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Application of Gray Relational analysis method in comprehensive evaluation on the customer satisfaction of automobile 4S enterprises

Yao Cenglin

*Department of Electrical and Mechanical Engineering, Wuhan Commercial Service College, Wuhan, China
wuhanycl@163.com*

Abstract

The car sales enterprises could continuously boost sales and expand customer groups, an important method is to enhance the customer satisfaction. The customer satisfaction of car sales enterprises (4S enterprises) depends on many factors. By using the grey relational analysis method, we could perfectly combine various factors in terms of customer satisfaction. And through the vertical contrast, car sales enterprises could find specific factors which will improve customer satisfaction, thereby increase sales volume and benefits. Gray relational analysis method has become a kind of good method and means to analyze and evaluate the enterprises.

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1. Introduction

According to international practice, as for cybernetics, the quantity of information is often presented by shade. Sufficient and definite (known) information is presented as white, and insufficient and indefinite information is presented as black, as for the only partly definite information is presented as grey.

Therefore, in cybernetics system, information unknown system is called black system, information completely determined system is called white system, and everything between the two whose information is still not completely determined or known is called the gray system.

The gray system is a system contains known as well as unknown or indefinite information. The main task of grey system theory is to propose a new modeling idea and method for a gray system of less clear overall insufficient information from the cybernetic angle. Through the analysis of relevance and measure of various factors, we could deal with random data and discover the discipline with the "grey data mapping" approach, thereby making our cognition of the development of system from none to some and

little to more. That is, decreasing the gray level and meanwhile increasing the white level of the system gradually, until we could master the change discipline in it.

As for the research process of grey system theory, we should start from the black box whose internal structure and characteristics completely unknown to the gray box whose partly unknown. The so-called "box", means that we should do research from the external characteristics of system, and the known information inside the "box" is just beyond our use. However, the gray system has broken the constraints of "box", trying to play the role of existent known information. The system mainly engages in the research of internal structure, parameters and characteristics and achieves the disciplinary cognition of the internal essence and development^[1].

At present, the research of gray system theory attaches more importance on the aspects such as social economy and business. With the development of research, gray system theory will play a more and more important role in enterprise planning and the evaluation of commercial activities.

2.Mathematical modeling idea of Grey comprehensive evaluation method

Gray relational analysis method is a new analysis method of grey system theory. According to the similarity or difference of the developmental trend among the factors, i.e. "grey relevancy", it could measure the relevancy among factors. The grey relational analysis method can be used to describe the relative changes among factors in the system development process. If the relative changes of the two were basically the same in the development process, we could consider the relevancy between them is large, and conversely, the relevancy is small.

In the real world, the relevancy among many factors is grey, namely the overall information and mutual relevancy is indefinite. Therefore, when analyzing the relationship between two things, we could bring in the concept of relevancy to measure the relation between each factor and describe their relative changes quantitatively.

3.Significance of comprehensive evaluation on customer satisfaction of automobile 4S enterprises

3.1. Connotations of automobile 4S enterprises

4S store is an automobile franchise operation mode with the core of "four-in-one", including vehicle sales (Sale), spare parts (Sparepart), the post-sale Service (Service), information feedback (Survey) and so on. It has the unified characteristics of appearance, identification and administrative standards, operating only one single brand. It is a tangible market with prominent individuality, consistent channel and unified culture idea. 4S stores are obviously superior in ascending the brand and image of the automobile enterprises.

3.2.Characteristics of automobile 4S enterprises

4S mode is actually the product under the fierce competition of automobile market. As the market gradually becomes mature, so does the user's consumer psychology. Since the user's demand diversity, and higher requirements on products as well as the services, the original sales agent system has no more been able to adapt the needs of both the market and user. The emergence of 4S stores could right satisfy the customers' different requirements. The stores could provide well-equipped and clean maintenance area, modern equipment and service management, highly professional atmosphere, well-maintained service facilities, sufficient supply of spare parts and timely tracking service system. Through the 4S store services, the consumer could get a sense of trust to the brand, therefore expand the automobile sales.

3.3. Necessity of quantitative evaluation on customer satisfaction of automobile 4S enterprises

With the continuous development of automobile industry, as a commodity, automobile has already transformed from the seller's market to the buyer's market. Customers' enjoyment of the effective, convenient, high-quality and humanized service in 4S enterprises has become an important guarantee of increasing sales and creating profits for itself. What is more, in recent years, the amount of 4S enterprises has increased. It is normal that the same automobile manufacturing enterprise has opened several 4S enterprises in the same area. In sales of the same automobile type, every 4S enterprise could attract more customers and create greater efficiency only through continuously increasing the customer satisfaction and improving the service quality [2]

4. Comprehensive evaluation on customer satisfaction of automobile sales enterprises based on the grey relational analysis

4.1. Determine the index value progression and assessment standard progression of the evaluated enterprises

We choose the 2008, 2009 and 2010 (the first ten months) of a certain brand automobile sales 4S enterprise in Wuhan as the sampling time for evaluating the customer satisfaction index. Adopting the form of questionnaire to customers, we would compare and analyze the hardware facilities, personnel quality, service process, maintenance quality and customer care and so on. The questionnaire involves 100 customers who have purchased and used automobiles. The customers would give marks to the after-sales service, service charge, special maintenance, maintenance quality, Spare parts quality and customer care and so on of the 4S enterprise, rating by 10 cents. According to the simple addition of the customers' marks in terms of the annual customer satisfaction index, we could get the scores of the 4S enterprise by calculating the total points and the corresponding list and schematic of scores, namely table 1 and chart 1:

TABLE I. LIST OF SCORES OF CUSTOMER SATISFACTION OF THE THREE ENTERPRISES

the 4S enterprise	after-sales service	service charge	special maintenance	maintenance quality	Spare parts quality	customer care
The year 2008	876	925	931	882	926	907
The year 2009	903	899	943	901	891	912
The year 2010	918	907	876	914	902	898
Average score	899	910.33	916.67	899	906.33	905.67

As for the comparison of customer satisfaction of this automobile 4S sales enterprise in the recent three years, it is actually the comparison of the analysis of geometries among the three curves. In fact, it is difficult to find a mathematical method to do the quantitative calculation for the judgment and comparison of the curve geometries, especially when the differences of the curve shape are not particularly evident or the shape is similar in some intervals of the three curves. The relevancy of all the curves is difficult to be judged through a visualized method (comparison of the interval geometry).

In order to quantize the relevancy of various factors of the automobile 4S enterprise customer satisfaction through mathematical method intuitively, we could try to use the grey relational analysis method to quantize and compare the relevancy of the three curves.

First, we can determine the comparison progression of the various factors of the automobile 4S enterprise customer satisfaction by the grey relational analysis from table 1, according to the year 2008, 2009 and 2010, the sequence as follows:

$$\begin{aligned} \{x_1\} &= \{876 \ 925 \ 931 \ 882 \ 926 \ 907\} \\ \{x_2\} &= \{903 \ 899 \ 943 \ 901 \ 891 \ 912\} \\ \{x_3\} &= \{918 \ 907 \ 876 \ 914 \ 902 \ 898\} \end{aligned}$$

Second, according to the average data of various factors we could construct the reference progression as follow:

$$\{x_0\} = \{899 \ 910.33 \ 916.67 \ 899 \ 906.33 \ 905.67\}$$

In addition, for consumers, the importance of the various factors of 4S enterprise satisfaction is different. Through combining consumers' questionnaire and consulting relevant experts as well as determining the weight of various evaluation factors by using AHP method, we could get weight matrix of the six factors in terms of 4S enterprise customer satisfaction:

4.2. Dimensionless processing to the original data of reference progression and comparison progression

Because of the meaning contained by various customer satisfaction indexes is different which gives rise to the difference in the dimension of data, it is not easy to do the comparison work. Therefore, we must process the original data and make it dimensionless before the grey relational analysis is taken.

The commonly used dimensionless methods are index method and the averaging method. Averaging method is used in this sampling data, namely the averages of each progression are used to divide the entire original datum in this progression to get the comparison progression. As for the choice of reference progression, it is consisted of the highest score of each customer satisfaction index. The comparison progression and reference progression are listed as follows

$$\begin{aligned} \{\bar{x}_1\} &= \{0.9744 \ 1.0161 \ 1.0156 \ 0.9811 \ 1.0217 \ 1.0015\} \\ \{\bar{x}_2\} &= \{1.0044 \ 0.9876 \ 1.0287 \ 1.0022 \ 0.9831 \ 1.0069\} \\ \{\bar{x}_3\} &= \{1.0211 \ 0.9963 \ 0.9556 \ 1.0167 \ 0.9952 \ 0.9915\} \\ \{\bar{x}_0\} &= \{1.0211 \ 1.0161 \ 1.0287 \ 1.0167 \ 1.0217 \ 1.0069\} \end{aligned}$$

4.3. Determination of Grey relational coefficient

- *Determination of the minimum absolute difference and the maximum absolute difference*

As for the above comparison progression and reference progression, we could get their difference progression of every item in them as follows:

$$\begin{aligned} \{\Delta\bar{x}_1\} &= \{0.0467 \ 0.0000 \ 0.0131 \ 0.0356 \ 0.0000 \ 0.0054\} \\ \{\Delta\bar{x}_2\} &= \{0.0167 \ 0.0285 \ 0.0000 \ 0.0145 \ 0.0386 \ 0.0000\} \\ \{\Delta\bar{x}_3\} &= \{0.0000 \ 0.0198 \ 0.0731 \ 0.0000 \ 0.0265 \ 0.0154\} \end{aligned}$$

According to the difference of comparison progression and reference progression, we could get the minimum absolute difference and maximum absolute difference of both index progression and reference progression, namely absolute difference progression.

$$\begin{aligned} \min \Delta\bar{x}_i &= \{0.0000 \ 0.0000 \ 0.0000 \ 0.0000 \ 0.0000 \ 0.0000\} \\ \max \Delta\bar{x}_i &= \{0.0467 \ 0.0285 \ 0.0731 \ 0.0356 \ 0.0386 \ 0.0154\} \end{aligned}$$

Therefore, minimum absolute difference $\min \min \Delta\bar{x}_i = 0.0000$

Maximum absolute difference $\max \max \Delta\bar{x}_i = 0.0731$

- *Determination of Grey relational coefficient*

According to the grey relational theory and algorithm, we could present the difference in each point of each comparison curve (x1, x2, the x3 curve) and reference curve (average curve) by using the following relations, so as to determine the grey relational coefficient of various factors relative to the referent factors:

$$\xi_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \xi \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \xi \max_i \max_k |x_0(k) - x_i(k)|}$$

In this equation, $\xi_i(k)$ is the relative difference of the comparative curve and reference curve in k moments, the relative difference of this form is called relational coefficient of x_i to x_0 in k moments. In addition, ξ is the distinguish coefficient, $\xi \in [0,1]$. ξ was brought in to decrease the influence of extremum to calculation. In the actual use of grey relational analysis, $\xi \leq 0.5$ is generally more appropriate to be taken^[3].

Substituting each data of comparison progression into the formula of grey relational coefficient, we could get the grey relational coefficient of each factor of customer satisfaction in each year as follows (here $\xi = 0.5$):

$$\begin{aligned}\xi(x_1) &= \{0.0726 \quad 1.0000 \quad 0.7362 \quad 0.5066 \quad 1.0000 \quad 0.8713\} \\ \xi(x_2) &= \{0.6864 \quad 0.5619 \quad 1.0000 \quad 0.7160 \quad 0.4864 \quad 1.0000\} \\ \xi(x_3) &= \{1.0000 \quad 0.6486 \quad 0.3333 \quad 1.0000 \quad 0.5797 \quad 0.7036\}\end{aligned}$$

4.4. Calculate gray relation and establish relational ordinal

According to the grey relational coefficients of various factors of customer satisfaction in these three years, we could calculate the grey relation of customer satisfaction in the year 2008, 2009 and 2010 based on the different weight of each factor in customer satisfaction as follows:

$$\begin{aligned}r_1 &= 0.0726 \times 0.20 + 1.0000 \times 0.20 + 0.7362 \times 0.10 + 0.5066 \times 0.25 + 1.0000 \times 0.15 + 0.8713 \times 0.10 = 0.65192 \\ r_2 &= 0.6864 \times 0.20 + 0.5619 \times 0.20 + 1.0000 \times 0.10 + 0.7160 \times 0.25 + 0.4864 \times 0.15 + 1.0000 \times 0.10 = 0.70162 \\ r_3 &= 1.0000 \times 0.20 + 0.6486 \times 0.20 + 0.3333 \times 0.10 + 1.0000 \times 0.25 + 0.5797 \times 0.15 + 0.7036 \times 0.10 = 0.77037\end{aligned}$$

According to the calculated grey relational values of customer satisfaction, the three years' customer satisfaction gray relation could be sequenced as:

$$r_3 > r_2 > r_1$$

4.5. Analysis of the evaluation on customer satisfaction of the automobile 4S enterprises

Through the calculated results of the grey relation of customer satisfaction, we could find its ascending trend in this automobile 4S enterprise in the past 3 years. Apparently, although customer satisfaction is low in 2008, but its "service charge" and "spare parts quality" are in a leading position. From the relative balanced datum in 2009, we could find that the customer satisfaction in the enterprise this year keeps a balanced benign rising status. Customer satisfaction of 2010 is the best of all three years, but we should also know that the "special maintenance" and "customer care" remains to be improved in this year.

5. Conclusion

According to the grey relational analysis method, we could simply evaluate and analyze the customer satisfaction of some brand automobile 4S enterprise in Wuhan in the recent three years. It is a method with convenient operation, less data and clear conclusion. Meanwhile, we could do the horizontal analysis for large enterprises according to the method with the help of computer simulation computation which will help the mutual evaluation between the internal enterprises and the external enterprises.

As for gray relational analysis method, although it could be easier to evaluate and analyze the affective factors of the enterprise, the following respects in terms of this method should be concerned:

- When using grey relational analysis method to analyze the customer satisfaction, we should first obtain the basic data through appropriate methods. For instance, we adopt questionnaire complemented with the customer interview to obtain customers' accurate data in order to ensure the rigor and completeness of data.
- In addition, as for the determination of the various factors that influence customer satisfaction, we should combine both the customers' actual psychological feeling and the actual consumption in the

process of using the automobile. Besides, we should also combine the advice of experts in the field of automobile consumption and try our best to make the weights of various factors scientific and perfect.

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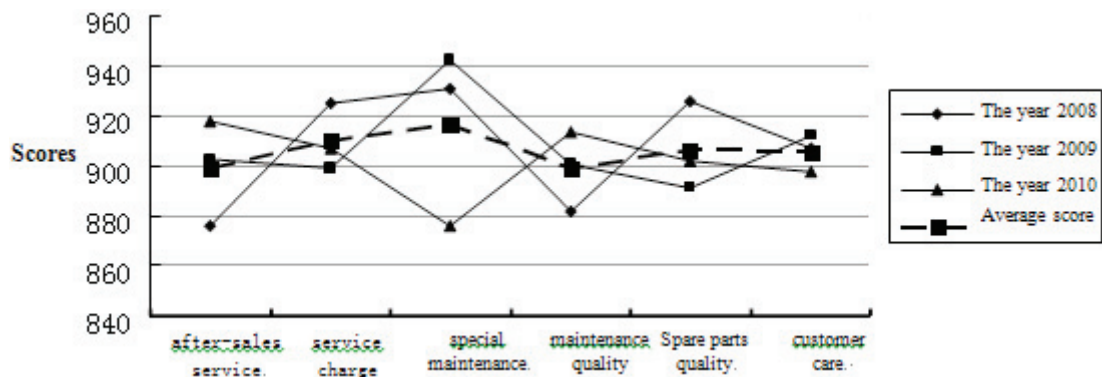


Figure 1. Score chart of various factors of the automobile 4S enterprise customer satisfaction in the recent three years