The Application of Fuzzy Comprehensive Analysis Method in the Purchase of Private Cars

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Abstract: Along with the social economy continuous high-speed development, people's income is more and more high, the level and quality of life continues to improve, the consumption level and the consumption ability also in the continuous improvement, the quality of consumption has become harsh. With the progress of science and technology, the rapid development of the automotive industry, a variety of models emerge in an endless stream, which allows consumers to choose from a variety of cars in the most appropriate that a car. In this thesis, first of all, through investigation, the impact on consumers buy car factor analysis; then according to these factors. Application of fuzzy comprehensive analysis method to establish the evaluation index system, proposed based on fuzzy comprehensive analysis of the private car purchase options evaluation model. In the numerical validation, we select the recently listed five cars for fuzzy comprehensive analysis, and draw the corresponding conclusion.

Keywords: Private cars; Purchase; Fuzzy comprehensive analysis method; Evaluation

1. Introduction

Along with our country economic development, the living standard of residents in our country also constantly improve, originally belong to high income groups to buy private cars, has gradually become a mass consumer behavior. From 2000 to 2000, the China car from production and sales, has a great growth. Production volume, respectively, 2.0691 million cars in China in 2000 and 2.0886 million; While, the production volume in 2013 to 22.1168 million and 2198.41. Thirteen years, our country's automobile production volume has increased by 10 times, illustrates the demand for automobile consumption market in China and have great potential for development. At the same time, the keep the number of private cars in China is also huge. By the end of 2014, private car ownership in China is close to 75.9 million vehicles, up 18.4% from 2013. The future of our country automobile consumption level will also be further improved.

Researchers also gradually into the field at home and abroad in recent years. Source of domestic researchers have focused on cars, car brand or car tax research aspects such as research, and from the perspective of consumer oneself to choose the type of car purchase research is few and far between. Domestic research scholars mostly using analytic hierarchy process (AHP) from the buyer to buy cars needed to focus on the main points of the factors, such as fuel consumption, brand, after-sales service and so on were analyzed, and draw a car purchase scheme layer. But few researchers using the fuzzy comprehensive evaluation method to study consumer car buying.

This paper, after examining the article on the basis of related literature at home and abroad, however, at present China's powerful and formidable huge market scale, per capita purchasing power that car purchase decision factor analysis will be a future research and discussion of the topic does not decrease heat. Using the fuzzy comprehensive evaluation method to analysis the current Chinese consumers when buying private car by considering the influence of factors on the auto purchase decisions.

Fuzzy comprehensive evaluation method in fuzzy environment, considering the influence of many factors, for a certain purpose to make comprehensive decision method on the one thing. Its characteristic is that the evaluation objects one by one, to be evaluation objects have a unique value, is not affected by the influence of the collection of objects by the evaluation objects. Comprehensive evaluation of the purpose is to choose superior object from the object, so you also need to sort all the objects of comprehensive evaluation result. So the fuzzy comprehensive evaluation method will also be aimed at the evaluation object, according to the condition of given for each object gives a nonnegative real number — evaluation indicators, and then choose according to sort out the most optimal.

This paper, based on research on the basis of fuzzy comprehensive evaluation method, through the questionnaire survey to collect data, sorting, and establish the mathematical model of five private type car recently listed on

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the market for analysis and evaluation, finally it is concluded that consumers in the car buying decisions.

2. Analysis of the Factors Influencing Consumers to Buy Cars

Through the relevant investigation, consumers in the purchase of the car when the most concerned about the factors include the following points: price, appearance, fuel consumption, safety performance, the car space, and acceleration time. In this paper, the above factors to do the corresponding evaluation. There are the following five factors:

· Safety performance. Due to the sharp growth in the number of car safety accidents occurred in the process of driving risk also increased accordingly. Therefore has a good safety performance of private cars more popular with the consumers. And consumers will consider price factors when the choice and buy a car after the first consider the factors.

· Fuel consumption. In recent years, the continuous fluctuations in international oil prices, but also for the decision of when consumer is buying a car has brought the unstable factors. Because of the unstable factors, also makes more and more consumers consider car fuel consumption. But China's domestic refined oil market price does not appear significant motion, coupled with a buyer from the use of purpose, fuel consumption cannot be regarded as one of the most key factors when consumers to buy a car.

· Appearance. With the development of the people consumption idea, appearance also became the consumers in a factor to consider when buying a car. For most Chinese consumers, and good appearance of family car is not just a good user experience, but also brought more face for buyers. At the same time, the appearance also can fully reflect the comprehensive strength of the manufacturers, consumer decision-making in appearance, directly decides the personal consumption willingness and brand integrated force.

· Acceleration time. Car acceleration determine the car's acceleration time, start time and acceleration time namely body will also be a consumer to buy cars. The vast majority of consumers are more likely to start faster, and accelerate the time series models of shorter, because this kind of cars can save time, reduce fuel consumption.

· The price. Price is the consumer in choosing whether to buy cars one of the most important factors. Many consumers in the first consideration when buying a car often is the price. Price not only affects the decisions when consumers to buy a car, also affects the development of the automobile industry itself. Price fluctuations may be formed by many factors, including the change of the market, the price of raw materials, the development of science and technology, consumer preferences, and even

national policy, these changes will affect the price, will also affect the consumers to change when the car buying decisions.

· Interior space. The size of the interior is also emphatically considered when consumers to buy a car. Research shows that the concept of modern more and more tend to buy the car space larger series models. Interior contains multiple factors, including the head space, the leg space, storage space, boot space, the back width.

3. Fuzzy Comprehensive Evaluation Model

3.1. Evaluation factors set building

The factors that affect consumers to buy cars, mainly by the above mentioned aspects, the application of fuzzy comprehensive evaluation method to establish the evaluation factor set U.

$$U = \left\{ \begin{array}{l} safety\ performance\ U_1, fuel\ consumption\ U_2, \\ appearance\ U_3, acceleration\ time\ U_4, \\ the\ price\ U_5, interior\ space\ U_6 \end{array} \right\}$$

3.2. The comprehensive evaluation index system model building

According to the relevant U and its two level indicators, the establishment of evaluation index system model is shown in Figure 1.

3.3. Establish a comprehensive evaluation of evaluation set

The object of this evaluation is to select five different brands, price, appearance and other factors of the car type from the market analysis. The five car types are: Chery Arrizo 7, Dongfengfengxing Joyear, Skoda Fabia, Beijing hyundai Elantra, Changan Alsvin v7. So, this evaluation select the five car types as an evaluation set V.

$$V = \left\{ \begin{array}{l} Chery\ Arrizo\ 7 - A, Dongfengfengxing\ Joyear \\ -B, Skoda\ Fabia - C, Beijing\ hyundai\ Elantra \\ -D, Changan\ Alsvin\ v7 - E \end{array} \right\}$$

3.4. Each factor weight analysis

Weighting factors can be calculated by judgment matrix and check whether they have satisfactory consistency. Due to primary index of safety performance and interior also have multiple secondary indexes, so also to calculate and verify their secondary indexes, finally obtaining the factors weight. First of all, to introduce consumers to purchase domestic automobile factors model, the various indicators as shown in Table 1.

Step 1: according to table 1, the judging matrix was established to calculate the weighting factors. Where, the private car purchase factor matrix as shown in Table 2. Calculate eigenvectors W can be obtained by the judg-

ment matrix and the maximum characteristic value $\lambda_{\max}$, the consistency index CI, the mean random consistency index RI, random consistency ratio CR.

$W = (0.288 \quad 0.160 \quad 0.029 \quad 0.093 \quad 0.263 \quad 0.167)^T$,

$\lambda_{\max} = 6.619, CI = 0.123, RI = 1.24,$

$CR = \dfrac{CI}{RI} = 0.099 < 0.10$

After the inspection, the judgment matrix is satisfied.
Step 2: Establish secondary index judgment matrix of safety performance, performance and consistency inspection, calculate the weight. According to Table 3, we can also get $W, \lambda_{\max}, CI, RI, CR$.

Through the calculated, we find

$W = (0.67 \quad 0.06 \quad 0.27)^T, \lambda_{\max} = 3.026,$

$CI = 0.013, RI = 0.58,$

$CR = \dfrac{CI}{RI} = 0.03 < 0.10$

Also, after the inspection, the judgment matrix is satisfied.
Step 3: Establish secondary index judgment matrix of interior space, performance and consistency inspection, calculate the weight. Where, secondary index judgment matrix of interior space as shown in Table 4.
Through the calculated, we get the result by following:

$W = (0.49 \quad 0.23 \quad 0.09 \quad 0.14 \quad 0.05)^T$,

$\lambda_{\max} = 5.13, CI = 0.03,$

$RI = 1.12, CR = \dfrac{CI}{RI} = 0.03 < 0.10$

After the inspection, there is no doubt that the judgment matrix is satisfied.

3.5. Single factor fuzzy evaluation

Investigating the factors of five cars, various factors of fuzzy comprehensive evaluation resulting from the data processing, as shown in Table 5.

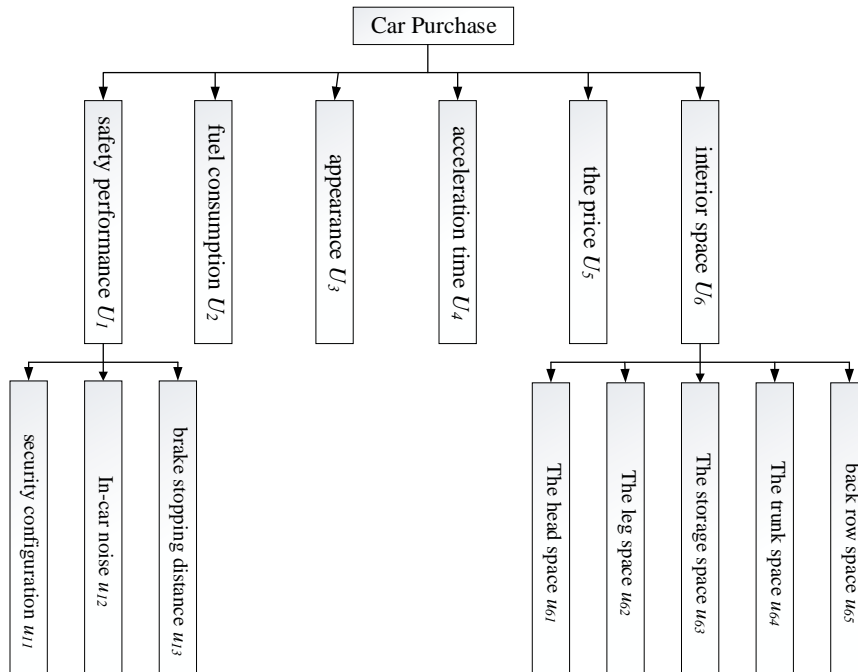**Figure 1. The comprehensive evaluation index system of consumer automobile purchasing factors**

Table 1. The factors of purchase private cars

primary index	secondary index
safety performance U_1	security configuration u_{11}
	In-car noise u_{12}
	brake stopping distance u_{13}
fuel consumption U_2	
appearance U_3	
acceleration time U_4	
the price U_5	

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	The head space u_{61}
	The leg space u_{62}
interior space U_6	The storage space u_{63}
	The trunk space u_{64}
	back row space u_{65}

Table 2. The private car purchase factor matrix

	safety performance U_1	fuel consumption U_2	appearance U_3	acceleration time U_4	acceleration time U_4	interior space U_6
safety performance U_1	1	3	7	5	1	1
fuel consumption U_2	1/3	1	9	1	1	1
appearance U_3	1/7	1/9	1	1/7	1/5	1/4
acceleration time U_4	1/5	1	7	1	1/4	1/3
the price U_5	1	1	5	4	1	3
interior space U_6	1	1	4	3	1/3	1

Table 3. Secondary index judgment matrix of safety performance

	security configuration u_{11}	In-car noise u_{12}	brake stopping distance u_{13}
Security configuration u_{11}	1	9	3
In-car noise u_{12}	1/9	1	0.2
brake stopping distance u_{13}	1/3	5	1

Table 4. Secondary index judgment matrix of interior space

	The head space u_{61}	The leg space u_{62}	The storage space u_{63}	The trunk space u_{64}	back row space u_{65}
The head space u_{61}	1	2	3	4	7
The leg space u_{62}	1/3	1	3	2	5
The storage space u_{63}	1/5	1/3	1	1/2	1
The trunk space u_{64}	1/4	1/2	2	1	3
back row space u_{65}	1/7	1/5	1/2	1/3	1

Table 5. Fuzzy comprehensive evaluation of five private cars

	A	B	C	D	E
security configuration u_{11}	0.40	0.37	0.39	0.40	0.40
In-car noise u_{12}	0.63	0.69	0.67	0.64	0.64
brake stopping distance u_{13}	0.18	0.17	0.16	0.16	0.15
fuel consumption U_2	0.79	0.87	0.70	0.90	0.76
appearance U_3	0.66	0.79	0.51	0.73	0.81
acceleration time U_4	0.14	0.12	0.11	0.10	0.11
the price U_5	0.70	0.80	0.80	0.65	0.61
The head space u_{61}	0.68	0.51	0.65	0.41	0.52
The leg space u_{62}	0.16	0.22	0.11	0.18	0.20
The storage space u_{63}	0.15	0.14	0.14	0.15	0.14
The trunk space u_{64}	0.12	0.11	0.06	0.12	0.10

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back row space u_{65}	0.54	0.56	0.46	0.59	0.56

3.6. Comprehensive evaluation

Fuzzy comprehensive evaluation factor set is divided into two layers, first to the second floor.

The comprehensive evaluation of safety performance U_1

The set $U_1 = \{u_{11}\, u_{12}\, u_{13}\}$, the weight $A_1 = (0.67 \quad 0.06 \quad 0.27)$,

Combine fuzzy evaluation of u_{11}, u_{12}, u_{13} into a single factor matrix R_1 as follows:

$$R_1 = \begin{pmatrix} 0.18 & 0.17 & 0.16 & 0.16 & 0.15 \\ 0.63 & 0.69 & 0.67 & 0.64 & 0.64 \\ 0.40 & 0.37 & 0.39 & 0.40 & 0.40 \end{pmatrix}$$

Then, according to the following formula to calculate B_1 as follows:

$$B_1 = A_1 \circ R_1 = (0.27 \quad 0.26 \quad 0.25 \quad 0.25 \quad 0.25).$$

The comprehensive evaluation of interior space U_6

The set $U_6 = \{u_{61} \quad u_{62} \quad u_{63} \quad u_{64} \quad u_{65}\}$.

The weight $A_6 = \{0.49 \quad 0.23 \quad 0.09 \quad 0.14 \quad 0.05\}$.

Combine fuzzy evaluation of u61, u62, u63, u64, u65 into a single factor matrix R6 as follows:

$$R_6 = \begin{pmatrix} 0.68 & 0.51 & 0.65 & 0.41 & 0.52 \\ 0.16 & 0.22 & 0.11 & 0.18 & 0.20 \\ 0.12 & 0.11 & 0.06 & 0.12 & 0.10 \\ 0.54 & 0.56 & 0.46 & 0.59 & 0.56 \\ 0.15 & 0.14 & 0.14 & 0.15 & 0.14 \end{pmatrix}$$

Then, according to the following formula to calculate B_6 as follows:

$$B_6 = A_6 \circ R_6 = (0.46 \quad 0.39 \quad 0.42 \quad 0.33 \quad 0.39)$$

The first layer of the comprehensive evaluation

$$B = A \circ R = A \circ \begin{pmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \\ B_6 \end{pmatrix}$$

$$= (0.288 \quad 0.160 \quad 0.029 \quad 0.093 \quad 0.263 \quad 0.167) \circ \begin{pmatrix} 0.27 & 0.26 & 0.25 & 0.25 & 0.25 \\ 0.79 & 0.87 & 0.70 & 0.90 & 0.76 \\ 0.66 & 0.79 & 0.51 & 0.73 & 0.81 \\ 0.14 & 0.12 & 0.11 & 0.10 & 0.11 \\ 0.70 & 0.80 & 0.80 & 0.65 & 0.60 \\ 0.46 & 0.39 & 0.42 & 0.33 & 0.39 \end{pmatrix}$$

$$= (0.50 \quad 0.52 \quad 0.49 \quad 0.47 \quad 0.45)$$

Accordingly, the comprehensive evaluation result of five brand cars is the sort: B, A, C, D, E. The above results are normalized to be $(0.21, 0.21, 0.20, 0.19, 0.19)$, we can come conclusion that if there are 100 people want to buy a private car, 21 of them would choose to buy Chery Arrizo 7 or Dongfengfengxing Joyear; 19% of them are willing to buy Beijing hyundai Elantra or Changan Alsvin v7; the rest prefer to buy Skoda Fabia.

4. Summary and Conclusions

The car on the market at present there are many kinds of, care about most when everyone choose different car types in different factors. Select car type method also are not identical, for now, can be introduced through people, can evaluate yourself, or the brands are optional to fit their own hobbies, this paper is mainly based on the questionnaire survey and oral form, get the owner is the main consideration in choosing a private car base on these factors: the price, appearance, fuel consumption, safety performance, interior space, and acceleration time. Then, using the fuzzy comprehensive evaluation method, on the basis of several factors, for Chery Arrizo 7, Dongfengfengxing Joyear, Skoda Fabia, Beijing hyundai Elantra, Changan Alsvin v7 this several cars were evaluated. Through preliminary using fuzzy comprehensive evaluation method, the following conclusions: in the investigation of the population, 21% of people will choose to buy Chery Arrizo 7, 21% of people will choose to buy popular in Dongfengfengxing Joyear, 20% of people will choose to buy the Skoda Fabia, 19% of people will choose to buy Beijing hyundai Elantra, 19% of people will choose to buy Changan Alsvin v7.

Fuzzy comprehensive evaluation has many advantages, for example, it can make the information in real life cannot be quantified, with digital display, although the process is fussy, and the calculation amount is relatively large, but the final presentation of the results is very intuitive. And its evaluation by object, the object has a unique evaluation value, not affected by other factors. But there are certain limitations, is to determine the membership degree of the time requirements, evaluation of the number of people cannot be too small, and the selection of the evaluation of the people must have a certain understanding of the evaluation. Only using the correct method to determine the membership degree, can make the final results close to the real market. Finally, the fuzzy comprehensive evaluation method can determine the relative optimal between several products, the purpose of the object is to take into account the comprehensive sort of factors, and cannot determine its accurate data.

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