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Research on Consumers' Use Willingness and Opinions of Electric Vehicle Sharing: An Empirical Study in Shanghai

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Abstract: An empirical study in Shanghai was performed to explore consumers' use willingness and opinions on electric vehicle sharing (EVS) to help operators effectively operate and expand the new business model. Through the multinomial logistic regression developed for different groups, the results show that the factors of the main trip mode in daily use, monthly transportation expenditure, driving range of electric vehicles, gender, age, marital status and occupation have significant influences on consumers' use willingness. In short, the population characteristics of people choosing to use EVS are male, aged between 18 and 30 and usually taking the subway and bus as the daily transportation modes. Otherwise, the factors of the acceptable highest price of EVS, occupation and personal monthly income have significant impacts on the use willingness of people who keep a neutral stance. These people pay more attention to convenience and the economy of EVS. These results reveal that a reasonable price, accurate positioning of target groups, convenient site layout and usage are required for operators to successfully launch a new transportation mode of EVS.

Keywords: electric vehicle sharing; multinomial logistic regression; survey; use willingness

1. Introduction

Research indicates that electric vehicles are not only able to decrease vehicle emissions [1] and slow global warming [2], but also are able to enhance the sustainability of road traffic in the future [3]. With energy, environment and other issues becoming increasingly prominent, many countries began to realize the importance of environmentally-friendly electric vehicles. Most manufacturers also have started to develop and commercialize environmentally-friendly electric vehicles [4]. However, electric vehicles are currently limited by insufficient charging infrastructures and driving mileage (the longest driving range per battery charge). Considering that car sharing is more suitable for people's short-term travel demands, the combination of electric vehicles and car sharing is a good way to avoid these weaknesses and to provide a cleaner transport mode.

Certain cities in the world, such as Barcelona, Paris, Berlin, Hamburg, Rotterdam and Stockholm, are implementing electric vehicle sharing (EVS) [5]. In China, EVS is still in the initial development phase. China Car Club in Hangzhou and Eduoauto in Beijing are the pioneers for developing EVS. China Car Club was invested in by Intunecapital in early 2013, and it is based on the model of self-purchasing cars. Eduoauto is based on the model of light assets, and the operational vehicles are mainly provided by enterprises qualified for car rental, not bought by the company itself. eHi Car Services launched a pilot EVS program in Jading district of Shanghai in June 2013, but the progress is very slow. At present, there are several EVS services, such as EVCARD hosted by Shanghai International Automobile City, YiKaZuChe in Beijing, Weigongjiao in Hangzhou, *etc.*

In recent years, governments have begun to attach more importance to EVS, which contributed to the rapid development of EVS. In July 2014, the General Office of the State Council in China released the No. 35 document of “Instructions on accelerating the promotion and application of new energy vehicles” [6], which emphasized the needs of “exploring innovative business models, such as the time-sharing leasing, car sharing, vehicle leasing, mortgage purchase for new energy vehicles, *etc.*”. The EVS program also has received support from the local governments. The Beijing Municipal Science and Technology Commission has listed EVS as a key supported project and set up many operational indicators. Other cities, such as Shanghai, Hangzhou, Shaoxing, Ningbo, Wuhan, Shenzhen, Yancheng, Chongqing, and so on, have launched or are actively ready to launch an EVS program.

From the analysis above, it can be known that the number of EVS enterprises operating is few, and most of them lack experience. With the support from the government, there will be more and more domestic companies involved in EVS in the next few foreseeable years. Nevertheless, how consumers think about EVS, whether they will use the service and their related preference are still unclear. Therefore, in order to promote all-round development of EVS and to help the enterprises achieve better operation, a questionnaire was designed to collect information about the acceptance of consumers and influencing factors for using EVS. Some suggestions are provided for EVS operators to promote its rapid development in China.

2. Literature Review

In the late 1980s, a preliminary model of car sharing appeared abroad. However, scholars started to research car sharing in the 1990s. At the beginning of the research, most studies were at the qualitative level, and scholars paid more attention to the feasibility of the car sharing model and consumer usage. Based on a large number of empirical studies, Meijkamp [7] in The Netherlands pointed out that car sharing as an alternative to private cars, because it had higher economic and ecological efficiency. Barth and Shaheen [8] had an opinion that car sharing could improve the traffic efficiency by reducing the number of private cars and improve the efficiency of energy and emissions. They also introduced a variety of car sharing systems and described the development prospect of car sharing in China. Prettenthaler and Steininger [9] researched how driving mileage influenced the car sharing users to make decisions. Results showed that using car sharing was better than using private cars when user’s travel range was less than 18,000 km per year. However, if insurance and the vehicle depreciation rate are taken into account, the balanced driving distance of users decreased to 15,000 km. Seik [10] studied car sharing in Singapore and found that members still mainly used public transport for travelling to work after attaining membership, but turned more often to shared cars rather than public transport for marginal uses, such as leisure and social trips. Most of them chose car sharing for its marginal use and cost savings.

Entering the 21st century, foreign scholars gradually began to study the operation system of car sharing, the optimization of staff, site layout, vehicle allocation, *etc.*, from the quantitative perspective. Barth and Todd [11] used a computer to simulate the distribution of available vehicles and energy consumption in car sharing sites. Results showed that the influencing factors of the car sharing system were the proportion of demand, the charging strategy for the electric vehicles and the vehicle allocation algorithm. The main problems of the car sharing service that should be considered at the beginning of the establishment were service pricing, target customer selection, vehicle type selection, site location, *etc.* [12]. Xu and Lim [13] established a mathematical model for the vehicles sharing site layout in Singapore and used the improved neural network model to predict the car sharing net flows. Kek *et al.* [14] provided a three-stage decision optimization model for the car sharing operator. They analyzed the optimal distribution of staff and vehicles and used operational data from the Singapore sharing company to verify the model. Correia and Antunes [15] had studied the problem of car sharing site planning. Under the goal of maximizing the profit for the car sharing operating company, they established a mixed integer programming model to solve the unbalanced number of sharing cars between different sites.

At present, there are few research works on EVS abroad, and most of them focus on operating status analysis and consumer surveys. Quantitative studies on EVS are rare. Alessandro *et al.* [16] introduced the EVS project of Green Move and studied the shared service strategies and objectives. By investigating the feasibility of EVS as a private car for elderly, Shaheen *et al.* [17] found that 30% of respondents were interested in participating, but all participants would make a plan before they would use the car, indicating that EVS still has the range anxiety problem. This problem is caused by the limited driving range of electric vehicles. Using data from 533 members of the EVS program in Seoul, Kim *et al.* [18] found that the participants were rather reluctant to change their car ownership, but had intentions to continue participating in the program. Social and economic perspectives were the most important factors affecting the participants' attitudes. In addition, the attitudes varied depending on personal characteristics, such as gender, age and income.

Domestic research progress on the car sharing model is relatively late. In 2000, Huang and Yang [19] were the first to research car sharing and introduced its development history abroad. They summarized the benefits of this new public transport pattern, the impact on travel behavior and its possible target market (people who have no private cars or have a high cost of ownership). Market demand, quality of service and advanced public transportation are important factors for successful car sharing. Ye and Yang [20] summarized and introduced the concept, development status and influence of car sharing. They also explained its characteristics (low-cost, flexible) and target group (replacement selection for people who wanted to buy a second car). Gao [21] explained the concept of "shared car" in detail and presented the concept of "Auto Club". Its development prospect in China was also studied. Qiu [22] analyzed the key influencing factors for car sharing development in China. Results showed that educational level of respondents, number of owned private cars and convenience of EVS had impacts on consumers' use willingness. Xue *et al.* [23] combed the classification of car sharing and analyzed the impact of this service on car ownership, travel cost, usage cost, energy savings and emission reduction. Through an empirical study, they found that the target group of car sharing was people who are 25–40 years old and have an above average educational level. The model of Zipcar in the United States was studied by Wu [24]. He investigated the potential market of car sharing service in Guangzhou and demonstrated the significance of promoting car sharing. He pointed out that car sharing is very promising in China and will be an alternative to other means of transportation. By introducing the development of car sharing in Hanover, He [25] pointed out that a shared car could replace 6–10 private cars and radically reduce automobile usage. Xia *et al.* [26] had carried out empirical research on an informal car sharing service in Beijing from the perspective of economic and ecological efficiency. They suggested that the government should regulate such an industry and formulate relevant policies to support the development of shared services.

From the analysis above, it is obvious that domestic research on EVS is very small in quantity. More studies are focused on the operating model description, case analysis and the prospect forecast of traditional vehicle sharing. From the perspective of operators, a questionnaire was implemented in Shanghai to find factors affecting consumers' use willingness of electric vehicle sharing, including travel characteristics, expectation of EVS and socio-demographics and then proposed corresponding suggestions for station location, driving range choice and model selection for EVS. At the same time, the target group and potential market in Shanghai for using EVS were pointed out. This will help the operations of enterprises effectively.

3. Research Method

3.1. Questionnaire Design

The paper questionnaire was implemented and disseminated offline. Through this, we have learned comprehensive knowledge about EVS acceptance. Finally, the target population of EVS was pointed out by analysis.

The questionnaire was divided into three parts. The first part has three questions about travel characteristics, including main trip mode in daily use, factors considered when choosing the trip mode and monthly transportation expenditure. Based on a simple explanation of EVS, the second part was questions about the expectations of EVS, including the use willingness, the attractive point for the respondent, the suitable usage scenario, *etc.* The last part was personal information, including gender, age, occupation, educational level, marital status, personal monthly income, *etc.* The whole questionnaire was designed as shown in Table 1.

Table 1. The designed questionnaire for investigation. EVS, electric vehicle sharing.

	Variable	Description
Travel characteristics	Main trip mode in daily use	Subway, bus, private car, taxi, walking, bicycle, motorcycle/scooter riders
	Factors considered when choosing the trip mode	Time, expenditure, weather condition, degree of comfort, travel distance, travel purpose, body condition, others
	Monthly transportation expenditure	≤100 yuan, 101–200 yuan, 201–300 yuan, 301–400 yuan, ≥401 yuan
Expectation of EVS	Whether to choose EVS	Will choose, keep neutral stance, will not choose
	Attractive points of using EVS	Convenient appointment, cost-effective, shorter distance, parking space saving, no overhead cost, others
	Suitable usage scenario of EVS	Work, school, shopping, entertainment, seeing a doctor, visiting relatives or friends, individual business, work business, others
	Suitable vehicle type for EVS	Mini car, small car, compact car, midsize car, medium and large size car, luxury car, SUV, MPV (multi-purpose vehicles), microvan
	Acceptable minimum driving range of EV	Not less than 50 km, not less than 80 km, not less than 120 km, not less than 150 km, not less than 200 km, not less than 250 km, not less than 300 km, not less than 350 km
	Acceptable maximum duration for going to stations	Time for walking is 5 min, time for walking is 10 min, time for walking is 15 min
	Acceptable maximum duration for waiting and handling procedure	5 min, 10 min, 15 min
	Acceptable highest price of EVS	30 yuan/month + 60 yuan/h, 30 yuan/month + 40 yuan/h, 30 yuan/month + 20 yuan/h
	Gender	Male, female
	Age	Under 18, 18–25, 26–30, 31–40, 41–50, above 50
Socio-demographics	Number of owned private cars	None, one, not less than two
	Marital status	Single, married, but have no child, married and have kids
	Educational level	Junior high school and the following: senior high school, junior college, Bachelor's, Master's and above
	Occupation	Party and government cadre/teacher/police, clerk, business owner/shareholder, <i>etc.</i> , technician, worker/server, company management personnel, freelancer, retired staff/student
	Personal monthly income	Under 1000 yuan, 1000–3000 yuan, 3001–6000 yuan, 6001–10,000 yuan, 10,001–15,000 yuan, above 15,001 yuan, no fixed income

* The black bold items are reference categories used in the multinomial logistic regression model.

3.2. Data Collection

From May 2014–November 2014, 410 respondents participated in the survey. As is known to all, EVS is more convenient than bus, more predictable and accurate than taxi and more economical than private cars. For the above reasons, EVS will replace part of the public and private transportation in

the future. Therefore, the investigation object should be universal to balance people with different characteristics. Choosing residents in Shanghai as the main investigation object, questionnaires were distributed randomly at railway stations, commercial shopping centers, bus stop waiting areas, public squares, university areas, and so on. According to the standard that the number of answers for one questionnaire should be not less than half, 394 effective questionnaires were received.

3.3. Model Formulation

In this paper, choice willingness for EVS (“will not choose” is coded as 1, “keeping neutral” as 2, “will choose” as 3) is the dependent variable, which is ordinal. Ordinal regression was used, and a test of the parallel lines was done to check whether the method was appropriate. According to the research of Zhang [27] and Li *et al.*, [28], when the value of P for the test of parallel lines is far less than 0.05, this indicates that the ordinal regression is not appropriate, and multinomial logistic regression should be used. As shown in Table 2, the value of significance (Sig.) is 0.001, which is far less than 0.05. Therefore, multinomial logistic regression is used in this paper, finally.

Table 2. Test of parallel lines.

Model	−2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	667.011			
General	579.259	87.751	51	0.001

The multinomial logistic regression model is often used to handle the case where the dependent variable has several classified categories ($N > 2$). During the process, the model will choose one category of dependent variable as the reference category to establish the general logits models. Furthermore, if the dependent variable Y is coded 0, 1 or 2 and using $Y = 0$ as the baseline, the probabilities of each dependent variable category [29] are:

$$P(Y = 0) = \frac{1}{1 + e^{g_1(x)} + e^{g_2(x)}} \quad (1)$$

$$P(Y = 1) = \frac{e^{g_1(x)}}{1 + e^{g_1(x)} + e^{g_2(x)}} \quad (2)$$

$$P(Y = 2) = \frac{e^{g_2(x)}}{1 + e^{g_1(x)} + e^{g_2(x)}} \quad (3)$$

where:

$$g_1(x) = \text{logit} \frac{P(Y = 1)}{P(Y = 0)} = \beta_{10} + \beta_{11}x_1 + \dots + \beta_{1p}x_p \quad (4)$$

$$g_2(x) = \text{logit} \frac{P(Y = 2)}{P(Y = 0)} = \beta_{20} + \beta_{21}x_1 + \dots + \beta_{2p}x_p \quad (5)$$

where $\beta_{10}, \beta_{11}, \beta_{1p}, \dots, \beta_{2p}$ are coefficients for the logistic regression model, which can be obtained by using SPSS software.

4. Analysis Results

4.1. Descriptive Statistics

4.1.1. Demographic Variable

Table 3 illustrates the demographic characteristics of respondents. As shown in Table 3, most respondents are male (61.6%), which is higher than the proportion of women. The main age groups are 20s and 30s, which should be the major groups for using EVS. Forty one-point-seven percent of

respondents are single, and the percentage of married having kids is 37.6%. Fifty eight-point-six percent of people have private cars, and 7.9% of them even have two or more cars. Most respondents (68.3%) had a Bachelor's degree or above. The monthly income is mainly concentrated in 3001–10,000 yuan (49.1%), and more than 15,000 yuan or below 1000 yuan are the least, which accords with the research. The distribution of the occupation is relatively balanced overall. Ordinary staff and technical staff account for 20.2%, respectively.

Table 3. Descriptive statistics for the demographic characteristics of respondents.

Variable	Description	Percentage
Gender	Male	61.6%
	Female	38.4%
Age	Under 18	1.5%
	18–25	28.1%
	26–30	30%
	31–40	24.6%
	41–50	8.4%
	Above 50	5.4%
Number of owned private cars	None	41.4%
	One	50.7%
	Not less than two	7.9%
Marital status	Single	41.7%
	Married, but have no child	20.7%
	Married and have kids	37.6%
Educational level	Junior high school and the following:	3.6%
	Senior high school	10.2%
	Junior college	17.9%
	Bachelor's	49.1%
	Master's and above	19.2%
Occupation	Party and government cadre/teacher/police	7.2%
	Clerk	20.2%
	Business owner/shareholder, etc.	4.3%
	Technician	20.2%
	Worker/server	5.4%
	Company management personnel	7.9%
	Freelancer	5.4%
	Retired staff/student	29.4%
Personal monthly income	Under 1000 yuan	5.3%
	1000–3000 yuan	18.5%
	3001–6000 yuan	26.6%
	6001–10,000 yuan	24.0%
	10,001–15,000 yuan	10.6%
	Above 15,001 yuan	6.6%
	No fixed income	8.4%

4.1.2. Travel Characteristics

As shown in Figure 1, 83.5% of percipients have a monthly transportation expenditure within 300 yuan. The percentage spending more than 400 yuan monthly is only 10.4%. In the aspect of factors considered when choosing the trip mode, most respondents consider time primarily. The secondary is travel purpose, and cost is the least considerable factor (Figure 2). The above result conforms to the normal situation that residents in big cities consider travel time, cost, convenience, safety and comfort when they choose the trip mode [30].

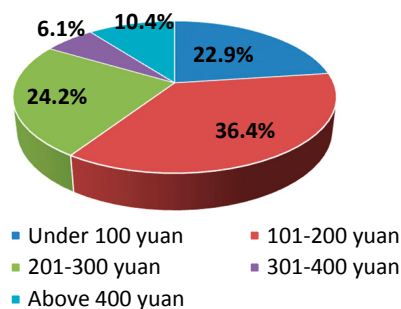


Figure 1. Distribution of monthly transportation expenditure.

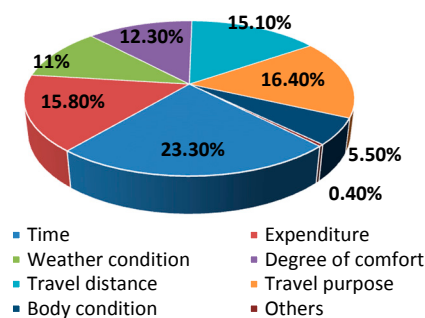


Figure 2. Factors considered when choosing the trip mode.

4.1.3. Expectations for EVS

With assistance from the investigators, respondents had preliminarily knowledge of EVS. The percentage of people who chose to use EVS is 42.4%. About 27% of people kept a neutral stance, which means quite a few people still maintain a wait-and-see attitude towards new things. This will be a customer resource to pursue during the development of EVS in the near future. The distribution of use willingness is shown as Figure 3.

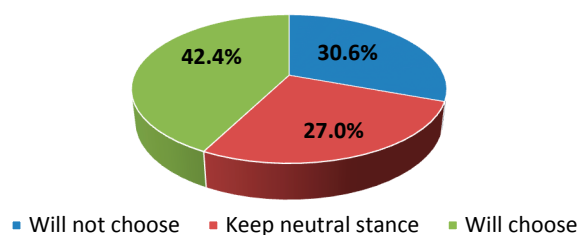


Figure 3. Whether to choose EVS.

When the respondents were asked about the attractiveness of EVS, their opinions were rather dispersed. More respondents selected the options of “the appointment and self-help picking cars are convenient and efficient”, “it charges by hour and that is more cost-effective than renting for one day” and “it is more flexible than leasing and has no overhead costs” (as shown in Figure 4). It can be concluded that most consumers pay more attention to the convenience and economic benefits of the EVS service. Therefore, the service price should be as low as possible to offer consumers a chance to experience its economy and convenience, thus enlarging customer population.

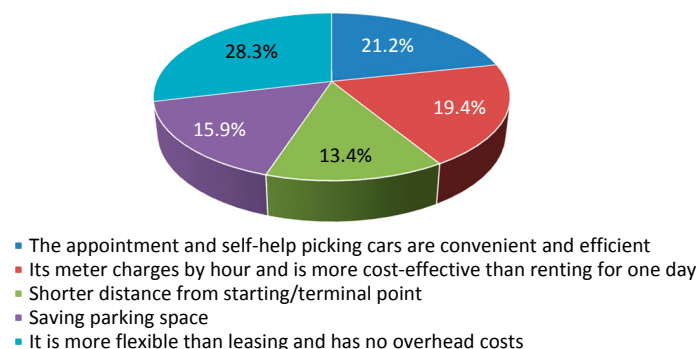


Figure 4. Attractive points of using EVS.

When the respondents were asked about the suitable usage scenario of EVS, the two options that had the largest proportions are shopping and entertainment, with percentages of 22.1% and 23.8%, respectively (Figure 5). As a result, stations for EVS can be deployed around shopping malls, entertainment and leisure centers, so it can be convenient for users to rent and return vehicles.

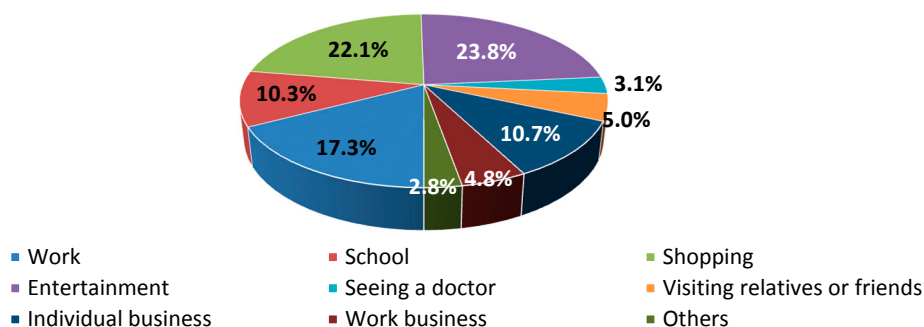


Figure 5. Suitable usage scenario of EVS.

For the question of suitable vehicle type for EVS, respondents said that compact, small or mini cars would be more suitable. Cars of the A0 segment (small cars) accounted for the highest percentage of 27.2%. Respondents also preferred compact cars and mini cars (Figure 6). This also suggests that EVS is mainly used to meet people's needs for daily short-distance flexible transportation, and their demand for space is small.

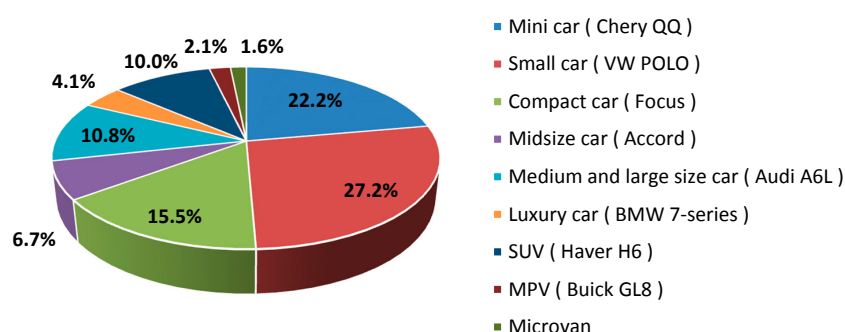


Figure 6. Suitable vehicle types for EVS.

When asked about the acceptable minimum driving range of electric vehicles, 26.8% of respondents held the opinion that it should not be less than 150 km, as shown in Figure 7. The sum of percentages for "not less than 50 km", "not less than 80 km", "not less than 120 km" and "not less

than 150 km" is 79.2%. A deep travel behavior investigation was done in 2014 with 67 residents in Shanghai. All travel behaviors were recorded for 14 days, including trip mode, time, distance, *etc.* The results show that the average travel distance for a single trip is 15.8 km, and the average daily travel range is 33.8 km, which is far lower than what the mainstream models on the market can offer. Another research work showed that when consumers were asked about the driving range for private electric vehicles, 35.8% of them responded that it should be between 120 km and 160 km [31]. Thus, it can be seen that most participants have higher tolerance towards the driving range of shared electric vehicles than private ones.

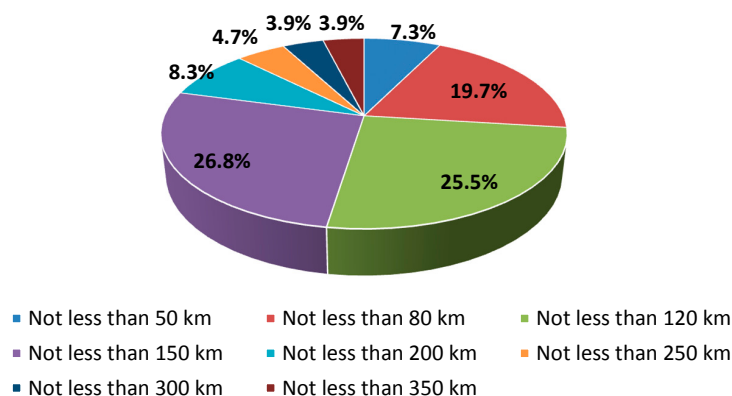


Figure 7. Acceptable minimum driving range of EV.

4.2. Statistics in Cross Tabulation Table

Figure 8 indicates that the number of owned private cars has an impact on the willingness to use EVS.

(1) With an increase in the number of owned private cars, the ratio of people who are willing to use the service shows a declining trend soon after rising. That is to say, the EVS acceptance of people in possession of only one private car is higher than that of people who do not have or have more than one private car. The reasons for this phenomenon may be that: (i) people in possession of private cars have more driving experience, and it is easier for them to accept a new transportation pattern; (ii) the EVS is a new type of transportation, and even the people who have a private car want to experience this new transportation system; (iii) because of severe traffic jams during rush hour, parking difficulty and high parking fees, a car owner is more willing to choose EVS as a method for short trips; (iv) the economic environment of people who have two or more private cars is better, and they tend not to consider whether the means of travel is economical. Compared to people who only have one car, reducing their usage willingness is also reasonable. At the same time, it also indicates that the target group of EVS is not only the people who have no private cars.

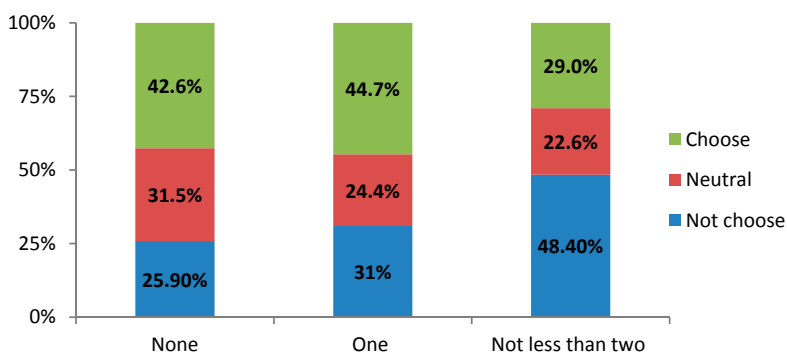


Figure 8. The relationship between willingness and the number of owned private cars.

(2) Along with the increase of owned private cars, people's attitude towards whether to adopt EVS becomes clearer. The ratio of keeping neutral decreases.

4.3. Multinomial Logistic Regression for the Target Group

In this paper, the dependent variable is the choice willingness for EVS ("will not choose" is coded as one, "keeping neutral" as two, "will choose" as three). In order to define the target group of EVS, multinomial logistic regression was used. Independent variables were selected from three aspects: (1) travel characteristics (including main trip mode in daily use and monthly transportation expenditure), (2) expectations for EVS (including acceptable minimum driving range of the EV, acceptable maximum duration for going to stations, acceptable maximum duration for the waiting and handling procedure and acceptable highest price of EVS) and (3) demographic characteristics (including gender, age, number of owned private cars, marital status, educational level, occupation and personal monthly income).

4.3.1. Model Fitting Test

SPSS20.0 was used to analyze the questionnaires, and Table 4 shows the likelihood ratio test for the final model and the intercept-only model. Here, the value of chi-squared is equal to the difference value between the $-2 \log$ likelihood in the intercept-only model and the final model. The significance level of the chi-squared test was 0.001, which is far less than 0.05. Therefore, the final model is superior to the intercept-only model, which means that the final model is established, and the fitting effect is significantly good. The indexes of Cox and Snell R-squares, Nagelkerke R-squared and McFadden R-squared were used to test the explainable degree of the equations on the variation of the explained variables. The bigger the R-squared is, the better the goodness of fit is. The value of these three indexes are 0.353, 0.400 and 0.204, and they indicate that independent variables can explain 35.3%, 40% and 20.4% of the variation of the explained variables. Although the three R-squared values are not very high, the result is acceptable.

Table 4. Model fitting information.

Model	Model Fitting Criteria	Likelihood Ratio Tests			R ²	
	$-2 \log$ likelihood	Chi-square	Sig.	Cox and Snell	Nagelkerke	McFadden
Intercept-only	762.673	-	-	-	-	-
Final	607.323	155.350	0.001	0.353	0.400	0.204

4.3.2. Coefficient Test of Variables

Table 5 shows the likelihood-ratio test in the final model for each independent variable. Through the statistical results, it can be seen that main trip mode in daily use, monthly transportation expenditure, acceptable minimum driving range of the EV, acceptable highest price of EVS, age and marital status have significant influences on the willingness to use EVS when the significance level is 0.1 [18]. People who usually take the subway or bus for daily transportation have a strong willingness to use EVS. People with a high monthly transportation expenditure are more likely to pursue the economical mode of EVS. Marital status often decides whether the respondents need to buy private cars, and this has a great impact on the decision to use the EVS service. The driving range of EV affects respondents' decisions of whether to choose the shared service instead of other modes of transportation. Respondents aged between 20 and 40 years old show a stronger receptivity to new things and the concept that they must have private cars is weaker. This makes them more willing to use the EVS service.

Table 5. Likelihood ratio test.

Effect	Model Fitting Criteria	Likelihood Ratio Tests	
	−2 log likelihood of reduced model	Chi-square	Sig.
Intercept	607.323 ^a	0.000	0.000
Main trip mode in daily use	632.206	24.883	0.015
Monthly transportation expenditure	631.696	24.373	0.002
Acceptable minimum driving range of EV	638.755	31.432	0.005
Acceptable maximum duration for going to stations	611.525	4.202	0.379
Acceptable maximum duration for waiting and handling procedure	612.404	5.081	0.279
Acceptable highest price of EVS	615.445	8.122	0.087
Gender	611.914	4.591	0.101
Age	633.589	26.266	0.003
Number of owned private cars	610.889	3.566	0.468
Marital status	624.302	16.979	0.002
Educational level	620.193	12.870	0.116
Occupation	624.859	17.536	0.229
Personal monthly income	621.654	14.331	0.280

^a The ellipsis effect does not increase the degree of freedom. As a result, the simplified model is equal to the final model.

4.3.3. Parameter Estimation Results

Tables 5 and 6 show the parameter estimation results of different groups. The reference category for the dependent variable is choose not to use. The reference categories for the independent variables are in black bold, as shown in Table 1.

If the estimated coefficient of a factor (B) is significantly positive, then the probability of this factor belonging to the current category level is higher than the probability of it belonging to the reference category, with all of the other factors being fixed [32].

Estimated Model Results of the Choose to Use Group

As shown in Table 6, the factors of main trip mode in daily use, monthly transportation expenditure, driving range of electric vehicles, gender, age, marital status and occupation are statistically significant. The following is a detailed analysis of these results. (1) People who usually take the subway, bus or bike are more willing to use EVS. (2) With the increase of monthly transportation expenditure, its regression coefficient changes from negative to positive, which indicates that the higher the monthly transportation expenditure is, the more consumers prefer to choose EVS. (3) The driving range of electric vehicles has a significant influence on consumers' willingness to use EVS, with a negative coefficient. The absolute value of the coefficient increases as the driving range of electric vehicles increases, indicating that when the driving range of electric vehicles is higher, more consumers tend not to use EVS services. This result conflicts with previous expectations. The reasons may be that EVS is designed to provide a short commute for people, and the driving range of general electric vehicles has been able to meet that demand. The total cost of the operator increases as the driving range of electric vehicles increases, and then, the single use price for EVS may increase. For reasons of travel economy, consumers are more reluctant to use this business. It should be pointed out that the front reason is just guesswork; further research is required to give more information and to find out the cause. (4) Gender is significant to consumers' use willingness, with the probability ratio of male being 2.081-times higher than that of female. This means that males are more willing to use EVS than females. (5) Age has a significant influence on consumers' choices, and the coefficient is positive. The absolute value of the coefficient decreases as the age increases, which indicates that consumers' use willingness of EVS will be reduced as the age increases. People who are aged between 18 and 30 have the strongest use willingness. The reasons may be that this group is at the beginning of economic independence and usually pursue economic and effective ways to travel, and their receptivity to new modes of transportation is better. (6) Marital status

is significant with a negative coefficient, indicating that the use willingness of unmarried people is lower than that of married people. This may controvert the former expectations. However, through the former analysis, the results can be obtained that people who own private cars have a stronger use willingness than people having no cars (that can be found in Figure 8). In this investigation, 73.2% of participants having private cars are married. Therefore, the use willingness of married people being higher than that of unmarried people is understandable. From the analysis above, the population characteristics of people choosing to use EVS are male, aged between 18 and 30, and usually taking the subway and bus as the daily transportation modes.

Table 6. Parameter estimation results: choose to use.

Independent Variables	B	Wald	Sig.	Exp(B)
Intercept	−2.283	1.437	0.231	
[Main trip mode in daily use = 1]: subway	1.705	2.870	0.090	5.499
[Main trip mode in daily use = 2]: bus	2.016	3.750	0.053	7.508
[Main trip mode in daily use = 6]: bicycle	3.226	7.190	0.007	25.173
[Monthly transportation expenditure = 1]: 0–100 yuan	−1.260	3.092	0.079	0.284
[Monthly transportation expenditure = 4]: 301–400 yuan	1.606	3.593	0.058	4.981
[Minimum driving range of EV = 4]: not less than 150 km	−1.882	3.523	0.061	0.152
[Minimum driving range of EV = 6]: not less than 250 km	−2.564	4.403	0.036	0.077
[Minimum driving range of EV = 7]: not less than 300 km	−4.939	12.600	0.000	0.007
[Gender = 1]: male	0.733	4.517	0.034	2.081
[Age = 2]: 18–25 years old	3.571	10.951	0.001	35.556
[Age = 3]: 26–30 years old	2.194	4.545	0.033	8.969
[Marital status = 1]: single	−2.289	11.271	0.001	0.101
[Occupation = 3]: business owner/shareholder, etc.	2.154	4.159	0.041	8.619

Estimated Model Results of the Choose to Remain Neutral Group

As shown in Table 7, the factors of acceptable highest price of EVS, occupation and personal monthly income have significant impacts on the use willingness of people who keep a neutral stance. The detailed analysis is as follows. (1) The acceptable highest price of EVS is significant to consumers' use willingness with a negative coefficient, indicating that the increasing service price could reduce consumers' willingness to use it. (2) Business owners/shareholders hold a neutral opinion about the EVS service. This may relate to their existing economic and social status, etc. These people have better living conditions, and they may not need this service to save money or improve travel conditions. (3) The probability of keeping neutral is higher than that of not choosing, which indicates that the exclusion effect of people with lower average monthly income for EVS is reduced. From the analysis above, people who keep a neutral stance have lower personal monthly income. If we want to encourage these people to change their existing attitude to use the EVS, a reasonable price should be offered to attract them to join in on the premise of guaranteeing profits.

Table 7. Parameter estimation results: choose to remain neutral.

Independent Variables	B	Wald	Sig.	Exp(B)
Intercept	−2.888	1.743	0.187	
[Acceptable highest price of EVS = 1]: 30 yuan/month + 60 yuan/h	−0.829	2.864	0.091	0.436
[Occupation = 3]: business owner/shareholder, etc.	1.887	2.924	0.087	6.598
[Personal monthly income = 1]: below 1000 yuan	2.348	4.402	0.036	10.463
[Personal monthly income = 2]: 1000–3000 yuan	1.767	4.051	0.044	5.854

Prediction for Use Proportion

As shown in Table 2, most respondents are male clerks aged 26–30 years old and have an average monthly income of 3001–6000 yuan. For a respondent having these features, the probability that he will choose, not choose and keep a neutral stance can be calculated by Equations (1)–(5) according to the multinomial logistic regression results.

$$g_1 = -2.283 + 0.733 + 2.194 + 1.169 = 1.758 \quad (6)$$

$$g_2 = -2.888 + 0.363 + 0.817 + 0.768 = 0.215 \quad (7)$$

$$P(Y = \text{will choose}) = \frac{e^{g_1}}{1 + e^{g_1} + e^{g_2}} = 0.721 \quad (8)$$

$$P(Y = \text{will keep a neutral stance}) = \frac{e^{g_2}}{1 + e^{g_1} + e^{g_2}} = 0.154 \quad (9)$$

$$P(Y = \text{will not choose}) = \frac{1}{1 + e^{g_1} + e^{g_2}} = 0.125 \quad (10)$$

Therefore, the probability for a 26–30-year-old male clerk who has a personal monthly income of 3001–6000 yuan to use EVS is 72.1%.

According to the calculation method above, when other factors remain unchanged, the relationship between age and the use probability ratio of male clerks who have a 3001–6000 yuan monthly income can be obtained and is shown in Figure 9. It is possible to see that age has a great influence on personal decisions to use the EVS, which is consistent with the former analysis. People aged 18–30 are more likely to use EVS. When people's age is more than 30 years old, the probability of not choosing is bigger than that of choosing. Additionally, as the age increases, the probability of a neutral stance increases, and consumers are more reluctant to use EVS. Furthermore, the post-1990s generation in China is growing up, and their receptivity is better than other groups. They will be the major customers of EVS in the near future. Therefore, the market space for EVS business is huge. The suggestion is that the EVS service could aim at young people aged between 18 and 30 as their customers.

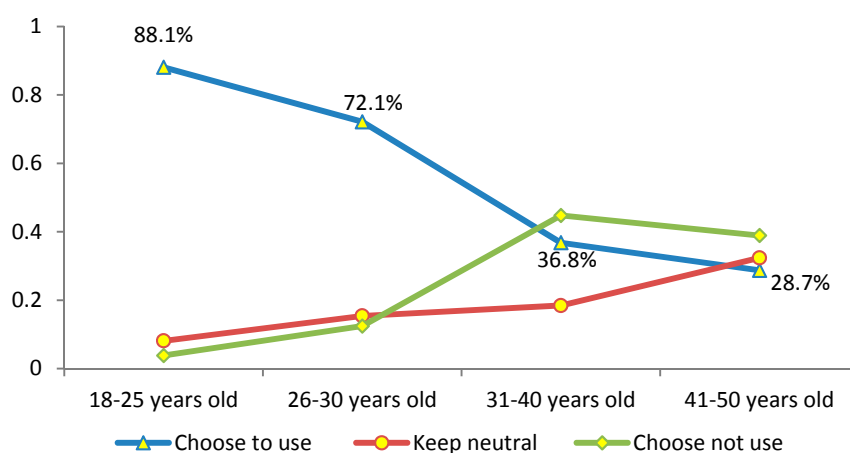


Figure 9. The relationship between age and the willingness to using EVS.

In a similar way, when other factors keep constant, the relationship between personal monthly income and the willingness to use EVS is shown as Figure 10. The following is the results. (1) Overall, with the increase of personal monthly income, the choice probability of individuals to use EVS decreases after rising first. When the personal monthly income is 3001–6000 yuan, the probability of choosing reaches the maximum of 72.1%. (2) When the personal monthly income is low, the

probability of not choosing is high. The reason may be the relatively weak economic capacity of the low income group. When the monthly income is higher (more than 15,001 yuan), the probability of choosing is higher than that of not choosing. However, the value of the former is still below 50%, which indicates that the probability of not choosing for consumers with high monthly income (more than 15,001 yuan) is very big. This may be related to their social status, economic condition, *etc.* Therefore, EVS should be geared toward the needs of the main group at middle-income level.

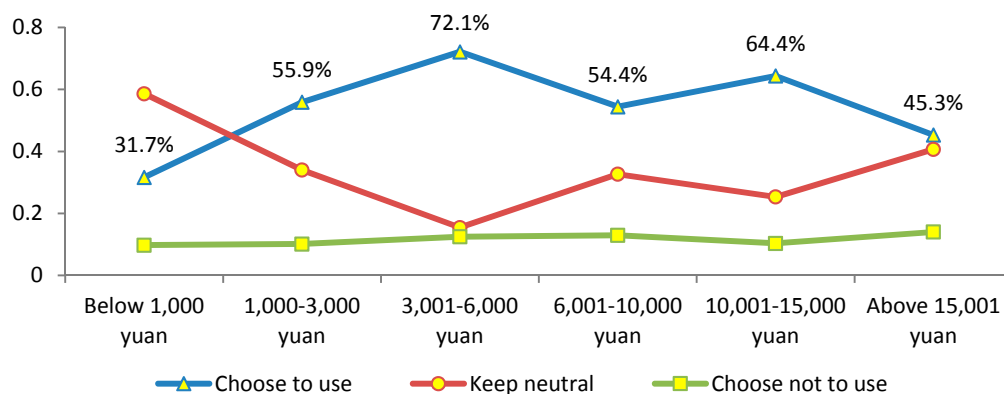


Figure 10. The relationship between monthly income and the willingness to use EVS.

5. Suggestions

In the operational aspect, the following suggestions are offered for the development of EVS.

(1) According to the regression analysis results (Tables 6 and 7), people who are male, aged between 18 and 30 and usually taking the subway and bus as the daily transportation mode are the target group for using EVS. Combined with the probability calculation (Figures 9 and 10), the suggestion is that operators should pay more attention to young people who are 18–30 years old and have a middle-level income.

(2) In the early development of EVS, the type of shared electric vehicles should give priority to compact, small or mini cars.

Car sharing is designed to satisfy people's short, temporary and flexible transportation demand. Most people will use it for shopping and entertainment (Figure 5), and they expect that the EVS would be economical (Figure 4). Most people who would like to use EVS are young, and their income is not very high (Figure 10). In order to decrease consumers' use-cost to show the economy of sharing and satisfy the need to carry certain items at the same time, the type of shared EV should focus on compact, small or mini cars. This can reduce the cost of operators and indirectly reduce the use-cost of shared cars. On the other hand, governments can offer certain subsidies to reduce the enterprises' pressure on operating funds in the early stage. This can promote the industrialization of electric vehicles and also improve the operational enterprises' enthusiasm.

(3) In the early developmental stage, the driving range of shared electric vehicles should reach 120 km.

More than half of the respondents (Figure 7) said the driving range of shared electric vehicles should reach 120 km at least, which indicates that most people hold tolerant attitudes towards the problem of driving range. However, there were more than a quarter of people who hoped that the driving range could reach 150 km. From regression the result in Table 6, it is indicated that the increasing driving range will decrease consumers' use willingness (the reason is stated in Section 4.3.3). Therefore, in the early stage of development, for reasons of cost, capital, *etc.*, it is recommended that the driving range of shared electric vehicles should reach 120 km.

(4) When laying out the sites, the walking time for consumers to stations should be controlled to be within 10 min.

Theoretically, the walking time for consumers to the stations should be as short as possible, which means more sites are needed. However, more sites mean large amounts of money for investment, and it is also likely to cause high operational and maintenance cost, a low utilization rate, *etc.* Therefore, a reasonable number and layout of sites are needed to improve vehicle utilization, reduce operating costs, and at the same time, meet consumers' need for the convenient usage of cars. According to Figures 11 and 12 92.5% of participants accept the walking time within 10 min. When the walking time increases from five to 10 min, the percentage of people who are willing to use EVS decreases by 4.7%, which is acceptable. Considering the cost and utilization rate, the suggestion is that the walking time for consumers to the station should be controlled to be within 10 min.

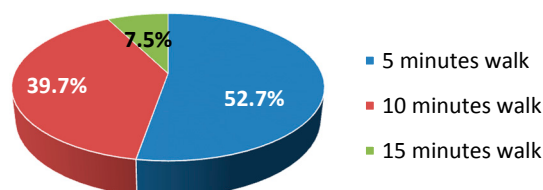


Figure 11. Acceptable maximum duration for going to stations (N = 385).

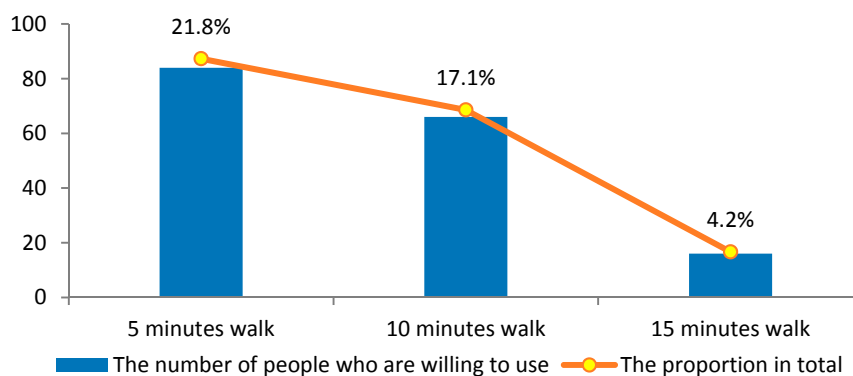


Figure 12. The relationship between time for going to stations and use willingness (N = 385).

(5) The waiting time for consumers to go through the formalities and pick up cars should be controlled within five minutes.

Convenient appointments and self-help picking up cars are some of the most attractive points that consumers think the EVS service should have. As shown in Figures 13 and 14 89.4% of participants can accept that the longest waiting time is within 10 min. However, when waiting time increases from five to 10 min, the percentage of people who are willing to use EVS decreases from 24% to 14%, which is a big decline. Therefore, services, such as picking up the cars or returning the cars, should be automatic and self-supported. The suggestion is that operators should open a variety of channels for customers to complete the procedures of booking, picking up cars, returning cars and paying the bill conveniently and effectively. These can help control the total waiting time to be within five minutes.

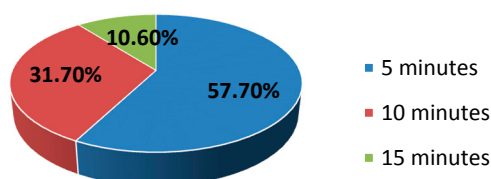


Figure 13. Acceptable maximum duration for the waiting and handling procedure (N = 385).

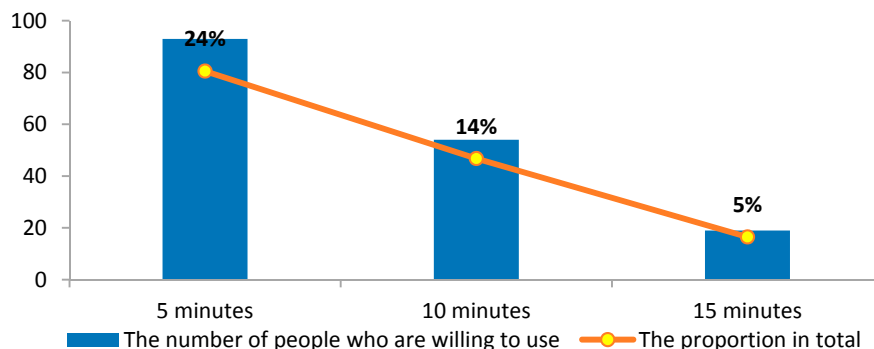


Figure 14. The relationship between waiting time and use willingness (N = 385).

6. Conclusions

In the early development of EVS, in order to achieve a good commercial operation, it is necessary to investigate with respect to the consumers the important influencing factors for the acceptance of EVS. Therefore, to solve these problems, a questionnaire was conducted in Shanghai. According to the results, relevant suggestions are offered to achieve a wide range promotion of EVS.

Through the multiple logistic regression analysis, the factors of the main trip mode in daily use, monthly transportation expenditure, acceptable minimum driving range of electric vehicles, gender, age, marital status and occupation have significant influences on the willingness to choose EVS. Males are more willing to use EVS than females. Younger people have a stronger receptivity to new things than the old. As age increases, the use willingness of consumers decreases. In short, the population characteristics of people choosing to use EVS are male, aged between 18 and 30 and usually taking the subway and bus as the daily transportation modes. Otherwise, the factors of acceptable highest price of EVS, occupation and personal monthly income have a significant impact on the use willingness of people who keep a neutral stance. The increase of service price will reduce the use willingness, and the exclusion effect of people with a low average monthly income is lower. As a result, if we want to encourage these people to change their existing attitude to use EVS, a reasonable price should be made to attract them to join on the premise of incurring no deficit. The probability for a 26–30 year-old male clerk who has a personal monthly income of 3001–6000 yuan in Shanghai to use EVS is as high as 72.1%, which indicates that the development prospect for EVS in Shanghai is good.

In the operational aspects, suggestions are provided for operators as follows. (1) The operators should pay more attention to people who are 18–30 years old and have a middle-level income. (2) In the early development of EVS, the electric vehicles used for sharing should be concentrated on compact, small or mini cars to achieve the aim of low-cost operation and good sharing economy. (3) The driving range of shared electric vehicles should not be less than 120 km to reduce consumers' range anxiety. (4) During the laying out of sites, a reasonable number of sites are necessary to guarantee that the walking time to stations is within 10 min for consumers. (5) Operators need to optimize the leasing system and implement automation and self-support as far as possible. This can help control the total waiting time to within five minutes.

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References

1. Brady, J.; O'Mahony, M. Travel to work in Dublin. The potential impacts of electric vehicles on climate change and urban air quality. *Transp. Res. Part D* **2011**, *16*, 188–193. [[CrossRef](#)]

2. Hawkins, T.R.; Singh, B.; Majeau-Bettez, G.; Stromman, A.H. Comparative environmental life cycle assessment of conventional and electric vehicles. *J. Ind. Ecol.* **2013**, *17*, 53–64. [CrossRef]
3. Hanschke, C.B.; Uyterlinde, M.A.; Kroon, P.; Jeeninga, H.; Londo, H.M. Duurzame Innovatie in Het Wegverkeer. Available online: <https://www.ecn.nl/docs/library/report/2008/e08076.pdf> (accessed on 2 December 2015). (In Dutch)
4. Sierchula, W.; Bakker, S.; Maat, K.; Van Wee, B. The competitive environment of electric vehicles: An analysis of prototype and production models. *Environ. Innov. Soc. Transit.* **2012**, *2*, 49–65. [CrossRef]
5. IEA (International Energy Agency). EV City Casebook. 2012. Available online: <http://www.iea.org/publications/freepublications/publication/EVCityCasebook.pdf> (accessed on 2 December 2015).
6. Instructions of the General Office of the State Council in China on Accelerating the Promotion and Application of New Energy Vehicles. Available online: http://www.gov.cn/zhengce/content/2014-07/21/content_8936.htm (accessed on 21 July 2014).
7. Meijkamp, R. Changing consumer behaviour through eco-efficient services: An empirical study of car sharing in the Netherlands. *Bus. Strateg. Environ.* **1998**, *7*, 234–244. [CrossRef]
8. Barth, M.; Shaheen, S.A. The Potential for Shared-Use Vehicle Systems in China. Available online: <http://76.12.4.249/artman2/uploads/1/UCD-ITS-RR-03-11.pdf> (accessed on 2 December 2015).
9. Prettenhaler, F.E.; Steininger, K.W. From ownership to service use lifestyle: The potential of car sharing. *Ecol. Econ.* **1999**, *28*, 443–453. [CrossRef]
10. Seik, T.F. Vehicle ownership restraints and car sharing in Singapore. *Habitat Int.* **2000**, *24*, 75–90. [CrossRef]
11. Barth, M.; Todd, M. Simulation model performance analysis of a multiple station shared vehicle system. *Transp. Res. Part C* **1999**, *7*, 237–259. [CrossRef]
12. Brook, D. Carsharing—Start Up Issues and New Operational Models. In Proceedings of the Transportation Research Board Annual Meeting, Chicago, IL, USA, 18–20 November 2004.
13. Xu, J.X.; Lim, J.S. A new evolutionary neural network for forecasting net flow of a car sharing system. In Proceedings of the Evolutionary Computation, Singapore, 25–28 September 2007.
14. Kek, A.G.; Cheu, R.L.; Meng, Q.; Fung, C.H. A decision support system for vehicle relocation operations in carsharing systems. *Transp. Res. Part E* **2009**, *45*, 149–158. [CrossRef]
15. Correia, G.H.; Antunes, A.P. Optimization approach to depot location and trip selection in one-way carsharing systems. *Transp. Res. Part E* **2012**, *48*, 233–247. [CrossRef]
16. Luè, A.; Colorni, A.; Nocerino, R.; Paruscio, V. Green move: An innovative electric vehicle-sharing system. *Procedia Soc. Behav. Sci.* **2012**, *48*, 2978–2987. [CrossRef]
17. Shaheen, S.; Cano, L.; Camel, M. Exploring Electric Vehicle Carsharing as a Mobility Option for Older Adults: A Case Study of a Senior Adult Community in the San Francisco Bay Area. *Int. J. Sustain. Transp.* **2015**. [CrossRef]
18. Kim, D.; Ko, J.; Park, Y. Factors affecting electric vehicle sharing program participants' attitudes about car ownership and program participation. *Transp. Res. Part D* **2015**, *36*, 96–106. [CrossRef]
19. Huang, Z.Y.; Yang, D.Y. The development of car sharing abroad. *Urban Plan. Forum* **2000**, *6*, 50–55.
20. Ye, L.; Yang, D.Y. The development and applied research on car sharing and mobile management in China. In Proceedings of the China's Sustainable Development Forum, Shandong, China, 2010; Available online: <http://cpfd.cnki.com.cn/Article/CPFDTOTAL-ZKZC201010001051.htm> (accessed on 2 December 2015).
21. Gao, Y.M. Car Sharing—A new model of automobile consumption. *Traffic Trans.* **2005**, *4*, 39–40.
22. Qiu, L. Market prospects and marketing research on car sharing service in China's. Master's Thesis, Fudan University, Shanghai, China, 2009.
23. Xue, Y.; Yang, T.Y.; Wen, S.B. Social Characteristics and Development Models of Car Sharing. *Techno-econ. Manag. Res.* **2008**, *1*, 54–58.
24. Wu, W.D. Research on car sharing pattern and analysis on its development in Chinese market. Master's Thesis, Zhongshan University, Guangzhou, China, 2010.
25. Jing, H. The green traffic of car sharing in Hanover. *Traffic Trans.* **2005**, *6*, 13.
26. Kaixuan, X.; Mingsheng, H.; Hua, Z. The economic and ecological efficiency of car sharing service and the feasibility to implement the service in Beijing. *China Soft Sc.* **2006**, *12*, 64–70.
27. Zhang, W.T. *Advanced Courses for SPSS Statistical Analysis*; Higher Education Press: Beijing, China, 2004; pp. 189–203. (In Chinese)

28. Li, K.; Guo, Z.; Hu, L.; Xu, Y. Analysis method for ordered categorical data of cumulative score model. *Chin. J. Health Stat.* **1993**, *4*, 35–38.
29. Hosmer, D.W.; Lemeshow, S. *Applied Logistic Regression, Second ed*; Wiley: New York, NY, USA, 2000.
30. Wen, X.X.; Tan, G.X.; Yao, S.S.; Huang, Z. Traffic flow characteristics and short-term prediction model of urban intersection. *J. Traffic Transp. Eng.* **2006**, *1*, 103–107.
31. Zhou, M.J. An empirical study of factors affecting electric car purchase decision. *Shanghai Auto* **2013**, *4*, 39–44.
32. Sun, Y.; Shang, J. Factors affecting the health of residents in China: a perspective based on the living environment. *Ecol. Indic.* **2015**, *51*, 228–236. [[CrossRef](#)]



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