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Article

Analysis of the Barriers to Wide Spread Adoption of Electric Vehicles in Shenzhen China

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Abstract: China planned to promote the large scale adoption of Electric Vehicles (EVs) in the thirteenth five year plans, however, this target faces numerous obstacles. This paper was trying to analyze the main barriers to wide spread adoption of EVs through a survey in Shenzhen, which has the biggest EVs market share in China major cities. On the basis of previous scholarly findings, a new survey was conducted and 406 approved questionnaires were collected among 500 participants. Five hypotheses were established to examine the main barriers to wide spread adoption of EVs. The analysis conducted by statistical methods: two-way frequency contingency tables, chi-square test and factor analysis. The study observed that the perception of EVs advantages and recharging access remained the main barriers of EVs large scale penetration, in addition, the new finding was that financial incentives cancellation would not result in big drop of EVs adoption in future. The study proposed suggestions to car maker and government policy administrator upon the analysis and discussion.

keyword: EVs; PHEVs; Penetration; Adoption; Barriers; Preference; Willingness; Attitude

1. Introduction

EVs can be categorized as four types according to their fuel technologies: plug in hybrid electric vehicles (PHEVs), extended-range battery electric vehicles (E-REVs), battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs)[1]. Additionally, traditional internal combustion engine vehicles, hereafter that will be abbreviated as ICEVs.

EVs have been proposed as a good solution for the problem of transportation GHG(greenhouse gas) and air pollutant emissions[2]. Most of the developed countries have been implementing variety public policies and financial incentives for EVs large scale adoption[11]. In the existing literatures, numerous researchers focus on the topics of consumers' choice decision, recharging station deployment and economic analysis of EVs promotion[2-10].

Despite there is a broad consensus on EVs large scale adoption in the world, however, the benefits and realize ultimately falls on the consumers' willingness to accept the new technology[2]. According to a survey conducted in 2008, 69%of US consumers have little or no familiarity with PHEVs technology[3]. A later research also indicates that people could not accept premiums for EVs Adoption[4]. In order to fully understand the consumer's choice behavior, another survey research conducted in the major United States(U.S.) large cities, which examined consumer's willingness and attitudes toward plug-in electric vehicles[5]. The result reveals that the overall willingness ratio to purchase or lease electric vehicles is low, however, the interest in PHEVs technology is somewhat

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greater related technology status and public perceptions[5]. Furthermore, range anxiety also be considered as a barrier to EVs spread adoption[2-10], several researchers implies that people with less willingness to choose EVs because of range anxiety and inconvenient recharging access[2-10].

Many of existing literature analyzed consumer's perception, willingness and attitude toward EVs[1,6-10], even some other society or psychology factors influencing on EVs spread adoption was also studied[7]. Furthermore, previous study also indicates that EVs spread adoption influenced by public policies, financial incentives and energy price as well[9,11]. In addition, lots of previous studies were aim to investigate consumers' pro-environmental lifestyle,technology oriented lifestyle and openness to change[6,7], Another survey research was conducted to investigate consumers' environment awareness, technology perceptions, experiences and interests on EVs[7,8,10]. As we know, China is the second biggest market for car makers in the world, however, no much studies on the behavior of Chinese consumers for electric vehicles. This study will be as a complementary of previous research according to a new survey in Shenzhen of China.

China has become as the largest vehicle producer and the second largest consumption market of passenger vehicles in the world since 2009. The demographic data published by the government shows that EVs market share of China has exceeded the United States, the production and sales data can be reviewed from website news on august thirteenth, 2015(http://www.chinadaily.com.cn/business/motoring/2015-08/13/content_21585953.htm). Meanwhile, Shenzhen is well recognized as the most innovative city and EVs operation demonstration city in China, which has significant contribution in innovation and the openness for global market. Thereby, it is valuable to study EVs adoption status and consumers purchasing behavior on EVs in Shenzhen. However, previous scholarly findings shows that there are dramatically differences exist in decision-making and value orientation between Western people and Chinese[12], some other research findings indicates that Netherlands consumers pay high attention to value and safety[13], the French favor design, style and fashion in car advertisement[13], German and Italian consumers have similar characteristic with French, they prefer fast, advanced technology and stylish and multi-function cars[13]. In contrast, American consumers consider cars as a symbol of status and pursue big and powerful vehicles[13]. How about Chinese consumptions behavior toward EVs? This study made a survey among Shenzen residents, the major contribution of which is that the participants have at least three to ten years of driving experiences and they are fully aware of vehicle and urban transportation conditions. Additionally, at least one third of respondent have EVs driving experience. The survey will focus on the participant's preference for EVs, willingness and attitudes toward EVs.

The remainder of this paper is organized as below: Section 2 describes material and methods; section 3 states data quality controls; section 4 presents the main results of this survey and make some discussion on it; section 5 is conclusions of this paper.

2. Material and Methods

This paper was aim to study Chinese EVs consumer consumption behaviors through a questionnaire survey in Shenzhen. The other purpose was to develop procedures for investigating five hypotheses based on literature review, then collected and analyzed data to confirm them:

hypotheses # 1: The participants showed more preference for EVs with local brand and elegant style.

hypotheses# 2: The participants attitude toward EVs fully depends on the perception to EVs technology advantages comparing with ICEVs.

hypotheses# 3: The participants purchasing willingness depends on EVs recharging access and EVs technology advantages.

hypotheses# 4: EVs high price was key barrier to influence the participants' purchasing willingness.

hypotheses# 5: Consumers' purchasing willingness would drop significantly when financial subsides be canceled.

To examine these hypotheses, the survey conducted among residents in Shenzhen which is committed to develop low carbon economy including EVs, PHEVs and solar energy application.

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Shenzhen owns BYD-an EVs leader producer in China which have full direction solutions of EVs for GHGs reduction, including EVs passenger car, electric bus and electrical engineering vehicles such as BYD-E-Bus K9, Van T5 and special truck T7. Meanwhile, total operation miles of EVs and E-Bus in Shenzhen already achieved 150 million kilometers[15]. There were at least one thousand EVs taxis and three thousands E-Buses were put into operation in Shenzhen during the past three years[15]. Thereby Shenzhen residents have less distance to close EVs. Although Shenzhen owns a population of 1,178,900, the registered population was only3,549,900 from Shenzhen government published data, all others residents come from different provinces almost covering whole China. Consequently, the study chooses Shenzhen residents as a research topic which was good representatives of the general situation in stead of a special case.

The study collected survey data among Shenzhen residents including EVs experienced drivers, PHEVs consumers or residents who were familiar with EVs or PHEVs. The survey target group was setup and the questionnaires and website address were delivered to participants in the group. Receivers were asked to accomplish the questionnaire and feedback automatically, then they can obtain the bonus from researcher. 500 questionnaires were delivered to the participants and 406 approved results were collected in the end.

Basic statistics methods were applied to analyze the survey results and present the variable's distribution deviation. Two-way frequency contingency tables were generated by IBM statistical product and service solutions (SPSS) then the chi-square and fisher test were applied to investigate the differences between factors and consumers willingness.

In the chi-square test and fisher-test, the study used standard 5 percent or 0.05 cut-off for defining what was a statistically significant difference. Therefore, an associated p-value less than 0.05 showed that there was significant evidence of an association between variables[7]. Fisher test was employed because some items' sample size was small so that some associations between factors were not accurate.

Additionally, the study also conducted the factor analysis to investigate the relationship between factors and dependent variables by IBM SPSS software[8].The following sections presented the survey and statistics result based on these methods.

3. Data and Control

In order to ensure the survey data reflect the actual situation of Shenzhen, participants who did not finished all of the survey questions were removed. Additionally, we abandoned the survey questionnaires which were completed within 3 minutes, only four participants were removed according to the time requirement. The survey was composed of 52 questions which were ordinary multi-choice style(e.g., not at all, a little, somewhat, a lot). In order to do statistical analysis specifically, the questionnaire answer options were given different scores depending on the degree, option "not at all" can obtain 1 point, "a little " can obtain 2 points, "somewhat" can obtain 3 points and "a lot" can obtain 4 points, thus all the answers obtained the specific scores. Factor analysis and regression analysis were conducted based on the score data. Preliminary testing indicated that the survey need at least 10 minutes with the fastest speed to complete, all survey results showed that the mean value of individual time spent in the survey is 17 minutes. The maximum is 33 minutes and the minimum is 2 minutes.

The survey were categorized into four sections:

I.**Basic Information**: age, gender, income, education, occupation, driving experiences, home ownership and travel pattern.

II. Preference for EVs: EVs characteristics pursued by consumers.

III. Purchasing willingness and attitude toward EVs: present consumer's real willingness and attitude toward EVs

IV. Public policy and financial incentives: present the main public policy and financial incentives established in China currently.

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4. results

4.1. Sample Description and Basic information

In terms of the research target, it aimed to investigate the consumers' purchasing willingness, attitudes toward EVs from Shenzhen residents, and to reveal the main barriers to wide spread adoption of EVs in China. Moreover, the study results could be used as a reference for some other cities of China in public policy making, adjustment and optimization for EVs large scale penetration in future.

Although all of the respondents were Shenzhen residents, most of whom come from different provinces in China, thereby it had good representativeness of Chinese consumer characteristic. 406 valid questionnaires were collected in the survey, males respondents accounted for 76.4% of the whole population(n=310), 23.6% of participants were females(n=96). Respondents were mainly concentrated between 22 to 35 years old, which accounted for 53.4% of the whole population, over 35 years old group ranked second position and accounted for 45.5%, only 5 participants less than 22 years old. In terms of the occupation of the participants, most of them were office workers who were regarded as more aspire to new technology and the main force of EVs adoption in future, the proportion occupied 40.4% of the total participants. Private firms owners ranked second, the Senior managers group following behind, in addition, there are 9.4% participants were research and design engineers, the remaining were students in university. The entire sample population represents EVs potential consumers. The demographic distribution was shown in table 1

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Table 1. Sample Description

Gender	**Male**	76.40%
	Female	23.60%
Age	**18-22 Years old**	1.20%
	22-35 Years old	53.40%
	Over 35 Years old	45.30%
Occupation	**Office worker**	40.40%
	Senior Manager	21.20%
	Private Firm Owner	24.40%
	University Student	4.70%
	Research &Design Engineer	9.40%
Drive Experience	**Less than 3 years**	31.50%
	Between 3-5 years	15.00%
	Between 5-8years	19.70%
	Over 8 years	33.70%
Annual Income	**Less than $8000**	18.00%
	$8000-15000	33.50%
	$15000-50000	35.70%
	Over $50000	12.80%
Home Ownership	**Owned Apartment**	54.20%
	Rent Room	30.80%
	Dormitory	11.30%
	Others	3.70%
Travel Pattern	**Owned Private Car**	55.70%
	Company Scheduled Bus	6.20%
	Public Bus or Metro	26.60%
	Others	11.60%

Additionally, the survey also investigated the respondents' driving experiences, annual income level, home ownership and trip mode options, most of participants owned vehicles and apartments, more than 50% respondents annual income were situated at middle even middle high level in China, one third of participants had driving experiences with EVs or PHEVs.

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4.2. The Preference for EVs

Overall, according to the basic statistical analysis with figure 1, the majority of surveyed respondents were apt to adopt Chinese brand EVs, the proportion occupied 59.3%(n=242), 17.9%(n=73) respondents preferred to Germany brand EVs, the following was 15.9%(n=65) of participants who aspired to US brand EVs and the last was 6.9%(n=28) of participants who chose Japan brand. Moreover, Fisher's test results (p-value=0.007) also revealed that there were considerable differences between gender and consumers' preference for EVs brand. Males expressed more interest in China EVs brand while females implied more preferable to Germany EVs brand. The further analysis presented that occupation also had an impact on consumers' preference, Fisher's test (p-value=0.004) revealed that 68.3% office worker group were more likely consider about Chinese brand, 65.8% Research and Design(R&D) participants selected Chinese EVs brand, private firm owner group and high level management group had similar preference for EVs brand, the proportion accounted for 57.6% and 47.6% respectively. In terms of vehicles style, males showed more prefer to sport utility vehicle(SUV) PHEVs than females, females implied more interest in hatchback car than males.

Table 2. Fisher Test Between Factors and Brand Preference

Factors	Pearson Chi-Square Sig.	Fisher's Exact Test Sig.
Occupation	0.004	0.004
Gender	0.013	0.007

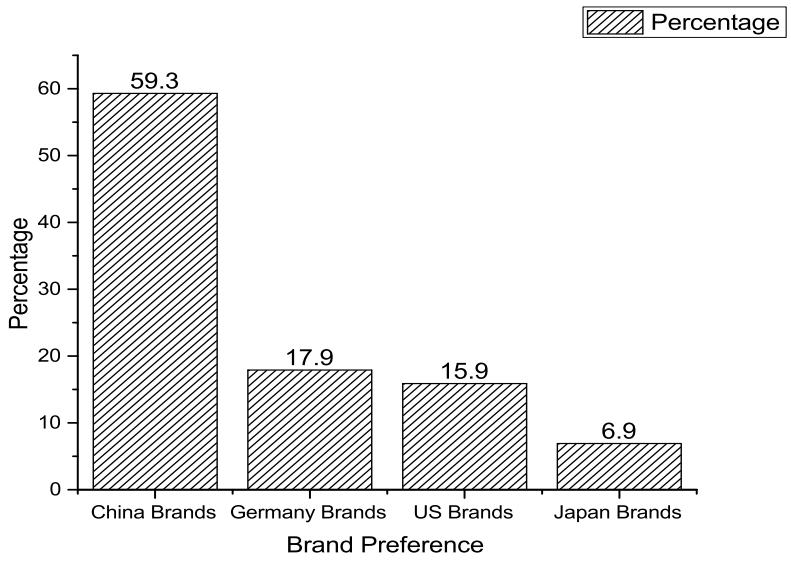

Figure 1. Brand Preference Analysis Demographic

55.7% of the participants had private cars, 68.4% (n=279) surveyed respondents had EVs driving experiences, the fishers' tests (p-value=0.029) showed little differences between gender and EVs experience, males indicated more EVs experiences than females. Furthermore, no significant differences between driving experience and factors such as age (p-value=0.654), income level (p-value=0.318), occupation (p-value=0.135), home ownership (p-value=0.214) and region (p-value=0.463). However, significant differences existed between driving experience and EVs closing experience (p-value=0.006).

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Table 3. Fisher Test Between Variables and EVs Driving Experiences

Factors	Pearson Chi-Square Sig.	Fisher's Exact Test Sig.
Gender	0.039	0.029
EVs closing Experience	0.008	0.006
Age	0.582	0.643
Income level	0.321	0.317
Occupation	0.132	0.135
Home Ownership	0.224	0.214
Origion	0.07	0.07

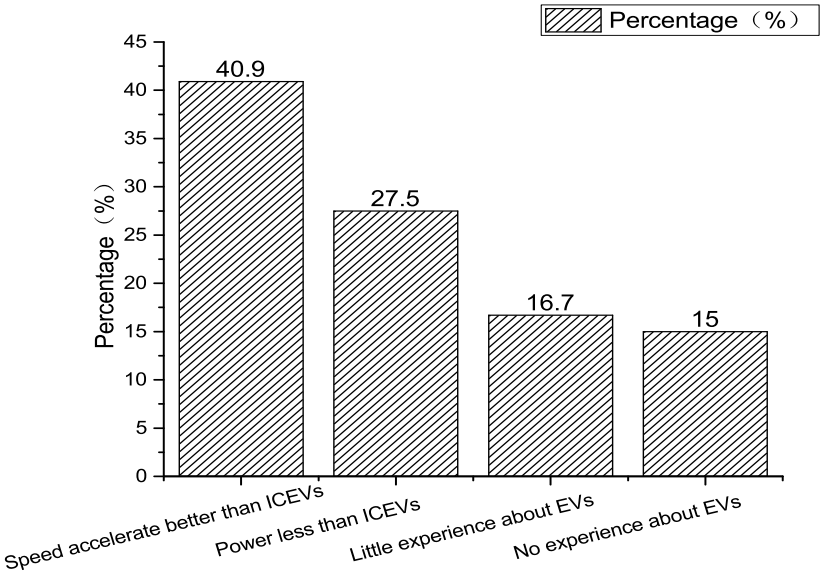

Figure 2. EVs Driving Experiences

Additionally, the study conducted the factor analysis to retain the main factors which dominate the preference for EVs, the factor analysis results showed by table 4, table 5, figure 3 and table 6. The common factors were extracted by rotated components matrix in table 6 with IBM statistical product and service solutions(SPSS). Retained common factors were filtered by the loading absolute value greater than 0.5 and the common factors were renamed as below:

I.**Perception of environment protection and energy safety**: They highly aspire to protect living environment conditions and contributed to environmental improvement continuously.

II.**EVs potential demand**: Potential demand of consumers for EVs

III.**EVs Operation cost**: Consumer's travel cost monthly.

IV.**EVs Characteristics**: low operation cost, zero tail pipe emissions, symbol of status etc..

V.**Daily travel mileage**: Consumer's travel mileage every day.

Moreover, in order to examine the relationship between consumers preference and common factors specifically, the study conducted a regression analysis by SPSS based on the common factors. The regression residual distribution test was presented as figure 4, which implied that the regression equation was valid.

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Table 4. Factor Analysis Test of EVs Purchasing Preference

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.684
Bartlett's Test of Sphericity	Approx. Chi-Square	578.781
	df	105
	Sig.	.000

Table 5. Total Variance of Principal Components

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.589	17.262	17.262	2.589	17.262	17.262	1.912	12.748	12.748
2	1.580	10.533	27.795	1.580	10.533	27.795	1.677	11.183	23.930
3	1.292	8.611	36.406	1.292	8.611	36.406	1.439	9.593	33.523
4	1.119	7.463	43.869	1.119	7.463	43.869	1.384	9.228	42.751
5	1.020	6.803	50.672	1.020	6.803	50.672	1.188	7.921	50.672
6	.967	6.447	57.119						
7	.881	5.874	62.993						
8	.862	5.747	68.739						
9	.851	5.675	74.414						
10	.823	5.490	79.904						
11	.745	4.967	84.870						
12	.657	4.379	89.250						
13	.601	4.008	93.258						
14	.537	3.581	96.839						
15	.474	3.161	100.000						

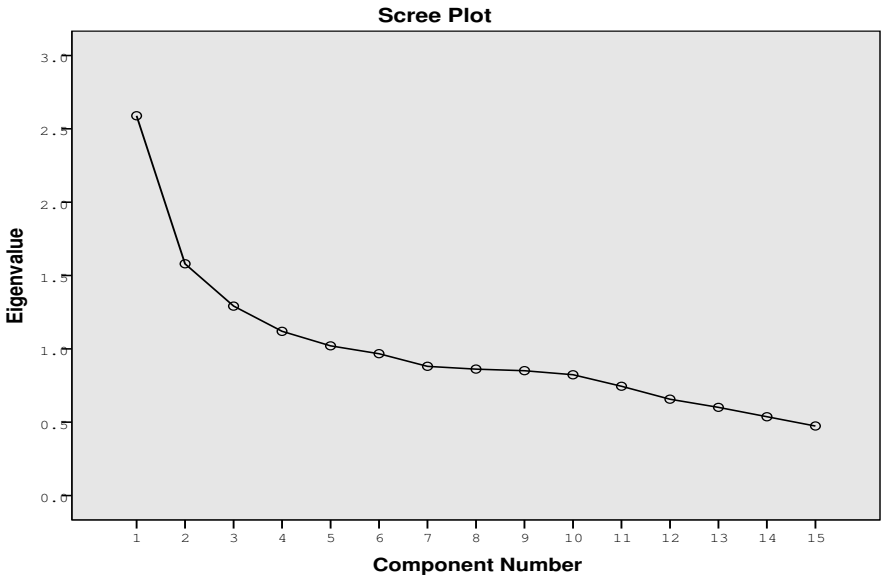

Figure 3. Scree Plot of Principal Analysis

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Table 6. Rotated Components Matrix

	Component				
	1	2	3	4	5
Q9	.534	.006	.122	.037	.379
Q10	-.127	.398	.047	.467	.100
Q11	.169	.179	.555	-.155	.287
Q12	.053	-.082	-.612	.228	.416
Q13	.022	.020	.083	.017	-.790
Q14	.003	-.058	.720	.210	-.091
Q15	-.154	-.192	-.119	.610	.073
Q16	.703	.119	.030	-.027	-.021
Q17	.751	.106	.063	.041	-.032
Q18	.294	.579	.103	.082	.232
Q19	.536	.240	-.104	-.016	-.038
Q20	.139	.151	.201	.594	-.011
Q21	.137	.661	-.078	-.142	-.167
Q22	.162	.748	.118	.090	-.025
Q23	.244	-.039	-.335	.531	-.237

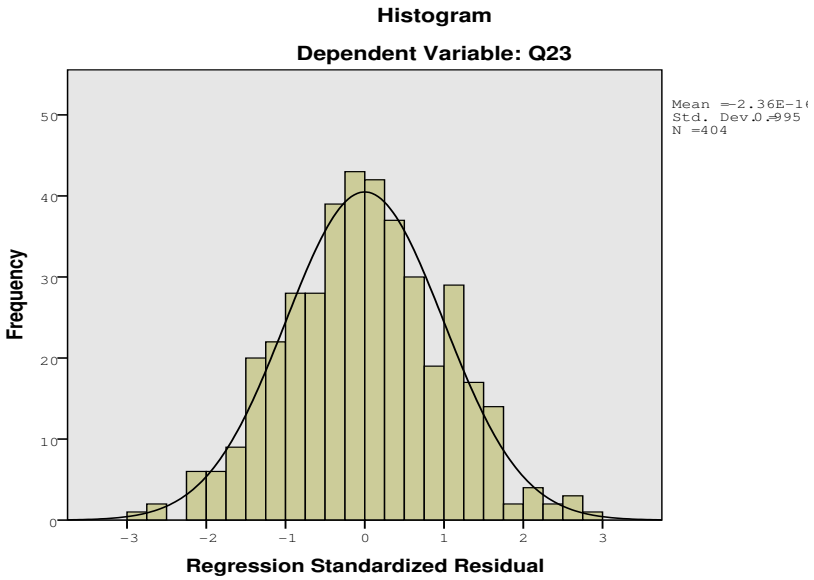

Figure 4. Regression Residual Distribution

Table 7. Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.364	.030		77.536	.000		
factor 1	.212	.031	.244	6.958	.000	1.000	1.000
factor 3	-.291	.031	-.335	-9.549	.000	1.000	1.000
factor 4	.462	.031	.531	15.147	.000	1.000	1.000
factor 5	-.206	.031	-.237	-6.752	.000	1.000	1.000

The linear regression equation operated by SPSS software, in which the consumer's preference for EVs was regarded as the dependent variables, the common factors score as the independent variables, thus the output showed by table 7, and it was explained by equation:

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Preferences =2.364+0.212× Perception of environment protection and energy safety−0.291× operation cost+0.462× EVs potential demand+0.061× travel mileage.

4.3. Consumers Purchasing Willingness and Attitude

In terms of purchasing willingness to EVs, on one hand, the study investigated the first-time car buyers decision, which indicated that 41.7% (n=170) respondents were willing to buy EVs if recharging access be available, 36% (n=147) participants expressed strong interests in EVs because of its performance and economic operation cost. On the other hand, it examined the non first-time car buyers' willingness to EVs, the result revealed that 54.9% (n=224) respondents had more willingness than their decisions at first time, 31.6% (n=129) respondents would to buy EVs as complementary of traditional fuel car, the total proportion accounted for 86.5% (n=353), there was 8.8% (n=129) increment comparing with first-time car buyers' response. However, further analysis showed that there were significant differences between occupation (p-value=0.025), income level (p-value=0.021) and purchasing willingness. It was found that the office worker group showed more willingness to buy EVs than others. Moreover, middle income level respondents implied more willingness as well. Once respondents have private car or driving experiences, they showed greater probability to buy EVs than other participants.

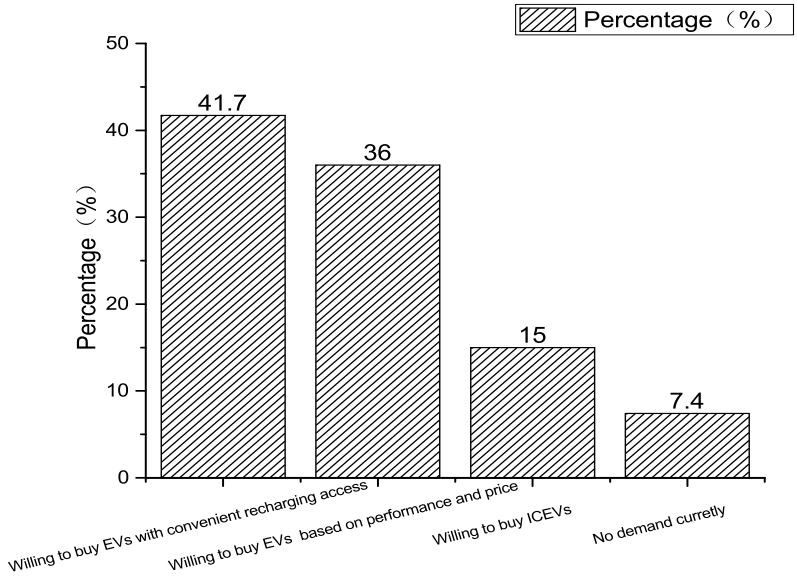

Figure 5. Willingness of The First time Car Buyer

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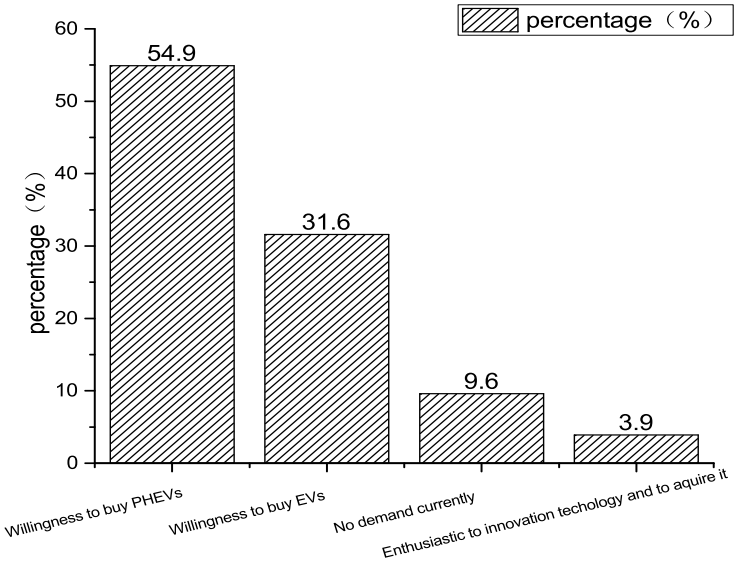

Figure 6. Willingness of The Second time Car Buyer

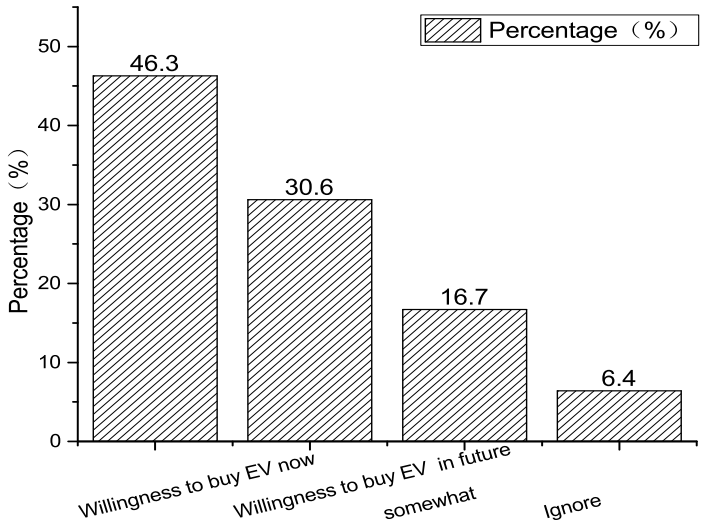

Figure 7. Willingness to buy EVs considering national energy safety

In addition, the respondents willingness would be influenced by social circle and public policy and energy safety tactical based on the study, the data analysis showed that 29.9%(n=122) respondents' willingness changed with respect to friend group members' opinion, 27.9% participants willingness changed due to family member's decision. To our surprising that, 46.3% (n=189) surveyed participants expressed strong willingness to buy EVs to support national energy crisis immediately, 30.6%(n=125) respondents would to buy EVs considering national energy safety in future. Furthermore 16.7%(n=68) participants showed somewhat aspire to buy EVs considering energy safety, consequently that the total willingness increased to 93.6%(n=382) under continuously appealing to the national energy safety and crisis.

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Table 8. Association Test for Willingness to Buy EVs

Factors	Pearson Chi-Square Sig.	Fisher's Exact Test Sig.
Occupation	0.043	0.025
Income level	0.014	0.025
Society network members	0	0.001
ICVs technology improve	0	0
Attitude toward Evs	0.001	0.001

Considering that ICEVs fuel saving technology improvement or fuel price decrease in future, the participants still had strong willingness to buy EVs significantly, the proportion occupied 75.8% and 80.7% respectively, which was showed in figure 8. If the fuel price rises, the intention to buy EVs would rise more significantly.

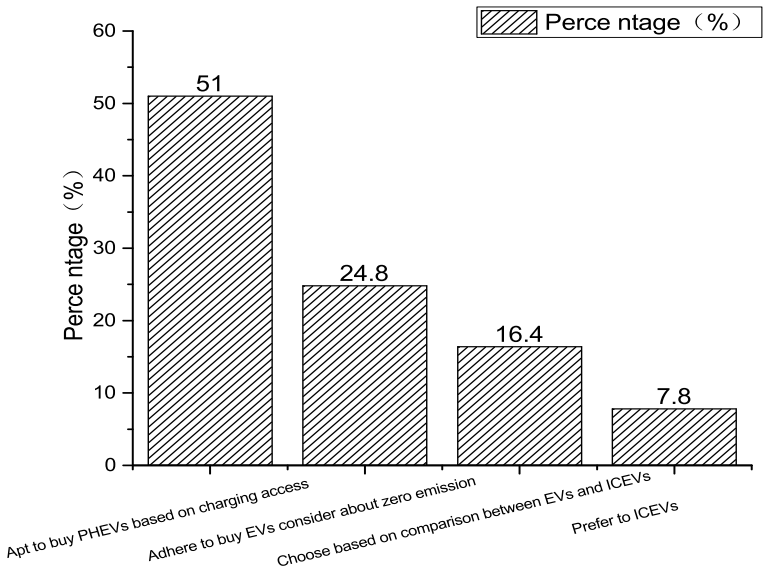

Figure 8. Purchasing Willingness Based on ICEVs Technology Improvement

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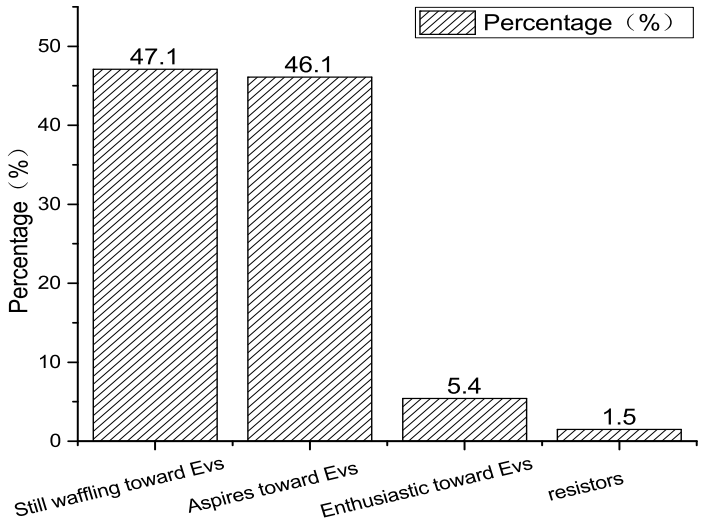

Figure 9. The Participants attitudes toward EVs

Despite people considered that EVs would be a good option for environmental protection and energy safety, their attitudes toward EVs were crucial to EVs large scale penetration in the market. It implied by figure 9 that 47.1%(n=192) participants kept undecided toward EVs, 46.1%(n=188) surveyed respondents showed good aspires toward EVs, 5.4%(n=22) respondents were enthusiastic to EVs, Only 1.5% participants were against EVs. Moreover, Fishers'tests showed by table 8 (p=value=0.001) also presented significant differences between participants attitudes and willingness to buy EVs, the more positive attitudes toward EVs, the stronger willingness to buy EVs.

In terms of the insights of EVs large scale penetration in China market, it was presented by figure 10 which indicated that most of the participants (46.8%) held optimistic about the prospective even the technology still scarce in China, 38.2% respondents believed that EVs would be mainstream products in future.

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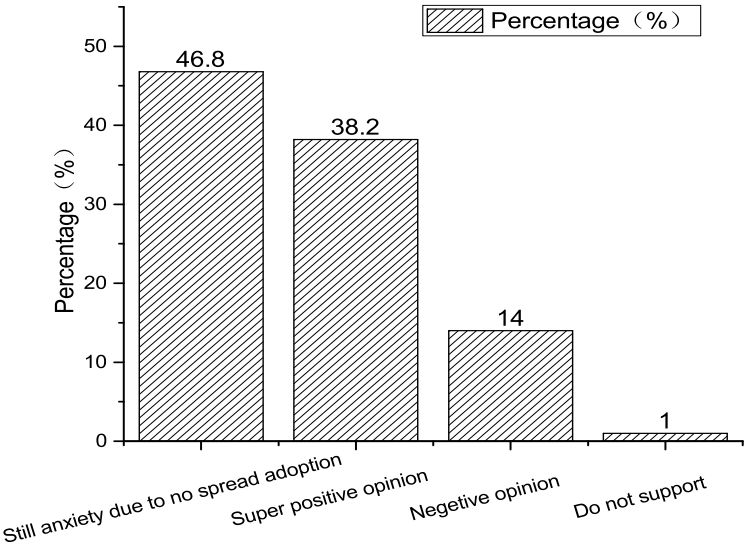

Figure 10. The Participants insights of spread adoption of EVs in future

Additionally, the factor analysis was conducted to investigate the key variables in this section. The common factors were extracted by SPSS, the execution procedure was same with the last section, the output results showed as below:

Table 9. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.771
Bartlett's Test of Sphericity	Approx. Chi-Square	1420.388
	df	153
	Sig.	.000

Table 10. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.834	21.297	21.297	3.834	21.297	21.297	2.603	14.463	14.463
2	1.863	10.348	31.645	1.863	10.348	31.645	2.054	11.410	25.873
3	1.498	8.323	39.968	1.498	8.323	39.968	1.813	10.071	35.944
4	1.089	6.048	46.016	1.089	6.048	46.016	1.543	8.575	44.519
5	1.035	5.749	51.765	1.035	5.749	51.765	1.304	7.246	51.765
6	.999	5.550	57.315						
7	.948	5.269	62.585						
8	.851	4.728	67.312						
9	.810	4.502	71.814						
10	.742	4.122	75.937						
11	.691	3.839	79.776						
12	.660	3.668	83.444						
13	.647	3.596	87.040						
14	.588	3.268	90.308						
15	.549	3.052	93.360						
16	.530	2.943	96.303						
17	.449	2.492	98.795						
18	.217	1.205	100.000						

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Table 11. Rotated Component Matrixa

	Component				
	1	2	3	4	5
Q24	.628				
Q25			.935		
Q26			.926		
Q27					.788
Q28					
Q29					
Q30					
Q31	.554				
Q32	.526				
Q33		.532			
Q34		.678			
Q35		.636			
Q36					
Q37	.603				
Q38				.815	
Q39				.804	
Q40					
Q41	.680				

KMO(Kaiser-Meyer-Olkin) test of factor analysis carried out by SPSS and presented in table 9, in which if the KMO value greater than 0.5, which implied the original data was suitable for factor analysis. The total variances of all components were explained by the table 10. The common factors were filtered and divided into five groups which can be renamed according to the table 11. The renamed five common factors were explained as below:

I.**Perception of EVs advantages**: The individual feeling or sense about EVs based on experiences and knowledge

II.**EVs competitiveness**: EVs special performance comparing with ICEVs or other fuel vehicles

III.**EVs prices**: EVs price opened by officially.

IV.**EVs full-charge range**:EVs operation mileage with fully battery charge.

V.**EVs operation cost**: Operation cost within life cycle period.

Consequently, the linear regression was executed by SPSS with the common factors. The regression residual test showed by figure 11 and figure 12, the equation coefficients presented in table 12 and table 13. Thus the regression equation was expressed as below:

Attitude toward EVs =2.446+0.390× Perception of EVs+0.127× EVs competitiveness+0.073× EVs full-charge range,Purchasing willingness=1.944+0.259× Perception of EVs+0.670× EVs competitiveness+0.182× EVs prices−0.182× EVs operation cost.

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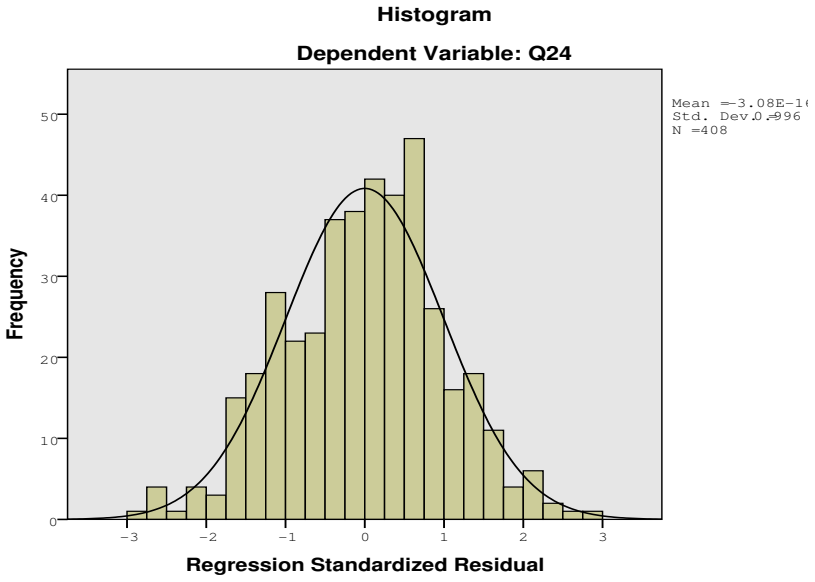

Figure 11. The regression standard residual of attitude toward EVs

Table 12. Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	2.446	.023		106.930	.000		
factor score 1	.390	.023	.628	17.011	.000	1.000	1.000
factor score 2	.127	.023	.205	5.558	.000	1.000	1.000
factor score 4	.073	.023	.118	3.197	.001	1.000	1.000

Dependent Variable: Attitudes toward EVs

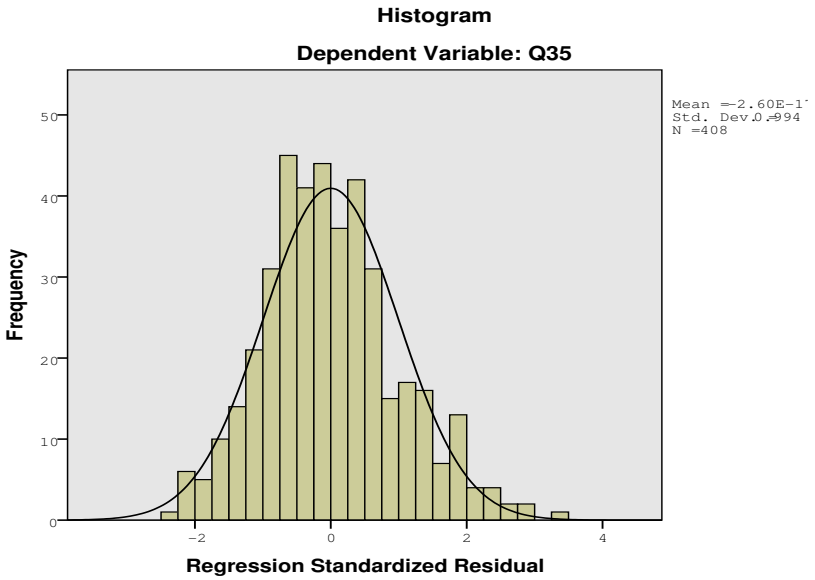

Figure 12. The regression standard residual of purchasing willingness to EVs

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Table 13. Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	1.944	.036		53.732	.000		
factor 1	.259	.036	.245	7.140	.000	1.000	1.000
factor 2	.670	.036	.636	18.487	.000	1.000	1.000
factor 3	.182	.036	.172	5.016	.000	1.000	1.000
factor 5	-.182	.036	-.173	-5.023	.000	1.000	1.000

a. Dependent Variable: Purchasing willingness

4.4. Public Policy and Price Incentive

Attempting to encourage consumers spread adopt EVs, public policy and financial incentive were established to stimulate EVs large scale penetration in the world, China government had implemented various incentives for EVs adoption, which presented in table 14 and table 15. Purchasing intention comparison was made between financial incentives at present and canceled in future by figure 13 and figure 14. The results showed that 65.7% of respondents were willing to buy EVs based on financial incentives, 63.9% participants were willing to buy PHEVs based on incentives. If the incentives would be canceled in 2020, the purchasing willingness would drop but not significantly, it was showed by figure 15 that there were 45.6% respondents still willing to buy EVs because of technology development trend and market share expectation, moreover, 22.3% participants insisted on purchasing EVs based on their enthusiastic about EVs. Meanwhile, comparing with consumers' willingness status, a Chinese government published data showed that EVs production also increased robustly in the past three years especially pure electric vehicles increased significantly presented by Figure 16.

Table 14. EVs price subsides in China

Vehicle Type	Range with Pure Electricity Model			
	80Km⩽R≤150Km	150Km ⩽R⩽250Km	R≥250Km	R≥50Km
PEVs(2013) Unit: Ones	$5,319.07	$7,598.67	$9,118.40	N
PEVs(2014) Unit: Ones	$5,319.07	$7,598.67	$9,118.40	N
PHEVs(2013) Unit:Ones				$5,319.07
PHEVs(2014) Unit:Ones				$5,319.07

Table 15. EVs price subsides in Shenzhen

Vehicle Type	Range with Pure Electricity Model			
	80Km⩽R≤150Km	150Km ⩽R⩽250Km	R≥250Km	R≥50Km
PEVs(2013) Unit: Ones	$5,319.07	$7,598.67	$9,118.40	N
PEVs(2014) Unit: Ones	$5,319.07	$7,598.67	$9,118.40	N
PHEVs(2013) Unit:Ones				$5,319.07
PHEVs(2014) Unit:Ones				$5,319.07

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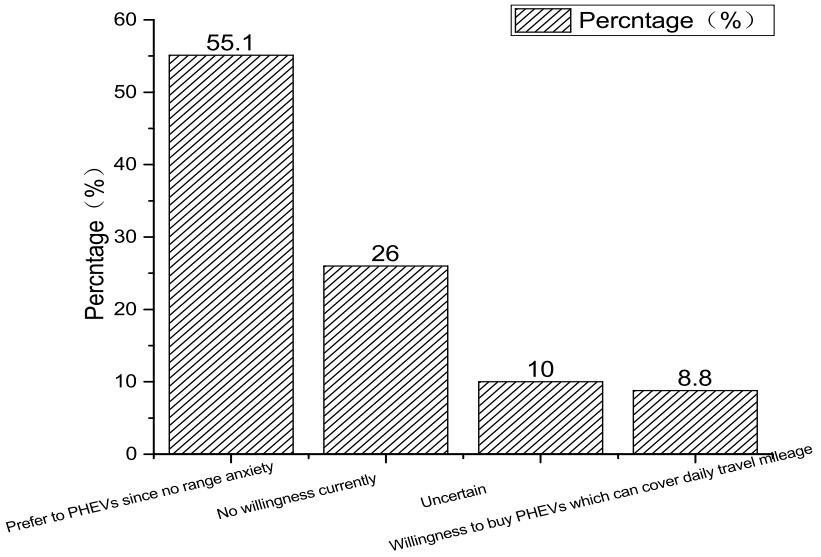

Figure 13. PHEVs purchasing Willingness Based on Incentives

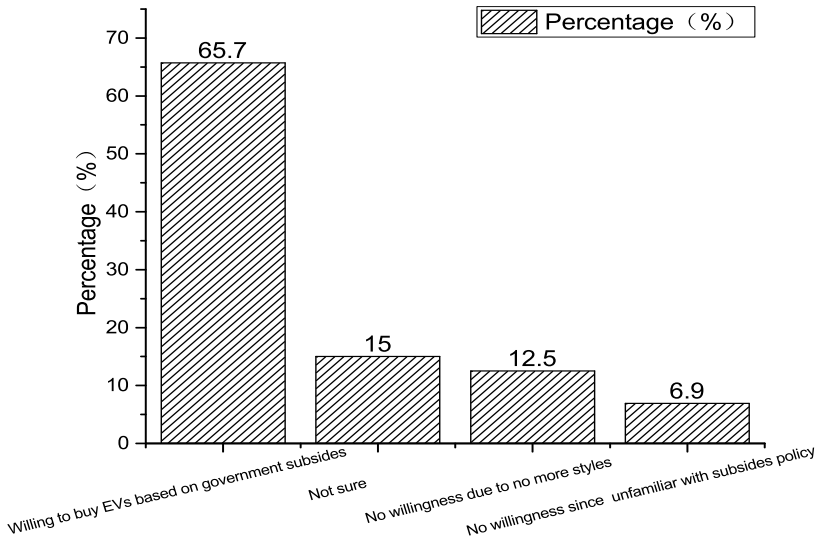

Figure 14. EVs Purchasing Willingness Based on Inventives

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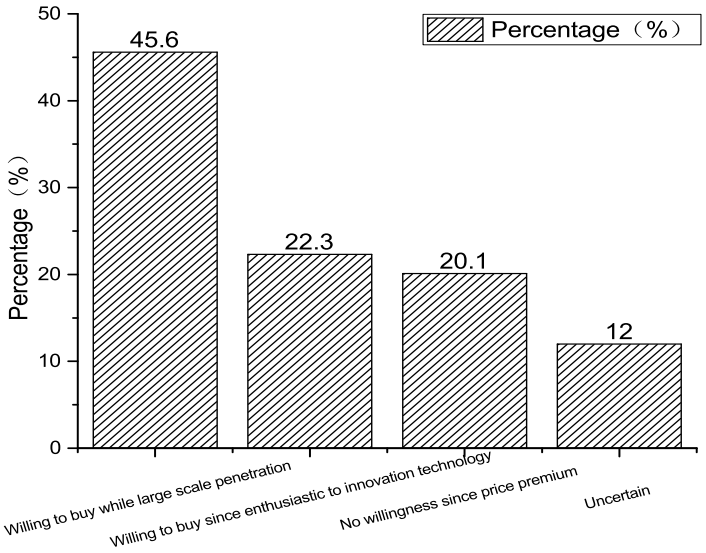

Figure 15. Willingness Changed When Subsides Canceled by 2020

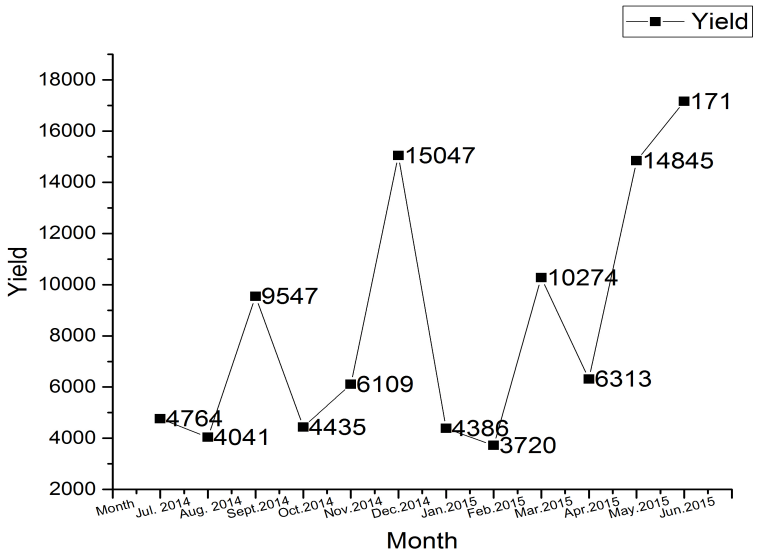

Figure 16. Passengers EVs Yield Past Years

In terms of EVs high price premium,this study investigated the Shenzhen residents' acceptance altitude of EVs price, which showed that 50% (n=204) of respondents' expectation range concentrated between $13071 and $24509, 37.3% (n=152) of respondents price expectation range concentrated between $24509 to $40849, 10.3% (n=42) of participants price expectation range concentrated between $40849 to $65359 and only 2.5% percent respondents could accept EVs price range upper $65359. In terms of consumers acceptance of PHEVs prices, which had similarly statistical result with EVs. As it examined the EVs sales price in China market which showed that the main products price range concentrated between $24509 and $40849.

Furthermore, the study deeply analyzed the common factors which affect the consumers purchasing willingness based on factor analysis and regression by IBM SPSS. It was examined by the KMO test which implied that it was suitable for the factor analysis,and the scree plot presented

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the principal components distribution. Moreover, the total variance and rotated component loading value sheet was delivered as below:

Table 16. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.818
Bartlett's Test of Sphericity	Approx. Chi-Square	839.176
	df	66
	Sig.	.000

Table 17. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Lo		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumu
1	3.321	27.672	27.672	3.321	27.672	27.672	2.767	23.059	2
2	1.402	11.687	39.359	1.402	11.687	39.359	1.915	15.961	3
3	1.094	9.117	48.476	1.094	9.117	48.476	1.135	9.456	4
4	.959	7.988	56.464						
5	.921	7.672	64.136						
6	.775	6.459	70.595						
7	.758	6.315	76.910						
8	.673	5.606	82.516						
9	.646	5.385	87.901						
10	.597	4.974	92.875						
11	.468	3.900	96.775						
12	.387	3.225	100.000						

Extraction Method: Principal Component Analysis.

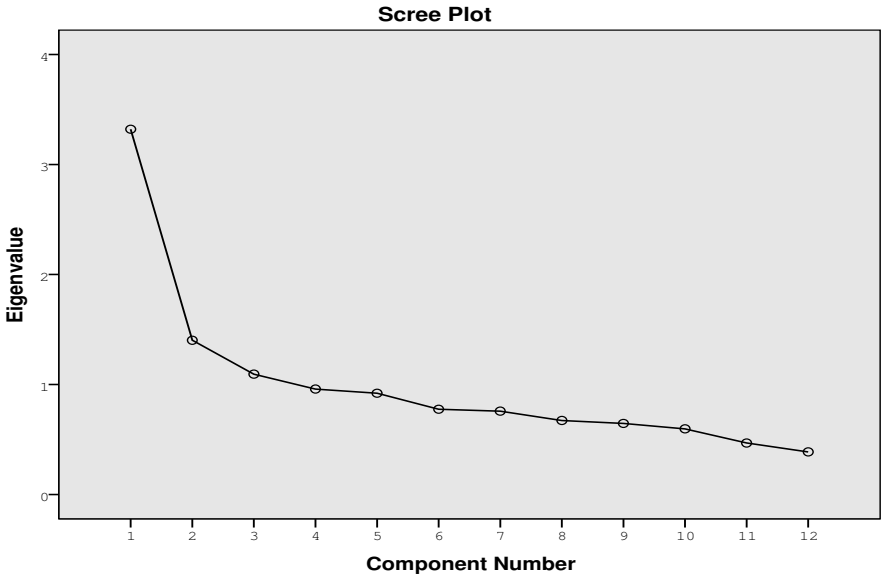

Figure 17. Scree Plot

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Table 18. Rotated Component Matrix

	Component		
	1	2	3
Q42			.566
Q43		.643	
Q44			.663
Q45	.726		
Q46			.550
Q47	.742		
Q48	.733		
Q49	.660		
Q50	.677		
Q51		.545	
Q52		.620	
Q53		.757	

Table 19. Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	1.429	.029		48.634	.000	1.371	1.487
factor score 1	.225	.029	.296	7.634	.000	.167	.282
factor score 3	.417	.029	.550	14.174	.000	.359	.475

The rotated components matrix is filtered by SPSS software then output the three categories common factors as below:

I.**Price subsides**

II.**Public Policy Support**:Public policy supporting EVs operation conveniently.

III.**EVs Charge infrastructure deployment**: Recharge public station deployment and available.

In terms of the common factors, the paper investigated the relationship between common factors and depend factor by regression analysis, which were explained by the regression equation:Purchasing willingness=1.429+0.025×public policy support+0.417× EVs charge infrastructure deployment.

5. Discussion

5.1. Preference for EVs

It is found by basic statistical analysis and Fisher test that the results limited support the hypotheses #1, however, the factor regression analysis shows definite conclusion that consumer's preference for EVs is mainly determined by consumers' potential demand toward EVs[6]. Thereby, it has to do more research on potential consumers and their behaviors for EVs spread adoption In addition[11]. Moreover, the results indicates that the perception of environmental protection and energy safety has a big influence on consumer's preference[10,11,14,15,17], which was in consistence with public policy support and environmental education driven from central and local government of China. Similarity with previous scholarly findings that the consumers also pursue lower operation cost with EVs[11,21,26], which is concluded by the inverse proportional to the preference, the higher the operation cost, the lower preference for EVs.

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5.2. Consumers Purchasing Willingness and Attitude

Overall,basic statistical analysis shows that the participants have strong willingness to adopt EVs no matter first time car buyer or non-fist time car buyer, they all consensus on the EVs developing trend and express optimistic about the prospective of EVs spread adoption[11,31], however, the majority of them concern about convenient recharging access. Despite Chinese consumers shows strong willingness to purchasing EVs with more recharging access available in future, in order to derive the main factors influencing on consumers purchasing decision, the quantitative analysis is needed. Consequently, it is concluded by the analysis that consumers' attitude toward EVs is determined by perceptions of EVs[7,10,23], EVs advantages and full-charge range based on the regression equation[19], which support the hypotheses#2 and hypotheses #3. Furthermore, the perception item has maximum regression coefficient which indicates that it influences the consumers attitudes significantly[7,10]. In addition, EVs competitiveness and full-charge range determine the consumers attitudes simultaneously, which match with the real situation and consistent with previous findings[5,7,20,21].

Additionally, the regression analysis indicates that purchasing willingness is determined by perception of EVs[6,8,10], EVs competitiveness[20,21], EVs price and operation cost[4,20,21]. Whereas, EVs operation cost has inverse proportion to the purchasing willingness. Moreover, all other items efficients are positive and EVs competitiveness occupies higher proportion in the equation. It is concluded that when consumers have enough opportunity to close EVs and understand EVs performance and advantages rightly, the perception of EVs may rise significantly, purchasing willingness rise simultaneously[23,24]. Furthermore, in terms of EVs performance, if competitiveness is stronger comparing with ICEVs, which also increase the consumers willingness significantly. Furthermore, comparing with other factors, EVs price accounts for lower proportion in consumers' purchasing willingness determined factors which is observed by regression efficiency of 0.182, it shows some differences with previous findings.

5.3. Public Policy and Price Incentive

As the analysis implies that consumers purchasing willingness are positively stimulated by public policy support such as national level price subsides and Shenzhen government subsides. Factor analysis indicates that public policy support and charging infrastructure deployment are crucial factors to EVs spread adoption[9,25,26,35], even the later item has maximum association efficient in the regression analysis, which supports the hypotheses 3 and 4. However, the result rejects the hypotheses 5 that the participants purchasing willingness will not be affected significantly by canceling the subside before 2020, which is a new findings related to previous studies[4].

The study inherits the general structures of previous researches, some results verify the formal conclusions. Furthermore, it replenishes the previous study limitation that survey respondents lack of understanding about operation cost differences between ICEVs and EVs[1,41]. The study's contribution is that the most surveyed participants who have direct experiences in EVs driving, thereby the response of participants can reflect the real situation of consumers behaviors specifically. Furthermore, the study proposes five types hypotheses based on literature review and then verifies the hypotheses according to factor analysis, which overcomes utilize the fragment of previous findings and hard to know where important knowledge gaps lies and where contribution can be made in future research[1]. Thus it is valuable for identifying the potential market trend and adjusting the EVs industrial policies in China. However, the study may not representative of the entire Shenzhen residents situation because of limit survey population, and the study can be as the foundation of intercity comparison study or cross culture in global scope in future.

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6. Conclusions

Firstly,it is concluded from the data analysis that Shenzhen participants have strong willingness to buy EVs despite many drawbacks exist in real operation condition, which limited support the hypothesis. However, considering EVs uptake in future, the spread adoption of EVs depends on more recharging access deployment in community and working place rather than public recharging station[11,27,28,40]. Secondly, the analysis results indicated that perception of EVs could be a significant barrier to EVs penetration[23,41], once consumers can obtain the EVs knowledge accurately and experience it closely, attitudes and willingness toward EVs will be rising significantly, which implies that EVs maker or government should do more promotion related to EVs technology advantages. In addition, in terms of recharging behavior, it was observed that the majority of consumers prefer to home night charging and working place charging. Furthermore, EVs competitiveness , full-charge range, EVs price, Operation cost and public policy are explained as crucial factors which determine the consumers' purchasing willingness and supports the hypotheses very well. However, it is found that financial incentives cancellation and EVs price would't be a barrier to EVs spread adoption, which is proved by the analysis and limited supports the hypotheses.

There are several limitations need to be improved in future study, firstly the survey population was limited so that the results may not representative the whole China situation very well. Secondly, the survey questionnaire options should be optimized and tested ensure it can more suitable for statistical analysis. Additionally, the gender proportion should more balanced than currently. However,the survey provides a reasonable representation of the Shenzhen residents in terms of age, income level and occupations.

The study is valuable for EVs makers understanding about Chinese consumption behaviors despite it is just regional research, its aim is to do more comparison study between Shenzhen and some other China cities in future, especially the differences among the first tier cities, the second tier cities and rival area situations in terms of EVs spread adoption. Moreover, it is valuable to do more research across the cultural differences in global scope.

Acknowledgments

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Appendix

The questionnaire mentioned in our study is available in the URL of"http://www.lediaocha.com/pc/s/neutew "

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