Research on the purchase decision of family cars

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Abstract. Faced with a wide variety of cars in the automobile market, many consumers often find it difficult to choose. In order to solve the decision-making problem in the purchase of private cars, this paper takes several compact family cars as the research object. The price, power, fuel consumption, configuration and space of the car are selected as the research indicators. The relevant mathematical model is established based on analytic hierarchy process combined with relevant data information of automobile market. The results of this paper can provide consumers with some decision references and suggestions in reality.

1. Introduction
The purchase of family cars has become a new demand of people. Many consumers have a lot of emotional thinkings when buying cars and make decisions based on personal experiences or subjective judgment, but fail to make rational analyses and judgments. The purpose of the establishment of the purchase model of cars is to help consumers to make the decisions more rationally in the process of purchasing cars according to their own needs and hobbies. Since the automobile was born at the end of the last century, it has developed and matured over the past 100 years. In order to meet the needs of consumers for a wide variety of automotive styles and qualities, there are many different kinds of cars in different countries. In the face of the comfort of American cars, the cheapness of domestic cars, the energy saving of Japanese cars, the preciseness of German cars and so on, consumers find it hard to make their own decisions. Decisions can be made by comparing the price, power, fuel consumption, configuration and the space of a car. Based on the relevant data, the model is established and the relevant factors are quantitatively analyzed. Quantitative analysis focuses on the breadth and depth, the scientificity of decision-making. Therefore, it will be more reasonable and meaningful to make rational decisions than choices by actual perception or experiences.

Many researchers have established different decision models of purchasing cars from different perspectives. For example, Xiao, Ren and Guo [1] established a Analytic hierarchy process (AHP) mathematical model for purchasing the car, and the criterion layer is the price of the car, exterior design, comfort and oil consumption. Li [2] used the method of AHP to analyze the most competitive three models SUV: Tiguan, CR-V, Ford. Ruan and Ning [3] combed the technical efficiency indicators of new energy vehicles based on the relevant data of technical efficiency of new energy automobile industry. The results can be referenced for establishing the criterion layer of the AHP model. Li and Gao [4] compared and calculated the importance of 5 kinds of vehicles, such as subway, public transport, automobile, battery car and bicycle by the AHP. Yin., et al [5] proposed a model which investigated factors influencing consumers’ purchase intentions of new energy vehicles based on Technology Acceptance Model (TAM) and Perceived Risk Theory (PRT). He [6] established
an optimal choice model for consumers to choose the car based on the discrete choice model. In this paper, several family cars, namely, Corolla, Lavida, Bora, Sagitar and Sylphy are taken as research objects. Five important indexes, such as the price, power, fuel consumption, configuration and space, are selected to establish the purchase decision model of family cars from qualitative and quantitative perspectives by using the AHP combined with relevant data of automobile market.

2. Analytic Hierarchy Process

AHP is a decision making method that decomposes decision-making problems with complex multiple attributes. The complex decision-making problem is decomposed into the target hierarchy, the criterion hierarchy and the scheme hierarchy. On this basis, the qualitative and quantitative analysis is carried out. The steps of AHP are as follows:

(1) A hierarchical hierarchy structure is established. The hierarchy is generally divided into three types, namely, the target hierarchy, the criterion hierarchy and the scheme hierarchy. The target hierarchy is the final goal of the decision maker. The criterion hierarchy is the intermediate step of the decision making, and it is composed of optional constraint factors (elements). Those factors are set to reach the final goal of the target hierarchy by the decision maker. The scheme hierarchy is made up of all the alternatives.

(2) The judgment matrix of each hierarchy is established and assigned. The pairwise comparison method is used to establish the judgment matrix. The basic idea of the pairwise comparison method is to compare two attributes, and the estimated value is given according to their relative importance. The judgment matrix and the attribute’s weight coefficients are obtained.

(3) The maximum eigenvalue and the corresponding eigenvector are calculated and the consistency test is conducted. The corresponding eigenvector to the maximum eigenvalue $\lambda_n$ of the judgment matrix $A$ is denoted as $\omega$. The so-called consistency test refers to determining the allowable range of inconsistency for $A$. Where, the unique non-zero eigenvalue of the $n$-order consistent matrix is $n$, the maximum eigenvalue of the $n$-order positive reciprocal matrix $A$ is $\lambda \geq n$. $\lambda \geq n$ if and only if $A$ is the consistent matrix. For the pair comparison matrix with the dimension of the matrix $n \geq 3$, the test of the consistency index is calculated in the equation (1):

$$CR = \frac{CI}{RI}$$

The consistency index of the tested judgment matrix is $CI = \frac{\lambda - n}{n-1}$ (where, $\lambda$ is the maximum eigenvalue of the consistent matrix to be tested, and $n$ is the dimension of the matrix). The larger the $CR$, the worse the consistency. When $CR < 0.1$, the judgment matrix is considered to be satisfactory consistency, otherwise, the judgment matrix needs to be adjusted to be consistent.

(4) The combination weight vector is calculated and the combination of consistency test is conducted. The weight vectors $\omega_j (i = 1, 2, \ldots, n)$ of the criterion hierarchy to the target hierarchy constitute the matrix $w$, then the combination weight vector of the decision-making is $W = \omega_j w$, and the test of the consistency index is calculated.

3. The Model of Purchase Decision-Making

In order to highlight the application of AHP in the decision-making of purchasing a car, the following two assumptions are made:

1) The consumer intends to purchase a compact car.
2) The price of the car is about 120 thousand to 160 thousand.

The following 5 kinds of cars, i.e., Corolla (1.2T), Lavida (1.5L), Bora (1.5L), Sagitar (1.2T) and Sylphy (1.6L) are selected as research objects in this paper. The price, power, fuel consumption, configuration and space of the car are selected as the research indicators. The hierarchy structure model is shown in the Figure 1.
In the hierarchy structure model, the target hierarchy is purchasing a car, the criterion hierarchy is the price ($B_1$), power ($B_2$), fuel consumption ($B_3$), configuration ($B_4$) and space ($B_5$) of the car. The scheme hierarchy is Corolla (1.2T), Lavida (1.5L), Bora (1.5L), Sagitar (1.2T) and Sylphy (1.6L). Pairwise comparison is made between the five factors of the criterion hierarchy, and the pairwise comparison matrix is constructed as follows:

$$
A = \begin{pmatrix}
1 & 3 & 1 & 1/3 & 3 \\
1/3 & 1 & 1 & 1 & 1/3 \\
1 & 3 & 1 & 1 & 3 \\
3 & 5 & 3 & 1 & 2 \\
1/3 & 3 & 1 & 2 & 1
\end{pmatrix}
$$

The maximum eigenvalue of $A$ is $\lambda = 5.3160$, the corresponding eigenvector $\omega$ is as follows:

$$
\omega = [0.3939 \ 0.1153 \ 0.3939 \ 0.7889 \ 0.2324]^T
$$

The result of the consistency test is $CR = 0.0705$. Since $CR < 0.1000$, the consistency test is satisfied. The pair comparison matrices of scheme hierarchy to criterion hierarchy are $B_1$, $B_2$, $B_3$, $B_4$ and $B_5$ respectively. $B_1$, $B_2$, $B_3$, $B_4$ and $B_5$ represent the judgment matrixes of the price, power, fuel consumption, configuration and space respectively.
Therefore, the maximum eigenvalues of \( B_1, B_2, B_3, B_4 \) and \( B_5 \) are respectively \( \lambda_1 = 5.0881 \), \( \lambda_2 = 5.3847 \), \( \lambda_3 = 5.1641 \), \( \lambda_4 = 5.1855 \) and \( \lambda_5 = 5.2185 \) and the corresponding eigenvectors are respectively as follows:

\[
\omega_1 = \begin{bmatrix} 0.7419 \\ 0.2246 \\ 0.4684 \\ 0.1591 \\ 0.3930 \end{bmatrix}^T
\]

\[
\omega_2 = \begin{bmatrix} 0.2207 \\ 0.6472 \\ 0.6551 \\ 0.2050 \\ 0.2477 \end{bmatrix}^T
\]

\[
\omega_3 = \begin{bmatrix} 0.5375 \\ 0.7717 \\ 0.2483 \\ 0.0623 \\ 0.2238 \end{bmatrix}^T
\]

\[
\omega_4 = \begin{bmatrix} 0.2392 \\ 0.3416 \\ 0.3523 \\ 0.1913 \\ 0.8157 \end{bmatrix}^T
\]

\[
\omega_5 = \begin{bmatrix} 0.7280 \\ 0.1597 \\ 0.2451 \\ 0.4992 \\ 0.3678 \end{bmatrix}^T
\]

The test results of consistency indexes are in the Table 1:

| Comparison matrices | \( B_1 \) | \( B_2 \) | \( B_3 \) | \( B_4 \) | \( B_5 \) |
|---------------------|----------|----------|----------|----------|----------|
| CR                  | 0.0197   | 0.0859   | 0.0366   | 0.0414   | 0.0488   |

Since \( CR < 0.1000 \), the consistency test is satisfied.

The calculation results of the total weight vector are in the Table 2:

| Criterion hierarchy | Price | Power | Fuel consumption | Configuration | Space | The total weights vector |
|---------------------|-------|-------|------------------|---------------|-------|-------------------------|
| Weights             | 0.3939| 0.1153| 0.3939           | 0.7889        | 0.2324|                         |
| Corolla             | 0.7419| 0.2207| 0.5375           | 0.2392        | 0.7280| 0.8873                 |
| Lavida              | 0.2246| 0.6472| 0.7717           | 0.3416        | 0.1597| 0.7737                 |
| Bora                | 0.4684| 0.6551| 0.2483           | 0.3523        | 0.2451| 0.6927                 |
| Sagitar             | 0.1591| 0.2050| 0.0623           | 0.1913        | 0.4992| 0.3778                 |
| Sylphy              | 0.3930| 0.2477| 0.2238           | 0.8157        | 0.3678| 1.0005                 |
The calculation results of the total weight vector are as follows:

\[ W = \begin{bmatrix} 0.8873 & 0.7737 & 0.6927 & 0.3778 & 0.0005 \end{bmatrix} \]  \hspace{1cm} (3)

It can be known from the results of the total weight vector in the equation (3), the ranking result of the scheme hierarchy is Sylphy > Corolla > Lavida > Bora > Sagitar. It is recommended to purchase the Sylphy (1.6L).

4. Conclusions

In this paper, the five compact cars are analyzed and compared by the AHP, and the ultimate purchase decision is obtained. As can be seen from the purchase decision, the Sylphy (1.6L) should be considered to be purchased preferably, and Carola (1.2T) is considered secondly. The decision result is consistent approximately with the consumer’s choice in reality. Results show that the purchasing with the AHP is reasonable in this paper. However, the subjective factors of the decision maker in the AHP have too much influence on the ultimate decision result. The decision results with the AHP cannot satisfy all consumers.

Acknowledgments

This work was supported by the Natural Science Foundation of Hubei Province (Grant No.2019CFB782).

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