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The Study of China Vehicle Internet-Consumer Satisfaction Based on Bayesian Network

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Abstract

With the high-speed development of China's Internet, e-commerce and network information communication make consumers on product quality of service have a more clear understanding. The competition of network sales market brought the traditional automobile sales and services the unprecedented pressure. This paper analysis the theories about customer satisfaction model both in China and abroad. All of them are expected difference theory as the core, evaluating the benefit of consumer satisfaction by perception the difference of perceived benefits and loss. On this basis, by the internet-questionnaire survey, the China internet-automobile customer satisfaction evaluation system of the bayesian model is established. From this, it can be obtained the main factors of the customer satisfaction and their influence degree.

Keywords: *Vehicle; Customer satisfaction; Influence factors; Bayesian network*

1. Introduction

In recent years, in China the domestic automobile products are busy constructing their brands unceasingly, the service concept, service quality continues to improve, at the same time a variety of services for the majority of consumers also bring a lot of convenience, the car products is starting from the software and hardware, processes, and improve network layout, gradually turns into a focus on customer satisfaction, focus on service quality and value [1]. Under the condition of the new car market sales in China development rapid growth, how to improve the customer satisfaction become the primary concern of many automobile production enterprises. In the increasingly competitive automotive market, it becomes more and more difficult to expand in new car sales and profit, automobile enterprises only focus on creating a high level, differentiation, personalized service to more and more consumers, further exploring car market.

In the face of increasingly fierce market competition, how to strengthen customer service, improve customer satisfaction, has become the auto makers, especially the brand 4S shops priority [2].

Through understanding of the methods and research results of customer satisfaction, this paper studies the basic elements of influence consumer satisfaction and satisfaction evaluation indicators, constructs the customer satisfaction evaluation of the bayesian network model, using BayesiaLab 5.0 software tools for bayesian network inference and evaluation on the questionnaire survey result, and combining the results of the questionnaire, survey results

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do classification statistical analysis, on the basis of this puts forward countermeasures to improve China automobile customer satisfaction [3-5].

2. The Research Results of the Customer Satisfaction

Customer satisfaction is actually reflects a state of mind of consumers, it comes from the consumer to the enterprise after the consumption of a product or service produced by the feelings and their expectations of comparison is shown in Figure 1. Therefore, satisfaction is not an absolute concept, in real life, enterprise can pursue relative consumer satisfaction. In the case of a simple relationship between customer satisfaction and customer loyalty, satisfaction of consumers is more likely to be loyal, loyal customers normally would also be gratified by the product. However, customer satisfaction is not equal to consumer loyalty, it is necessary for the consumer loyalty, is not a sufficient condition. The BAIN of an American company, according draw a conclusion in a survey that there are 85% - 85% of the consumer will continue to buy the same brand products. Customer satisfaction research began in the early 1980 s, the purpose is to improve the quality of enterprise products and services, and improve enterprise profit ability, the enhancement enterprise competitiveness. Some research has focused on how to measure customer satisfaction, the customer satisfaction and enterprise competitiveness, market share, profitability, the relationship between the other studies have focused on using the customer satisfaction data for empirical research, according to the result of empirical analysis enterprise strategic planning, to improve customer relationship, maintain customer loyalty.

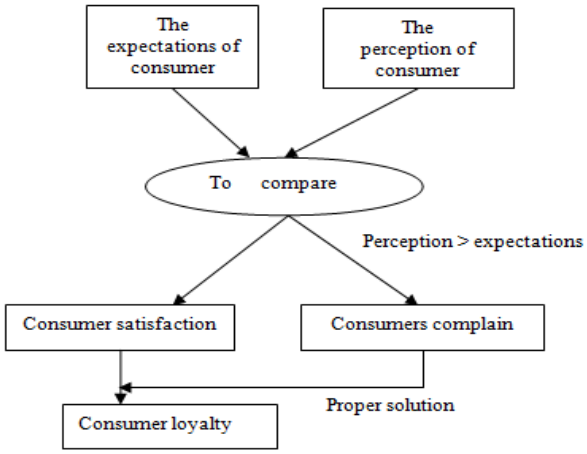

Figure 1. The Customer Satisfaction and Customer Perceived Service Quality (Consumer Expectations)

In the empirical analysis, however, sometimes the result and theory of difference is too big, make theory lacks empirical support. The cause of the result mainly have two aspects, one is the data itself, such as broadcast and authenticity of the data sampling and data processing in the process of error; The second is the diversity of the industry, industry product and service attributes, consumer pursuit of value, expectation is different also, therefore differ in terms of individual factors.

3. The Construction of Bayesian Network of China Automobile Customer Satisfaction

3.1. The Basic Principle of the Bayesian Network

Bayesian network is based on probability analysis, graph theory, a kind of uncertainty knowledge expression and reasoning model, is a kind of combining causal knowledge and probability of information presentation framework. It can under the uncertain factors, using the intuitive visual graphic representation, on the basis of bayesian probability reasoning, achieve the purpose of forecasting and decision-making [3-4]. Acyclic graph (DAG) represents the bayesian network, which is composed of nodes and directed arcs. Node is the basis of bayesian network structure, it represents the basic elements of bayesian network modeling event. The directed arc represents conditional dependencies between each node, the cause of the node to the node. Mathematical representation is: the DAG = (P, L), P = PI (p1, p2,...), L = (l1, l2,... li), represent the P and L nodes and directed arcs. Nodes of Pi variable is expressed as: a1, a2,... Ai, and meet the P (a1) + P (a2) +... + P (ai) = 1. Similarly to the node (P1, P2,... The corresponding variable Pi - 1 said. Assume there are I independent node P1, p2,... Pi in Bayesian network.

$$P(p_1, p_2, ?\ p_i) \quad P(p_1)\ P(p_2)?\ P(p_i) \tag{1}$$

Joint for conditional probability:

$$P(p_1, p_2, ?\ p_i) \quad P(p_1 | p_2, 처 p_i)\ P(p_2 | p_3, \quad p_i)?\ P(p_{xi-1} | p_{xi}) \tag{2}$$

Is the

$$P(p_1, p_2, \tfrac{1}{4}\ p_i) = \tilde{O}_{i=1}^{n} P(p_i | p(p_i)) \tag{3}$$

Eq(3), is the parent node of Xi. In a bayesian network, if connected node of X and Y have to arc by the node point X, Y, called the parent node of X to Y, Y to the child nodes of Xi. If Xi no parent node, called the root node.

In practical applications, the specific research object of bayesian network structure is more complex, often to the bayesian network probabilistic reasoning will be relatively difficult and complicated. Assumption among the adjacent nodes in the network are independent of each other, you can define a node as the intermediate node, and with his son and parent node to form a "child bayesian network". Thus, the conditional probability of bayesian networks can be calculated by the probability of child bayesian network.

3.2. The Design of Bayesian Network Model of Vehicle Customer Satisfaction

Through the research and survey on the foreign customer satisfaction, it can be seen that the customer satisfaction index model is similar to the bayesian network. Therefore, this study based on random interviews to auto consumer internet-questionnaire survey, want to obtain relevant to Chinese internet-consumers cognitive evaluation in the field of automobile consumption. Questionnaire consists of two parts: the first part is a survey of respondents' condition, including gender, occupation, family income levels, vehicle ownership situation, etc. Evaluation index of the second part is for question, according to the consumer in the process of car use and consumption, enjoy the manufacturers and auto after-sales service related services to make evaluation, prioritize, factors that affect the satisfaction evaluation,

listed the problems in the process of consumption and opinion of manufacturer and dealer and service providers. The survey sample number of 1000, the effective sample number of 849. Questionnaire effective rate was 84.9%. Sample characteristics are shown in Table 1 below.

Table 1. Characteristics of Sample Distribution

Indicators	Category	Distribution
gender	male	66.90%
	female	33.10%
age	20-30	27.09%
	30-40	33.21%
	40-50	28.03%
professional	others	11.67%
	Enterprise staff	52.0%
	Education personnel	21.0%
	Civil servants	12.0%
annual household income	others	15.0%
	>24,000$	5.5%
	18,000-24,000$	15.1%
	10,000-18,000$	44.2%
	5000-10,000$	30.5%
	<5000$	4.7%

In the process of bayesian network model building, data collection is the first step, so as to obtain consumer data needed for building model, including the choice of data items such as work directly determines the final of the model is consistent with the research target. The second step is pre-treatment the initial consumer data obtained, because the initial consumer data does not necessarily meet the demands of our model, and the data noise and other problems also exist, so the pre-treatment is an essential requirement to guarantee the accuracy of the model results. Finally, the bayesian network model built by the questionnaire survey is analysed, which help us to draw the conclusion that some beneficial to obtain customer satisfaction. The process is shown in Figure 2.

3.2.1. The Data Preparation Phase: It is important influence for the further research and study conclusion correctly to the validity of the data. Research on the field of automobile consumption, the consumer data is roughly divided into the basic characteristics of consumer data, consumer behavior characteristics of three kinds of data and consumer relations. As shown in Table 2.

a. Basic features a consumer data: age, gender, education, occupation, income, *etc.*, consumers, with different demographic characteristics and their satisfaction level.

b. Consumer sensory characteristics data: refers to the particular sensory data that reflect the customer satisfaction. Through the analysis of customer satisfaction situation, from which it is concluded that the main factors influencing the degree of satisfaction, whether can improve customer satisfaction to provide certain help.

c. The characteristics of data in relation to consumers: this portion of the data can well describe the relationship between consumption of consumer and enterprise, through the investigation of the data, to make judgments on the stability of consumer satisfaction.

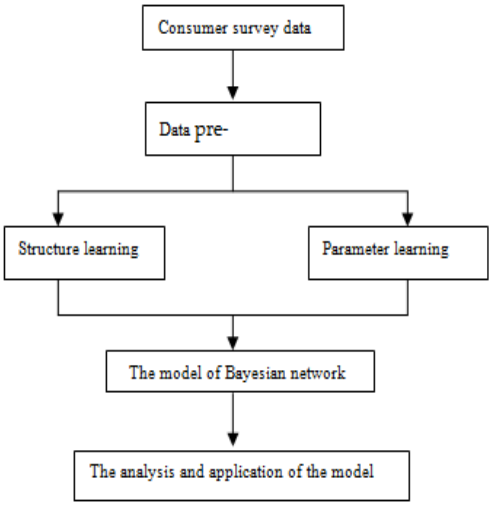

Figure 2. The Analysis Process of Bayesian Network Model

Consumer satisfaction aspects of auto service evaluation, evaluation is divided into five levels: very satisfied, satisfied, general, not too happy, not satisfied, respectively is: remember 5, 4, 3, 2, 1. Each factor index of the evaluation results are achieved. It is necessary to pre-process these data, for example, the handling of missing data domain, and to quantify the non numeric data processing. If necessary, it must deal with the raw data normalization processing, these actions contribute to the effective application of the method and reduce the deviation of data in the results. We will also pre-treat the data set is used to build a bayesian network model, and validate the established model is we succeed. To evaluate model more practical, we should use reasonable factors as model, the measure of using all of the factors as metric is unrealistic and impossible. It needs to remove some redundant factors and some of the same. In this thesis, the secondary indexes for the evaluation index system of customer satisfaction and its content as a measurement model metric respectively, namely the bayesian network model of the node. Auto consumers through before the content of the customer satisfaction index system of the secondary indicators for secondary index scores and evaluation.

Table 2. AUTO Consumer Survey Data Classification

Data items	Data content
Consumers basic characteristics	Gender, age, occupation, income, car brand, car consumption by age
Consumer perception characteristics	Products, pre-sale service, sales service, after-sale service and other aspects of satisfaction evaluation
The relationship between consumer characteristics	Awareness of the brand, the automobile sales and service quality evaluation, the overall satisfaction, etc

3.2.2. The Learning of the Bayesian Network Structure and Parameter: In General, the possible network structure of N variables number greater than N as the index function. Learning bayesian network structure is a very difficult problem completely, several researchers' work shows that it is good method to use the greedy search to choose a single good model usually get accurate predictions. In the use of Cooper and Herskovits of K2 algorithm to study the structure of this method, the basic idea started with an empty network, according to the pre-determined sequence of nodes, choose the posterior structure nodes as

the parent node with the highest probability, traverse all the nodes, in turn gradually add best parent for each variable. The biggest variable in the parent node of the algorithm number is 4 to optimize. After determining the bayesian network structure, the parameters can be studied, calculating the conditional probability distribution of each variable in the bayesian network. The maximum a posteriori parameter estimation method is used.

3.2.3. The Analysis and Application of Model: Through the above three stages (data preparation stage, the bayesian network structure learning, bayesian networks parameter learning phase) and bayesian network model is established, taken both bayesian network results and the probability distribution of all nodes, and the next is to use the application of the results were analyzed.

First, we should be prepared in the data sample set to build a bayesian network model of prediction accuracy analysis and evaluation to determine the success of the bayesian network modeling. Then, we can use the result of the structure and parameter learning, deducing the nodes of main influence factors, and further analyzes the results of the real possibility. All in all, based on bayesian network method of China customer satisfaction model, help us analysis of customer satisfaction effectively, and help to formulate the corresponding countermeasures, so as to get more satisfied customers.

3.2.4. The Analysis of the Experimental Results: Using the aforementioned K2 algorithm and maximum a posteriori parameter estimation method for structure and parameter learning, the auto customer satisfaction and its related influencing factors of bayesian network model is built. Using BayesiaLab 5.0 software, the relations between the automobile consumer satisfaction and its influencing factors is analyzed. The experiment process is divided into two steps:

a. Using the BNT software, the auto consumer satisfaction bayesian network model is established in Matlab. Experiment content is using the collected data to train the model, and verify the accuracy of the model. The 200 sample data is used to train the model. After training model, the relation of each metric nodes is examined.

Table 3. The Training Sample Data

Sample	product	Pre-sale service	Sales service	After-sales service	Customer satisfaction
1	4.0	4.0	2.0	3.7	4
2	5.0	4.0	4.0	1.8	5
3	5.0	4.0	3.5	2.5	5
4	4.7	5.0	2.8	3.5	4
5	3.7	3.3	3.5	1.7	4
6	5.0	4.0	5.0	2.7	5
7	4.0	3.0	3.5	2.5	4
8	4.5	4.0	3.0	1.7	4
9	4.5	4.0	3.5	2.5	4
10	4.0	3.7	2.5	3.3	4
11	3.5	4.0	3.3	1.8	4
…	…	…	…	…	…

b. BayesiaLab 5.0 software is used to establish the bayesian network model, with 849 valid questionnaire survey data obtained as sample to train model, respectively by the

secondary indicators and secondary indicators content as metric building a network of several different respectively explain its metric relationship with customer satisfaction.

From model 1, the independent test G, P (G) incidence from small to large order of sequence is products, sales and service, after-sale service, age, income, pre-sale service. And the lower the independence shows that the greater the relevance. So in these six factors, passive impact on consumer satisfaction degree and the product is the primary influence factors; From the value of P (G), product, sales, service, after-sales service are the main factors influencing customer satisfaction. Figure 3 shows that young people more clearly the degree of satisfaction is lower than middle-aged and old. The young people emphasis the auto products and services of higher quality requirements. This is the need to pay attention to.

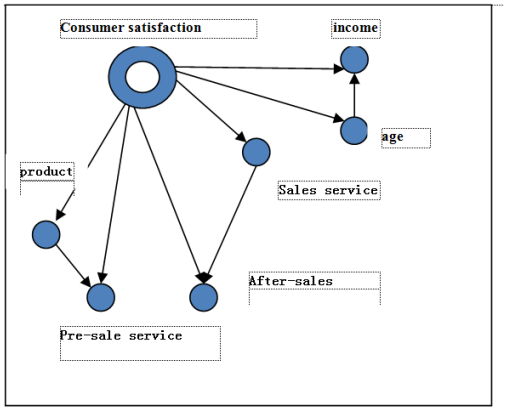

Figure 3. The Model 1 of Bayesian Network

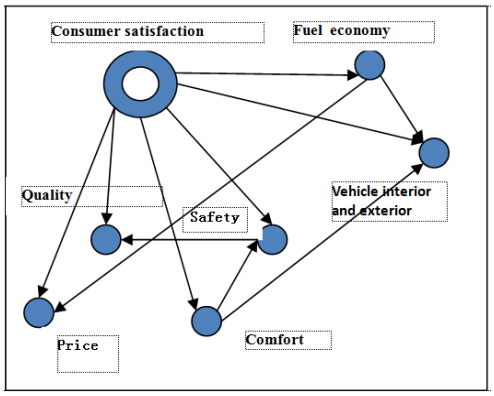

Figure 4. The Model 2 of Bayesian Network

The model 2 shows that the product of "price, quality, efficiency, safety, comfort, appearance and interior" are the influence factors of customer satisfaction, quality affect the safety, security, appearance interior influence its comfort, price, appearance, interior linked to the economy. All of this and priori knowledge is more appropriate. We observe this model the independence of the test: price, fuel economy, vehicle exterior and interior minimum value of P (G) is 0.00%, and then followed by the quality, comfort and safety. That China auto consumer groups are more focused on the price of the product, fuel economy, vehicle exterior and interior, the larger influence on customer satisfaction.

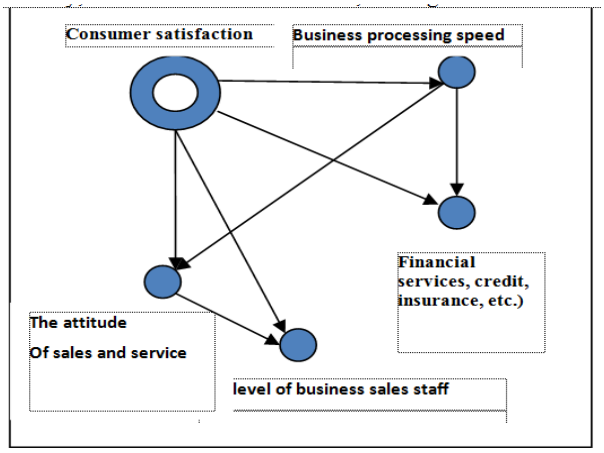

Figure 5. The Model 3 of Bayesian Network

The model 3shows, the sales and service content are all of the indexes in the influence factors of customer satisfaction, financial services is influenced by business conduction velocity, sales personnel professional level will affect the quality of service attitude, and service attitude and financial services will be related to business to deal with speed. To observed from this model the independence of the test: sales personnel professional level, sales staff attitude, financial services, business to deal with the speed of the increasing value of P (G). Obviously, the professionalism of the sales staff is an important factor in customer satisfaction.

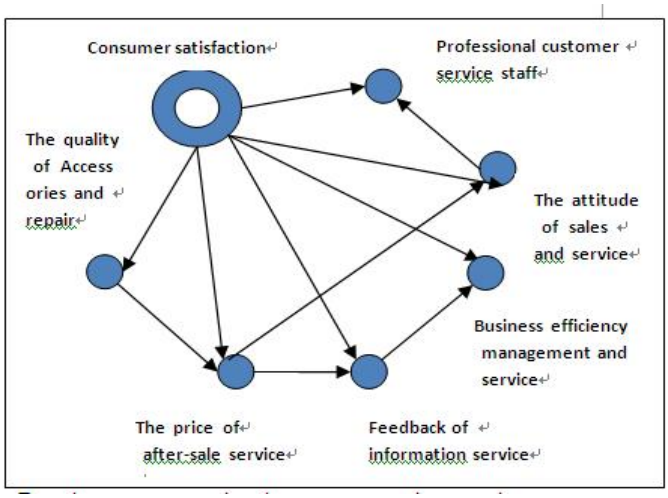

Figure 6. The Model 4 of Bayesian Network

By model 4, the after-sales service of each index content is the influence factors of customer satisfaction, service price by accessories and maintenance quality (service quality), after-sales service attitude and after-sales personnel professional level, the influence of information feedback service is influenced by business is dealt with and the service efficiency, including after-sales service attitude and after-sales personnel professional level. To observed from this model the independence of the test: after-sales personnel professional level minimum value of P (G), the second for after-sales service attitude, service information feedback and after-sales service prices, business and service efficiency, handling accessories

and maintenance quality. Similarly, after-sales service professional of the staff are the key factors that affect customer satisfaction. In the auto sales, consumers often want to meet professional responsible for staff for the vehicle to add more security.

4. Conclusion

With the rapid development of network applications and the pattern of competition increasingly update, Chinese auto market competition fiercely, consumer is faced with the choice of more diversified, also to the requirement of automobile enterprises is increasing day by day. Global market by seller's market into a buyer's market, the competition between the enterprises way also transformed, by the original focused on quality and price of the competition, which is the centre with consumer competition Consumers as one of the most important resource of enterprise, has been the enterprise put in the position of the most important, "to the consumer as the centre" the idea is becoming more and more entrenched.

Based on consumer loyalty concept and research status at home and abroad on the basis of analysis and research, the method of bayesian networks is introduced to the study of consumer loyalty, K2 algorithm is put forward to the parameters of the structure and maximum parameter learning method study method to establish the combination of between customer satisfaction and its related influencing factors of bayesian network model. By the BayesiaLab 5.0 software bayesian network model established is calculated. Experimental results show that the established model can explain the relationship between customer satisfaction and its related influencing factors for more accurate determination and analysis, and on this basis to take effective measures to retain access to more customers.

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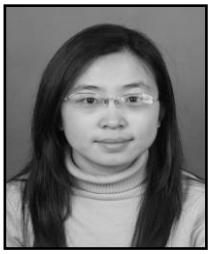

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