https://doi.org/10.48047/AFJBS.6.8.2024.3097-3099

African Journal of Biological Sciences

Research Paper Open Access

Identifying Factors influencing willingness to pay for EV in Kunming city, China.

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9 Article Info Volume 6, Issue 8, 2024 Received: 12 Apr 2024 Accepted: 28 May 2024 Doi:10.48047/AFJBS.6.8.2024.3097-3099

***Abstract*—** To reduce energy consumption and environmental pollution, the Chinese government is strongly promoting the use of electric vehicles (EVs). Kunming, as one of the most promising cities for EV development in China, plays an important leading role in the promotion of EVs. Based on the Theory of Planned Behaviour (TPB), this study aims to identify the factors that influence the willingness to pay (WTP) for EVs for Chinese citizens. These factors include consumers' environmental awareness, consumers' technological awareness, attitudes, subjective norms. This study employs the questionnaire method to survey 400 consumers in Kunming. Understanding the factors that influence consumers' willingness to purchase electric vehicles can inform policymakers on effective strategies to encourage the adoption of EVs in Kunming, with potential economic and social benefits.

Index Terms—Energy Vehicles; Sustainable Development; Willingness to Pay

I. INTRODUCTION

Transport, as a significant source of carbon dioxide (CO2) emissions, has attracted worldwide attention for environmental protection. According to the International Energy Agency (2022), the transport sector accounts for 23 per cent of total global CO2 emissions. China is the world's largest industrialised country with the highest carbon emissions. in 2022, the transport sector accounted for only 10.4% of total CO2 emissions [7].

Electric vehicles (EVs) are increasingly seen as a promising alternative to conventional vehicles (CVs) due to their potential benefits to the global and local environment and energy systems [8]. EVs can reduce greenhouse gas (GHG) emissions, improve local air quality [4], and are more efficient in terms of energy consumption per mile travelled [6].

China has recognized that the adoption of electric vehicles is an effective way to reduce harmful greenhouse gas emissions. In order to achieve the goals of carbon capping by 2030 and carbon neutrality by 2060, China has made significant progress in the supply of electric vehicles in recent years. In recent years, China has introduced a series of relevant policies in the field of EV supply, such as the EV double points policy and EV purchase subsidies. This has strongly promoted the adoption of electric vehicles.[8] Given the rapid growth of private car ownership, there is no doubt that transport will soon become one of the major factors affecting the country's energy security and greenhouse gas emissions.

EVs are not only a green and environmentally friendly means of transportation, but also crucial to national energy security, so the Chinese government has been vigorously introducing and promoting electric vehicles [9]. on January 24, 2009, the central government of China launched the "Thousand Vehicles in Ten Cities Program" to stimulate the popularity of electric vehicles, including Kunming. stimulate the popularization of electric vehicles, including Kunming. Green energy industry has become the first pillar industry in Yunnan Province, and Yunnan Province as the center of the construction of new energy automobile industry for ASEAN's international development of the agglomeration area, the capital city of Kunming's geographic location, high altitude and abundant light, Kunming around the rich non-ferrous metal minerals. Kunming has abundant non-ferrous metal minerals around it, which provides a great competitive advantage for new energy battery and new energy automobile industries.

II. CURRENT SITUATION OF KUNMING

By 2022, China has 97,000 electric vehicles, a 94.4% increase from 2021. This number is expected to exceed 110,000 vehicles by 2023 [1]. Actively promoting the application of electric vehicles, 100% of the new and replaced

cruising taxis, network reservation taxis, and city buses in Kunming's five main urban areas use electric vehicles.

The Kunming government has taken positive actions to promote the development of electric vehicles in the field of urban transport. Carbon oxides have long been a major source of CO2 emissions in Yunnan. For this reason, Kunming has introduced a subsidy policy for electric vehicles to promote the development of electric vehicles. For example, the government will provide a certain amount of subsidy, which is determined based on a combination of factors such as the vehicle's displacement and the type of energy used, with a maximum subsidy of up to RMB 8,000. This will encourage more consumers to buy electric vehicles and increase their willingness to consume.

At present, Kunming has not imposed any restrictions on electric vehicles as they can reduce pollution and meet the goal of environmental protection. Kunming City has seized the major opportunities for the promotion and application of electric vehicles and industrial development, actively created a development environment, done a good job in the top-level design of the electric vehicle industry, improved the park's supporting facilities, and promoted the rapid development of the electric vehicle industry.

III. Research Method

This study investigated the factors influencing electric vehicle purchasing behavior. We used the data from the questionnaire in Kunming, a second-tier city in China, as an illustrative example. The study utilized the "Wenjuanxing" application to conduct the survey and collect the data.

It is important to note that the Yamane Taro formula employed to calculate the sample sizes of those who own new energy vehicles and those who do not, respectively.

$$n = \frac{N}{1 + N(e^2)}$$

Where, n: sample size
N: population of Kunming (Yunnan Provincial People's Government, 2021)
e: allowable error (%)
Therefore, the sample size is 400.

IV. Results and Discussion

The data was collected by using the online questionnaire from website (www.wjx.cn) and sample size was calculated by Taro Yamane. A total of 401 valid questionnaires were gathered and examined using reliability analysis and validity analysis.

4.1 Socio-demographic profile

The socio-demographic profile of the Kunming respondents in this study is shown in Table 1. Of the 400 respondents in this study, 50.37% (n = 202) were female and 49.63% (n = 199) were male. The respondents lived in Xishan District (24.69%), and in Wuhua District (22.94%), Panlong District (17.71%), Guandu District (19.2%), and Chenggong District (15.46%). Most respondents were between 20-25 years old (30.42%), followed by 26-30 years old (27.68%) and 31-35 years old (20.7%). Nearly half of the respondents had a bachelor's degree (44.64%), while some of the respondents have high school and below and specialized degrees (38.4%) and master's degrees (10.72%). The range of acceptable new energy vehicles for most respondents is CNY 150,000-250,000 (32.67%), and nearly a quarter of respondents accept CNY 50,000-150,000 (24.5%).

Table 1 Socio-demographic profile

Category	Item	Frequency	%
Sex	Female	199	49.63
	Male	202	50.37
Age	20-25	122	30.42
	26-30	111	27.68
	31-35	83	20.7
Education	High school	154	38.4
	bachelor	179	44.64
	Master	43	10.72
Scope of purchasing new energy vehicles (CNY)	150,000-250,000	131	32.67
	150,000-250,000	180	44.89

4.2 Measurement model analysis

The study investigates the factors that influence Kunming's willingness to pay for electric vehicles. Therefore, we utilise reliability to assess the validity of the sample data and confirm its accuracy. When unified methods measure the same method in empirical research, the results obtained each time are consistent and credible. Table 2 reveals that the factor coefficient exceeds 0.7, suggesting a high level of reliability and quality in the research data. Therefore, the potential variable has internal consistency. We determine the convergence validity and evaluate the structural validity of the model. The range of AVE values for each thought is between 0.658 and 0.76, a recommendation value [4] higher than 0.5 (50%). Therefore, all the thoughts have sufficient convergence efficiency.

Table 4.2 construct reliability and validity

Item	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Environmental awareness (EA)	0.828	0.885	0.659
EV Technology Awareness (EVTA)	0.831	0.887	0.663
Subject Norms (SN)	0.767	0.864	0.76
Willingness to pay for EVs (WPE)	0.782	0.873	0.697

We assessed the discriminant validity of the constructs using the Fornell & Larcker criterion and the heterogeneous trait-to-monotropic trait (HTMT) ratio. Table 3 shows the

Fornell-Larcker criterion, which says that the square root AVE value of each construct should be higher than the correlations with other constructs, both across and down [2]. The square root AVE values of all constructs demonstrated adequate discriminant validity [3]. The HTMT ratio (Table 4) had a threshold of 0.9, indicating that the discriminant validity of the model was adequate. The constructs in the model had HTMT values that were below the threshold, establishing the model's discriminant validity.

Table 3 Fornell & Larcker criterion

Item	EA	FC	PI	SN	WTP
EA	0.812				
FC	0.493	0.813			
PI	0.464	0.499	0.871		
SN	0.532	0.556	0.55	0.872	
WTP	0.433	0.601	0.634	0.597	0.835

Table 4 Heterotrait-monotrait ratio

	EA	FC	PI	SN	WPE
EA					
FC	0.594				
PI	0.618	0.661			
SN	0.707	0.732	0.801		
WPE	0.534	0.745	0.865	0.812	

4.3 Hypothesis test

We performed path analysis using the bootstrapping method in SmartPLS 4.0 with 5,000 subsamples and 5% significance for hypothesis testing. The results are shown in Table 5, indicating that EA ($\beta = 0.406$, $p < 0.05$), FC ($\beta = 0.483$, $p < 0.05$), SN ($\beta = 0.431$, $p < 0.05$) and PI ($\beta = 0.853$, $p < 0.05$) have a significant effect on SN. Therefore, all hypotheses were supported. Figure 1 shows a graphical display of the path analysis.

Table 5 Hypothesis testing

Hypothesis	Path Correlation	Coefficient (β)	P-value (sig.)	Result
H_1	EA→SN	0.406	0.000	Supported
H_2	FC→SN	0.483	0.000	Supported
H_3	SN→PI	0.431	0.000	Supported
H_4	PI→WTP	0.853	0.000	Supported

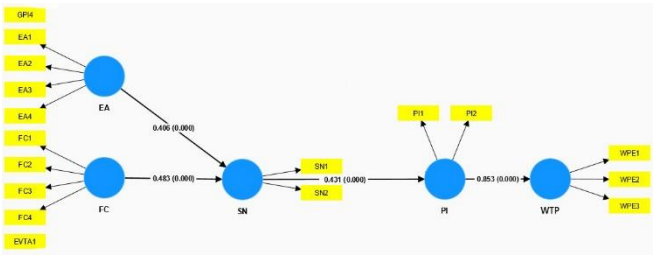

Figure 1 Path analysis of the research model

CONCLUSION

This study aimed to investigate the factors influencing the willingness to pay for electric vehicles in Kunming. A questionnaire was distributed online, resulting in 401 valid responses. The reliability and validity of the responses were analysed, and it was determined that the results were reliable. Additionally, the observations from this study indicated that three variables, consumer attitude (A), subjective norms (SN), and perceived behavioural control (PBC), positively and significantly influenced the WTP of electric vehicles. This study identified the importance of five factors influencing the purchase of new energy electric vehicles: policy incentives (PI), environmental awareness (EA), face consumption (FC), EV technology awareness (EVTA), and brand loyalty (BL). The results indicate that these factors influence the consumption of new energy vehicles in Kunming in a positive trend, suggesting that the exploration of the factors influencing new energy vehicles in Kunming is relatively successful.

The findings of the research allow for the formulation of several policy recommendations with the objective of enhancing the purchase intention of electric vehicles in China and promoting the development of this technology. Firstly, it is recommended that the Chinese government and enterprises prioritize the improvement of infrastructure for fast charging and the enhancement of vehicle safety. Secondly, it is proposed that the government and enterprises collaborate to enhance consumer awareness of electric vehicles. Furthermore, the government should encourage automotive manufacturers to enhance their brand reputation, for instance, by improving the safety and performance of their vehicles, in order to stimulate consumer spending.

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