Factors Influencing the Acceptance of Small Electric Vehicles in China: An Extended Technology Acceptance Model Analysis

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ABSTRACT. Small electric vehicles have become very popular in recent years. However, the psychological factors affecting the public's purchase of small electric vehicles and their role mechanisms are still unknown. For this reason, this paper first constructs an extended technology acceptance model(TAM) based on the technical characteristics of small electric vehicles by introducing three latent variables: environmental awareness, subjective norms, and policy perception. The extended model is used to analyze the mechanism of the psychological latent variables, such as perceived usefulness, perceived ease of use, policy perception, perceived social norms, environmental awareness, and behavioral attitudes, on the willingness to buy. We obtained 458 valid sample data through questionnaires, analyzed the relationship between the latent variables using structural equation modeling, conducted empirical tests, and calibrated the model parameters. The results show that the model fits well, perceived usefulness, perceived ease of use, social norms, environmental awareness, and policy perception have a significant positive effect on purchase intention, and environmental awareness and policy perception affect the willingness to use and purchase small electric vehicles by changing the public's behavioral attitudes. Based on the research, strategies for the development of small electric vehicles were proposed.

Keywords: small electric vehicles; purchase willingness; technology acceptance model; structural equation modeling

1 Introduction

Developing lightweight, small electric vehicles is an effective energy conservation and emission reduction measure in carbon peak carbon neutrality. As one of the essential types of new energy vehicles, small electric vehicles refer to A00-class cars and A0-class cars that use onboard batteries as the power output and electric motors to drive the vehicle and meet the requirements of road traffic, safety regulations, and national standards. Compared with traditional fuel vehicles and other new energy vehicles, it has a small size, low price, low pollution, and low energy consumption. In recent years,

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the market share has been expanding, especially in the lower-tier cities, to fill the gap in developing new energy vehicles. Research on the purchase intention of small electric vehicles will help promote small electric cars and the development of green transportation.

Currently, research on electric vehicles mainly focuses on government policy subsidies[1] and technological research and development[2]. Some scholars have also investigated the purchase intention of conventional electric vehicles, such as Virender Singh[3], who explored consumer intention to use electric cars from demographic, situational, contextual, and psychological perspectives. Consumers' intention to use electric vehicles and Ali[4] examined the effect of perceived usefulness, attitudes, subjective norms, and perceived behavioral control on the willingness to purchase electric vehicles. However, there needs to be more focus on small electric cars, and fewer studies analyze small electric vehicle ownership from the user perspective of intention to use.

Regarding statistical modeling, the research on acceptance is currently widely used in the technology acceptance model. Davis[5] first proposed the Technology Acceptance Model (TAM) to explain the degree of users' willingness to accept and use emerging technologies.TAM believes that behavioral intention directly determines actual behavior, behavioral attitude, and perceived usefulness jointly influence behavioral choice and perceived usefulness and perceived ease of use jointly influence behavioral attitude. In recent years, the technology acceptance model has been widely used in the field of transportation choice behavior research to predict the public's use of new travel modes, such as using the technology acceptance model to explore the public's acceptance of assisted driving technology[6], car sharing[7], self-driving cars[8] and other things. The evolution of technology acceptance models has centered around the addition of external variables, integration with other models, and the addition of moderating variables.

This paper adopts the Technology Acceptance Theory (TAM) as the primary research framework based on previous studies to study the willingness to use small electric vehicles. It constructs the model by integrating environmental awareness, subjective norms, and policy perception. Based on the characteristics of space, power, energy consumption, and purchase subsidy of small electric vehicles, we develop a questionnaire on the willingness to use small electric vehicles and analyze the data using Partial Least Squares (PLS) Structure Equation Modeling (SEM) to explore the factors and roles of the residents' willingness to use small electric vehicles and the impacts on the public's desire to use small electric cars. The data are analyzed using Partial Least Squares (PLS) and Structural Equation Modeling (SEM) to explore the influencing factors and paths of the public's willingness to use small electric vehicles. Finally, this paper proposes corresponding countermeasures for the future development of small electric cars in China from the current situation of the new energy automobile industry and technology development. It gives relevant suggestions on the future development path of small electric cars.

2 Theoretical foundation and modeling

2.1 Extended variables

Scholars have confirmed the influence of environmental awareness on travel mode choice behavior. J. Roberts[9] and others demonstrated that travelers' environmental attitudes significantly impact commuting mode choice, and Prasanna[10] found that environmental awareness significantly affects electric vehicle purchase behavior. Ecological awareness was introduced as a latent variable due to the technical characteristics of small electric vehicles, which are green and have low energy consumption. In addition, China is a country practicing collectivism, and policies and people around them inevitably influence members' social consumption behaviors. Therefore, policy perception and subjective norms are also introduced as the model's psychological latent variables.

Based on the existing research, the technology acceptance model is extended by introducing three explanatory variables, namely, environmental awareness, policy perception, and subjective norms, to increase the explanatory power and reliability of the technology acceptance model, given the technical characteristics of small electric vehicles. The theoretical model was demonstrated in Fig. 1.

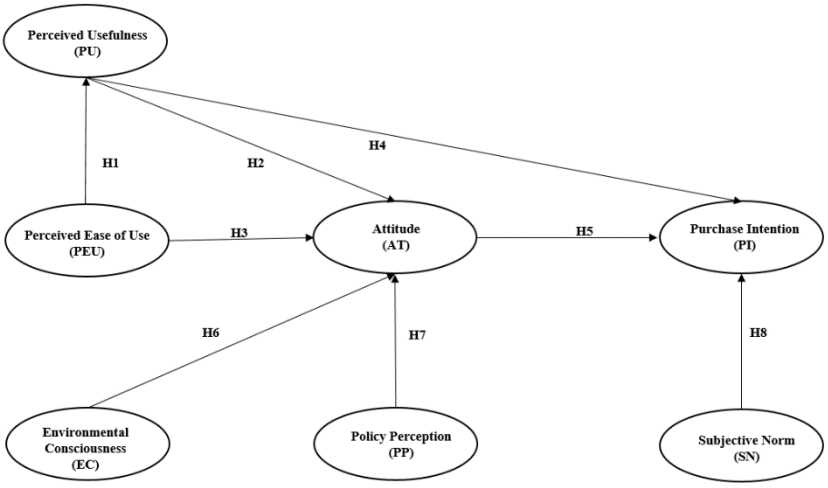

Fig. 1. Extended technology acceptance model

2.2 Model assumptions and latent variable scale design

Based on the model constructed in this paper, the hypotheses proposed are as follows:

H1: Perceived ease of use positively affects perceived usefulness.

H2: Perceived usefulness positively affects behavioral attitudes.

H3: Perceived ease of use will positively affect behavioral attitudes.

H4: Perceived usefulness will positively impact the willingness to purchase and use small electric vehicles.

H5: Behavioral attitudes positively affect the desire to purchase and use small electric cars.

H6: Small environmental awareness positively affects behavioral attitudes toward small electric cars.

H7: Policy perception positively affects behavioral attitudes toward small electric vehicles.

H8: Subjective norms positively affect the willingness to purchase and use small electric vehicles.

Based on the research results of scale development of the technology acceptance model and the theory of planned behavior, the measurement question items for each variable of the theoretical model were designed and developed by combining the technological characteristics of small electric vehicles. In the latent variable model section, several indicator variables were used to identify the latent variables, which were responses to the survey questions about different attitudes, and a list of the measurement items, as shown in Table 1, was finally formed.

Table 1. Interpretation of Latent Variables and their Measurement Question Items

Latent Variable	Definition	Title Number	Measurement Items
Perceived Usefulness (PU)	The extent to which the public perceives that the use of small electric vehicles improves their job performance	PU1	Small electric cars would work well for my mobility needs.
		PU2	Small electric vehicles can effectively solve traffic congestion problems.
		PU3	Small electric car would be an excellent way to improve my driving behavior (e.g., overtaking, stopping, etc.).
		PU4	Small electric cars would improve my quality of life.
Perceived Ease of Use (PEU)	The extent to which the public perceives no effort required to use small electric vehicles	PEU1	Using a small electric vehicle should be more straightforward than other types of motorized vehicles.
		PEU2	Using small electric vehicle amenities is easy for me (e.g., parking, charging).
		PEU3	It was easy for me to get the hang of the small electric car.
		PEU4	Small electric cars are easy to repair and maintain.
Environmental Consciousness (EC)	Level of public concern for environmental protection	EC1	I would be worried about air pollution from vehicle emissions..
		EC2	I think the impact on the natural environment should be considered when buying a car.
		EC3	I have a responsibility to adopt a low-carbon mode of transportation.
Subjective Norm (SN)	Individuals' perceived	SN1	I will use a small electric car if everyone around me uses it too.

	social pressure to adopt or not adopt a particular behavior	SN2	I should be surrounded by people who think that using a small electric car is a good choice.
		SN3	Mass media promotion of small electric vehicles will increase my willingness to use small electric vehicles.
Policy Perception（PP）	Impact of transportation policies, fiscal policies, etc., on public use of small electric vehicles	PS1	Small electric vehicles to receive policy support from government departments.
		PS2	There will be incentives for purchasing and using small electric vehicles in the future.
		PS3	The future mobility environment (mainly road facilities, social support, government policies, etc.) will be sufficient to support the use of small electric cars.
Attitude (AT)	Public Evaluation of Small Electric Vehicles	AT1	I think a small electric car is a good design.
		AT2	I think small electric cars can be trusted.
		AT3	In the future of small electric cars instead of traditional vehicles, I would support the.
Purchase Intention （PI）	The extent to which the public is ultimately willing to use small electric vehicles	PI1	When small electric cars are put on the market I want to use a small electric car.
		PI2	I would consider buying a small electric car.
		PI3	I would recommend that my friends and relatives buy and use a small electric car.

2.3 Structural equation model(SEM)

Structural equation modeling (SEM) is based on the covariance matrix of the variables, integrating path analysis and factorial analysis, integrating the measurement and analysis of latent variables, and consists of two parts: the measurement model and the structural model. Considering that many influencing factors affect the willingness to use small electric vehicles, and the mechanism of action between these factors cannot be directly measured, this paper chooses structural equation modeling as the mathematical analysis method.

3 Statistical Analysis

3.1 Data collection

The survey was conducted as a questionnaire in China. A total of 542 questionnaires were collected. It was determined that questionnaires with a response time of less than

50 and questionnaires that chose extreme values for multiple consecutive questions were invalid. After eliminating the invalid questionnaires, 458 valid questionnaires were finally obtained, with a validity rate of 84%. The survey respondents included members of the public with different demographic characteristics and from other cities and regions, and the sample was well-represented as a whole.

3.2 Reliability and validity tests

To ensure the stability and reliability of the questionnaire and the recovered data, the questionnaire was tested for reliability and validity using SPSS 24.0 and AMOS 24.0 before model fitting. Cronbach's alpha coefficient was used for the reliability test to analyze and test whether the observed variables were internally consistent for the latent variable measurements. As shown in Table 2, the Cronbach's alpha coefficients corresponding to each latent variable ranged from 0.761 to 0.856, which were higher than the critical value of 0.7, indicating that the observed variables corresponding to each latent variable had good internal consistency and that the questionnaire had good reliability. The Squared Multiple Correlations (SMC) value was used as the observation standard value, and the ideal SMC value should be greater than 0.5. The SMS value of each observed variable met the minimum value requirement, indicating that the measurement index had good reliability. The factor loadings of each observed variable obtained by fitting the structural equation model show that the factor loadings of each latent variable corresponding to the question items are all greater than 0.7, indicating that each latent variable related to the topic to which it belongs is highly representative.

Table 2. Results of Sample Reliability and Validity Tests

Latent Variable	Observed Variable	Cronbach'α	KMO	Factor Loads	Average	SMS
PU	PU1	0.832	0.802	0.791	58.572	0.577
	PU2			0.729		0.531
	PU3			0.787		0.620
	PU4			0.766		0.586
PEU	PEU1	0.856	0.825	0.802	59.769	0.644
	PEU2			0.750		0.563
	PEU3			0.791		0.625
	PEU4			0.745		0.554
EC	EC1	0.761	0.664	0.803	59.223	0.564
	EC2			0.851		0.724
	EC3			0.713		0.508
SN	SN1	0.825	0.717	0.805	60.447	0.648
	SN2			0.737		0.544
	SN3			0.805		0.649
PP	PP1	0.834	0.717	0.824	60.649	0.679
	PP2			0.763		0.582
	PP3			0.792		0.628
AT	AT1	0.796	0.705	0.732	60.794	0.536
	AT2			0.785		0.542
	AT3			0.788		0.574

	PI1			0.76		0.532
PI	PI2	0.837	0.724	0.79	61.749	0.579
	PI3			0.75		0.517

4 Results and discussion

The model fit test was conducted before hypothesis testing to ensure the quality of the research model. Model fit test (bootstrap 5000 times) was performed using AMOS 21.0. As shown in Table 3, the analysis found that $\chi 2$/df, which is lower than the critical value of 3, the CFI, GFI, and TLI values were 0.952, 0.921, and 0.928, respectively, higher than the critical value of 0.9. The RMSEA value was 0.042, lower than the critical value of 0.05, indicating that the research model is of good quality and the overall model reaches the desired level.

Table 3. Model fitness test results

Evaluation metrics	$\chi 2$/df	RMSEA	CFI	GFI	TLI
reference value	<3	<0.05	>0.90	>0.90	>0.90
fitted value	2.150	0.042	0.952	0.921	0.928

Based on structural equation modeling, the direct causal relationships between the seven variables of perceived usefulness, perceived ease of use, environmental awareness, policy perception, subjective norms, behavioral attitudes, and willingness to use and purchase were examined, and the standardized path coefficients between the latent variables are shown in Table 4. All hypotheses are valid except Hypothesis 3: Perceived ease of use has a positive effect on behavioral attitudes is not valid. Perceived ease of use has a significant positive impact on perceived usefulness ($\beta = 0.955$, $p < 0.001$); perceived usefulness has a significant positive impact on behavioral attitude ($\beta = 0.531$, $p < 0.001$); perceived usefulness has a significant positive impact on willingness to use ($\beta = 0.317$, $p < 0.001$); and behavioral attitude has a significant positive impact on willingness to use ($\beta = 0.766$, $p < 0.001$); environmental awareness has a significant positive impact on behavioral attitudes ($\beta = 0.195$, $p < 0.001$); policy perception has a significant positive impact on behavioral attitudes ($\beta = 0.695$, $p < 0.001$); and subjective norms have a significant positive impact on willingness to use ($\beta = 0.159$, $p < 0.001$)

Table 4. Model path coefficient estimation results

Pathway Relationship	Estimate	P-Value	Whether Valid
PEU→PU	0.955	***	Yes
PU→AT	0.531	***	Yes
PEU→AT	0.345	0.122	No
PU→PI	0.317	***	Yes
AT→PI	0.766	***	Yes
EC→AT	0.195	***	Yes
PP→AT	0.695	***	Yes
SN→PI	0.159	***	Yes

The results of the study show that:

(1) The more substantial the public's perceived usefulness and perceived ease of use of small electric vehicles, such as realizing that small cars can effectively meet the demand for travel, that their compact size and flexible operation can better improve driving behavior, and that the maintenance of small electric vehicles is more convenient and quicker, the public will have a positive behavioral attitude toward small electric vehicles, and then the stronger their willingness to purchase and use small electric vehicles;

(2) The environmental awareness of travelers has an essential impact on the choice of commuting mode because small electric vehicles have the technical characteristics of green and low energy consumption, so the introduction of environmental awareness improves the explanatory strength of the model. Environmental awareness affects the public's behavioral attitudes toward small electric vehicles, which affects purchasing behavior. This is consistent with the conclusion of previous related scholars who explored the environmental awareness of the use behavior of electric vehicles.

(3) In a collectivist society, consumers in China pay more attention to the suggestions and opinions of others when purchasing and using small electric vehicles; therefore, the publicity and attitudes of people around them, as well as the mass media towards small electric vehicles will change the residents' behavioral attitudes towards small electric vehicles. At the same time, positive policy perceptions will also improve the residents' behavioral attitudes toward small electric vehicles.

5 Conclusion

This study takes potential users of small electric vehicles as the research object, based on the technology acceptance model, combines the technical characteristics of small electric vehicles, and integrates public environmental awareness, subjective norms, and policy factors to study the residents' willingness to use. The study results show that the perceived usefulness, the perceived ease of use, the social norms, the environmental awareness, and the policy perception have a significant positive effect on the willingness to buy.

The use of small electric vehicles aligns with national conditions and has broad market prospects and excellent development potential. For the relevant government policy-making departments, the research in this paper can provide the following relevant suggestions:

First, it's necessary to raise public awareness of the negative impacts of traditional fuel vehicles. The government and electric vehicle enterprises can make people aware of the role of small electric vehicles in alleviating traffic congestion, air pollution, and energy consumption, and take the initiative to contribute to the reduction of air pollution and traffic congestion through the media, the Internet, and public service advertisements and other publicity media.

Second, relevant car companies should develop appropriate marketing strategies to stimulate dependent consumption. Studies have found that subjective norms help strengthen willingness to buy and use, and companies should promote relevance to

users who already have experience using cars and optimize product design to meet consumers' individual needs.

Third, the government administration should improve the infrastructure construction. Since perceived usefulness and ease of use will positively impact the attitude towards the use of small electric vehicles, it is necessary to improve the related infrastructure construction, including charging network and right-of-way protection, while enhancing the publicity and promotion of small electric vehicles.

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