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Characteristics of the NEVs' Potential Consumer Based on Logistic Model: Data from the Consumers of Shanghai

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Abstract: Due to the increasingly serious issues of air pollution, New Energy Vehicles (NEVs) has drawn more and more attention of government and consumers. The local government establish series of relevant policies to support the NEVs' industry according to the comprehensive planning of the state. However, the sales of the NEV have not reached the prospective goal. The major air pollutants in Shanghai come from the emission of vehicles' exhaust. Hence, it is urgent to develop the NEVs' industry. In this paper, we are willing to obtain the characteristics of the NEV's Potential Consumers and their willingness to pay for the NEVs. We construct the binary logistic model to analyze the characteristics of NEV potential consumer in Shanghai with the data obtained from the questionnaires. The consumers are classified into five categories by Twostep Cluster, and we also analyze the price range of whom are willing to purchase the NEVs. The conclusion indicates that the potential consumers of NEVs in Shanghai are people who are under 25 years old, having 4 family members, concerning on the national policies of the NEVs, acquiring the NEVs' information from the distributor and having a highly approval of Green Purchase. The firms should focus on these groups in their strategies. In addition, the hybrid energy vehicles between 10 million yuan and 20 million yuan appeal to the consumers more. The government of Shanghai should increase subsidies' strength of hybrid energy vehicles to gradually realize the goal of promoting the NEVs.

Keywords: New Energy Vehicles (NEVs), Binary Logistic Regression, Twostep Cluster Analysis

1. Introduction

The environmental problems that the public concerned most recently is undoubtedly the haze problems. The automobile exhaust make a considerable contribution to the culprit of the haze issue which is PM 2.5. The exhaust will emit the PM 2.5 particles, in the meantime, it will also release the nitrogen oxides and volatile organic compounds which are harmful. Since 2000, the data from the natives indicate that the proportion of the industrial production and automobile exhaust is 7:3. The researches in 2013 discovered the proportion of the automobile exhaust has risen sharply and hit 50%. Motor vehicles' exhaust has become the elemental reason for producing the PM 2.5 particles. [1] The adventure of NEVs offer a new direction to relieve the deterioration of air quality which caused by the automobile exhaust.

In 2012, the State Council issued the "energy-saving and development plan of NEV industry " (2012-2020) in which the government formulate the target that is by 2015, the production and sales of electric vehicles and plug-in hybrid car will try to reach a total of 500,000; the production capacity of electric vehicles and plug-in Hybrid Electric Vehicles (HEVs) should come to 2,000,000 and the cumulative production and sales should surpass 5,000,000.[2] On March 17th, 2013, " The implementation plan to promote the application of NEVs in Shanghai " (2013-2015) was announced, Shanghai plans to promote the application of 13,000 NEVs, which will save 75,000 tons of gasoline and diesel, and reduce the emissions of particulate for approximately 100 tons ,the greenhouse gases (carbon dioxide) emissions will be cut down to about 200,000 tons, the influence will cover various areas such as public transportations, corporations, environmental sanitations, logistics and other vehicles. By 2015, the first quarter of the national total sales of NEVs has reached 131,735, in which 27 271 were sold in 2015. It will be so tough to fulfill the expected goal through this increase of sales by the end of 2015. The positioning of NEVs is vague in China which cause the consumers feel confused while they make their choice. How to break the "bottle neck" of market promotion for NEVs in Shanghai has become the issue that is urgent to be solved.

Kahn noted environmentalists prefer to travel by public transport, and had more willingness to buy a HEV car to expend fewer resources.[3] H.O. and Kitirattragarn. V. studied the the New York taxi owners' purchasing preference for HEVs, the research pointed out that the drivers who were younger, had the less industry experience, and had the higher income would prefer to choose HEVs in the future. [4] Bradley took residents in Sacramento as the respondents, and the results showed that: families which had environmental attitudes owned fewer vehicles, had higher energy efficiency of the vehicles, driving less, and prefer fewer energy consumption. [5] Michael and other studies showed that: Consumers who had the lower age, higher education, the increasing expectation for gasoline prices, green lifestyle, loving the smaller models, willing to buy new products, willing to buy HEVs would have more responsibilities to buy electric vehicles.[6]

This paper will use Binary Logistsic Model to analyze the basic characteristics of potential consumers who will purchase NEVs, including gender, age, size of family, the degree of consumers' attention to the national policy of NEVs, the ways to know about NEVs, and whether support for green purchases or not. Then we classify the sample through TwoStep cluster analysis according to the independent variables and make comparison among each group on the willingness to purchase.

2. Data and Methodology

2.1. Data Collection

The data in this article are obtained from questionnaires. We select driving schools in Shanghai, auto 4S shops, on the streets, as well as online to distribute our questionnaires. A total of 1550 questionnaires were returned 1011 valid questionnaires. The content in the questionnaire is divided into three blocks: basic information, preferences, attributes, and willingness prices, respectively. What we mainly use in this article are basic information. in addition, we also use the understanding of the NEVs, the ways know about the NEVs, and whether concern about the national policy on NEVs. We analyze the characteristics of the NEVs' potential consumers by the above data. The descriptive statistics are shown in Table 1.

The proportion of male respondents is 61.2%, comparing with 38.8% of the females. The population under 35 years old accounted for 69.9 % of the sample, which means most are youngsters. The group whose annual household income are less than $39325 accounts for 78.9% of the sample, namely, the majority of respondents are middle and low-income population. Families of three people accounts for 57.8 % in our respondents, while 61.2% of people don't have children. In the respondents, the proportion of salaried class and students are 24% and 19.5%, respectively.People who have got bachelor degree accounts for 57%. The Kolomogorov-Simirnov test indicates that the data of basic information are shown to obey normal distribution.

Table 1. *Descriptive statistics.*

Variable	Percentage(%)
Sex	61.3
Age distribution	
25 or below	31.1
26-30	20.9
31-35	18.1
36-45	18.5
46-50	8.1
51 or above	3.4
Household income distribution(per year)	
Below $15730	14.5
$15730-$23595	29.0
$23595-$31460	20.5
$31460-$39325	14.6
$39325-$47190	6.0
$47190-$55055	3.9
$55055-$62920	4.5
Above $62920	6.9
Family size(person)	
2 or below	13.0
3	58.0
4	19.2
5 or above	9.9
Have kids or not(Y/N)	
Y	38.8
Education achievement	
High school or high school incomplete	6.3
Technical secondary school	4.9
Junior college	16.3
Bachelor	57.0
Master	11.6
Doctor	3.7
Profession	10.7
Enterprise manager	24.0
Enterprise employee	4.1
Operating company	13.3
Civil servant	13.6
Professional(teacher, doctor, lawyer etc.)	
Student	19.6
Freelancer	8.1
Other	6.7
Whether obtain the information from the dealer (Y/N)	
Y	13.6
Green purchase could relieve the situation that lacking in natural resource and energy	
Deeply disagree	1.8
Disagree	6.9
Neutral	22.0
Agree	53.7
Deeply agree	15.6
Whether concern about the policies of NEVs.	
Not concern	5.4
Not too concern	21.6
Neutral	42.7
Relatively concern	23.3
Deeply concern	6.9

2.2. Methodology

2.2.1. Binary Logistic Regression

The data used in this article come from the survey, The questions in questionnaire are all classification problems. We would like to analyze the characteristics that impact the choice of respondents who consider to purchase the NEVs(namely the potential consumers). Here we used binary logistic regression method to complete our research.The specific form of binary logistic regression is as follows:

$$logit\ \mathrm{P}=a+b_1x_1+b_2x_2+\cdots+b_ix_i \quad (1)$$

Where P represents the probability of the respondents who consider to buy NEVs. a and $\mathrm{b_i}$ are the estimators in the model, $\mathrm{x_i}$ represents the factors that affect respondents to purchase NEVs. The interaction terms in the model are considered to study the effects of the product of two factors make on the dependent variable (in this case ,it means the probability of purchasing NEVs), however we don't analyze the interaction item because of all the variables in this case are categorical variables.

2.2.2. Twostep Cluster Analysis

The size of sample is 1011, and the variables involved are all categorical variables, therefore we exclude the system cluster method and K-means cluster method, and use twostep cluster method to explain the issue. Twostep cluster method could cluster continuous variables and discrete variables comparing with hierarchical cluster method and K-means cluster method, the basic cluster method is as follows:

$$\xi_v=-\mathrm{n_v}\left(\sum_{j=1}^{p}\frac{1}{2}\log\left(\hat{\sigma}_{vj}^2+\hat{\sigma}_j^2\right)-\sum_{j=1}^{p}\sum_{l=1}^{m_j}\hat{\pi}_{vjl}\log\left(\hat{\pi}_{vjl}\right)\right) \quad (2)$$

ξ_v represents a dispersion within cluster v, and divided into two parts, $-\mathrm{n_v}\sum_{j=1}^{p}\frac{1}{2}\log\left(\hat{\sigma}_{vj}^2+\hat{\sigma}_j^2\right)$ measures dispersion of continuous variables $\mathrm{x_j}$ within cluster v. $-\mathrm{n_v}\sum_{j=1}^{p}\sum_{l=1}^{m_j}\hat{\pi}_{vjl}\log(\hat{\pi}_{vjl})$ measures the dispersion of categorical variables. The log-likelihood function for the step with k clusters is computed as

$$\mathrm{l_k}=\sum_{v=1}^{k}\xi_v \quad (3)$$

Firstly, according to the Akaike's Information Criterion

$$\mathrm{AIC_k}=-2\mathrm{l_k}+2\mathrm{r_k} \quad (4)$$

and the Bayesian Information Criterion

$$\mathrm{BIC_k}=-2\mathrm{l_k}+\mathrm{r_k}\log\mathrm{n} \quad (5)$$

We use the above criterions to implement the first step cluster. When $\mathrm{BIC_k}/\mathrm{BIC_1}$ is smaller than $\mathrm{c_1}(\mathrm{c_1}=0.04)$, k is the maximum number of clusters

Then we use ratio change $\mathrm{R(k)}=\mathrm{d_{k-1}}/\mathrm{d_k}$ in distance for k clusters to continue our cluster. Where $\mathrm{d_{k-1}}$ is the distance if k clusters are merged to $\mathrm{k-1}$ clusters. The ratio change is compute as $\mathrm{R(k_1)}/\mathrm{R(k_2)}$ for the two largest values of $\mathrm{R(k)(k}=1,2,\ldots,\mathrm{k_{max}};\mathrm{k_{max}}$ obtain from the first step). If the ratio change is higher than the threshold value $\mathrm{c_2}(\mathrm{c_2}=0.05)$, then the number of cluster is set equal to $\mathrm{k_1}$, otherwise the number of clusters is set equal to the solution with $\max(\mathrm{k_1},\mathrm{k_2})$.

3. Result and Analysis

3.1. Characteristics of the Potential Consumers Willing to Purchase NEVs

Through correlation analysis we could know that whether consider to purchase NEVs has the significant correlation with age, family size, whether obtain the information from the dealer, Green purchase could relieve the situation that lacking in natural resource and energy, and concerning about the NEVs' national policies. We use binary logistic regression to analyze how the characteristics of the potential consumers impact their willingness to purchase NEVs. The above 5 variables are used to estimate this model. Some parameters in the estimation are shown in Table 2.

Table 2. *Parameters of binary logistic regression model.*

Variables	Coefficient	Z-stat	Odds Ratio
Constant	-0.55	-0.79	0.58
Age(exclude 25 or below)			
26-30	-0.30	-1.37	0.74
31-35	-0.31	-1.19	0.73
36-45	-0.31	-1.28	0.73
46-50	-0.59	-2.04	0.55
51 or above	-1.02	-2.52	0.36
Family size(exclude 2 or below)			
3	0.24	1.04	1.27
4	0.67	2.51	1.96
5 or above	0.64	2.03	1.90
Concerning about the policies of NEVs(exclude not concern)			
Not too concern	- 0.05	-0.15	0.95
Neutral	0.17	0.55	1.19
Relatively concern	0.50	1.47	1.64
Deeply concern	0.86	2.05	2.38
Whether obtain the information from the dealer(exclude N)			
Y	0.77	3.37	2.16
Green purchase could relieve the situation that lacking in natural resource and energy (exclude Deeply disagree)			
Disagree	0.75	1.34	2.11
Neutral	0.74	1.42	2.10
Agree	0.93	1.83	2.53
Deeply agree	1.40	2.62	4.07

The parameter estimates and odds ratios for the model are shown in Table 2. These parameters represent the impact of an attribute on the probability of willingness to purchase the NEVs. For instance, the negative and significant parameter for the class 51 and above indicates respondents (51 or above) are less likely to purchase NEVs than the younger respondents(25 or below). The odd ratios shown in Table 2 give the relative odds of a person being in one class versus

the other for a given attribute. For example, the odds ratio of 1.96 for the respondent whose family has four people indicates that a person who has three other family members is 1.96 times more likely to purchase NEVs than a person who has just only one family member or don't have family members. The largest odds are 4.07 for deeply agree with that green purchase could relieve the situation that lacking in natural resource and energy, 2.38 for people who deeply concern about the policies of NEVs, 2.16 for obtaining the information of NEVs from the dealers. Through the above analysis, we have the following variables increase the potential consumers' willingness to purchase the NEVs:

- Being younger
- Having four members in the family
- Deeply concerning about the policies of NEVs
- Obtaining information of NEVs from the dealers
- Deeply agree with the green purchase could relieve the situation that lacking in natural resource and energy

The first and the last three results are similar with our expectation. Comparing with the former research like Bradly's study which indicates that families which had environmental attitudes owned fewer vehicles, had higher energy efficiency of the vehicles, driving less, and prefer fewer energy consumption. Michael and other studies showed that: Consumers who had the lower age, higher education, the increasing expectation for gasoline prices, green lifestyle, loving the smaller models, willing to buy new products, willing to buy HEVs would have more responsibilities to buy electric vehicles and we have the similar results on the age and green purchase. People who obtain the information of NEVs from the dealers means they could easily get the first-hand information and usually they will believe these information. People deeply concern about the policies of NEVs suggests that they will care about the information about NEVs than other people. What is interesting is the family size, the bigger family size doesn't have most preference for the NEVs. The reason might be more than five members in the family will decrease the willingness to purchase the NEVs.

3.2. Specific Groups' Willingness to Pay and Types of NEVs

From the previous analysis, we could know age, family size, concerning about national policies of NEVs, obtaining information of NEVs from dealers and Deeply agree with the green purchase could relieve the situation that lacking in natural resource and energy are significant factors affect consumer's purchase for NEVs. The overall sample are divided into five categories based on these factors through Twostage cluster analysis. The respondents in first category are under 30, the information of NEVs are not obtain from dealers and family size is 4 people, which accounts for 33.6% of the sample; the second category include the middle-aged people who relatively concern about the policies of NEVs, this group accounts for 24.6% of the sample, respondents who are in the third category are at the age between 36 and 45, neutral to the policies of NEVs and agree with the green purchase could relieve the situation that lacking in natural resource and energy, which accounts for 17.4% of the total sample ,the fourth category are young people who are under 25 years old, family size is 3 people, but this group is neutral to green purchase's impact on scarce natural resources and energy, the proportion of this category is 13.4 % in the total sample, the fifth category consist of people who acquire the information of NEVs mainly from dealers and this class accounts for 11% of the sample.

We analyze the five categories' willingness to pay for the NEVs longitudinally, most respondents in the former two categories have the willingness to pay which is between \$15730 and \$23595 (the mode is located in this interval). Most respondents in the latter three categories have the willingness to pay which is between \$25168 and \$31460(the mode is located in this interval). Then we analyze the willingness to pay for the NEVs among these categories laterally and discover that more people in category 1 are willing to pay \$9438 to \$15730 for NEVs than other categories, which means people in this category are so young that cannot afford expensive vehicles. The category 2 have more people choose the NEVs' price ranging from \$25168 to \$31460 and price above \$48763 than other categories. In this category, the respondents who are affluent, relatively concern about the policies of NEVs will choose the upscale models cars have a certain propensity to buy not necessarily new energy vehicles. Category 5 has more people choose the price ranging from \$25168 to \$31460, since that people in this category obtain the latest information of NEVs from the dealers and they know about that this price range is reasonable. Comparing with other categories, category 3 include more people would like to choose the price ranging from \$33033 to \$39325 because they are middle-aged people and agree with the green purchase, they prefer to pay more for the NEVs. The people in category 4 prefer to choose the price ranging from \$40898 to \$47190, the reason might be that this group consist of people who are under 25, family size is three people, have neutral attitude to the green purchase. They might just have the preference for upscale models which may not are NEVs. The percentages of people choosing the NEV's WTP in five categories are shown in Table 3.

Table 3. *The percentages of people choosing the NEV's WTP in five categories.*

WTP	Percentage (%)				
	C1	C2	C3	C4	C5
\$9438-\$15730	16.3	11.6	11.8	5.1	8.0
\$25168-\$31460	33.8	36.3	27.0	32.8	25.0
\$25168-\$31460	23.0	26.3	34.3	38.7	43.8
\$33033-\$39325	9.9	12.4	15.2	8.0	11.6
\$40898-\$47190	10.8	6.0	7.3	11.7	8.9
above \$48763	5.8	6.4	3.9	3.6	2.7

In these five categories, more than 70% people in each cate gory choose the HEVs which means most people show more preference for HEVs than EVs(Electric Vehicles). Several NEVs' market price and subsidies are shown in Table 4 as follows:

Table 4. *The market prices and subsidies of several NEVs.*

	Supervised price	Engine type	Subsidy	Reference Price for sale
BYD Qin	$29856	HEV	$5230 (The central)	$24625
Roewe 550	$39136	HEV	$5230 (The central) $4719 (Shanghai)	$29195
Shanghai GM sail	$40583	EV	$6292 (Shanghai)	$34291
Beijing E150	$36966	EV	$7472 (The central)	$31822
Toyota Prius	$36148	HEV	—	$36148
Smart fortwo	$20134	EV	—	$20134

We could know that the reference price for sale of NEVs after subsidy are located in the price ranging from $15730 to $39325 which approximately fit with the potential consumers' willingness to pay. However without the subsidy, the price of HEVs and EVs will be still unacceptable for consumers.

4. Conclusion

Through these above studies, we analyze the characteristics that impact the potential consumers' willingness to purchase the NEVs in Shanghai. The conclusion is that people under 25 years old, whose family size is 4 people, deeply concerning about the policies of NEVs, obtaining information from dealers and deeply agree with green purchase. We divide the sample into five categories based on the above characteristics, and acquire a preliminary analysis of the price range of willingness to purchase the NEVs in 5 categories.

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