Auto Sales Forecasting Model Based on Target Customer Satisfaction Theory

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Abstract

The development of new energy vehicles is highly supported by the country, but the sales strategy of new energy vehicles is not mature, and there are few studies on the relationship between vehicle performance and purchase intention in the existing sales strategy. This paper refers to the existing research on the vehicle performance of new energy vehicles and consumers' willingness to purchase, based on the research framework of target customer satisfaction, Pearson's correlation coefficient between various factors was obtained through the data correlation analysis, and three indicators that had a greater impact on the results were selected. This paper establishes a user mining model, selects the power comfort, safety and economy of the vehicle as indicators through factor analysis, and uses logistic regression for model prediction according to the linear hypothesis of each index, finally analyzes the sensitivity of the three indicators and puts forward a targeted new automotive product.

Keywords: *Target customer satisfaction, Logistic regression, Vehicle sales forecasting, Customer mining model*

1.INTRODUCTION

The electric vehicle industry is a strategic developing industry with extensive development prospects, but it must overcome market constraints to expand its market scale. We analyze different experience data of target customers regarding electric vehicles and information data of personal characteristics of target customer experiencers in this paper, and analyze the three most important factors of safety, economy, and power comfort that influence users' willingness to purchase vehicles from the seller's perspective, and analyze them using mathematical methods such as logistic regression, and establish a customer mining model to predict users' willingness to purchase vehicles. It's critical to boost electric vehicle performance and customer happiness, and then make sales recommendations based on the relationship between the three contributing elements and customers' willingness to buy a car. This study makes up for the deficiencies of existing sales strategies and innovatively proposes the research on the relationship between vehicle performance and purchase intention, which is of great significance to the targeted development of new energy vehicles.

2.RESEARCH QUESTIONS

The development of new energy vehicles is an important step to ease China's energy pressure, address climate change, and promote the sustainable development of the automotive and transportation industries. Under the continuous policy leadership, the new energy vehicle industry has been developing rapidly.[1]]However, the current market recognition of electric vehicle products is low and enterprises are not enthusiastic enough. From the perspective of market demand, due to the poor reliability of products, imperfect supporting facilities and lack of environmental awareness, consumers' recognition and acceptance of electric vehicles are not high, and only a few consumers are willing to buy electric vehicles even if they can enjoy high government subsidies.[2] Therefore, a large number of scholars have studied how to improve consumers' purchasing intention. In fact, the most important point in deciding an electric car company is the performance of the electric car itself, but most of the current research blames the slow construction of

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infrastructure and social factors such as environmental awareness for the obstruction of the expansion of the electric car market,[3] and there is less research on the vehicle performance and consumers' willingness to purchase.

As mentioned above, it is difficult to analyze the research results quantitatively because of obvious consumer differences. Most of the current studies on the factors influencing the sales of new energy vehicles are qualitative in nature, and there is still a great deal of controversy about the degree of influence of each factor, which to a certain extent hinders the pace of marketing of new energy vehicles.[4] Moreover, the existing studies on the relationship between brand image and purchase intention are mostly based on the consumer's position, and few studies are conducted from the seller's position. Therefore, this study creatively observes the relationship between vehicle performance and consumers' willingness to purchase from the seller's standpoint, and quantifies the relationship between vehicle performance and willingness to purchase by taking advantage of the seller's convenience in conducting surveys and statistics, in order to explore the following research questions: Based on the target customer satisfaction theory, explore how the comfort, economy, and safety performance of electric vehicles affect consumers' purchase.

This study attempts to answer this research question in two steps. First, an analytical framework is proposed to establish the relationship between electric vehicle power and comfort, economics, safety, and consumer purchase intentions by quantifying and operationalizing target customer satisfaction. Second, a quantitative test of the association is conducted using relevant data obtained from a questionnaire survey of customers in the electric vehicle market.

Based on the above analysis, this study aims to enrich and expand the quantitative research on the seller-centered electric vehicle marketing strategy to improve consumers' purchase intention, and to solve the problem that most of the existing research on purchase intention is qualitative rather than quantitative. The study also tries to provide new insights to explain the effect of different vehicles of electric vehicle manufacturers on consumers' purchase intention, and understand how to improve vehicle performance in terms of power and comfort, economy, and safety, which can help electric vehicle manufacturers to improve vehicle performance in a targeted manner to stimulate consumers' purchase intention.

3.DATA INTRODUCTION AND PROCESSING

3.1. Data Introduction

For data acquisition by means of questionnaires, market research was conducted on target customer individuals through stratified sampling and simple random sampling. The target customers were screened based on five aspects of segment measurability, accessibility, operability, discriminability, and importance, and the final market survey was conducted in terms of personal characteristics and eight aspects of satisfaction experience.

Table 1 Consumer Personal Characteristics and Satisfaction Experience Survey

Project Name	Survey Content	Name	Content	Name	Content
a1	Battery	B1	Household	B9	Education
a2	Comfort	B2	Living years	B10	Years of work
a3	Economic	B3	Living area	B11	Corporate
a4	Safety	B4	Driving age	B12	Position
a5	Power	B5	Family member	B13	Family income
a6	Controllability	B6	Marriage	B14	Personal income
a7	Decoration	B7	Childrен number	B15	Disposal income
a8	Configuration	B8	Year of birth	B16	Mortgage
B17		Car loan expense ratio			

3.2. Pearson correlation coefficient analysis

Based on the survey data obtained from the research, we used mathematical methods to analyze, build mathematical models and predict customers' future car purchase intentions. The covariance can reflect the correlation degree of 2 variables, but it is not accurate to judge the correlation degree of 2 variables simply by the size of the covariance, and the size of the covariance is related to the magnitude, which is not suitable for comparison, so here we use the Pearson correlation coefficient.

Correlation coefficient ρ_{XY} is the quotient of the covariance between the two variables and the standard deviation of the two variables. The range of values is [-1,1]. The higher absolute value of the coefficient ρ_{XY} indicates that the higher the correlation between the variable X and Y . And for the Pearson correlation coefficient of the sample it is defined as:

$$r_{XY} = \frac{\mathrm{Cov}(X,Y)}{S(X)S(Y)}$$

where $S(X)S(Y)$ denotes the sample standard deviation, and $S(X)S(Y)$ denotes the covariance of the sample data:

$$\mathrm{Cov}(X,Y)=\frac{\sum_{i=1}^{n}(X_i-E(X))(Y_i-E(Y))}{n-1}$$

To study which factors have influence on the sales of electric vehicles, in order to achieve such purpose, this paper performs correlation analysis on the data characteristics of the collected questionnaires, firstly, screens out all customers who are willing to buy electric vehicles, then, for the Pearson correlation coefficient modeling, and judges the magnitude of their influence by observing the Pearson correlation coefficient between each factor and the sales of electric vehicles. Through the scatter plot, it is possible to determine whether there is a linear relationship between the items as a way to determine whether the Pearson correlation coefficient is feasible.

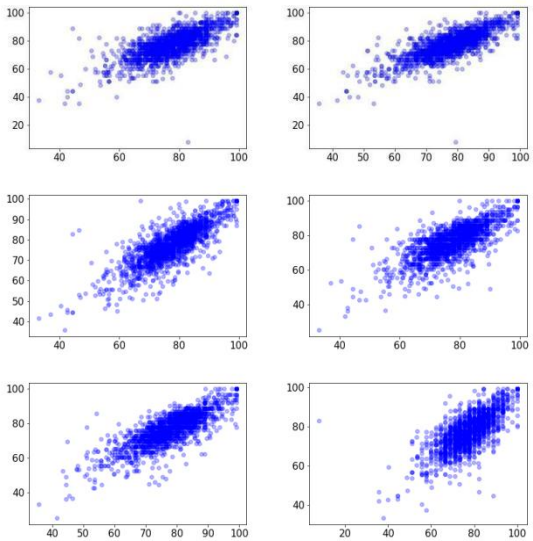

Fig1: Correlation analysis of indicators

Three of the evaluation indexes were used as the horizontal and vertical axes of each other, and the approach between other items was similar. Through plotting and screening, it was found that there is a linear relationship between the items, so the Pearson correlation coefficient can be applied for model building. The correlation coefficient between customer's willingness to purchase a car and each item is obtained by solving the Pearson correlation coefficient, which is shown in Table 2. According to the actual, after making the customer have a better experience, the satisfaction score is improved before the car can be sold, therefore, the willingness to purchase a car and each factor should be positively correlated, that is, the Pearson correlation coefficient should be taken as each factor that is greater than 0.

Table 2 Correlation coefficients between customers' intention to purchase a car and each item

Projects ρ_{XY}	Brand 0.004	a1 0.039	a2 0.241	a3 0.214	a4 0.219
ρ_{XY}	a5	a6	a7	a8	B1
	0.184	0.190	0.176	0.030	0.064
ρ_{XY}	B2 -0.04	B3 0.019	B4 0.002	B5 -0.02	B6 0.010
ρ_{XY}	B7 -0.01	B8 -0.02	B9 0.071	B10 0.047	B11 0.082
ρ_{XY}	B12 0.081	B13 0.055	B14 0.101	B15 -0.20	B16 -0.16
ρ_{XY}	B17		-0.156		

Through factor analysis, the technical performance indicators of car battery and car economy are unified into car economy indicators, and the overall satisfaction of driving handling performance (stability of turning and high speed), overall satisfaction of appearance and interior performance, overall satisfaction of configuration and quality, top speed of car, climbing ability and other power indicators and car comfort are unified into car power and comfort indicators. Safety indicators are separately classified as one category.

4.RESEARCH FRAMEWORK

4.1. Target Customer Satisfaction

The theory of target customer satisfaction refers to the customer's perception of the extent to which his needs or expectations have been met.[5] It has two meanings: customer satisfaction in the behavioral sense and customer satisfaction in the economic sense. In this study, customer satisfaction is divided into two levels according to its meaning with reference to the survey results, namely, the material satisfaction level and the spiritual satisfaction level. The elements of the material satisfaction level are the use value of the products, such as quality and design, which are the basic factors constituting customer satisfaction (shown as economy and safety in the survey report). Spiritual satisfaction is the customer's satisfaction status in terms of spiritual enjoyment, realization of values and change of identity brought about by the company's products (shown as comfort in the survey report).

4.2. Vehicle Performance Under The Seller's Position

Car performance is a characterization of structural properties that determine the efficiency and convenience of vehicle utilization. In contrast to the perspectives such as market and consumer, which are often used in existing studies, this study attempts to explore vehicle performance from the seller dimension. The producer is an important perspective for understanding vehicle performance, and its consideration of improving vehicle performance is more concerned with the importance of cost. This study is more concerned with how producers allocate their inputs in the three areas of economy,

comfort, and safety to maximize overall vehicle performance at a given cost.

First, economy is the key consideration of vehicle performance, mainly reflects the vehicle power performance. Vehicle economy is affected by the overall vehicle mass, the corresponding anti-skid resistance of the vehicle can affect the overall vehicle economy.[6] Second, comfort is the side reaction of vehicle performance. Broadly speaking, comfort refers to the vision, seat comfort, the quietness of the vehicle and the size of the vibration of each part. In terms of the vehicle as a whole, it includes the engine that generates periodic excitation and the road that generates random excitation.[7] Third, vehicle safety is divided into active safety and passive safety. Active safety mainly refers to maneuverability and the car's ability to avoid a collision; passive safety mainly refers to how the driver and occupants are protected in the event of an unexpected collision.[8] Overall, the best strategy for combining these three vehicle attributes to improve vehicle performance can be described as "drive the most comfortable car, do the safest thing, at the least cost."

4.3. Willingness To Buy a Car

The outcome of car purchase intention is a trade-off between consumers.[9] With reference to previous studies, potential factors for evaluating car purchase intention include the following three categories: first, most scholars believe that values, environmental attitudes and behavioral characteristics are more important for car purchase intention (Webster, 1975; Brooker, 1976; Chan, 1999). Second, consumers' own characteristics, such as age, income level and frequency of car use may also affect their willingness to pay for new energy vehicles (Hogberg, 2007). Third, consumers' preferences for clean energy vehicles and concluded that the performance of the vehicle is a key factor influencing consumer choice (Ewing and Sarigollu, 2000).

Comparing the three types of factors, we found that: 1) the accuracy of the measurement results with reference to the first factor is greatly limited due to the relatively limited sample available and the subjective nature of the judgments of "values and environmental attitudes". 2) due to the complexity of the car purchase decision process and the diversity of the results, the quantification of the second factor lacks clear criteria to determine which factors should be taken into account and which factors play a major role. In contrast, the third factor (vehicle performance factors set in three dimensions: economy, power and comfort, and safety) is clearly more suitable for the assessment of consumers' willingness to purchase a car from the producer's standpoint in this study.

5.RESEARCH HYPOTHESIS

5.1. Framework construction

By integrating the above three key concepts, this paper proposes an analytical framework for studying vehicle performance (economy, comfort, safety) and purchase intention under the seller's standpoint around the target customer satisfaction perspective, as shown in Figure 2. The usefulness of this perspective of target customer satisfaction theory is reflected in two aspects: on the one hand, the theory provides criteria for classifying vehicle performance under different producers' positions based on both material and spiritual dimensions, depicting different vehicle performance requirements (i.e., economy, power and comfort, and safety of new energy vehicles). On the other hand, drawing on the criteria for assessing customer satisfaction in both behavioral and economic senses, the characteristics of target customer satisfaction responding to consumers' needs and expectations are extracted to construct evaluation indicators for measuring the willingness to purchase a vehicle.

Fig2: Target customer satisfaction research framework

5.2. The impact of economy on the willingness to buy a car

Economy is concerned with the question of the price consumers are willing to pay. Adler et al. (2003) studied consumer choice between three types of vehicles: conventional gasoline, hybrid, and diesel, and found that fuel efficiency, gasoline type, gasoline price, maintenance cost, ease of refueling and repair, vehicle power, and pollution were all factors that attracted consumers to purchase hybrid vehicles. Ewing and Sarigollu (1998) and Potoglou and Kanaroglou (2007) found that factors such as purchase tax exemptions and free parking for new energy vehicles stimulate consumer demand for new energy vehicles. turrentine et al. (2009) argued that the increase in gasoline prices makes Turrentine et al. (2009) argue that the increase in gasoline prices has caused some consumers to switch to small cars and hybrid vehicles.[10] The findings of established scholars suggest that affordability is the key to determining consumers' willingness to purchase vehicles. Producers need to improve the economy performance of vehicles to stimulate the growth of car

purchase intentions. The worse the economy of a vehicle, the less likely consumers are to purchase a car given other options. Therefore, the following hypothesis is proposed1.

Hypothesis 1: Vehicle economic performance is related to the willingness to purchase a car, and better economic performance is positively related to the willingness to purchase a car.

5.3. The influence of power and comfort on the willingness to buy a car

Power and comfort are concerned with the degree of ride comfort that consumers bear the cost in exchange for. The excitation sources that affect the ride comfort performance of a car mainly include noise, engine, transmission system, tires, road surface and air, etc. The main excitation sources of a car vary at different speeds. In 1976, Guo Konghui and others studied the suspension parameters of the two-degree-of-freedom car model to improve the ride comfort of the car. In 2001, Wang-Feng et al. at Tohoku University in Japan developed a driver assistance system to modify driving behavior to improve the smoothness of the vehicle". Research related to car ride comfort is well reflected in the level of automotive products. In 1989, Toyota launched the luxury sedan Lexus 400 (Lexus) by adopting three major vibration and noise reduction measures through experimental research methods, thus making the car a great success with excellent comfort.[11] This implies that the comfort of a vehicle has a non-negligible and extremely effective impact on increasing purchase intention. Therefore, hypothesis 2 is proposed.

Hypothesis 2: Vehicle comfort performance is related to the willingness to purchase a car, and a comfortable ride is positively related to the willingness to purchase a car.

5.4. The impact of security on the willingness to buy a car

With the growing maturity of the concept of automobile consumption, vehicle safety evaluation from scratch, the current domestic new car airbag curtain, seat belt reminder, child seat interface (ISOFIX) and other restraint systems have basically become standard equipment; electronic stability control system (ESC) configuration rate from 42% in 2012 to 94% in 2019; automatic emergency braking system (AEB), blind spot warning The configuration rate of automatic emergency braking system (AEB) and blind spot warning system is also increasing significantly, and more and more safety configurations are becoming popular. Consumers are increasingly concerned about the safety of the battery involved in new energy vehicles and the safety of functional safety, human-machine interaction, data security and other safety issues brought about by autonomous driving, and new changes are brewing in automotive safety and its standards.[12] Existing studies all indicate that consumers' requirements for vehicle safety are increasing. Therefore, hypothesis 3 is proposed.

Hypothesis 3: Vehicle safety performance is related to the intention to purchase a car, and cars with high safety features have a positive impact on the intention to purchase a car.

6. LOGISTIC REGRESSION MODEL

In order to verify the above hypothesis, this study uses a survey distributed to the community to collect data, study the potential relationship between the relevant variables, and realize a user car purchase prediction model by modeling the collected data (data from a mathematical modeling contest) with the eventual purchase of cars by users.

By building a mining model to determine whether the user chooses to buy the product or not, the scatter plot shows a linear relationship between the data, so logistic regression is chosen for modeling and analysis, and a relatively high accuracy is obtained. Logistic Regression is a method used to solve binary (0 or 1) problems to estimate the likelihood of something. For example, the probability that a user will buy a certain product. Logistic Regression is a generalized linear model. Logistic regression assumes that the dependent variableYfollows a Bernoulli distribution. The sigmoid function is an s-shaped curve that takes values between [0, 1], and the value of the function quickly approaches 0 or 1 at places far from 0. This property is important for solving binary classification problems with the advantages of fast training, very good interpretability, and small memory consumption. This feature is important for solving binary classification problems.

Each feature of each sample in the data is combined linearly and then imported into the sigmoid function to obtain the logistic model.

$$h_\theta(x) = g(\sum_{i=1}^{n} \theta^T x)$$

where g(x) is the sigmoid function, and n is the dimensionality of the data. So given the parameters, y = 1 i.e. the probability that the user will buy the car becomes:

$$P(y = 1|x;\theta) = \frac{1}{1 + e^{-\sum \theta^T x}}$$

Here the threshold value is chosen to be 0.5

After establishing the optimization objective a gradient descent method is used to update the parameters with a cross-entropy loss function. And the

update method is improved using stochastic gradient descent by:

$$w_j = w_j - \frac{\propto}{m}\sum_{i=1}^{m}(h(x_i) - y_i)x^j$$

By comparing this study with Random Forest, Adaboost, this study finally uses logistic regression for analysis and prediction of sales, the model comparison chart and model design chart are as follows.

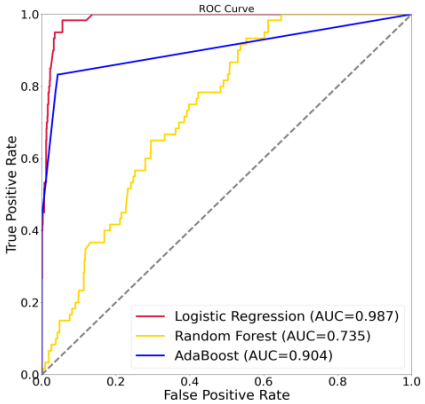

Fig3: User purchase prediction model

From the ROC curve in the figure, it can be seen that the effect of logistic regression is better due to the other two methods and can converge quickly, while the accuracy of prediction can reach 95.3%, while the model has the advantages of being simple and easy to implement. It can be seen that it has some application value, and logistic regression is used for modeling in the subsequent analysis.

After that, the model was tested for robustness: the robustness test examines the explanatory power of the evaluation methods and indicators, that is, whether the evaluation methods and indicators still maintain a relatively consistent and stable explanation of the evaluation results when certain parameters are changed.

After implementing the user car purchase prediction model, the discussion continues on the three hypotheses in the previous section.

The data of economy index, safety index, and comfort index described in the previous section are taken and fitted with the data of car purchase intention.

7.EMPIRICAL RESULTS

Calculate the partial derivatives of economy index, power and comfort index, and safety index on the model to establish the economy model, power and comfort model and safety model respectively as follows:

$$\frac{\partial h_\theta(x)}{\partial w_1} = \frac{1}{1+e^{-\theta^T x}} \times (1 - \frac{1}{1+e^{-\theta^T x}}) \times w_1$$

$$\frac{\partial h_\theta(x)}{\partial w_2} = \frac{1}{1+e^{-\theta^T x}} \times (1 - \frac{1}{1+e^{-\theta^T x}}) \times w_2$$

$$\frac{\partial h_\theta(x)}{\partial w_3} = \frac{1}{1+e^{-\theta^T x}} \times (1 - \frac{1}{1+e^{-\theta^T x}}) \times w_3$$

The influence of each of the three on the user's willingness to purchase a car is explored. The rate of change of the relationship between economy, safety, and power comfort indicators and willingness to purchase a car is made as shown in the figure.

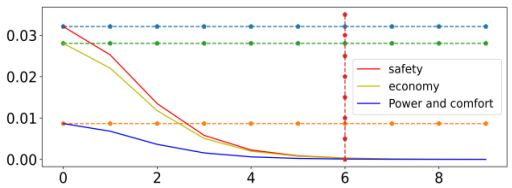

Fig4: The impact of three indicators on the rate of change in car purchase intention.

It can be verified that all three indicators are positively correlated with the willingness to purchase a car, and when each of the three indicators increases, the willingness to purchase a car is improved, and the safety and economy indicators occupy a higher position in the purchase of a car, while the comfort is second, and the growth rate of all three indicators tends to be linear after decreasing gradually as the attention to the three indicators increases. Therefore, it can be approximated that there is a linear positive correlation between the three and the willingness to purchase a car, which verifies the previous hypothesis.

Therefore, from the seller's perspective, the dynamic relationship between vehicle performance and willingness to purchase can be obtained, compared to the power and comfort of the car, when the sale of the vehicle is more economical and safe, the user's willingness to purchase increases more, the better the sales situation.

8.CONCLUSIONS

Based on the research framework of target customer satisfaction, this study expands and complements the existing literature by comparing and choosing logistic regression to model the factors influencing users' willingness to purchase a car, and exploring the research issues of performance indicators such as vehicle economy, comfort, and safety on target customers' willingness to purchase a car. The results show that all three types of indicators are positively and linearly correlated with vehicle purchase intention, with economy and safety having a more significant impact on the purchase intention of the target customer group. The results of the study have important theoretical and practical implications for the targeted development of electric vehicle manufacturers, the expansion of vehicle

sales market scale, and the resolution of multiple environmental and resource dilemmas. However, there is still room to improve the reliability and validity of the questionnaire, so one of the future improvement directions of this study is to improve the accuracy of the model by improving the questionnaire.The next optimization direction of this study is to establish sales prediction models of different vehicle performance based on the above research results

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