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Analysis of Chinese People's Choice Factors for Electric Vehicles with Electric Switching Mode

-- Based on Binary Logit Modeling Analysis

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Abstract

In recent years, with the increasing production and possession of new energy vehicles in the Chinese market, there are some drawbacks and deficiencies in the traditional charging mode, and the gradually emerging battery replacement mode may solve these problems to a certain extent. Therefore, we conducted a survey on the people in Chengdu, Sichuan Province, and mainly studied the influencing factors of people's behavior of choosing electric vehicles with electric switching mode and made specific analysis. Meanwhile, suggestions and references are provided for the development of electric vehicles in switching mode. This paper first introduces the overall situation of the survey, and then selects binary Logit model to conduct modeling and specific analysis on the index types of eight factors, and finally puts forward suggestions for the reference of relevant parties.

Keywords

New Energy Vehicles; Battery Swapping Mode; Market Research; Binary Logit Model.

1. Introduction

In the context of the “dual carbon” goal and the widespread use of new energy vehicles, with the reform and innovation of transportation electrification, it is expected to be the first to achieve zero carbon emissions. The main disadvantages of charging mode electric vehicles are:

1. Various types of infrastructure are not complete. Nowadays, within the scope of our country, there are few kinds of infrastructure related to the charging of new energy vehicles, and there are problems such as slow charging speed and low regional distribution density, and even the lack of electrical changing stations in most areas, and the events of unmanned electrical changing stations are also common. All these affect the development of new energy vehicles.

2. Battery life problem. It is more obvious in winter. A car with a claimed mileage of 300 kilometers will consume about one-third of the mileage in winter, so it can last about 200 kilometers.

3. The charging process is cumbersome and time-consuming. At present, fast charging generally takes two hours, which consumes a lot of car batteries, while slow charging generally takes eight hours or more.

The battery replacement mode can quickly fill up the power of the new energy vehicle by replacing the vehicle carrier battery. The battery replacement process can be completed within 3 to 5 minutes, which greatly compresses the time to replenish the power and saves the owner a lot of waiting time, and reduces “mileage anxiety” to a certain extent. The advantage of the power exchange mode lies in its fast and convenient, high safety factor and convenient

management in the electrical switching process, so it is more likely to be popularized and promoted in a certain range.

2. Overview of the investigation

2.1. Questionnaire design

The questionnaire survey is mainly divided into five aspects. The first aspect is to understand the basic information of the respondents. By understanding the basic characteristics of the respondents through the gender, age, employment, annual income, education, occupation of the respondents, which is conducive to the classification and analysis of the samples. The second aspect is to investigate whether customers are users of the battery swapping mode, so as to understand the usage and satisfaction of such respondents. At the same time, existing users and potential users can be distinguished, and the characteristics of existing customers and potential customers can be obtained by combining the basic information in the first aspect. The third aspect is the analysis of the price, reasons, and satisfaction of electric vehicles in battery-swap mode used by users. The fourth aspect is a survey of ordinary non-battery-swap mode users' perceptions of this mode, price and function expectations, and views on future development trends.

2.2. Survey results

Through the quality control of the browsing and inspection of the questionnaire results, the questionnaires with obviously inconsistent answers before and after are regarded as invalid questionnaires. Finally, a total of 1508 questionnaires were distributed and 1219 questionnaires were recovered, with a recovery rate of 80.83%. After removing invalid questionnaires, 1192 questionnaires were obtained with a recovery rate of 79.05% valid questionnaires.

3. Modeling of charging mode selection behavior of new energy vehicle users

3.1. Model selection and establishment

A binary choice model is a mathematical model established by the choice behavior of individuals who choose between two alternative answers and can only choose one of them. Considering that there are only two responses involved in whether to use a battery-swap mode electric vehicle, which is a binary dependent variable (that is, when the dependent variable is a categorical variable rather than a continuous variable), the results obtained by establishing a multiple linear regression model have a large error. In contrast, we should choose a binary choice model. The two types of Logit model and Probit model are binary choice models, but there are differences between the two due to the different distribution functions used. In this study, Logit model was used for analytical research [1]. The advantages of this model are very obvious: simple structure, strong universality, quick solution, convenient application, good science and good persuasion.

In this paper, the Logit model [2] is used to analyze the users of new energy vehicles in the battery swap mode, and the main factors that we believe have a greater impact on the choice of new energy vehicles in the battery swap mode are screened out. The selection of electric mode electric vehicles uses behavioral models.

The dependent variable of the study is “whether the people have used new energy vehicles in battery swap mode”, namely:

$$y = \begin{cases} 1 & \text{used a new car in change} - \text{over mode} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

Then, we can get the model expression as:

$$E(y)=P=e_0^{\beta}+\beta_i X_i+\cdots+\beta_k X_k/1+e_0^{\beta}+\beta_i X_i+\cdots+\beta_k X_k \quad (2)$$

where y represents the dependent variable, P represents the probability of the public using new energy vehicles in the battery swap mode, x_i represents the independent variable, and β_i is the coefficient corresponding to the independent variable.

Through preliminary research, we have determined that the seven main factors that affect people's choice to use battery-swapping models of new energy vehicles are family size, age, income, gender, consumer perception, environmentally conscious, social relevance impact, and charging mode satisfaction are set as eight independent variables.

3.2. Preprocessing

We will code the questions and options related to the selected eight independent variables to facilitate the following modeling analysis and parameter estimation.

Table1 Coding correspondence table

Question number	Titles	Options	Coding
01	What is your family size?	No more than 4	0
		More than 4	1
02	What's your age?	22 years old and under	0
		23-39 years old	1
		40-59 years old	2
		60 years old and above	3
03	What is your average monthly income (including wages and labor)?	Below 5000 yuan	0
		5000 yuan -8000 yuan	1
		8000 yuan -12000 yuan	2
		More than 12000 yuan	3
04	What is your gender?	Male	0
		Female	1
05	What do you think about your consumption attitude?	Special opening	0
		Generally open	1
		Balance	2
		Generally Conservative	3
		Particularly Conservative	4
06	What do you think about your environmental concept?	Low	0
		High	1
07	How do you think you are influenced by social groups?	Small	0
		Big	1
08	Satisfaction with current charging mode	Very satisfied	0
		Quite satisfied	1

		Generally	2
		Dissatisfied	3
		Very dissatisfied	4

3.3. Model estimation

The family size, age, income, gender, consumption concept, environmental protection concept, audience influence, satisfaction with the current charging mode are defined as $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8$ as independent variables, and Binary Logit regression analysis was performed with y as the dependent variable. We analyze the data online using the SPSSAU platform.

Firstly, as can be seen from the table 2, a total of 1192 samples were included in the analysis and there were no missing data.

Table2 Basic summary table of binary Logit regression analysis

Name	Options	Frequency	Percentage
y	0	736	61.74%
	1	456	38.26%
	total	1192	100.0%
Summary	efficient	1192	100.00%
	missing	0	0.00%
	total	1192	100.0%

Secondly, the overall validity of the model is analyzed, and the model likelihood ratio test is used to analyze the overall model validity. It can be seen from table 3 that the original hypothesis of the model test here is: whether the independent variables（$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8$）are put into the two cases, the quality of the model is the same, where the value of p is less than 0.05.

Table 3 Binary Logit regression model likelihood ratio test results

Model	-2 logarithmic likelihood	Chi-square value	df	p	AIC value	BIC value
Only intercept	1586.072	--	--	--	--	--
Final model	702.746	883.326	8	0.000	720.746	766.497

Table 4 Summary table of binary Logit regression analysis results

Items	Regression coefficients	standard error	Z value	Wald	p value	OR value	OR value 95%CI
Family Size	0.373	0.226	1.650	2.723	0.099	1.452	0.932 ~ 2.262
Age	-0.414	0.166	-2.501	6.257	0.012	0.661	0.478 ~ 0.914
Income	0.942	0.146	6.459	41.714	0.000	2.564	1.927 ~ 3.413

Gender	-0.051	0.201	-0.254	0.064	0.800	0.950	0.641 ~ 1.408
Consumer Perception	0.270	0.116	2.323	5.396	0.020	1.310	1.043 ~ 1.645
Environmentally Conscious	0.694	0.239	2.902	8.422	0.004	2.001	1.253 ~ 3.197
Social relevance impact	0.647	0.224	2.889	8.344	0.004	1.910	1.231 ~ 2.963
Charging mode satisfaction	2.373	0.129	18.379	337.789	0.000	10.735	8.334 ~ 13.827
Intercept	-7.554	0.593	-12.741	162.338	0.000	0.001	0.000 ~ 0.002

(Note: Dependent variable y: McFadden R square: 0.557; Cox & Snell R square: 0.532; Nagelkerke R square: 0.711)

Finally, it can be seen from table 4 that $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8$ are used as independent variables, and y is used as the dependent variable for binary Logit regression analysis. The model formula is:

$$\ln \frac{p}{1-p} = -7.554 + 0.373^* x_1 - 0.414^* x_2 + 0.942^* x_3 - 0.051^* x_4 + 0.270^* x_5 + 0.694^* x_6 + 0.647^* x_7 + 2.373^* x_8 \quad (3)$$

where p represents the probability that y is 1, and 1-p represents the probability that y is 0.

4. Variable significance specific analysis

(1) Family size: The regression coefficient value of the independent variable x_1 is 0.373, but it does not show significance (z=1.650, p=0.099>0.05), which means that family size does not have an impact only relation. But this is different from the actual situation, because as the population increases, families need to have their own vehicles to flexibly arrange their time.

(2) Age: The regression coefficient value of the independent variable x_2 is -0.414, and it is significant at the 0.05 level (z=-2.501, p=0.012<0.05), which means that age will have a significant negative effect on y to influence relationships. At the same time, the odds ratio (OR value) is 0.661, which means that when the age increases by one unit, the change (decrease) of y is 0.661 times. It shows that under the same circumstances, with the increase of age, people's willingness to use new energy vehicles in battery swap mode is lower, which is basically consistent with common sense: usually young people are more willing to accept new things, while the elderly are more inclined to believe in their existing experience, so the proportion of young people willing to use this mode of car is higher than that of old people.

(3) Income: The regression coefficient value of the independent variable x_3 is 0.942, and it is significant at the 0.01 level (z=6.459, p=0.000<0.01), which means that income will have a significant positive impact on y. At the same time, the odds ratio (OR value) is 2.564, which means that when income increases by one unit, the change (increase) in y is 2.564 times. This shows that under the same circumstances, with the increase of income, consumers are more willing to use new energy vehicles in battery swap mode. This may be because low-income earners are limited to their current income and are less likely to buy a car, which requires maintenance, insurance, and often overhauled products.

(4) Gender: The regression coefficient value of the independent variable x_4 is -0.051, but it does not show significance (z=-0.254, p=0.800>0.05), which means that gender does not affect y.

(5) Consumption concept: The regression coefficient value of the independent variable x_5 is 0.270, and it shows a significant level of 0.01 (z=2.889, p=0.004<0.01), which means that consumer perception will have a significant impact on y positive influence relationship. At the same time, the odds ratio (OR value) is 1.310, which means that when the consumption concept increases by one unit, the magnitude of the change (increase) in y is 1.310 times. This means that under the same circumstances, the more conservative the consumer's consumption concept, the less likely they are to choose a new model car. Generally speaking, the more open a person's consumption concept is, the more he will invest in travel expenses. On the contrary, the more conservative a person's consumption concerns, the more inclined he is to save money and use some cheaper products.

(6) Environmental protection concept: The regression coefficient value of the independent variable x_6 is 0.694, and it is significant at the 0.01 level (z=2.902, p=0.004<0.01), which means that the environmental protection concept will have a significant impact on y. Positive influence relationship. At the same time, the odds ratio (OR value) is 2.001, which means that when the environmental protection concept increases by one unit, the change (increase) of y is 2.001 times. This shows that other things being equal, the more a person is keen to protect the environment, the more he will be more willing to choose new energy vehicles.

(7) Audience influence degree: The regression coefficient value of the independent variable x_7 is 0.647, and it shows a significant level of 0.01 (z=2.889, p=0.004<0.01), which means that the degree of social relevance impact will affect y produce a significant positive impact relationship. At the same time, the odds ratio (OR value) is 1.910, which means that when the audience influence degree increases by one unit, the change (increase) of Y is 1.910 times. This shows that when other conditions remain unchanged, the more easily a person is influenced by the people around him, the more willing he is to use a car in battery swap mode. This is basically consistent with the actual situation in life. In the current era of big data, with the continuous development of self-media, most people will learn about the surrounding social dynamics through new media (we-media) platforms, Wechat moments, Weibo and other channels. They usually very sensitive to the situation of people around you. When they buy a car, they tend to search for relevant content, listen to the opinions of relatives and friends, etc., so socially relevant groups are a very significant factor for users to choose the electric vehicle behavior of battery swap mode.

(8) Satisfaction with the current charging mode: The regression coefficient value of the independent variable x_8 is 2.373, showing a significant level of 0.01 (z=18.379, p=0.000<0.01), which means satisfaction with the current charging mode will have a significant positive impact on y. The odds ratio (OR value) is 10.735, which means that when the satisfaction with the current charging mode (Charging mode satisfaction) increases by one unit, the change (increase) of y is 10.735 times. This means that people who are dissatisfied with the current charging mode of electric vehicles are more likely to choose a battery-swappable electric vehicle.

To sum up, income, consumption concept, environmental protection concept, audience influence degree, and satisfaction with the current charging mode will have a significant positive impact relationship on y, and age will have a significant negative impact relationship on y. It is worth noting that family size and gender do not affect the y relationship.

5. Conclusions and recommendations

Based on the above survey data and modeling analysis, we obtained the influence of six factors, including income, consumption concept, environmental protection concept, audience influence, and age, and analyzed the positive effects of these influencing factors on the variables

respectively. Finally, we put forward the following suggestions for the development of electric vehicles in battery swap mode:

1. The relevant national policies are the wind vane for the development of the electric vehicle battery swap industry, which determines whether the battery swap mode can develop sustainably, rapidly and healthily. Government functional departments can issue more detailed documents and provide guidance, clarify the conditions for applying for subsidies for the replacement mode to solve the worries of enterprises, increase publicity and education activities on public environmental protection and the use of clean energy knowledge, and better promote new energy electric vehicles automotive products.

2. Automakers should focus on research, investment and relaxation on battery swapping models, address the issue of insufficient batteries in a zero-battery business model.

3. Power grid service companies should continue to practice and pilot the charging and replacing mode of "mainly changing electricity, supplemented by plugging and charging, centralized charging, and unified distribution". This will continue to improve infrastructure construction and make full use of technologies such as the internet of things and blockchain to realize the construction of smart and green cities.

4. The battery swap mode can be popularized in taxis, time-sharing rental cars, logistics vehicles and other types of vehicles, so as to form an effective cooperation model between automobile enterprises and automobile operating enterprise.

5. More use of new media (self-media) and other methods should be used to strengthen the publicity of the battery swap model, and encourage major exhibitions (expo) to set up a battery swap model electric vehicle experience area to attract the attention of investors and the public.

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