2024 to 27 June 2024; wjx.cn (https://www.wjx.cn/, accessed from 11 April 2024 to 27 June 2024) is a popular online survey platform in China. Since its launch in 2006, users have published more than 274 million questionnaires and collected more than 21.307 billion questionnaires. The platform has maintained an annual growth rate of more than 100% and a market share of more than 60%. This study used the company to collect data from men and women aged 20 to over

60 in China in order to understand the WTB for electric vehicles. A total of 497 people were sent online surveys, of which 468 people's responses (excluding questionnaires with repeated answers or too short an answer time) were used for the final analysis. In terms of demographic characteristics of the survey subjects in the questionnaire collection for Chinese consumers, there were 257 males, accounting for 55%, and 211 females, accounting for 45%. In terms of age, 94 people (20%) were in their 20s, 174 people (37%) were in their 30s, and 109 people were in their 40s (23%); 14% (27 people) of the participants were over 50 years old, and 8% were over 60 years old. In terms of education level, the majority of the respondents were college graduates, accounting for 66% (307 people). In terms of the lifestyle of Chinese consumers, the proportions of respondents who thought that cars could show their social status and those who were interested in cars were similar, accounting for 127 and 125 people, respectively. In China, the majority of respondents owned electric cars, accounting for 239 people (51%), and the number of respondents who owned fuel cars was 156 (33%). For details, see Table 3.

Table 3. Demographic characteristics of the Chinese sample.

No.	Measure	Item	Count	%
1	Gender	Male	257	55
		Female	211	45
2	Age	20~29 years old	94	20
		30~39 years old	174	37
		40~49 years old	109	23
		50~59 years old	64	14
		<60 years old	27	6
3	Education level	High school	39	8
		Junior college	97	21
		University	307	66
		Graduate school	24	5
		Other	1	0
4	Lifestyle	I am attracted to the exterior of cars and I like cars	125	27
		I am not interested in cars	119	25
		I think the functionality of a car is important	97	21
		I think cars express my social status	127	27
5	Car ownership	I don't have a car	73	16
		I have a car with an internal combustion engine	156	33
		I have an electric car	239	51
6	Driving frequency	1 day or less per week	193	41
		2~3 days per week	178	38
		4~5 days per week	58	12
		More than 6 days per week	39	8

5.1.2. Analysis of Results

Reliability and Validity Test

This study first used SPSS27.0 for reliability and validity testing. When performing the KMO (Kaiser–Meyer–Olkin) test and Bartlett's test of sphericity, the KMO value was 0.902 (greater than 0.7), and Bartlett's test showed that the significance of sphericity was 0.000. The Cronbach's α test results of variables such as aes (measurement items AD1~AD4), func

(measurement items FD1~FD3), sym (measurement items SD1~SD4), PEU (measurement items PEU1~PEU3), PU (measurement items PU1~PU3), and EA (measurement items EA1~EA5), and WTB (measurement items WTB1~WTB3) also showed that the Cronbach's α of each dimension of the questionnaire was greater than 0.7 [72]. At the same time, the CITC values of the questionnaires were all higher than 0.5, indicating that the correlation between the scales is good and suitable for further analysis (for details, see Table 4).

Table 4. Chinese proportion attributes.

KMO and Bartlett's Test				
KMO sampling suitability measure				0.902
Bartlett's test of sphericity		Approximate chi-squared Degrees of freedom Significance		6533.05 300 0.000
Reliability Analysis of the Questionnaire				
Variable Name	Measurement Item	Correction Total Correlation (CITC)	After Deleting the Item's Cronbach's α Value	Each Variable's Cronbach's α Value
Aes	AD1 AD2 AD3 AD4	0.759 0.771 0.803 0.781	0.879 0.874 0.863 0.871	0.901
Func	FD1 FD2 FD3	0.663 0.601 0.675	0.710 0.775 0.697	0.801
Sym	SD1 SD2 SD3 SD4	0.720 0.795 0.709 0.678	0.837 0.808 0.841 0.853	0.871
PEU	PEU1 PEU2 PEU3	0.684 0.659 0.694	0.752 0.777 0.742	0.824
PU	PU1 PU2 PU3	0.658 0.695 0.666	0.759 0.727 0.760	0.816
EA	EA1 EA2 EA3 EA4 EA5	0.694 0.765 0.735 0.710 0.813	0.884 0.868 0.875 0.880 0.857	0.896
WTB	WTB1 WTB2 WTB3	0.676 0.738 0.702	0.804 0.744 0.782	0.840

Next, the data were extracted for principal components to obtain the initial eigenvalue, variance contribution rate, cumulative variance contribution rate, etc. The results are shown in Table 5. According to the extraction principle that the eigenvalue is greater than 1, seven factors were extracted; the cumulative variance contribution rate was 74.12%, and the commonality corresponding to each item was above 0.5, indicating that the seven factors extracted from 25 questions (component numbers 1, 2, 3, 4, 5, . . ., 25) provide a relatively ideal explanation for the original data.

Finally, the Kaiser standardized maximum variance rotation method was used to rotate the factor loadings, and the results are shown in Table 6 (aes (measurement items AD1~AD4), func (measurement items FD1~FD3), sym (measurement items SD1~SD4), PEU (measurement items PEU1~PEU3), PU (measurement items PU1~PU3), EA (measurement

items EA1~EA5), and WTB (measurement items WTB1~WTB3)). The loadings of each item on the corresponding factor are all over 0.5; color and bold are used in the table, so there is reason to believe that the scale of this study has good structural validity.

Table 5. Chinese variance explanation.

Component	Initial Eigenvalues			Sum of Squares of Rotating Loads			Commonality
	Total	Variance Percentage	Cumulative %	Total	Variance Percentage	Cumulative %	
1	8.402	33.606	33.606	3.566	14.262	14.262	0.754
2	2.637	10.549	44.156	3.156	12.625	26.888	0.764
3	2.232	8.929	53.084	2.969	11.874	38.762	0.800
4	1.733	6.932	60.016	2.278	9.111	47.873	0.783
5	1.279	5.117	65.133	2.269	9.076	56.949	0.730
6	1.186	4.744	69.876	2.189	8.758	65.707	0.670
7	1.060	4.241	74.117	2.103	8.410	74.117	0.749
8	0.579	2.315	76.433				0.729
9	0.535	2.142	78.575				0.800
10	0.497	1.987	80.561				0.729
11	0.440	1.760	82.322				0.676
12	0.432	1.728	84.049				0.716
13	0.403	1.611	85.660				0.757
14	0.398	1.591	87.251				0.748
15	0.384	1.538	88.789				0.750
16	0.361	1.443	90.232				0.716
17	0.347	1.390	91.621				0.773
18	0.324	1.295	92.916				0.661
19	0.293	1.172	94.088				0.759
20	0.283	1.131	95.219				0.707
21	0.265	1.058	96.277				0.677
22	0.253	1.010	97.288				0.795
23	0.247	0.987	98.275				0.735
24	0.235	0.939	99.214				0.791
25	0.197	0.786	100.00				0.757

Extraction method: principal component analysis.

Table 6. Load matrix after rotation.

Measures	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
AD1	0.107	**0.853**	0.032	0.038	0.045	0.070	0.072
AD2	0.099	**0.850**	0.074	0.042	0.126	0.030	0.091
AD3	0.137	**0.870**	0.114	0.024	0.047	0.027	0.088
AD4	0.140	**0.862**	−0.001	0.100	0.079	0.063	0.016
FD1	0.209	0.068	0.105	0.201	0.243	0.158	**0.739**
FD2	0.143	0.119	0.135	0.192	0.118	0.161	**0.735**
FD3	0.214	0.101	0.157	0.122	0.130	0.202	**0.772**
SD1	0.110	0.082	**0.828**	0.073	0.105	−0.020	0.091
SD2	0.166	0.052	**0.860**	0.107	0.086	0.066	0.084
SD3	0.097	0.089	**0.824**	0.001	0.097	0.148	0.034
SD4	0.203	−0.006	**0.767**	0.050	0.075	0.095	0.173
PU1	0.242	0.088	0.061	0.236	0.160	**0.736**	0.153
PU2	0.184	0.019	0.123	0.178	0.154	**0.781**	0.207
PU3	0.196	0.086	0.101	0.082	0.100	**0.808**	0.149
PEU1	0.171	0.074	0.124	**0.802**	0.144	0.104	0.160
PEU2	0.130	0.023	0.064	**0.779**	0.156	0.109	0.227
PEU3	0.131	0.105	0.029	**0.807**	0.170	0.240	0.084

Table 6. *Cont.*

Measures	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
EA1	**0.727**	0.085	0.150	0.018	0.237	0.152	0.154
EA2	**0.815**	0.139	0.125	0.163	0.152	0.100	0.031
EA3	**0.776**	0.151	0.126	0.105	0.081	0.177	0.129
EA4	**0.735**	0.178	0.161	0.102	0.054	0.133	0.220
EA5	**0.828**	0.065	0.144	0.164	0.120	0.161	0.136
WTB1	0.196	0.183	0.078	0.151	**0.782**	0.089	0.125
WTB2	0.184	0.077	0.141	0.164	**0.810**	0.160	0.149
WTB3	0.142	0.056	0.164	0.182	**0.784**	0.159	0.183

Rotation method: Kaiser normalized varimax. Rotation converged after six iterations.

In summary, the questionnaire used in this study has good validity and is suitable for further analysis.

In order to verify the validity of the questionnaire, confirmatory factor analysis was conducted on each structure. Confirmatory factor analysis can measure the correlation between latent variables in each model. This study divides the confirmatory factor analysis into product design variables such as aes, func, and sym; perceived variables such as PU, PEU, and EA; and WTB. The results of the analysis of the fitness of the model, using AMOS 26.0, showed that the chi-squared–degrees-of-freedom ratio of the confirmatory factor analysis model was 1.60, i.e., less than 3 (consistent with the standard value proposed by Bentler and Bonett (1980) [73] and Carmines and McIver (1981)) [74]. The RMSEA (root-mean-square error of approximation) was 0.04, i.e., less than 0.05 and within the good range [75]. The GFI (goodness-of-fit index) was 0.94, the AGFI (adjusted goodness-of-fit index) was 0.92, and the RFI (relative fit index) was 0.92, i.e., all greater than 0.8 (consistent with the recommended values of Browne and Cudeck (1992) [75], Hu and Bentler (1999) [76], Bentler (1990) [77], Byrne (1998) [78], and Doll et al. (1994)) [79]. The NFI (normed fit index) was 0.94, the IFI (incremental fit index) was 0.98, the TLI was 0.97, and the CFI (comparative fit index) was 0.98, i.e., all greater than 0.9 (consistent with the recommended values of Bentler and Bonett (1980)) [73]. As shown in Table 6, all fitting indices were within the critical range, so it can be considered that the confirmatory factor analysis model has a relatively good fit effect on the questionnaire data (see Table 7).

Table 7. Confirmatory factor analysis model fitness.

Fit Index		χ^2/df	RMSEA	GFI	AGFI	NFI	RFI	IFI	TLI	CFI
Evaluation standard	Ideal	<3	<0.05	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9
	Acceptable	<5	<0.08	>0.8	>0.8	>0.8	>0.8	>0.8	>0.8	>0.8
Structural model measurements		1.608	0.036	0.935	0.916	0.939	0.928	0.976	0.971	0.976

As shown in Table 8, the standardized loadings of the items corresponding to the seven variables (aes, func, sym, PEU, PU, EA, and WTB) were all greater than 0.5, indicating that each latent variable has high representativeness corresponding to the measurement item. According to the standard of Nunnally and Bernstein (1978) [80], when the composite reliability (CR) exceeds 0.8, and when the AVE (average variance extracted) exceeds 0.6 according to the standard of Bagozzi and Yi (1988) [81], the convergent validity is ideal. The results of this study show that the composite reliability (CR) is 0.88 for aes, 0.85 for func, 0.89 for sym, 0.85 for ease of use, 0.86 for usefulness, 0.92 for EA, and 0.84 for WTB—all exceeding 0.8—and the AVE is 0.65 for aes, 0.65 for func, 0.68 for sym, 0.65 for ease of use, 0.68 for usefulness, 0.7 for EA, and 0.63 for WTB. Since the average variance extracted (AVE) for each variable in the sample of Chinese consumers is greater than 0.6, and the composite reliability of each variable is greater than 0.8, it can be concluded that the convergent validity of the scale is ideal.

Finally, the test results of discriminant validity are presented. The values on the diagonal are the arithmetic square roots of the AVE of the seven variables: aes, func, sym, PEU, PU, EA, and WTB (color and bold are used in the table). The values of the lower triangular matrix are the Pearson correlation coefficients between the variables. Since the absolute value of the Pearson correlation coefficient between the variables is less than the arithmetic square root of the AVE, it can be inferred that the latent variables have good discrimination—that is, the discriminant validity of the scale used in this study is ideal (see Table 9).

Table 8. Convergent validity test.

No.	Variable	Measurement Item	Parameter Significance Estimate				Factor Loading	Item Reliability	Composite Reliability	Average Variance Extracted
			Unstd.	S.E.	*t*-Value	*p*	Std.	SMC	CR	AVE
1	Aes	AD4	1				0.833	0.694	0.881	0.652
		AD3	1.067	0.049	21.961	***	0.862	0.743		
		AD2	1.009	0.048	20.857	***	0.829	0.688		
		AD1	1.046	0.052	20.187	***	0.810	0.657		
2	Func	FD3	1				0.786	0.617	0.846	0.648
		FD2	0.894	0.063	14.278	***	0.694	0.481		
		FD1	1.032	0.064	16.102	***	0.796	0.633		
3	Sym	SD4	1				0.742	0.551	0.894	0.679
		SD3	1.097	0.067	16.346	***	0.777	0.604		
		SD2	1.134	0.062	18.220	***	0.881	0.776		
		SD1	1.052	0.064	16.367	***	0.778	0.606		
4	PEU	PEU1	1				0.787	0.619	0.848	0.654
		PEU2	1.005	0.065	15.559	***	0.753	0.567		
		PEU3	1.045	0.064	16.349	***	0.804	0.646		
5	PU	PU1	1				0.779	0.608	0.862	0.676
		PU2	0.990	0.060	16.375	***	0.806	0.649		
		PU3	1.095	0.071	15.369	***	0.745	0.554		
6	EA	EA5	1				0.871	0.759	0.919	0.695
		EA4	0.893	0.045	19.786	***	0.766	0.587		
		EA3	0.938	0.046	20.573	***	0.786	0.618		
		EA2	0.970	0.044	21.805	***	0.815	0.665		
		EA1	0.850	0.045	18.914	***	0.744	0.554		
7	WTB	WTB1	1				0.756	0.572	0.837	0.634
		WTB2	1.162	0.068	17.036	***	0.841	0.707		
		WTB3	1.192	0.072	16.495	***	0.801	0.642		

Note: *** indicate significance at the 1% levels.

Table 9. Correlation coefficient matrix and square roots of AVEs.

No.	Variable	1	2	3	4	5	6	7
1	Aes	**0.81**						
2	Func	0.408 ***	**0.81**					
3	Sym	0.400 ***	0.417 ***	**0.82**				
4	PU	0.446 ***	0.506 ***	0.486 ***	**0.82**			
5	PEU	0.340 ***	0.446 ***	0.344 ***	0.476 ***	**0.81**		
6	EA	0.357 ***	0.309 ***	0.443 ***	0.487 ***	0.412 ***	**0.83**	
7	WTB	0.395 ***	0.401 ***	0.463 ***	0.612 ***	0.395 ***	0.513 ***	**0.80**

Note: *** indicate significance at the 1% levels.

5.1.3. Structural Equation Modeling Results-Chinese Consumers

After conducting confirmatory factor analysis, AMOS 26.0 was used to construct a structural equation model. Through further processing, the path coefficients and significant coefficients between each latent variable were calculated to verify the hypotheses proposed in this study. The model path relationship diagram is shown in Figure 3.

The final model path fitness is shown in Table 10. Its chi-squared–freedom ratio is 1.7 < 3, which is within the ideal range of fitness; the RMSEA value is 0.04 < 0.08, which is within the acceptable range; the values of GFI, AGFI, and RFI are 0.93, 0.91, and 0.92, respectively—all greater than 0.8, and within the acceptable range; the values of NFI, IFI, TLI, and CFI are 0.94 and 0.97, which are also greater than 0.9, i.e., within the ideal range of fitness. In summary, it can be considered that the structural equation model has a relatively good fitting effect on the questionnaire data.

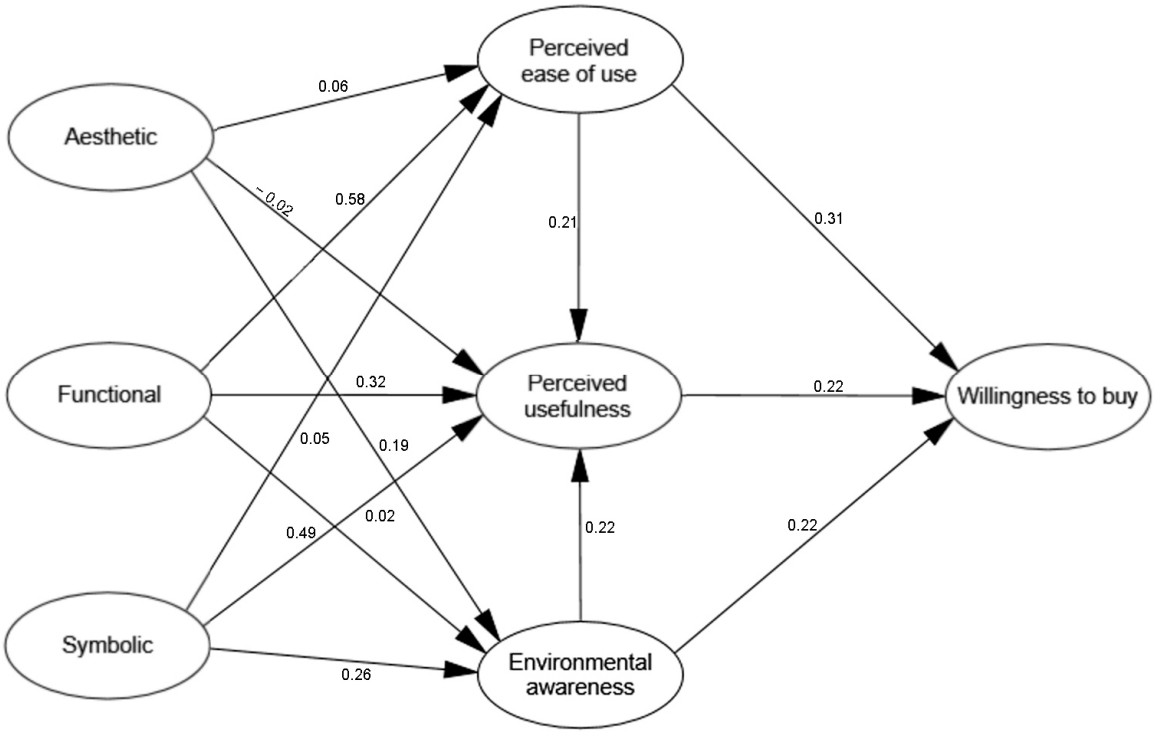


Figure 3. Results of structural equation modeling of Chinese consumers.

Table 10. The fitness of the Chinese consumer path model.

Fit Index		χ^2/df	RMSEA	GFI	AGFI	NFI	RFI	IFI	TLI	CFI
Evaluation standard	Ideal	<3	<0.05	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9
	Acceptable	<5	<0.08	>0.8	>0.8	>0.8	>0.8	>0.8	>0.8	>0.8
Structural model measurements		1.699	0.039	0.930	0.912	0.934	0.924	0.972	0.967	0.972

Relationship between Aesthetics (Aes) and Perceived Variables, Environmental Awareness (EA)

Hypothesis 1 is about the relationship between aes and perceived variables, EA. The results show that H1-1 that with the improvement of aes, the PEU of EV will increase ($\beta = 0.05$, $T = 1.26$) is not established, H1-2 that the PU of EV will increase ($\beta = 0.04$, $T = -0.45$) is not established, and only H1-3 that the EA of EV will increase ($\beta = 0.05$, $T = 3.96$) is established. Contrary to the research of Filieri and Lin (2017) [82], it can be seen that the aes of EV has not increased the purchasing intention of Chinese consumers but can actively improve consumers' EA. In other words, electric vehicles with

excellent appearance cannot make Chinese consumers perceive ease of use or usefulness, but Chinese consumers can improve their EA through appearance, thereby protecting the environment.

Chinese Consumers: Relationship between Function (Func), Perceived Variables, and Environmental Awareness (EA)

From the hypothesis of the relationship between func and the perceived variable EA, H2-1 that the PEU of EVs will increase with the optimization of functions; β = 0.07, T = 8.56), H2-2 (that PU will increase; β = 0.07, T = 4.60), and H2-3 (that EA will increase; β = 0.06, T = 7.80) are all established. This result explains the results of Sovacool et al. (2019) [83], who found that Chinese consumers' willingness to accept the use of EVs is related to the performance characteristics of EVs. Additionally, like in Lieven et al.'s (2011) [39] study on the German market, func is a key criterion for consumers.

Relationship between Symbolism (Sym), Perceived Variables, and Environmental Awareness (EA)

H3-1 of the relationship between symbolic and perceived variables and environmental protection (the PEU of EVs will increase as the value of symbols increases; β = 0.06, T = 0.89) and H3-2 (the PU will increase; β = 0.05, T = 0.35) are not established. However, H3-3 (β = 0.06, T = 4.39)—that the EA of EVs will increase—is established, which can be seen as the Chinese government's restrictions on carbon emissions [84] and the strengthening of Chinese consumers' EA [63]. In addition, the results of this study are consistent with the findings of Liu et al. (2020) [85] and Heffner et al. (2007) [86], so it can be considered that the most important symbolic meaning of EVs is EA, followed by aes.

Chinese Consumers: The Relationship between Perceived Variables, Environmental Awareness (EA), and Willingness to Buy (WTB)

As with the findings of He et al. (2015) [62], our results show that H4-1 (the higher the PEU, the higher the intention to purchase EVs; β = 0.06, T = 5.22), H4-2 (the higher the PU, the higher the willingness to purchase EVs; β = 0.07, T = 3.08), and H4-3 (which states that the stronger the EA, the higher the WTB electric vehicles; β = 0.05, T = 4.29) are all established. This shows that PEU, PU, and EA can all have a positive impact on WTB.

Finally, consistent with the research results of Davis (1989) [15], PEU has a significant positive impact on PU (β = 0.06, T = 3.62), and the results prove that EA also has a significant impact on usefulness (β = 0.05, T = 4.29) (see Table 11).

Table 11. Results of hypothesis testing on Chinese consumers.

No.	Path Relationship			B	β	S.E.	C.R.	*p*-Value	Result
H1-1	Aes	→	PEU	0.061	0.063	0.048	1.261	0.207	Fail
H1-2		→	PU	−0.018	−0.021	0.041	−0.446	0.656	Fail
H1-3		→	EA	0.188	0.180	0.048	3.96	***	Pass
H2-1	Func	→	PEU	0.582	0.567	0.068	8.557	***	Pass
H2-2		→	PU	0.325	0.349	0.071	4.603	***	Pass
H2-3		→	EA	0.488	0.437	0.063	7.796	***	Pass
H3-1	Sym	→	PEU	0.053	0.048	0.060	0.886	0.376	Fail
H3-2		→	PU	0.018	0.018	0.051	0.353	0.724	Fail
H3-3		→	EA	0.264	0.217	0.061	4.392	***	Pass
H4-1	PEU	→	WTB	0.311	0.332	0.060	5.224	***	Pass
H4-2	PU	→		0.219	0.212	0.071	3.083	0.002	Pass
H4-3	EA	→		0.217	0.252	0.051	4.288	***	Pass

Note: *** indicate significance at the 1% levels.

5.1.4. Insights into Chinese Consumers

EVs are a new means of transportation that has been developed for environmental protection. Unlike existing fuel vehicles, they provide a new driving experience by integrating new technologies. It is expected that the EV market will continue to grow in the future and become the main mode of transportation. As consumers' perceptions of electric vehicles change, this study uses Davis's TAM to apply the aes, func, and sym of product design to the TAM, along with EA, and explores the impact of product design dimensions on the willingness to purchase EVs.

The results of the analysis of Chinese consumers in this study are summarized as follows. First, in the product design dimension, aes was found to have no effect on PU and PEU, but it had a direct effect on EA. This suggests that the aes of electric vehicles can affect Chinese consumers' EA, thereby triggering WTB.

Second, in the product design dimension, func has a significant impact on all perceived variables and EA. As existing research mainly focuses on technology [87,88], the new technology of EVs will have a direct impact on WTB. Additionally, as reported by Clarkson et al. (2013) [89], consumers' knowledge can affect the novel consumption that they seek. As consumers' knowledge and experience increase, it can be inferred that their demand for EVs will also change accordingly.

Finally, in terms of the symbolic dimension of product design, although it has no direct impact on PEU and PU, it does affect EA. For Chinese consumers, PEU and EA both positively affect PU and directly affect WTB.

5.2. Korean Consumers

5.2.1. Korean Participants and Measures

This study also adopted the convenience sampling method. From 7 April to 29 June 2024, an online survey was conducted on 426 Korean men and women aged 20 to 60 years, using Google's questionnaire website "Google Forms". The responses of 409 people (excluding invalid questionnaires) were used for the final analysis. In terms of the demographic characteristics of the survey subjects, 229 were male, accounting for 56%, and 180 were female, accounting for 44%. In terms of age, 129 were in their 20s, accounting for 32%; 119 were in their 30s, accounting for 29%; 103 were in their 40s, accounting for 25%; and 3% of the participants were over 50 years old. In terms of education level, the majority of respondents were university graduates, accounting for 274 people, or 67%. In terms of the lifestyle of Korean consumers, the majority of respondents were interested in cars, accounting for 53%, followed by respondents who thought that cars' functions are the most important, accounting for 105 people, or 26%. Among Korean consumers, the majority of respondents owned internal combustion cars, accounting for 50% (204 people) (see Table 12).

Table 12. Demographic characteristics of the Korean sample.

No.	Measure	Item	Count	%
1	Gender	Male	229	56
		Female	180	44
2	Age	20~29 years old	129	32
		30~39 years old	119	29
		40~49 years old	103	25
		50~59 years old	47	11
		<60 years old	11	3
3	Education level	High school	52	13
		Junior college	47	12
		University	274	67
		Graduate school	34	8
		Other	2	1

Table 12. *Cont.*

No.	Measure	Item	Count	%
4	Lifestyle	I am attracted to the exterior of cars and I like cars	217	53
		I am not interested in cars	48	12
		I think the functionality of a car is important	105	26
		I think cars express my social status	39	10
5	Car ownership	I don't have a car	166	41
		I have a car with an internal combustion engine	204	50
		I have an electric car	39	10
6	Driving frequency	1 day or less per week	176	43
		2~3 days a week	84	21
		4~5 days a week	76	19
		More than 6 days a week	73	18

5.2.2. Analysis of Results

Reliability and Validity Testing

As with the reliability and validity testing for Chinese consumers, the reliability and validity analysis for Korean consumers also first used SPSS 27.0. The result was that the KMO value was 0.928 (greater than 0.7), and Bartlett's test of sphericity was significant, at 0.001. The Cronbach's α of each dimension of the questionnaire (aes, func, sym, PEU, PU, EA, and WTB) was greater than 0.7, indicating that the correlation between the scales of Korean consumers is good and suitable for further research. For further analysis, see Table 13.

Table 13. Korean proportion attributes.

KMO and Bartlett's Test				
KMO sampling suitability measure			0.928	
Bartlett's test of sphericity	6037.694 300 0.001		6533.05 300 0.000	
Reliability Analysis of the Questionnaire				
Variable Name	Measurement Item	Correction Total Correlation (CITC)	After Deleting the Item's Cronbach's α Value	Each Variable's Cronbach's α Value
Aes	AD1	0.717	0.852	0.878
	AD2	0.744	0.842	
	AD3	0.738	0.844	
	AD4	0.753	0.838	
Func	FD1	0.699	0.76	0.832
	FD2	0.703	0.756	
	FD3	0.673	0.786	
Sym	SD1	0.737	0.832	0.872
	SD2	0.726	0.837	
	SD3	0.702	0.847	
	SD4	0.742	0.830	
PEU	PEU1	0.721	0.765	0.842
	PEU2	0.721	0.765	
	PEU3	0.677	0.808	
PU	PU1	0.706	0.787	0.844
	PU2	0.696	0.796	
	PU3	0.728	0.765	

Table 13. *Cont.*

KMO and Bartlett's Test				
EA	EA1	0.766	0.875	0.900
	EA2	0.755	0.877	
	EA3	0.774	0.873	
	EA4	0.738	0.881	
	EA5	0.724	0.884	
WTB	WTB1	0.725	0.794	0.853
	WTB2	0.708	0.810	
	WTB3	0.739	0.781	

Next, the principal component extraction of the Korean consumer data was performed to obtain the initial eigenvalues, variance contribution rates, cumulative variance contribution rates, etc. The results are shown in Table 14. According to the extraction principle that the eigenvalue is greater than 1, seven factors were extracted, the cumulative variance contribution rate was 74.67%, and the commonality of each item was above 0.5, indicating that the seven factors extracted from the 25 questions provided a relatively ideal explanation for the original data.

Table 14. Korean variance explanation.

Component	Initial Eigenvalues			Sum of Squares of Rotating Loads			Commonality
	Total	Variance Percentage	Cumulative %	Total	Variance Percentage	Cumulative %	
1	10.173	40.692	40.692	3.651	14.606	14.606	0.726
2	1.979	7.918	48.610	3.009	12.034	26.640	0.748
3	1.526	6.105	54.714	2.976	11.906	38.545	0.730
4	1.503	6.010	60.724	2.301	9.206	47.751	0.757
5	1.271	5.083	65.807	2.287	9.149	56.900	0.744
6	1.193	4.773	70.580	2.281	9.124	66.024	0.773
7	1.022	4.087	74.667	2.161	8.644	74.667	0.719
8	0.542	2.169	76.836				0.732
9	0.479	1.916	78.752				0.723
10	0.454	1.814	80.566				0.705
11	0.446	1.785	82.351				0.758
12	0.429	1.715	84.066				0.789
13	0.395	1.579	85.644				0.792
14	0.382	1.527	87.172				0.730
15	0.362	1.449	88.621				0.763
16	0.354	1.418	90.039				0.753
17	0.337	1.346	91.385				0.780
18	0.333	1.333	92.718				0.739
19	0.311	1.245	93.964				0.740
20	0.29	1.159	95.122				0.747
21	0.273	1.093	96.216				0.691
22	0.264	1.055	97.271				0.691
23	0.25	1.001	98.271				0.788
24	0.218	0.872	99.143				0.758
25	0.214	0.857	100.00				0.792

Extraction method: principal component analysis.

Finally, the Kaiser standardized maximum variance rotation method was used to rotate the factor loadings, and the results are shown in Table 15. The loadings of each item on the corresponding factor are all over 0.5. Color and bold are used in the table, so there is reason to believe that the scale of this study has good structural validity.

Table 15. Load matrix after rotation.

Measures	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
AD1	0.221	0.184	**0.766**	0.059	0.047	0.189	0.121
AD2	0.190	0.114	**0.788**	0.103	0.146	0.087	0.193
AD3	0.218	0.174	**0.749**	0.134	0.173	0.110	0.176
AD4	0.214	0.082	**0.795**	0.139	0.141	0.122	0.134
FD1	0.228	0.180	0.157	0.157	**0.751**	0.169	0.131
FD2	0.180	0.124	0.157	0.156	**0.808**	0.124	0.090
FD3	0.144	0.185	0.136	0.205	**0.748**	0.190	0.095
SD1	0.155	**0.780**	0.146	0.143	0.095	0.146	0.165
SD2	0.152	**0.779**	0.152	0.178	0.089	0.098	0.142
SD3	0.170	**0.767**	0.080	0.106	0.196	0.078	0.160
SD4	0.132	**0.798**	0.146	0.151	0.133	0.196	0.049
PU1	0.153	0.184	0.148	0.160	0.100	**0.808**	0.144
PU2	0.141	0.208	0.169	0.151	0.114	**0.808**	0.104
PU3	0.164	0.092	0.138	0.095	0.304	**0.741**	0.158
PEU1	0.191	0.141	0.268	0.151	0.105	0.166	**0.757**
PEU2	0.258	0.210	0.157	0.179	0.108	0.122	**0.748**
PEU3	0.260	0.184	0.208	0.119	0.131	0.152	**0.762**
EA1	**0.792**	0.138	0.157	0.132	0.159	0.103	0.121
EA2	**0.787**	0.073	0.199	0.174	0.059	0.156	0.130
EA3	**0.776**	0.201	0.212	0.100	0.127	0.095	0.157
EA4	**0.726**	0.154	0.192	0.115	0.175	0.164	0.182
EA5	**0.761**	0.146	0.163	0.068	0.157	0.058	0.178
WTB1	0.198	0.219	0.127	**0.798**	0.099	0.160	0.109
WTB2	0.130	0.151	0.159	**0.779**	0.174	0.159	0.173
WTB3	0.154	0.192	0.105	**0.791**	0.262	0.093	0.133

Rotation method: Kaiser normalization with varimax. The rotation converged after six iterations.

In summary, the questionnaire used by Korean consumers has good validity and is suitable for further analysis.

Confirmatory Factor Analysis

Similar to the analysis of the results of Chinese consumers, in order to verify the validity of the questionnaire, confirmatory factor analysis was conducted on each structure. The results of the analysis of the fitness of the model using AMOS 26.0 showed that the χ^2/df value of the confirmatory factor analysis model was 1.34 (less than 3), the RMSEA was 0.03 (less than 0.05), the GFI was 0.94, the AGFI was 0.92, and the RFI was 0.94 (all greater than 0.8). Additionally, the NFI was 0.95, the IFI was 0.99, the TLI was 0.98, and the CFI was 0.99, i.e., all greater than 0.9 (Table 16). All of the fitting indicators were within the critical range, so it can be considered that the questionnaire data have a relatively good fitting effect.

Table 16. Confirmatory factor analysis model fitness.

Fit Index		χ^2/df	RMSEA	GFI	AGFI	NFI	RFI	IFI	TLI	CFI
Evaluation standard	Ideal	<3	<0.05	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9
	Acceptable	<5	<0.08	>0.8	>0.8	>0.8	>0.8	>0.8	>0.8	>0.8
Structural model measurements		1.339	0.029	0.938	0.921	0.945	0.935	0.985	0.983	0.985

Similar to the analysis of the results for Chinese consumers, the standardized loads of each item corresponding to the seven variables aes, func, sym, PEU, PU, EA, and WTB of Korean consumers were measured. The results showed that the composite reliability (CR) was 0.88 for aes, 0.83 for func, 0.87 for sym, 0.84 for ease of use, 0.84 for usefulness, 0.9 for EA, and 0.85 for WTB—all exceeding 0.8. The AVE was 0.65 for aes, 0.62 for func, 0.63 for sym, 0.64 for ease of use, usefulness, and EA, and 0.66 for WTB—all exceeding 0.6 (see Table 17). Therefore, it can be inferred that the convergent validity of the scale for Korean consumers is ideal.

Finally, the discriminant validity test results for the Korean consumer scale are presented. The values on the diagonal are the arithmetic square roots of the AVE of the seven variables: aes, func, sym, PEU, PU, EA, and WTB (color and bold are used in the table). As with the Chinese consumer scale, the discriminant validity of the Korean consumer scale is ideal (see Table 18).

Table 17. Convergent validity test.

Variable	Measurement Item	Parameter Significance Estimate				Factor Loading	Item Reliability	Composite Reliability	Average Variance Extracted
		Unstd.	S.E.	*t*-Value	*p*	Std.	SMC	CR	AVE
Aes	AD4	1				0.813	0.661	0.879	0.645
	AD3	0.997	0.056	17.91	***	0.814	0.662		
	AD2	0.905	0.051	17.739	***	0.807	0.652		
	AD1	0.906	0.053	17.126	***	0.777	0.604		
Func	FD3	1				0.77	0.593	0.832	0.624
	FD2	0.994	0.065	15.291	***	0.786	0.618		
	FD1	1.051	0.069	15.333	***	0.812	0.659		
Sym	SD4	1				0.813	0.661	0.872	0.631
	SD3	0.952	0.058	16.365	***	0.763	0.583		
	SD2	0.93	0.054	17.073	***	0.791	0.626		
	SD1	0.967	0.054	17.836	***	0.811	0.658		
PEU	PEU1	1				0.816	0.665	0.842	0.641
	PEU2	0.992	0.058	17.02	***	0.818	0.668		
	PEU3	0.919	0.059	15.668	***	0.768	0.589		
PU	PU1	1				0.795	0.632	0.844	0.644
	PU2	0.946	0.059	16.097	***	0.787	0.62		
	PU3	1.005	0.059	17.023	***	0.826	0.682		
EA	EA5	1				0.793	0.589	0.900	0.643
	EA4	1.047	0.057	18.265	***	0.832	0.629		
	EA3	0.986	0.056	17.473	***	0.799	0.693		
	EA2	1.017	0.057	17.965	***	0.818	0.639		
	EA1	0.953	0.057	16.724	***	0.768	0.668		
WTB	WTB1	1			1	0.812	0.659	0.854	0.660
	WTB2	0.955	0.057	16.614	0.955	0.792	0.627		
	WTB3	1.012	0.058	17.516	1.012	0.834	0.695		

Note: *** indicate significance at the 1% levels.

Table 18. Correlation coefficient matrix and square roots of AVEs.

No.	Variable	1	2	3	4	5	6	7
1	Aes	**0.803**						
2	Func	0.523 ***	**0.790**					
3	Sym	0.486 ***	0.527 ***	**0.795**				
4	PU	0.511 ***	0.576 ***	0.526 ***	**0.801**			
5	PEU	0.628 ***	0.512 ***	0.554 ***	0.547 ***	**0.803**		
6	EA	0.610 ***	0.556 ***	0.504 ***	0.493 ***	0.639 ***	**0.802**	
7	WTB	0.472 ***	0.604 ***	0.558 ***	0.519 ***	0.549 ***	0.503 ***	**0.813**

Note: *** indicate significance at the 1% levels.

5.2.3. Structural Equation Modeling Results

The same applies to the scale for Korean consumers. After confirmatory factor analysis, AMOS 26.0 was used to construct a structural equation model. Through further processing, the path coefficients and significant coefficients between each latent variable were calculated to verify the hypotheses proposed in this study. The model path relationship diagram is shown in Figure 4.

Table 19 shows the final model path fitness for Korean consumers, with a chi-squared–degree-of-freedom ratio of 1.47 (<3), RMSEA value of 0.03 (<0.08), a GFI value of 0.93, AGFI value of 0.91, and RFI value of 0.92 (all greater than 0.8) and NFI, IFI, TLI, and CFI values of 0.94 and 0.98 (all greater than 0.9). Therefore, it can be considered that the structural equation model for Korean consumers has a good fitting effect on the questionnaire data.

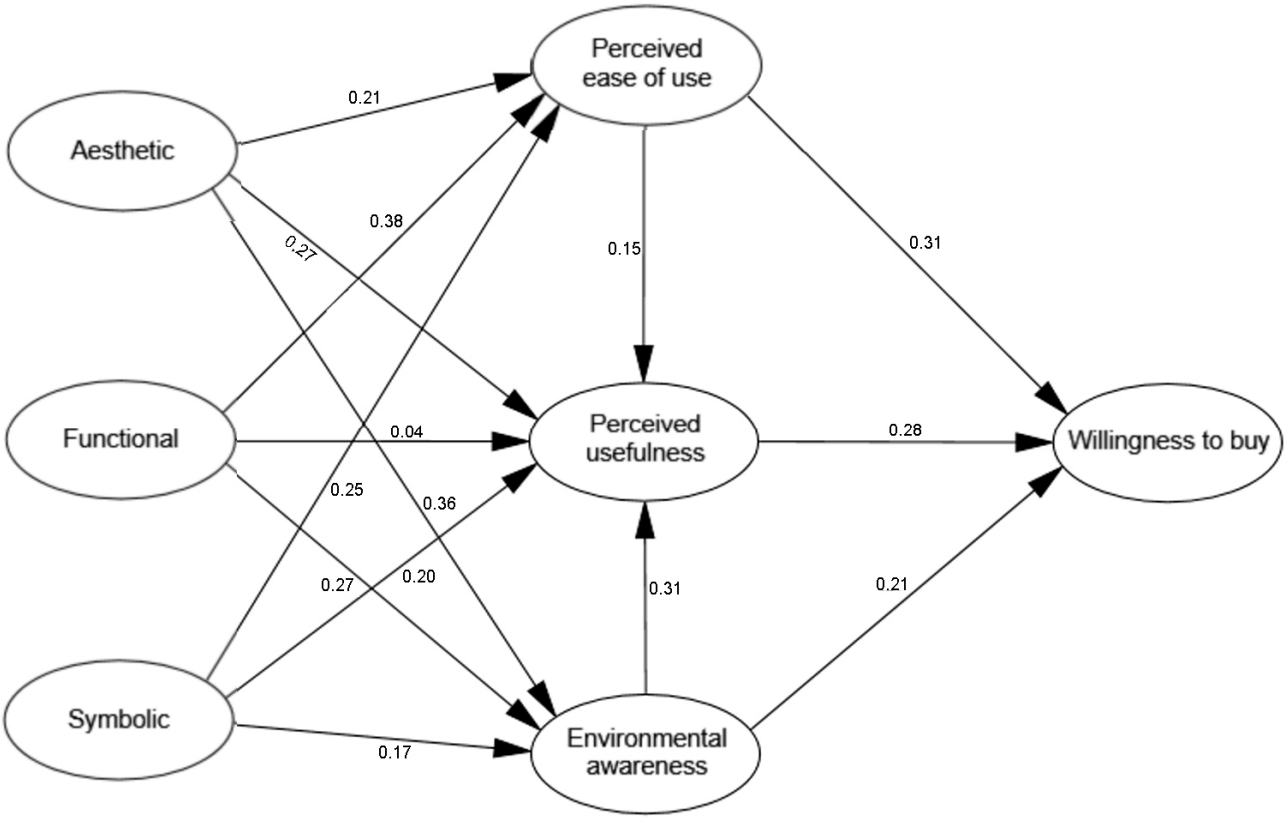


Figure 4. Results of structural equation modeling for Korean consumers.

Table 19. The fitness of the Korean consumer path model.

Fit Index		χ^2/df	RMSEA	GFI	AGFI	NFI	RFI	IFI	TLI	CFI
Evaluation standard	Ideal	<3	<0.05	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9
	Acceptable	<5	<0.08	>0.8	>0.8	>0.8	>0.8	>0.8	>0.8	>0.8
Structural model measurements		1.470	0.034	0.932	0.914	0.939	0.929	0.980	0.976	0.979

Relationship between Aesthetics (Aes), Perceived Variables, and Environmental Awareness (EA)

The research results between Korean consumers' aes, perceived variables, and EA show that H1-1 (aes affects the PEU of EVs; β = 0.06, T = 3.47), H1-2 (aes affects the PU of EVs; β = 0.07, T = 4.20), and H1-3 (aes affects the EA of electric vehicles; β = 0.06, T = 6.43) are all established. The results of this study show that, among Korean consumer groups,

aesthetic factors have a significant impact on the PEU, PU, and EA of electric vehicles. Specifically, aes can not only enhance consumers' perceptions of the ease of use and practicality of electric vehicles but also enhance their EA. Therefore, for Korean consumers, aesthetic factors play an important role in selecting and accepting EV technology, and this result reveals how aesthetic values influence Korean consumers' attitudes toward and adoption of new technologies in the context of Korean culture. This is contrary to the results of Jung et al. (2021) [90], who found that Korean consumers attach great importance to the future value of the car when buying a car but do not pay much attention to the aes of the EV.

Relationship between Function (Func), Perceived Variables, and Environmental Awareness (EA)

The survey results of Korean consumers show that H2-1 and H2-2, concerning the PEU of electric vehicles (β = 0.07, T = 5.25) and EA (β = 0.06, T = 4.32), respectively, are established, but H2-3 (that the PU of electric vehicles will increase) is not established (β = 0.08, T = 0.57). This means that Korean consumers tend to think that EVs are easier to use and more environmentally friendly. However, the PU can only be improved after a test drive [91].

Relationship between Symbolism (Sym), Perceived Variables, and Environmental Awareness (EA)

From the perspective of the relationship between symbolic and perceived variables and environmental protection, H3-1 (β = 0.06, T = 3.19), H3-2 (β = 0.05, T = 3.18), and H3-3 (β = 0.06, T = 2.81) are all valid for Korean consumers. In other words, sym can improve Korean consumers' PEU and PU, and it can also improve EA. This is consistent with the findings of Beak et al. (2020) [92] that Korean consumers have a relatively high willingness to pay for the carbon dioxide emission reduction rate of EVs.

The Relationship between Perceived Variables, Environmental Awareness (EA), and Willingness to Buy (WTB)

The research results on H4-1, H4-2, and H4-3 clearly show that, for the Korean consumers in this study, the effects of PEU, PU, and EA on the intention to purchase EVs are all positive. The higher the consumer's PEU for electric vehicles (β = 0.07, T = 4.67), the stronger the intention to purchase EVs. In other words, Korean consumers are more likely to choose EVs that they find easy to drive and operate. PU was also shown to have a positive impact on WTB (β = 0.08, T = 3.68). This proves that Korean consumers' perceptions of the functionality of EVs, such as their aes, func, and sym, will significantly influence their purchase decisions. The positive impact of EA on WTB has also been verified (β = 0.07, T = 2.81). This shows that concern and recognition of environmental protection issues will prompt Korean consumers to choose EVs.

In summary, in the EV market, PEU, PU, and EA have a significant impact on improving Korean consumers' WTB electric vehicles. Therefore, these factors should be paid attention to and strengthened in marketing and product development to meet consumers' needs and promote the popularity and market growth of EVs.

Finally, Korean consumers, much like Chinese consumers, were consistent with the findings of Davis (1989) [15]. PEU has a significant positive impact on PU (β = 0.07, T = 2.18), and the results prove that Korean consumers' EA also has a significant positive impact on perceived usefulness (β = 0.07, T = 4.41) (see Table 20).

Table 20. Results of hypothesis testing on Korean consumers.

No.	Path Relationship			B	β	S.E.	C.R.	*p*-Value	Result
H1-1	Aes	→	PEU	0.207	0.212	0.060	3.472	***	Pass
H1-2		→	PU	0.274	0.271	0.065	4.199	***	Pass
H1-3		→	EA	0.355	0.383	0.055	6.425	***	Pass
H2-1	Func	→	PEU	0.379	0.351	0.072	5.245	***	Pass
H2-2		→	PU	0.043	0.039	0.075	0.57	0.569	Fail
H2-3		→	EA	0.274	0.269	0.063	4.315	***	Pass
H3-1	Sym	→	PEU	0.255	0.252	0.064	4.057	***	Pass
H3-2		→	PU	0.200	0.192	0.063	3.186	0.001	Pass
H3-3		→	EA	0.175	0.183	0.055	3.186	0.001	Pass
H4-1	PEU	→	WTB	0.309	0.302	0.066	4.673	***	Pass
H4-2	PU	→		0.277	0.279	0.075	3.677	***	Pass
H4-3	EA	→		0.208	0.192	0.074	2.814	0.005	Pass

Note: *** indicate significance at the 1% levels.

5.2.4. Insights into Korean Consumers

Similar to the analysis of Chinese consumption, the aesthetics, function, symbolism, and environmental awareness of product design were applied to Davis's TAM to explore the impact of product design dimensions on the intention to purchase electric vehicles. However, unlike the analysis results for Chinese consumers, in the product design dimension of Korean consumers, aesthetics was found to have a direct impact on perceived usefulness, perceived ease of use, and environmental awareness. This shows that the aesthetics of electric vehicles can affect all perceived attitudes and environmental awareness, thereby triggering purchase intentions. Second, in the product design dimension, function has a significant impact on both perceived ease of use and environmental awareness; however, it has no effect on perceived usefulness. As reported by Kim et al. (2019) [91], for Korean consumers, perceived usefulness can only be improved after a test drive. Finally, in the symbolic dimension of product design, contrary to the results for Chinese consumers—that it has no direct effect on perceived ease of use and perceived usefulness, but affects environmental awareness—symbols have a positive effect on both perceived attitude and environmental awareness for Korean consumers. Additionally, like Chinese consumers, for Korean consumers, perceived ease of use and environmental awareness both positively affect perceived usefulness and directly affect purchase intentions.

6. Discussion

This study used the TAM to explore the factors that affect the intention to purchase EVs in the product design dimension of China (the world's largest EV market) and South Korea (an emerging EV market). The results show that, for Chinese consumers, H1-1, H1-2, H3-1, and H3-2 are not established. It can be concluded that Chinese consumers do not attach much importance to the aes and sym of EVs. The study of Korean consumers showed that the product design dimensions of aes, func, and sym have an impact on PEU, PU, and EA and can ultimately affect WTB; however, only H2-2 is not established, indicating that Korean consumers have a relatively low PU when accepting new technologies.

However, product preferences are influenced by cultural and social factors [93]. Cultural values are widely accepted beliefs, norms, and codes of conduct that influence people's thinking, decision-making, and behavior. History, religion, education, economic development, and social structure all influence cultural values, and these values affect the acceptance of specific cultural styles [94].

Cultural values directly affect the market position of EVs. For example, in Northern Europe, EVs are popular due to the emphasis on environmental protection and sustainable development, and governments have also introduced incentives. In Silicon Valley, United States, EVs are more acceptable due to the high acceptance of technology; in conservative cultures, promoting EVs requires more time and education. Companies need to understand these cultural differences and develop appropriate market strategies.

Hofstede's research (2001) [95] also explains the differences in results in different countries. China is a highly collectivist society, and consumers pay more attention to function rather than appearance when popularizing EVs under the government's promotion. South Korea scores high in uncertainty avoidance, and consumers have a strong avoidance of technological innovation. Therefore, the Korean market needs to reduce the uncertainty brought by new technologies by providing pre-driving experiences, and companies should reduce consumer concerns and promote the acceptance of new technologies through effective market communication and product education.

It should be added that, from a marketing management perspective, consumers' willingness to buy EVs is also affected by other options, such as cars with oil and diesel engines. Therefore, when studying EV purchasing behavior, one should not only consider product design, perceived acceptance and environmental awareness, but also consider the competition from other types of vehicles on the market, which differ from EVs in fuel, pricing, comfort, and aesthetic features and can provide consumers with diverse choices.

Finally, just as the 2024 Paris Summer Olympics will take "sustainable development" as a core concept, when exploring the factors affecting EV purchase intentions, we need to consider not only product design dimensions but also broader behavioral motivations and attitudes. In recent years, there have been an increasing number of studies on clean energy technologies, which reveal consumers' behavioral motivations and attitudes towards clean energy technologies in their daily lives.

For example, Kyriakopoulos (2022) [96] recently provided a comprehensive overview of the research on energy community management policies, economic aspects, technologies, and models, exploring the application of clean energy technologies therein. The study emphasized the social acceptance and support for clean energy technologies, which is very important for understanding the context of EV purchasing behavior.

7. Managerial Implications

The results of this study have several important implications for theory and practice.

First, this study applied product design to the TAM and investigated the purchase intentions of Chinese and Korean consumers.

Second, the research findings provided by this study can help automakers and marketers gain a deeper understanding of the characteristics of Chinese and Korean electric vehicle consumers. For example, Chinese consumers pay more attention to the new technology and functions of products than to aes and sym. This means that, when targeting the Chinese market, automakers should focus on promoting the advanced technological features and functional advantages of electric vehicles in order to attract the interest and purchasing desire of Chinese consumers.

Third, Korean consumers are more interested in aes and sym than in functions. This suggests that, in the Korean market, automakers should emphasize the aes and sym in the design of electric vehicles in order to cater to the preferences of Korean consumers. This can include promoting the fashionable design, brand image, and sym of EVs as environmental and social responsibilities.

Fourth, another effective communication strategy is to emphasize the contribution of electric vehicles to environmental protection, because both Chinese and Korean consumers believe that EA is an important factor in using electric vehicles. Automakers and marketers can enhance the appeal of electric vehicles and meet consumers' demand for environmental protection by promoting their low emissions and sustainability. As the Korean EV market matures, environmental concerns and reputation issues may become

more important. Therefore, automakers should continue to pay attention to and respond to Korean consumers' concerns about environmental protection and social responsibility. This will not only enhance the brand image but also increase consumers' recognition and trust in EVs.

In summary, the findings of this study provide automakers with a basis for formulating differentiated marketing strategies for different markets. By understanding the unique needs and preferences of Chinese and Korean consumers, EVs can be promoted more effectively, and market share can be increased.

8. Limitations and Future Research Directions

This study has some limitations and provides multiple directions for future research. The following is a discussion of these limitations and future research directions.

8.1. Limitations

First, this study mainly used the technology acceptance model (TAM) to explore the impact of product design dimensions on the intention to purchase EVs among Chinese and Korean consumers, so the results may be limited to product design dimensions. This study ignored other consumer needs and dimensions, such as sustainability and technological innovation. Sustainability affects consumers' environmental awareness and social responsibility, while technological innovation meets the demand for new functions and high technology. These dimensions interact with aes, func, and sym and may jointly affect consumers' purchase decisions.

Second, this study did not analyze consumer differences such as gender and age. Future research could be extended to explore gender differences (such as males and females) and age differences, in order to investigate whether these differences affect the role of aes, func, and sym design on the intention to purchase EVs. For example, male consumers may be more interested in technological innovation and performance, whereas female consumers may pay more attention to safety and environmental protection; young consumers may be more open to new technologies, whereas older consumers may pay more attention to the reliability and long-term value of vehicles.

In addition, this study is also lacking in theoretical research depth. Only partial theories using the TAM may overlook factors such as social influence, personal attitudes, or external environment. Future research could incorporate the theory of planned behavior (TPB) or the unified theory of behavior (UTAUT) to build a more comprehensive theoretical model, in order to provide a deeper understanding and more accurate prediction of consumer acceptance of EVs.

In addition, the results of this research are based only on data from Chinese and Korean consumers, which may not be applicable to consumers in other countries. The cultural background and market environment of each country are different, and future research should consider the impacts of cultural, regional, and subcultural differences on consumer behavior. For example, the difference in the degree of modernization between eastern and inland China, South Korea, and other regions, as well as ethnic minority culture, age generation differences, etc., may significantly affect consumer purchasing behavior and preferences.

Possible biases in this study include social desirability bias, memory bias, and inconsistent responses, which may affect the accuracy and reliability of the data. Therefore, future research should consider how to reduce these biases in order to improve the validity of the research results.

8.2. Future Research Directions

- Multidimensional analysis: Future research should consider the impacts of sustainability and technological innovation on the willingness to purchase EVs and explore the interactive relationships between these dimensions and aes, func, and sym.
- Gender and age differences: In-depth exploration of the impact of gender and age on the willingness to buy EVs and analysis of the differences in the needs of different groups in aes, func, and sym design.
- Expansion of the theoretical framework: Combining other theories in the TAM or integrating the theory of planned behavior (TPB) and the unified theory of behavior (UTAUT) to build a more comprehensive theoretical model, in order to enhance the explanatory power of consumers' willingness to buy EVs.
- Cultural differences research: Expand to other countries and regions to analyze the impacts of cultural background, economic development, degree of modernization, and ethnic minority culture on consumer behavior.
- Dynamic data collection: A longitudinal research design should be adopted to obtain dynamic data by tracking the attitude and behavior changes of the same group over a long period of time, especially under new technologies and market changes.
- Application of biometric technology: Citing the research results of biometric technology, explore its potential impact on EV consumer decision-making. For example, the use of advanced biometric technology may enhance the safety and personalization of EVs and attract more consumers who pay attention to these features [97].
- As the electric vehicle market develops rapidly, and as consumer preferences and technological advances continue to change, manufacturers should continue to innovate, invest in R&D, cooperate with technology companies, conduct dynamic market analysis, flexibly produce, optimize the supply chain, adjust brand positioning, strengthen digital marketing, and provide comprehensive charging and after-sales services in order to maintain market relevance and meet changing needs.

In short, future research should focus on making up for the shortcomings of existing research and, through multidimensional theoretical discussions and data analysis, gaining a deeper understanding of consumers' willingness to purchase EVs, so as to provide more valuable insights and suggestions for the further development of the EV market.

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