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Investigation of the Influencing Factors on Consumers' Purchase Willingness towards New-Energy Vehicles in China: A Questionnaire Analysis Using Matrix Model

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Abstract: New-energy vehicles (NEV), particularly electric vehicles, are globally popular with political and financial support from governments, which aim at reducing energy consumption and environmental pollution in the transportation sector. This paper designs a matrix model which identifies the factors influencing the decision-making process on purchasing NEVs, and applies the model on a Chinese case to investigate the impact of influencing factors on Chinese consumers' purchase behavior to NEVs. The influencing factors are divided into five groups: economic, political, social, technological and environmental. Through a detailed questionnaire survey of 526 consumers in China, this paper conducts a correlation and difference analysis between these consumers' status and the influencing factors on the purchase decision-making of NEVs through SPSS software. The results indicate that economic, technological and political factors have a strong influence on purchase behavior, while social and environmental factors have a weaker influence. Additional principal component analysis on influencing factors' preference reveals that consumers' preferences have two tendencies: practicability or appearance, with the former is attracting far more attention. Rather than practicability or appearance, consumers care more about economic and political factors. According to these results, this paper suggests several policy implications on enhancing the consumers' willingness to purchase NEVs.

Keywords: new-energy vehicle; consumer behavior; matrix model for influential factors; low-carbon transportation; China



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1. Introduction

During a decade from 2008 to 2018, the number of cars in China rapidly increased from 65 million to 240 million, with an average annual increase of 27%. In large cities, these cars are exhausting 70–80% of the city's air pollutants, which brings about serious environmental impact. Moreover, the number of cars is predicted to increase much more in the future because of the rapid economic development in China. To feed the huge gasoline demand from the conventional cars using an internal combustion engine, China has to import a large amount of crude oil from the overseas, which intensifies the dependence of foreign oil from 49.8% in 2008 to 69.8% in 2018. This unbalance between oil supply and demand is forecasted to be much worse in the future due to the increment of the driving license issue [1,2].

Facing the problem mentioned above, low-carbon transportation has become one of the key issues in China for achieving the ambitious national targets on energy conservation

and emission reduction, where promoting New-energy Vehicles (NEVs) is thought to be an effective way in this fraction. Notably, NEVs in China are generally defined as the vehicles powered by electricity, hydrogen energy, dimethyl ether and other unconventional fuels. By the end of 2018, the number of NEVs owned in China had reached 2.61 million, only accounting for 1.09% of the total number of vehicles, but compared with the number in 2017, the increase achieved 1.07 million. Among them, the number of pure electric vehicles was 2.11 million, accounting for 81.06% of the total number of NEVs. Thus, this paper mainly focuses on the NEVs including pure electric vehicles, plug-in hybrid electric vehicles and fuel cell electric vehicles.

Both the central government and the local governments in China have introduced various policies to popularize the usage of NEVs in the domestic market. In 2018, the number of NEVs produced and sold in China reached 1.27 million and 1.256 million with an increase rate of 59.9% and 61.7%, respectively, compared with the number in 2017. Still the annual sales of NEVs is thought to substantially increase due to the continuous compensation from the government to consumers, where the governmental cognition and attitude towards NEVs is very likely to affect the consumers' purchase decision towards NEVs. In addition, the government and public institutions in China are also regarded as critical consumers who are likely to purchase NEVs, particularly focusing on new-energy buses and official cars. In an overall perspective, what are the critical factors and how are these factors influencing the consumers' decision-making on purchasing NEVs, this is a critical question. In order to seek the answer to this question which helps the government evaluate and formulate relevant policies, this paper develops a matrix model to analyze the influencing factors on consumers' purchase preference to NEVs and to identify the key factors by principal component analysis.

Many previous studies have proved that numerous factors influence consumers to buy NEV. Some of the literature simply believes that purchase intention is the main influencing factor of actual buying behavior [3–5]. Some of the literature analyses the influencing factors of purchasing new-energy vehicles is a multi-objective decision-making analysis process, which has been validated from the cases of Poland and Mumbai, India [6,7]. This paper holds that there are more complicated factors, and it is proposed that consumer buying behavior of NEV is influenced by many factors, such as economic factors, policy factors and social factors [8,9].

In addition, through a questionnaire survey, this paper divides the respondents' areas into two categories: areas with policies of restriction on vehicle purchase and use, and areas without such policies. It is found that in policy areas, respondents are concerned more with the free lottery of license plate, whereas in non-policy areas, respondents pay more attention to government financial subsidies [10,11]. The implication is that, stricter policies have a stronger impact on consumer buying behavior, making them pay more attention to the introduction of policies. Most of the existing research focusses on the content of policy setting and the effect of policy implementation, but few of them conduct a comprehensive comparative analysis between policy areas and non-policy areas. Therefore, this paper takes the promotion policy of NEV as a moderating variable, and explains the socio-economic factors behind consumer buying behavior [12–14].

This paper contains two contributions in discussing the influencing factors of NEV buying behavior. In the first place, this paper presents that there are comprehensive factors influencing consumers to buy NEV, including economic factors and policy factors. Through correlation analysis, difference analysis and principal component analysis on the collected questionnaire data with SPSS software, it is found that there is a strong positive correlation between the annual income of consumers and the acceptable price of NEV within a certain range: respondents with an annual income above RMB 300,000 are no longer sensitive to price. Many studies, to some extent, ignore the economic and policy influence factors, which only emphasizes the influence of subjective consciousness on the buying behavior of NEV. Furthermore, some studies focus on one kind of NEV, such as Kang and Park (2011)

on fuel cell vehicles, and Chandra, Gulati and Kandlikar (2010) [15] on hybrid cars, rather than analyzing NEV as a whole.

In the second place, this paper divides the population according to whether the areas have policies of restriction on vehicle purchase and use or not, which is rare in previous research. Through correlation analysis and difference analysis of the questionnaire data, it is found that consumers in policy areas pay more attention to the preferential policy of the free license plate lottery for NEV, whereas those from non-policy areas are concerned more with government's financial subsidies for NEV purchase. The implication is that the strict policy of restriction on vehicle purchase and use has a great impact on consumer purchasing psychology.

2. Methods and Data

2.1. Matrix Model for Influence Factor Identification

Through a comprehensive review on previous studies using matrix models for influencing factor analysis [16,17], this paper designs a matrix model (Figure 1) specified to identify the factors influencing the purchase decision-making of consumers on NEVs that allows to quantitatively compare the importance between various influencing factors.

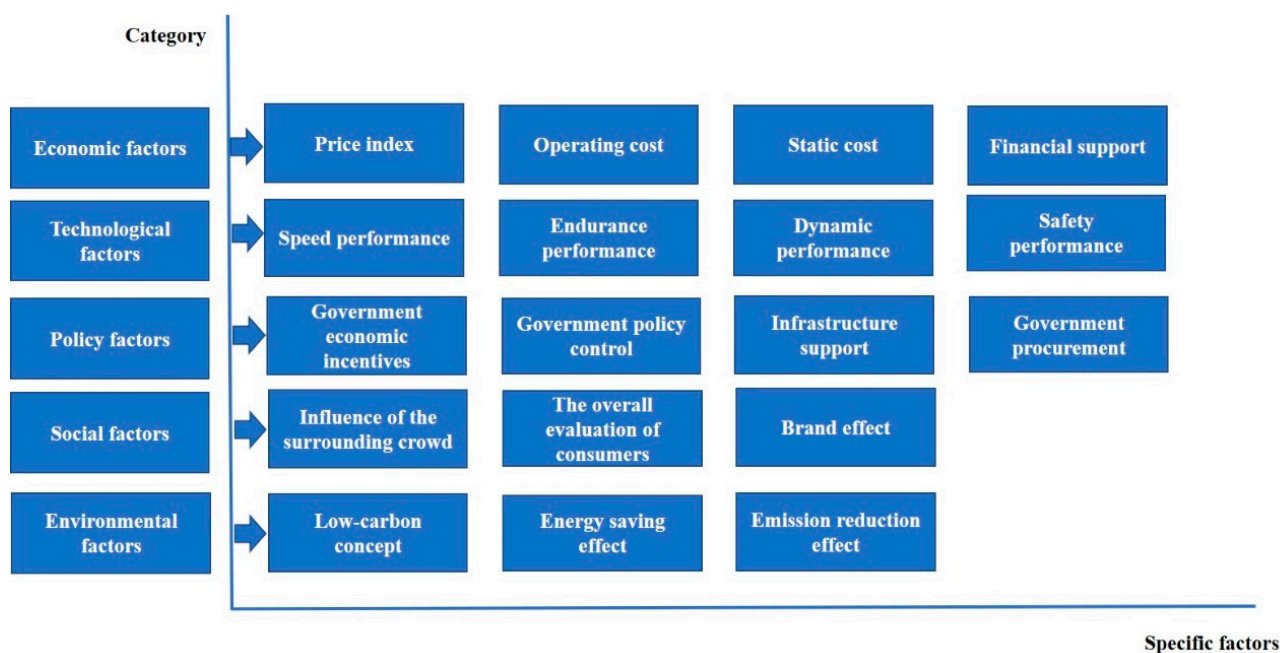


Figure 1. Matrix model for identifying factors influencing the purchase behavior to NEVs.

The matrix model divides the influencing factors into five categories, namely economic factors, technological factors, political factors, social factors and environmental factors. Economic factors include price index, operating cost, static cost and financial support. Technological factors include speed performance, endurance performance, dynamic performance and safety performance. Policy factors include government economic incentives, government policy control, infrastructure support and government procurement. Social factors include the influence of the surrounding crowd, the overall evaluation of consumers and brand effect. Environmental factors include the low-carbon concept, the energy saving effect and the emission reduction effect [18–20].

Notably, these five categories and the influencing factors contained in each category are generalized from more specific items, which are defined and embedded in the questionnaire survey to a certain country or region. It is possible to redefine and flexibly adjust these factors and categories according to the case study.

Shown as Figure 2, this study proposes an analysis framework to identify the possible factors influencing the decision-making on purchasing NEVs based on the matrix shown

in Figure 1 through a comprehensive questionnaire survey in the case area. The analysis process can be divided into three steps. The first step is to develop a matrix including all possible influencing factors on purchasing NEVs which is specified to the characteristics of the case area. The next step is to collect necessary data from consumers through a comprehensive questionnaire, which supports the following correlation analysis, difference analysis and principal component analysis on the decision-making on purchasing NEVs, so as to identify the key influencing factors according to the specific matrix to the case area. With these supports, the final step is to evaluate the decision-making process on purchasing NEVs, analyze the difference of consumers' preference due to their attributes, so as to provide policy implications for promoting NEVs [21,22].

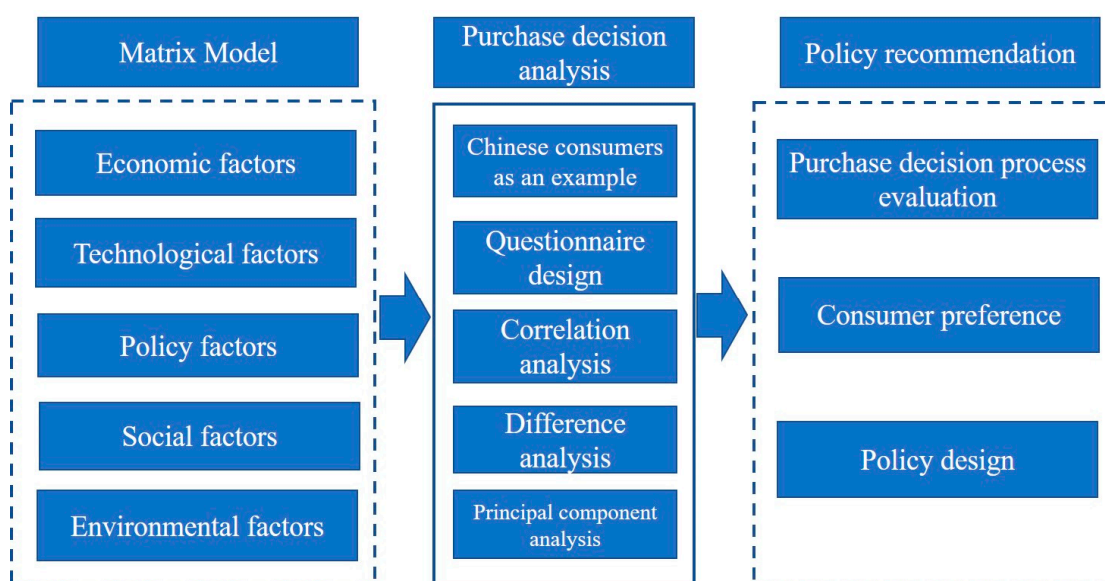


Figure 2. Model framework for analyzing the decision-making process on purchasing NEVs.

2.2. Data Collection

This paper takes the Chinese NEVs market as a case, where a board questionnaire survey is conducted to apply the matrix model noted above for identifying the factors influencing the consumers' purchase behavior to NEVs. Comprehensively considering the characters such as vehicle type, market environment, relevant policies and consumer behavior towards NEVs in the Chinese car market, the influencing factors contained in the five categories are specifically defined as follows. In the economic category, the price index is defined as the car sales price, the operating cost is defined as the energy consumption, the static cost is defined as the maintenance cost and the financial support is defined as the governmental subsidy at the time of purchase. In the technological category, the speed performance is specified as the maximum speed, and the endurance performance is defined as the range. In the policy category, the economic incentive is defined as whether the governmental subsidy is available at the time of purchase or not, while the governmental policy control is defined as whether the license plate lottery and the daily restriction of car usage are adopted or not, and the infrastructure support is defined as whether charging piles are introduced in the residence/workplace or not. In the social category, the influence from the surroundings is defined as the attitude towards NEVs within family and friends, the overall evaluation by consumers is defined as the public praise, and the brand effect means the awareness to the brand. In the environmental protection category, that is, the low-carbon environmental protection concept for consumers purchasing behavior of new-energy vehicles.

Before the formal questionnaire survey, a pre-survey was released on the Internet, where 88 effective questionnaires were received for checking the appropriateness of the questions and revising. According to the revisions, the questionnaire was finally reformed

to include 2 parts with 22 questions, covering all categories such as economic, technological, political, social and environmental factors towards the popularization of NEVs. In the first part, the basic information of the respondents was collected to identify personal attributes, while in the second part, the importance of each factor influencing the consumers' purchase attitude towards NEVs was evaluated, including their deepness of understanding towards NEVs and their rating to the influencing factors towards final decision-making on purchase.

Finally, the questionnaire was released on the Internet with the guarantee in randomness to the respondents who are Chinese and willing to buy NEVs in near future. In total, 626 questionnaires were issued and recorded, of which 526 are effective with an effective rate of 84%.

3. Results Description

3.1. Individual Characteristics of Respondents

In total, 526 samples are valid from the questionnaire survey of which 266 are males and 260 are females, accounting for 50.47% and 49.53%, respectively. The cross distribution by age and individual annual income are shown in Table 1. Among these respondents, the three most important ways to know about NEVs are searching the information on the Internet, attending auto shows and reading newspapers or books. 468 respondents disclosed the willingness to buy an NEV in 2 years, accounting for 88.8%. A total of 62.62% of the respondents answered that they can accept the range of market price between 100,000 RMB and 200,000 RMB, which indicates a strong willingness of respondents to buy low-and-medium-grade NEVs. Moreover, according to the questionnaire results, the majority of respondents have a deep enough understanding on vehicles that ensures that the survey results are feasible for the following analyses [23,24].

Table 1. Distribution of Respondents by Age and Individual Annual Income.

			Age					Total
			Below 25	25–35	35–45	45–55	Above 55	
Annual household income	Below RMB 50,000	Count	0	5	0	0	0	5
		% annual income	0.0	100.0	0.0	0.0	0.0	100.0
		% age	0.0	1.5	0.0	0.0	0.0	1.0
	RMB 50,000–100,000	Count	6	33	11	6	1	57
		% annual income	10.5	57.9	19.3	10.5	1.8	100.0
		% age	27.3	9.9	8.2	17.6	25.0	10.8
	RMB 100,000–200,000	Count	11	141	62	21	0	235
		% annual income	4.7	60.0	26.4	8.9	0.0	100.0
		% age	50.0	42.5	46.3	61.8	0.0	44.7
	RMB 200,000–300,000	Count	4	106	39	7	2	158
		% annual income	2.5	67.1	24.7	4.4	1.3	100.0
		% age	18.2	31.9	29.1	20.6	50.0	30.0
	RMB 300,000–500,000	Count	0	35	15	0	1	51
		% annual income	0.0	68.6	29.4	0.0	2.0	100.0
		% age	0.0	10.5	11.2	0.0	25.0	9.7
	Above RMB 500,000	Count	1	12	7	0	0	20
		% annual income	5.0	60.0	35.0	0.0	0.0	100.0
		% age	4.5	3.6	5.2	0.0	0.0	3.8
Total		Count	22	332	134	34	4	526
		% annual income	4.2	63.1	25.5	6.5	0.8	100.0
		% age	100.0	100.0	100.0	100.0	100.0	100.0

3.2. Influence of the Household Annual Income on Purchase Intention

As shown in Figure 3, the majority of the respondents have an annual household income of 100,000–200,000 RMB or 200,000–300,000 RMB, where the richer households reveal higher interest and ability to pay for high-grade NEVs.

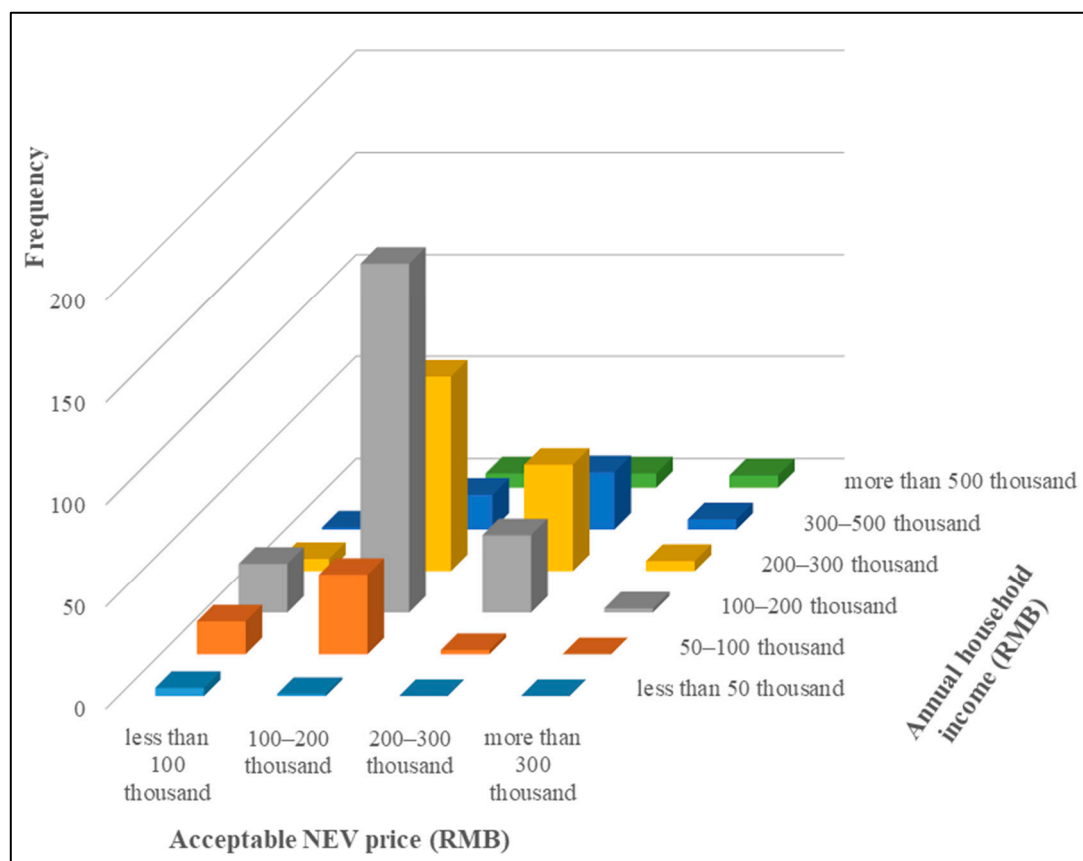


Figure 3. Frequency distribution of households between the annual household income and the acceptable NEVs sale price.

As shown in Figure 3, the respondents' annual household income is mainly in the 100,000–200,000 RMB and 200,000–300,000 RMB categories, where their acceptable NEVs sale price is mainly at the range of 100,000–200,000 RMB. Through the Chi-square test on the crosstab of annual household income and acceptable NEVs sale price, the Pearson Chi-square value is found to be 168.810, while Sig. = 0.000, less than 0.05, that indicates a significant correlation between the annual household income and the acceptable NEVs sale price. The correlation coefficient between the annual household income and the acceptable NEVs sale price is Gamma = 0.621 and Sig. = 0.000, less than 0.05. Therefore, the correlation coefficient between the annual household income and the acceptable NEVs sale price is confirmed to be statistically significant. In addition, Gamma = 0.621 means the correlation between the annual household income and the acceptable NEVs sale price is statistically strong. It is not difficult to understand this result, because respondents with different annual household incomes have different affordability to the NEVs sale price, which leads to a strong correlation.

It is interesting that a significant correlation is still found between the two factors, even with the controlling factor of the respondents' education background, while considering the annual household income as an independent variable, and acceptable NEVs sale price as a dependent variable. Compared with the testing result without considering the education background as a variable, the correlation is not obvious so that the causal relationship between the household income and the acceptable NEVs sale price does exist.

As shown in Table 2, the annual household income is divided into six groups: below 50,000 RMB, 50,000–100,000 RMB, 100,000–200,000 RMB, 200,000–300,000 RMB, 300,000–500,000 RMB and above 500,000 RMB. According to the results of the independent-sample *t*-test of each group's acceptable sale price, the annual household income during 300,000–500,000 RMB and above 500,000 RMB does not reveal a statistical significance (Sig. = 0.146, above 0.05), whereas other groups, the annual household income below 50,000 RMB, 50,000–100,000 RMB, 100,000–200,000 RMB and 200,000–300,000 RMB, show a statistical significance (Sig. less than 0.05). Obviously, families with annual income above 300,000 RMB are not sensitive to the sale price, while those with an annual income below 300,000 RMB are sensitive to the NEVs sale price. This phenomenon suggests that the higher annual income one family has, the less important the NEVs sale price will be. The NEVs sale price at 300,000 RMB is likely to be the division whether the sale price is a strong influence factor on consumers' decision-making or not. Therefore, when selling NEVs, manufacturers should reasonably set the price corresponding to the target consumers at the different income levels in order to increase the sales. At the same time, the government can also refer to this result to determine appropriate subsidies for popularizing NEVs to the market.

Table 2. Independent-sample *t*-test between the annual household income and the acceptable NEVs sale price.

	Below RMB 50,000	RMB 50,000–100,000	RMB 100,000–200,000	RMB 200,000–300,000	RMB 300,000–500,000	Above RMB 500,000
Below RMB 50,000 RMB		0.042	0.001	0.000	0.000	0.000
50,000–100,000 RMB			0.000	0.000	0.000	0.000
100,000–200,000 RMB				0.000	0.000	0.000
200,000–300,000 RMB					0.000	0.000
300,000–500,000 above RMB 500,000						0.146

3.3. Influence of the Restriction Policy on the Purchase Intention

The questionnaire data are also divided into two categories: respondents from the areas with the policy to restrict vehicle purchase and use (named “areas with restriction policy”) and the other areas without the policy to restrict vehicle purchase and use (named “areas without restriction policy”). Areas with the restriction policy include eight cities: Beijing, Shanghai, Guangzhou, Guiyang, Shijiazhuang, Tianjin, Hangzhou, Shenzhen, Nanchang, Changchun, Lanzhou and Chengdu, while the others are areas without the restriction policy. Within the 526 valid questionnaires, 266 respondents are from the areas with the restriction policy, and 260 respondents are from the areas without the restriction policy.

Figure 4 shows the frequency distribution of the respondents' attitude towards the policies in the areas with or without preferential policies. 52.9% of respondents prefer the preferential subsidies for purchasing NEVs, while 34.2% prefer the free license-plate lottery, 9.9% of the total prefer free tax incentives and 3% of the total prefer free parking. Obviously, people pay more attention to the policies such as the free license-plate lottery policy and subsidies. However, respondents from the areas without the restriction policy seem to pay more attention to the subsidies, whereas those from the areas with the restriction policy are concerned more with the free license-plate lottery policy.

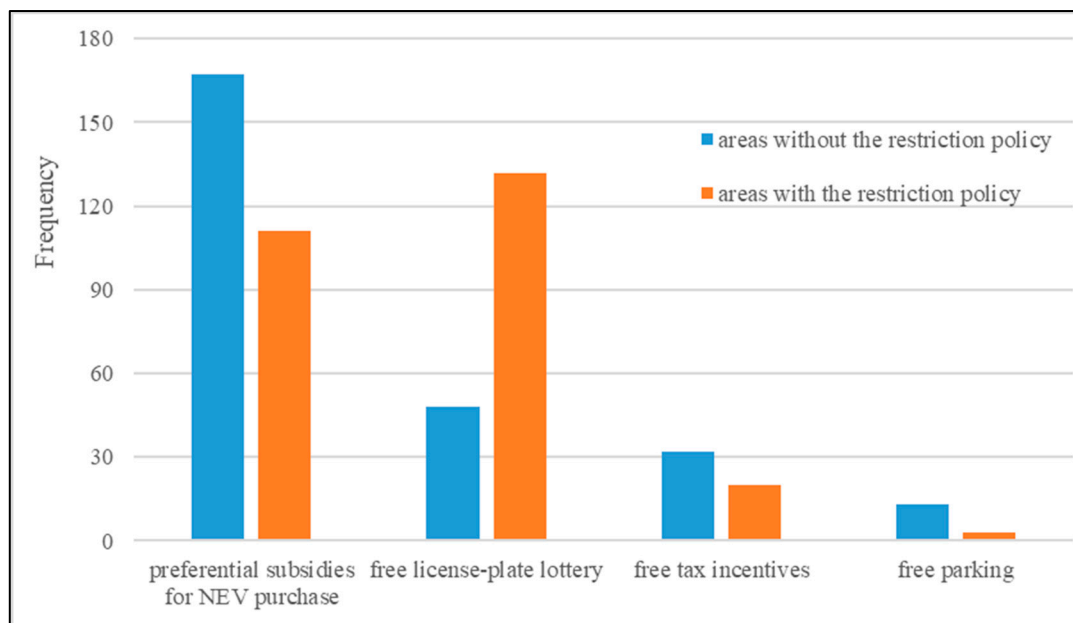


Figure 4. Frequency distribution of the respondents' attitude towards the policies in the areas with or without the preferential policies.

For further data analysis, an independent-sample test is applicable to understand the relationship between the area type and the influencing factors such as the respondents' preferred preferential policies, governmental subsidies, free license-plate lottery, car use restriction, maximum speed and range, availability of charging piles in residence/workplace, as well as low-carbon environmental development. Accordingly, this study conducted an independent-sample *t*-test to measure if there is any apparent difference between the two types of areas during these influencing factors. The significant values (Sig.) are shown in Table 3. As a result, the significant value of each factor remains greater than 0.05, which means that there is no significant difference between these factors on the impact to NEVs purchase intention.

Table 3. Independent-sample *t*-test for areas with/without the restriction policy.

	Sales Prices	Energy Consumption and Maintenance Cost	Brand Awareness	Government Subsidy	Free License-Plate Lottery	Top Speed and Range	Charging Piles	Low Carbon Environmental Development
Sig.	0.895	0.415	0.734	0.754	0.000	0.891	0.632	0.123

According to Table 3, Sig. = 0.000 < 0.05 in the case of the free license-plate lottery, that means a significant difference between the areas with or without the restriction policy, i.e., restriction policies will substantially affect the consumers' purchase willingness. When applying the independent-sample *t*-test for testing the influence from preferential policies in both the areas, the results show Sig. = 0.004 less than 0.05, which reveal a significant difference in the respondents' expected preferential policies between the two areas. As shown in Figure 4, respondents in two kinds of areas are more interested in the financial subsidies on car purchase and the free license-plate lottery. Respondents in the areas without the restriction policy pay more attention to the financial subsidies for vehicle purchase, while those in the other areas are more concerned with the free license-plate lottery. This difference is very likely to be caused by the restriction policy. Respondents from the areas with the restriction policy are likely to firstly consider whether they can enjoy the free license-plate lottery policy when consider purchasing a NEV, while respondents from the other areas are inclined towards the financial subsidies.

Since restriction policy may strongly impact on the consumers' attitude on other related policies and subsidies, before carrying out NEVs promotion policies, the government should consider how to combine the restriction policy on NEVs purchase and usage with the other policies such as the license-plate lottery and the financial subsidies. Moreover, NEV manufacturers can also improve the communication strategies according to the local policies to enhance or reduce the influence on consumers' psychology [25,26].

3.4. Principal Component Analysis on the Purchase Behavior of NEVs

This study applied SPSS16.0 as an analysis tool for the principal component analysis on the scores given by respondents on purchase willingness from the 526 questionnaires. Firstly, KMO (Kaiser–Meyer–Olkin) and Bartlett's test is adopted for the sample sufficiency test to evaluate if the samples are suitable for such analysis. Table 4 is the result of the KMO and Bartlett's test. The KMO coefficient of the 526 samples is 0.639, which means that there is a certain correlation between the variables. A KMO coefficient above 0.5 is a basic requirement for performing principal component analysis. In addition, the result of the Bartlett's test shows the significance is 0.000, which means that the correlation coefficient matrix is not a unit matrix. The Bartlett's test significance below 0.05 means that there is some correlation between the 526 samplers, which is another basic requirement for performing principal component analysis. The above two tests prove that the scoring of important factors by respondents in the questionnaires is suitable for the principal component analysis [27,28].

Table 4. KMO and Bartlett's test results from the 526 questionnaires.

Test		Value
Kaiser–Meyer–Olkin	Measure of sampling adequacy	0.639
Bartlett's Test of Sphericity	Approx. Chi-Square	433.990
	df	45
	Sig.	0.000

In the second part of the questionnaires, the respondents are required to score their preference on the proposed ten influencing factors towards the purchase willingness of NEVs at a range from 1 point to 7 points. The proposed ten influencing factors include sales prices, energy consumption and maintenance cost, brand awareness, consumers' praise, governmental subsidies, free license-plate lottery, maximum speed and range, availability of charging piles at residence and workplace, performance on low-carbon and environmental concerns and recommendations from friends and relatives. As repeated, these influencing factors are divided into five categories: economic, technological, political, technological and environmental. The average score of each factor and category is summarized in Table 5.

The top three categories of influencing factors for consumers are "energy consumption and maintenance cost", "availability of charging piles at residence and workplace" and "consumer praise", followed by "maximum speed and range", "sales price" and "governmental subsidy". The three least influential factors are "recommendation from family and friends", "low-carbon and environmental performance" and "brand awareness". Among the ten factors, the standard deviation of factors, including "free license-plate lottery and no car use restriction" and "recommendation from family and friends", is much larger than the other factors, which indicates a substantial difference in consumers preference. If we divide the respondents' living areas into the areas with or without the restriction policy, it is found that in areas with the restriction policy, the average value is 5.73 and the standard deviation is 1.421, while they are 4.99 and 1.596, respectively, in the areas without the restriction policy. An Independent-sample t-test for these two situations on the difference significance shows a result that Sig. (2-tailed) is $0.000 < 0.01$. This shows a highly significant difference in the score of this factor between the respondents living in the two different areas. Respondents in the areas with the restriction policy gave much higher scores to the

importance of restriction policy than those in the areas without the restriction policy, and this indicates that the restriction policy has a great influence on purchase willingness.

Table 5. Average score and its rank of each factor and category.

Five Categories	Ten Factors	Average Score of Factor	Average Score of Category
Economic category	Sales price	5.8	5.8
	Energy consumption and maintenance cost	6.1	
	Government subsidy	5.7	
Technological category	Maximum speed and range	5.8	5.8
Policy category	Governmental subsidy	5.7	5.7
	Free license-plate lottery, no restriction of vehicle use based on the last digital of plate	5.3	
	Availability of charging piles in residence and workplace	6.0	
Social category	Recommendations from family and friends	4.5	5.2
	Consumer praise	5.9	
	Brand awareness	5.1	
Environmental category	Low-carbon and environmental preformance	5.1	5.1

Principal component analysis is conducted for the data above, and the variance contribution rate of each influencing factor is summarized in Table 6. Results show that the cumulative eigenvalue of the first four factors reaches 57.19%. Through analyzing the rotated component matrix, the contribution of each influencing factor to the first four factors are shown in Table 7.

In the first category of factor loading, the critical influential factors are “energy consumption and maintenance cost”, “availability of charging piles in residence or workplace”, “public praise” and “maximum speed and range”. These four factors are also the four top-ranking factors influencing the purchase willingness in Table 6. In fact, they represent that NEVs are successful in drawing people’s attention in terms of practicability compared with conventional vehicles. These factors are called “practicability factors”, while this kind of consumption preference is called “practicability consumption” [29].

Table 6. Variance contribution rate of factors to the purchase willingness on NEVs.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.058	20.584	20.584	2.058	20.584	20.584
2	1.531	15.306	35.89	1.531	15.306	35.89
3	1.108	11.076	46.966	1.108	11.076	46.966
4	1.022	10.224	57.19	1.022	10.224	57.19
5	0.88	8.8	65.991			
6	0.813	8.127	74.118			
7	0.723	7.231	81.348			
8	0.699	6.988	88.336			
9	0.638	6.38	94.717			
10	0.528	5.283	100			

Table 7. Rotated component matrix of influencing factors.

	1	2	3	4
Sales price	0.388	−0.411	−0.133	0.606
Energy consumption and maintenance costs	0.639	−0.321	0.12	−0.25
Brand awareness	0.411	0.447	−0.398	0.41
Public praise	0.557	0.099	−0.513	−0.083
Subsidy	0.335	−0.179	0.560	0.479
Plate lottery and restriction of car use	0.357	0.209	0.423	0.000
Maximum speed and range	0.554	−0.098	0.258	−0.341
Charging piles	0.562	−0.327	−0.239	−0.26
Low-carbon and environmental performance	0.349	0.646	0.17	−0.07
Recommendations from family and friends	0.187	0.663	0.093	0.009

Note: Important weights (value above 0.4) were marked by background color.

In the second category of factor loading, the critical influential factors are “recommendation from family and friends”, “low-carbon and environmental performance” and “brand awareness”. These three factors are also the ones at the lowest rank influencing the purchase willingness as shown in Table 6. These three factors are also called tag factors. To some extent, they represent consumers’ attitude to the specific appearance of NEVs. Due to the ranking of these factors, it indicates that a few Chinese consumers have a deep interest in the low-carbon and environmental performance, as well as other appearance tags. Notably, these factors are usually classified as “appearance factors”, while this kind of consumption preference is named “appearance consumption”.

In the third category of factor loading, the critical influential factors are “governmental subsidy” and “free license-plate lottery and car use restriction”. The two factors actually belong to the political category, and the foregoing analysis has proved that they are significantly affected by relevant policies introduced in the areas where the consumers are living. Through the principal component analysis, they are indicated to significantly impact on consumers’ purchase willingness on NEVs. This result also reflects the rationality of categorizing the influencing factors, that these factors influence on people’s purchase behavior through different ways.

In the fourth category of factor loading, the critical influential factors are “sales price” and “government subsidy”. These two factors belong to the economic category, and their influences are indicated to be independent with other factors through the principle component analysis. The score of three factors in the economic category is relatively high as shown in Table 5, which means that consumers are still more concerned about economic factors compared to the preference on practicability and appearance [30]. This also reflects the rationality of categorizing as economic factors, which are independent with the influencing factors in other categories.

As shown in Table 6, the eigenvalue of the fourth factor category only accounts for 10.224% in the principal component analysis, that is far less than the contribution rate of the first category 20.584%. This suggests that consumers are less sensitive to the variation of sales price when considering buying a NEV if the sales price is set within a fixed range. At the same time, practicability seems more important for making the decision to purchase a NEV.

4. Discussions

According to the results from the correlation analysis, variance analysis and principal component analysis on the data collected from the 526 questionnaires, this study identified the influencing factors and their impacts on the decision of purchasing NEVs from five categories, including economic, political, social, technical, and environmental factors [31,32]. Several discussions are summarized as follows.

4.1. Pricing Strategy

Economic factors, including sales price, energy consumption and maintenance cost and government subsidy, are indicated as having a strong impact on promoting the purchase of NEVs. Not only the price of NEVs, but also the annual household income is quite related to car purchase behavior in that an appropriate pricing system is indispensable. Noted in this study, the annual household income at 300,000 RMB is a division of the consumers' attitude towards NEVs. Families with a lower annual income than 300,000 RMB are more sensitive to the sales price of NEVs, while the richer families become relatively insensitive to the price change of NEVs. This result reflects the same tendency with Larson (2014)'s research [33] in the case of Canadian consumers. Therefore, NEV dealers can have flexible pricing strategies for target consumers with different household incomes and price elasticity. At the same time, the government can quantitatively evaluate the difference between the manufacturing cost of NEVs and a friendly price to consumers to specify the amount of the subsidy. Innovative automobile finance with an appropriate business model will surely help in accelerating the expansion of the NEV market share [34].

4.2. Policy Making

Results from this study indicate a strong influence from the governmental policies on the consumers' purchase willingness on NEVs. Consumers in the areas with the restriction policy pay more attention to the preferential policy such as the free license-plate lottery, while the ones in the areas without the restriction policy care more about the financial subsidy from the government. This suggests that the restriction policy, as a strong coordinating tool on consumers' psychology, makes it differ in the way of policy-oriented promotion for NEVs. Improving the response from consumers on political incentives can substantially help in speeding up the scale production and commercialization of NEVs [35]. In addition, noted from the high ranking factors such as the "availability of charging piles" in the survey, it is necessary to promote the cooperation between the government and NEV manufacturers to improve the related infrastructures, responding to the requirement from NEV drivers [33].

4.3. Publicity Strategies

The results in this study show that female and male respondents reveal different preferences in choosing NEVs; female respondents are more sensitive to brand awareness and public praise compared with male respondents. Psychological factors are likely to strongly influence women's purchase willingness. Therefore, manufacturers and dealers can carry out distinguished publicity strategies to recommend NEVs to female and male consumers according to their preferences. Advertising and publicity for NEVs should be different to meet the needs of men and women [35,36].

4.4. Technology Innovation

According to the results, consumers are more concerned about the advantages of driving NEVs compared to driving conventional vehicles, especially on technical aspects such as maximum speed and range. In general, male respondents in the survey scored higher for the performance of NEVs than female respondents, which indicates that men are more interested with the performance of NEVs and a deeper understanding. Accordingly, NEV designers should intensively work on improving the performance of NEVs and precisely launch the advertisement to male consumers [37].

4.5. Environmental Concern

Results in this study indicate that the concept of low-carbon and environmental improvement brought from using NEVs seems not to substantially affect consumer's purchase willingness to NEVs. However, if an environmental subsidy or tax is adopted in the future, environmental concern can be transferred into an economic incentive, so that more consumers will be aware of the public welfare problems and NEVs' social impact

on environmental protection. Strengthening the self-identity of driving NEVs as a kind of eco-driving will contribute to creating a social atmosphere for green purchasing and green consumption.

5. Conclusions

In recent years, promoting the usage of NEVs is thought to be an important way to reduce the energy consumption and emissions from the transportation sector. In order to promote NEV, the Chinese Government has issued many policies. Relevant research have attracted extensive attention from scholars at home and abroad. Most existing research focus on summarizing and analyzing the influence of current policies on consumers, but relatively few research analyze and evaluate policies from the perspective of the consumer purchasing intention. The main contribution of this study is to classify the factors that affect Chinese consumers when buying NEV, and highlight views on China's current policies on NEV through correlation analysis, difference analysis and principal component analysis of the questionnaire data with SPSS analysis [38].

This paper argues that economic factors, including sales price, energy consumption and maintenance cost and government subsidy, are indicated as having a strong impact on promoting the purchase of NEVs. Not only the price of NEVs, but also the annual household income is related to car purchase behavior suggesting that an appropriate pricing system is indispensable. As regards policy making, results from this study indicate a strong influence from the governmental policies on the consumers' purchase willingness on NEVs. Consumers in the areas with the restriction policy pay more attention to the preferential policy such as the free license-plate lottery, while the ones in the areas without the restriction policy care more about the financial subsidy from the government. Publicity strategies, due to the results from this study, show that female and male respondents reveal different preferences in choosing NEVs; female respondents are more sensitive to brand awareness and public praise compared with male respondents. Technology innovation, according to the results, shows that consumers are more concerned about the advantages of driving NEVs compared to driving conventional vehicles, especially on technical aspects such as maximum speed and range. For environmental concerns, results in this study indicate that the concept of low-carbon and environmental improvement brought from using NEVs seems not substantially to affect consumer's purchase willingness to NEVs.

This paper provides a new analytical framework on evaluating the influencing factors towards popularizing NEVs. This paper also finds that when formulating policies related to new-energy vehicles, the government should consider whether to lift the restrictions on the purchase of new-energy vehicles in regions with and without restrictions. Different financial subsidies for vehicles purchases will be established for regions with and without policies, and targeted policies will be implemented for different regions. This will enable manufacturers to promote new-energy vehicles in accordance with policies, provide discounts that meet consumers' preferences in different regions and break the psychological impact of policies on consumers' consumption. However, this framework can be further improved in future studies. For example, although this study identified the key influencing factors to the consumers' purchase willingness towards NEVs, the correlation between the purchase willingness and the comprehensive benefits, including economic, social and environmental benefits, is not clear. Future studies can explore the complex interaction between the purchase willingness towards NEVs and the total benefits mentioned above, so as to help formulate a reasonable and attractive pricing system for popularizing NEVs. With more closed and appropriate collaboration with policy and subsidy systems, NEVs are expected to be more popular, which will help in reducing the fossil energy consumption and environmental pollutions from car use.

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References

- China Electric Power Equipment Network (CEPEN). Situation Analysis of Clean Energy Generation of China. Available online: <http://www.cceep.com/news/20680.html> (accessed on 10 June 2023).
- Li, Y.; Zhang, Q.; Liu, B.; McLellan, B.; Gao, Y.; Tang, Y. Substitution Effect of New-Energy Vehicle Credit Program and Corporate Average Fuel Consumption Regulation for Green-car Subsidy. *Energy* **2018**, *152*, 223–236. [\[CrossRef\]](#)
- Michalek, J.J.; Chester, M.; Samaras, C. Getting the most out of electric vehicle subsidies. *Issues Sci. Technol.* **2012**, *28*, 25–27.
- Gecan, R. *Effects of Federal Tax Credits for the Purchase of Electric Vehicles*; Reports; Congressional Budget Office: Washington, DC, USA, 2012; pp. 134–139.
- British Petroleum, BP Statistical Review of World Energy. 2014. Available online: www.bp.com (accessed on 10 June 2023).
- Duggal, D.; Shitole, M.V. An analytical study on customers buying behavior towards electric cars in Mumbai region. *Online J. Distance Educ. E-Learn.* **2023**, *11*, 129–136.
- Turoń, K. Multi-Criteria Analysis of the Selection of Vehicles with Electric, Hybrid, and Conventional Drive for Car-Sharing Services from the Perspective of Polish Occasional System Users. *Energies* **2022**, *15*, 9027. [\[CrossRef\]](#)
- Batlle, C. A method for allocating renewable energy source subsidies among final energy consumers. *Energy Policy* **2011**, *39*, 2586–2595. [\[CrossRef\]](#)
- Weiller, C.; Neely, A. *Business Models for Electric Vehicles: Lessons from the Japanese EV Ecosystem*; Springer International Publishing: Cham, Switzerland, 2014; pp. 197–213. [\[CrossRef\]](#)
- Ou, S.; Lin, Z.; Qi, L.; Li, J.; He, X.; Przesmitzki, S. The dual-credit policy: Quantifying the policy impact on plug-in electric vehicle sales and industry profits in China. *Energy Policy* **2018**, *121*, 597–610. [\[CrossRef\]](#)
- Du, H.; Liu, D.; Benjamin, K.; Wang, Y.; Ma, S.; Rita, Y. Who buys New Energy Vehicles in China? Assessing social psychological predictors of purchasing awareness, intention, and policy. *Transp. Res. Part F* **2018**, *58*, 56–69. [\[CrossRef\]](#)
- Cherry, C.R. *Electric Two-Wheelers in China: Analysis of Environmental, Safety, and Mobility Impacts*; Institute of Transportation Studies Dissertation: Los Angeles, CA, USA, 2007.
- Mackay, D.J.C.; Hafemeister, D. Sustainable Energy-Without the Hot Air. *Am. J. Phys.* **2010**, *78*, 222–223.
- Ma, L.; Zhong, W.; Mei, S. An innovative research on subsidy policies in new energy automotive industry under the background of “supply-front reform”. *Syst. Eng.-Theory Pract.* **2017**, *37*, 2279–2288.
- Nesamani, K. Estimation of automobile emissions and control strategies in India. *Sci. Total. Environ.* **2010**, *408*, 1800–1811. [\[CrossRef\]](#)
- EPA & NHTSA. Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022–2025. Available online: <https://www.epa.gov/regulations-emissions-vehicles-and-engines/midterm-evaluation-light-duty-vehicle-greenhouse-gas> (accessed on 10 June 2023).
- Tang, Y.; Zhang, Q.; Li, Y.; Wang, G.; Li, Y. Recycling Mechanisms and Policy Suggestions for Spent Electric Vehicles’ Power Battery—A Case of Beijing. *J. Clean. Prod.* **2018**, *186*, 388–406. [\[CrossRef\]](#)
- Dhameja, S. *Electric Vehicle Battery Systems*; Newnes: New York, NY, USA, 2002.
- Mao, J.S.; Lu, Z.W. Study on the resource efficiency of lead for China. *Res. Environ. Sci.* **2004**, *17*, 78–80.
- Zhang, X. Reference-dependent electric vehicle production strategy considering subsidies and consumer trade-offs. *Energy Policy* **2014**, *67*, 422–430. [\[CrossRef\]](#)
- iCET. *Annual Report on Passenger Car Corporate Average Fuel Consumption in China*; Innovation Center for Energy and Transportation: Beijing, China, 2017.
- Wang, S.; Zhao, F.; Liu, Z.; Hao, H. Impacts of a super credit policy on electric vehicle penetration and compliance with China’s Corporate Average Fuel Consumption regulation. *Energy* **2018**, *155*, 746–762. [\[CrossRef\]](#)
- Joseph Room. *Reviewing the Hydrogen Fueland Freedom CAR Initiatives, The Hype about Hydrogen*; Island Press: Washington, DC, USA, 2004.
- Dalmazzone, S.; La Notte, A. Multi-scale environmental accounting: Methodological lessons from the application of NAMEA at sub-national levels. *J. Environ. Manag.* **2013**, *130*, 405–416. [\[CrossRef\]](#) [\[PubMed\]](#)
- Mensink, C. Validation of Urban Emission Inventories. *Environ. Monit. Assess.* **2000**, *65*, 31–39. [\[CrossRef\]](#)

26. Kendall, K.; Kendall, M.; Liang, B.; Liu, Z. Hydrogen vehicles in China: Replacing the Western Model. *Int. J. Hydrog. Energy* **2017**, *42*, 30179–30185. [\[CrossRef\]](#)
27. Nykvist, B.; Nilsson, M. Rapidly falling costs of battery packs for electric vehicles. *Nat. Clim. Chang.* **2015**, *5*, 329–332. [\[CrossRef\]](#)
28. La Notte, A.; Tonin, S.; Lucaroni, G. Assessing direct and indirect emissions of greenhouse gases in road transportation, taking into account the role of uncertainty in the emissions inventory. *Environ. Impact Assess. Rev.* **2018**, *69*, 82–93. [\[CrossRef\]](#)
29. Vanholme, B.; Gruyer, D.; Lusetti, B.; Glaser, S.; Mammarr, S. Highly Automated Driving on Highways Based on Legal Safety. *IEEE Trans. Intell. Transp. Syst.* **2012**, *14*, 333–347. [\[CrossRef\]](#)
30. Marique, A.-F.; Reiter, S. A method for evaluating transport energy consumption in suburban areas. *Environ. Impact Assess. Rev.* **2012**, *33*, 1–6. [\[CrossRef\]](#)
31. Chen, F.; Sui, J. Collaborative innovation and evolution of emerging industries: A case study of new energy vehicle. *J. Sci. Res. Manag.* **2015**, *36*, 26–32. (In Chinese)
32. Wang, H.; Zhang, X.; Ouyang, M. Energy consumption of electric vehicles based on real-world driving patterns: A case study of Beijing. *Appl. Energy* **2015**, *157*, 710–719. [\[CrossRef\]](#)
33. Paul, D.; Larson Jairo, V.; Robert, V.; Parsons, A. Consumer attitudes about electric cars: Pricing analysis and policy implications. *Transp. Res. Part A Policy Pract.* **2014**, *69*, 299–314.
34. Liu, Z.; Hao, H.; Cheng, X.; Zhao, F. Critical issues of energy efficient and new energy vehicles development in China. *Energy Policy* **2018**, *115*, 92–97. [\[CrossRef\]](#)
35. Saunders, M.J.; Kuhnimhof, T.; Chlond, B.; da Silva, A.N.R. Incorporating transport energy into urban planning. *Transp. Res. Transp. Res. Part A Policy Pract.* **2008**, *42*, 874–882. [\[CrossRef\]](#)
36. Rachel, M.; Sanya, R.; Bradley, W.; John, D. Perception and reality: Public knowledge of plug-in electric vehicles in 21 U.S. cities. *Energy Policy* **2013**, *63*, 433–440.
37. Muniz, I.; Galindo, A. Urban form and the ecological footprint of commuting. The case of Barcelona. *Ecol. Econ.* **2005**, *55*, 499–514. [\[CrossRef\]](#)
38. Li, W.; Long, R.; Chen, H. Consumers' evaluation of national new energy vehicle policy in China: An analysis based on a four paradigm model. *Energy Policy* **2016**, *99*, 33–41. [\[CrossRef\]](#)

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