

Research on Automobile Brand Asset Evaluation Method Based on Fuzzy Mathematics and Dynamic Simulation Modeling

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Abstract: In order to provide the automotive industry with an accurate and reliable engineering method for calculating automobile brand assets, this paper first establishes various indicators for calculating brand assets. Secondly, based on the theoretical methods of fuzzy mathematics, it constructs object sets and factor sets, sets basic weights using the enforced method, utilizes fuzzy relations to determine the comprehensive calculation set, and ultimately employs dynamic simulation and simulation techniques to calculate the comprehensive scores of fuzzy relations. Experiments demonstrate that this method can effectively calculate automobile brand assets in the automotive industry, promoting the healthy development of the automotive sector.

Keywords: Fuzzy Mathematics; Weights; Dynamic Simulation and Simulation.

1. Literature Analysis

The automotive industry serves as a cornerstone industry in China, with its supply chain spanning across numerous fields. In recent years, major automotive enterprises in China have entered an era of intense competition, each striving to secure a pivotal position in the industry and increase market share. Consequently, these companies employ various mathematical engineering methods to calculate the assets of their respective automotive brands [1-5]. This enables an accurate and real-time understanding of the brand assets of their products, facilitating timely adjustments to strategies and plans in response to unforeseen events. Therefore, there is an urgent need within the automotive industry for an accurate and reliable engineering method to calculate automotive brand assets.

Currently, fuzzy mathematics, from its theoretical establishment to practical application, has undergone extensive engineering research by scholars. For instance, scholars like Zhao Yangyang [6], based on comprehensive factors such as bridge deck, upper structure, and lower structure, proposed a fuzzy mathematics-based method for evaluating the technical condition of urban bridges. The results of this method indicate that using vector-based steps such as factor domain, annotation level domain, fuzzy relationship matrix, evaluation factor full vector, and fuzzy comprehensive calculation results provides a theoretical approach for accurately evaluating and analyzing the technical condition of urban bridges. It also offers technical support for the maintenance and decision-making of urban bridges. Scholars like Xu Rongxia [7] combined fuzzy mathematics with grey theory to calculate the damage caused by stress below the fatigue limit to automotive components. They established an equidistant GM (1,1) model for stress and membership, fitted its function expression, and calculated the damage caused by stress below the fatigue limit. The estimated results had an error of around 7.5% compared to experimental results, demonstrating an improvement in

fatigue life prediction accuracy compared to models like the Miner theory. Scholars like Liu Fengfeng [8] proposed a method for dynamically monitoring the underground gas environment safety in coal mines using fuzzy mathematics theory to reduce mining hazards. Through fuzzy mathematics theory-based monitoring, an index monitoring matrix was constructed, indicating vector weights, and comprehensive calculations determined monitoring conditions. Performance experiments demonstrated that the proposed method accurately monitors harmful gas content and fluctuation changes in underground coal mines. It is evident that fuzzy mathematics methods have achieved significant research outcomes in actual engineering construction.

Dynamic simulation and simulation technology simulate real-world situations through computer calculations, controlling different parameter sizes and mixed calculations of different parameters. Utilizing the powerful computing capabilities of computers, this technology simulates the possibility of all model results. Currently, dynamic simulation and simulation technology have been widely adopted in systems engineering, yielding satisfactory results. For example, scholars like Wang Min [9] applied the basic principles and methods of system dynamics to dynamically simulate the logistics support capabilities of military logistics bases. Through simulation calculations, they quantitatively analyzed the impact of the growth rates of various input factors on the enhancement of military logistics base support capabilities, providing a scientific and quantitative reference basis for resource input decision-making. Scholars like Wang Jiangfeng [10] conducted theoretical research on traction power system load flow calculation methods and high-speed train simulation models. They designed simulation platforms for traction power system load flow calculations and high-speed train traction drive systems, collectively forming a digital simulation platform for high-speed railway traction power systems. Finally, they established a dynamically simulated platform scaled down in proportion to the high-speed railway traction power system, greatly promoting the

development of high-speed rail projects in China. Scholars like Zhang Weikui [11] used dynamic simulation and simulation technology to address complex problems in the actual grid structure and uneven distribution of loads in the Xinjiang distribution network. They performed grid reconstruction and verified the self-diagnosis, isolation, and recovery functions of faults. The results showed that this method effectively ensured the planned downtime of the project and improved the reliability of terminal equipment operation after debugging. It is clear that dynamic simulation and simulation technology have provided scientific and accurate simulation data for most systems engineering, facilitating the resolution of practical engineering problems.

Given the outstanding performance of fuzzy mathematics and dynamic simulation and simulation technology in engineering technology, coupled with the unique and specialized nature of automotive brand assets, this paper proposes a research on Automobile Brand Asset Evaluation Method Based on Fuzzy Mathematics and Dynamic Simulation Modeling

2. Research Methodology

The research methodology employed in this paper is illustrated in Figure 1. The first part involves establishing functional indicators for calculating brand assets. The second part constructs an engineering model using the theoretical methods of fuzzy mathematics. The third part utilizes the control variable method based on the engineering model to dynamically simulate all relevant factors of product brand

assets. Finally, the fourth part encompasses the conclusion and analysis.

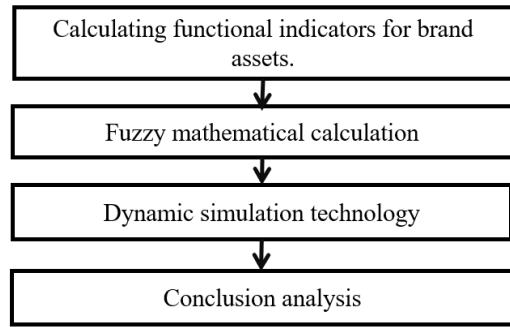


Figure 1. Research Methodology in this Paper

2.1. Building Functional Indicators for Brand Assets

The calculation of functional indicators for brand assets involves a system comprising three primary indicators (Social Impact Indicators, Industry Impact Indicators, Market Impact Indicators). Each primary indicator includes three secondary indicators. The Social Impact Indicators encompass company size, company type, and company tenure. The Industry Impact Indicators involve product patent status, product release status, and product production capacity. The Market Impact Indicators include product sales volume, product prices, and product market share. Details are outlined in Figure 2 below.

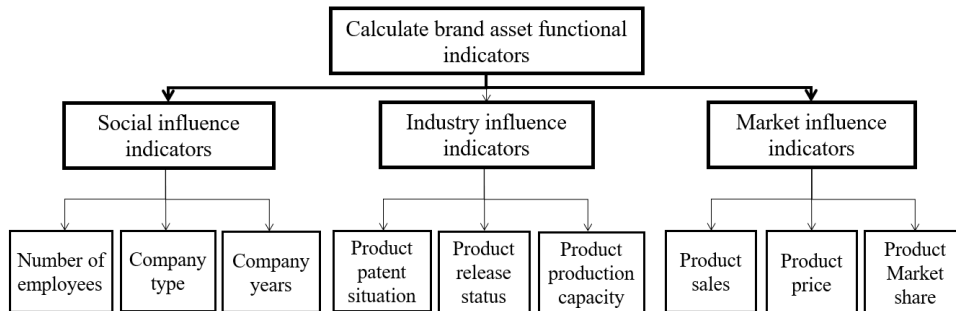


Figure 2. System for Calculating Functional Indicators for Brand Assets

2.2. Fuzzy Mathematics Model

2.2.1. Introduction to Fuzzy Mathematics

Fuzzy comprehensive evaluation is a method for making comprehensive decisions to calculate the assets of a specific automotive brand in a fuzzy environment, considering the influences of multiple factors. Fuzzy comprehensive evaluation exhibits characteristics of clear results and strong systematicity, making it suitable for solving fuzzy and difficult-to-quantify problems, particularly applicable to various uncertain situations. The process of fuzzy mathematics calculation is illustrated in Figure 3.

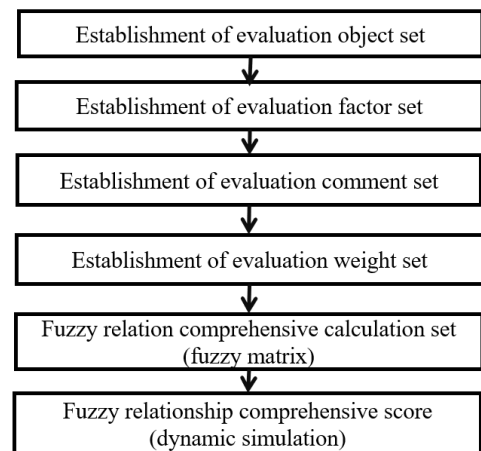


Figure 3. Fuzzy Mathematics Calculation Method

As shown in Figure 3, the fuzzy mathematics calculation comprises six steps: establishing the evaluation object set, establishing the evaluation factor set, establishing the evaluation comment set, establishing the evaluation weight set, synthesizing the fuzzy relation set (fuzzy matrix), and

obtaining the comprehensive score through fuzzy relation synthesis (dynamic simulation and simulation method).

2.2.2. Establishing the Comprehensive Evaluation Object Set

In this paper, six different automotive companies producing a certain brand of cars are sequentially numbered as $s_1, s_2, s_3, s_4, s_5, s_6$. Therefore, the evaluation object set can be obtained as $s = \{s_1, s_2, s_3, s_4, s_5, s_6\}$.

2.2.3. Establishing the Comprehensive Evaluation Factor Set

The factor set consists of various factors influencing the evaluation object $S_i \in S, i = 1, \dots, 6$ and is typically represented as $U, U = \{u_1, u_2, u_3\}$, where the element u_i represents the i th factor influencing the evaluation object. For instance, considering the Industry Impact Indicators, which require assessing product patent status, product release status, and product production capacity, u_1 would be the product patent status, u_2 would be the product release status, and u_3 would be the product production capacity. These factor indicators typically exhibit varying degrees of fuzziness.

2.2.4. Establishing the Comprehensive Evaluation Comment Set

Each evaluation indicator requires an evaluation result, and the rating indicators include excellent, good, fair, and poor, represented by V . The comment set is denoted as $V = \{v_1, v_2, v_3, v_4\}$, where v_1 represents an excellent evaluation, v_2 represents a good evaluation, v_3 represents a fair evaluation, and v_4 represents a poor evaluation.

2.2.5. Establishing the Comprehensive Evaluation Weight Set

Based on the importance of factors such as automotive product patent status, product release status, and product production capacity in the industry impact of automotive brands, the weights of various factors can be determined using the forced decision method according to the actual situation. Let the evaluation weight set be represented as $W = \{w_1, w_2, w_3\}$, where the weights satisfy the condition $\sum w_i = 1$.

2.2.6. Fuzzy Relation Synthesis Set

Based on the results above, calculate the comprehensive assessment result (comprehensive judgment set) for a specific automotive brand's assets using the formula $Y = W_i * R$, where Y is the comprehensive assessment result, W is the comprehensive judgment weight set, and R is the fuzzy matrix.

2.2.7. Fuzzy Relation Synthesis Score

Assign scores to the excellent, good, fair, and poor evaluation indicators of the comprehensive evaluation result, respectively, as 90 points, 80 points, 70 points, and 60 points, based on the principles of dynamic simulation and simulation. Multiply each transformed fuzzy evaluation result by the corresponding score, sum them up, and obtain the final score for each evaluation object $S_i \in S, i = 1, \dots, 6$.

3. Practical Engineering Validation

3.1. Construction of Assessment Results

This paper selects different car brands produced by six different automotive companies, using a four-level evaluation system with indicators of excellent, good, fair, and poor. Following the established calculation method, 10 experts are chosen to assess the importance of automotive product patent status, product release status, and product production capacity in the industry impact of automotive brands. The assessment results are presented in Table 1.

Excellent, Good, General, Negative Review

Table 1. Assessment Results of Automotive Brand Industry Impact

Car brand No.	Patent situation of automotive products				Release status of automotive products				Production capacity of automotive products			
	Excellent	Good	General	Negative	Excellent	Good	General	Negative	Excellent	Good	General	Negative
S_1	2	4	2	2	6	2	2	0	5	3	1	1
S_2	5	3	1	1	6	3	1	0	5	4	1	0
S_3	3	4	2	1	2	4	3	1	2	3	5	0
S_4	1	4	4	1	1	3	5	1	2	3	5	0
S_5	6	3	1	0	4	4	1	1	2	5	2	1
S_6	2	2	4	2	0	2	3	5	1	2	4	3

According to Table 1, according to the evaluation results of the influence of the automotive brand industry, among the 10 experts, 2 were excellent, 4 were good, 2 were average, and 2 were poorly evaluated in terms of the patent status of the S_1 automotive product. Therefore, the evaluation set can be obtained $U_1=(0.2, 0.4, 0.2, 0.2)$. Similarly, a set of evaluations can be obtained for the release status of automotive products $U_2=(0.6, 0.2, 0.2, 0)$ and evaluation set of production capacity of automotive products $U_3=(0.5, 0.3, 0.1, 0.1)$. Form a matrix of the evaluation results of the three factors obtained R_1 :

$$R_1 = \begin{bmatrix} 0.2 & 0.4 & 0.2 & 0.2 \\ 0.6 & 0.2 & 0.2 & 0 \\ 0.5 & 0.3 & 0.1 & 0.1 \end{bmatrix}$$

Similarly, the corresponding matrix $S_2 \sim S_6$ for automotive brand number $R_2 \sim R_6$ can be obtained. The specific matrix is as follows:

$$R_2 = \begin{bmatrix} 0.5 & 0.3 & 0.1 & 0.1 \\ 0.6 & 0.3 & 0.1 & 0 \\ 0.5 & 0.4 & 0.1 & 0 \end{bmatrix} \quad R_3 = \begin{bmatrix} 0.3 & 0.4 & 0.2 & 0.1 \\ 0.2 & 0.4 & 0.3 & 0.1 \\ 0.2 & 0.3 & 0.5 & 0 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 0.1 & 0.4 & 0.4 & 0.1 \\ 0.1 & 0.3 & 0.5 & 0.1 \\ 0.2 & 0.3 & 0.5 & 0 \end{bmatrix} \quad R_5 = \begin{bmatrix} 0.6 & 0.3 & 0.1 & 0 \\ 0.4 & 0.4 & 0.1 & 0.1 \\ 0.2 & 0.5 & 0.2 & 0.1 \end{bmatrix}$$

$$R_6 = \begin{bmatrix} 0.2 & 0.2 & 0.4 & 0.2 \\ 0 & 0.2 & 0.3 & 0.5 \\ 0.1 & 0.2 & 0.4 & 0.3 \end{bmatrix}$$

$$Y_1 = W \times R_1 = \{0.3, 0.4, 0.3\} \times \begin{bmatrix} 0.2 & 0.4 & 0.2 & 0.2 \\ 0.6 & 0.2 & 0.2 & 0 \\ 0.5 & 0.3 & 0.1 & 0.1 \end{bmatrix} = \{0.45, 0.29, 0.17, 0.09\}$$

Similarly, the following can be derived,

$$Y_2 = W \times R_2 = \{0.54, 0.33, 0.1, 0.03\}$$

$$Y_3 = W \times R_3 = \{0.23, 0.37, 0.33, 0.07\}$$

$$Y_4 = W \times R_4 = \{0.13, 0.33, 0.47, 0.07\}$$

$$Y_5 = W \times R_5 = \{0.4, 0.4, 0.13, 0.07\}$$

$$Y_6 = W \times R_6 = \{0.09, 0.2, 0.36, 0.35\}$$

3.3. Calculate Score

Certainly, to calculate the industry influence indicator scores for various car brands produced by six different automotive companies, assign the values 90, 80, 70, and 60 points to the respective rating levels: excellent, good, average, and poor. Utilize the calculation method outlined in Section 2.2.7 to determine the scores based on the assigned point values for each brand's evaluation results.

$$H_1 = \{0.45, 0.29, 0.17, 0.09\} \times [90, 80, 70, 60]^T = 81.0$$

$$H_2 = \{0.54, 0.33, 0.1, 0.03\} \times [90, 80, 70, 60]^T = 83.8$$

$$H_3 = \{0.23, 0.37, 0.33, 0.07\} \times [90, 80, 70, 60]^T = 77.6$$

$$H_4 = \{0.13, 0.33, 0.47, 0.07\} \times [90, 80, 70, 60]^T = 75.2$$

$$H_5 = \{0.4, 0.4, 0.13, 0.07\} \times [90, 80, 70, 60]^T = 81.3$$

$$H_6 = \{0.09, 0.2, 0.36, 0.35\} \times [90, 80, 70, 60]^T = 70.3$$

3.4. Comprehensive Calculation of Total Score

Similarly, it is possible to calculate the social impact score and market impact score for different car brands produced by six different automotive companies; the comprehensive scoring formula is as follows.

$$S_i = \sqrt{\frac{A_{i,1}^2 + A_{i,2}^2 + A_{i,3}^2}{3}}$$

Where S represents the comprehensive calculated score for different car brands produced by various automotive

3.2. Fuzzy Matrix and Fuzzy Transformation

(1) Definition of Weights

After consulting relevant literature, for the industry impact of automotive brands, the weight for patent situations of automotive products is set to 0.3, the weight for the release of automotive products is set to 0.4, and the weight for the production capacity of automotive products is set to 0.3. Therefore, the weight set for the industry impact of automotive brands is $W = \{0.3, 0.4, 0.3\}$.

(2) Matrix Transformation of $R_1 \sim R_6$

Fuzzy transformation is applied to $R_1 \sim R_6$, and from the fuzzy relation comprehensive judgment set $Y = W \times R$, the following data can be obtained,

companies, $A_{i,1}^2$ denotes the square of the social impact score for car brands produced by different automotive companies, $A_{i,2}^2$ denotes the square of the industry impact score for car brands produced by different automotive companies, and $A_{i,3}^2$ denotes the square of the market impact score for car brands produced by different automotive companies. The comprehensive scoring results are presented in Table 2 below.

Table 2. The comprehensive scoring results

Car brand No.	Social influence indicators (Score)	Industry influence indicators (Score)	Market Impact Index (Score)	Comprehensive Calculation Score
S ₁	81.5	81.0	82.2	81.5
S ₂	81.5	83.8	84.1	83.1
S ₃	79.2	77.6	79.8	78.9
S ₄	77.6	75.2	76.8	76.5
S ₅	81.4	81.3	81.9	81.5
S ₆	72.3	70.3	75.4	72.7

Therefore, the comprehensive calculation scores of different car brands produced by the six different automotive companies are arranged as follows: $S_2 > S_1 = S_5 > S_3 > S_4 > S_6$. The first place in S_2 score is mainly due to the fact that the second company's social influence index, industry influence index, and market influence are all ranked first; The reason why the score of S_6 ranks last is mainly due to the fact that the sixth company ranks last in three primary indicators: social influence, industry influence, and market influence. The conclusion of this research method is consistent with reality, therefore it can provide an accurate and reliable engineering method for the industry to calculate automotive brand assets.

4. Conclusion and Analysis

In the comprehensive evaluation method of fuzzy mathematics, the determination of fundamental weights is crucial as it significantly influences the final evaluation results. Although this paper successfully determined the weights of various factors using the enforced method, achieving favorable outcomes, future research should

consider assigning different weight coefficients to each factor based on different years' market conditions, consumer preferences, and processing objectives. This adjustment aims to enhance the accuracy and reliability of the model results, making it more adaptable to evolving market dynamics and consumer trends.

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