International Journal of Hybrid Information Technology
Vol. 9, No.11 (2016), pp. 267-274
http://dx.doi.org/10.14257/ijhit.2016.9.11.23

Subsidy Program Evaluation based on Rough Set

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Abstract

Taxi subsidy program established is reasonable or not is one important step to research the "taxi difficult" issue in today's society. In this paper, we analyze the correlation of the three indicators and 15 factors, get the correlation between the index and its influencing factors, then reuse rough set preliminary screening for data factors, combined factor analysis to obtain the final subsidy program evaluation model. Substituted into the value of the three indicators before and after subsidies respectively, obtained the evaluation value before and after the subsidy. Q_1, Q_2, and $Q_1<Q_2$, the subsidy program for "ease taxi difficult" has some help.

Keywords*: rough set; factor analysis; taxi subsidy*

1. Introduction

From the beginning of the 1970s, extensive research in the taxi industry began in abroad, research focused on aspects of the taxi market model and economic analysis of the taxi industry. Urban passenger subsidy issues have been extensively studied and achieved fruitful results. At present, the researches on the urban passenger transport subsidies focused on public subsidies. Yang Yuanzhou (2010) and others based on the analysis on the principle of public transport subsidies, constructed the subsidy model of public transport. Beijing public transport subsidies as a background, research the influence of public transportation structure coefficient, share ratio and operating costs on public transport subsidies. The results show that a reasonable allocation of the various modes of public transport passengers, on the one hand it makes the government share of public transport subsidies in the amount of revenue among the not too large, it also meets the public passenger transport share ratio requirements and give public transportation subsidy program under certain conditions [1]. Wu Ruixian and Xu Qing (2012) established a principal-agent model of best government subsidies from a quantitative point of view and discussed the affecting factors of the optimal subsidy contract and impact of incentives on bus companies' effort. The study also shows that when the government can not measured on the bus company's efforts to increase social welfare, it should not be incentives for the task and at the same time weaken the incentive to increase the economic benefits [2]. Nils Fearnley (2004), who proposed a performance-based contract enables government agencies and rail operators combined interests, but thus obtained performance-based transport subsidies will be higher than the existing level of subsidy[6]. KARLAFTIS and Mc CARTHY (1998) studied the impact of subsidies on public transit system performance. By analyzing the state of Indiana A fixed-line data bus system, we discovered subsidies are no major impact on the public performance and the size of the public transport system will significantly affect the impact of subsidies on public property. The simulation analysis found that when the total subsidy unchanged, only redistribute subsidies will not have an impact on the efficiency of the public transportation system[7]

From the beginning of the 1990s, Chinese scholars began to study the issue of public subsidies. Previous studies mainly focus on the welfare characteristics of urban public transport. From the subsidy objects, the subsidy calculation method and sources of

ISSN: 1738-9968 IJHIT

funding subsidies aspects discuss the urban public transport subsidies [8]. In recent years, public subsidies research diversified development trend. Wang Jian, An Shi *et al*. (2006) using transportation behavioral science and systems science theory, combined the bus fees, financial subsidies and congestion pricing and other issues, construct of the bus toll model based on financial subsidies congestion pricing. Combined the case and analyze how to use public subsidies congestion pricing and transit fees and other means to achieve the ease traffic congestion, reduce traffic management objectives[9]. Zhou Chunyan, Wang Qionghui (2007), based on the characteristics of rail transit, proposed to build government-subsidized public participation, encourage while rail companies to reduce operating costs, improving service quality[10]. Li Jianping *et al*. (2008) on the basis of analyze the characteristics of public transport and the necessity of price subsidies, summarizes the main issues of public transport price subsidy mechanism exists and puts forward measures to improve the subsidy mechanism[11]. Many cities at home and abroad have introduced the subsidy programs of taxi operators, mainly through government subsidies and fuel surcharges two forms to achieve, but theoretical studies on the aspects of taxi subsidies are not many. Therefore, it is necessary from the theory to use its the three index value before and after the subsidy to evaluate and then evaluate the subsidy program.

2. Factors Primaries of the Taxi "Matching Supply and Demand" Evaluation Level

Primary the factors of the taxi "matching supply and demand" evaluation level (hereinafter referred to as "targets"). First, combined the actual situation of taxi operations, in actual evaluation, there is overlap between the various factors indicators, requiring the use of rough set reduce the extracted factors. Use the reduction factors of the index system to evaluate, calculate the weight of every factor, using linear weighting method calculating an evaluation value of the last of each indicator and as a primary basis for index, selected indicators for solving the final comprehensive index as a basis.

2.1. The Construction of Indexes Factors System

City Taxi "matching supply and demand" level reflects the current status of the merits of the city taxi transportation. On the "supply and demand match" Assessing is to consider whether the city taxi industry need for further construction and development or not. This article used mileage utilization, vehicle load factor and taxi million ownership these three indicators to evaluate the amount of the city's taxi "supply and demand match" degree based on relevant literature. Specific evaluation system as shown in Table 1

Table 1. City Taxi "Matching Supply and Demand" Degree Evaluation System

Evaluation	The factors of evaluation
mileage utilization x_1	Total urban GDP r_1
	City population r_2
	The number of bus r_3
	The number of private cars r_4
	Residents' per capita annual income r_5
taxi million ownership x_2	Taxi ownership r_6
	Household consumption r_7
	The average starting price r_8

vehicle load factor x_3	The prices of per kilometer r_9
	Pilot single shift monthly revenue r_{10}
	Urban per capita road area r_{11}
	Volume of passenger buses r_{12}

From Table 1, Taxi city's "supply and demand match" degree evaluation system has multiple specific evaluation, these indicators reflect information on the relevant issues from different angles and extent. With the increasing influence of factors inevitably result in the possibility of the meaning of certain factors overlap and the degree of overlap increases, so some of the less important factors have been added, having an impact on the accuracy of the city taxi "matching supply and demand" degree evaluation, hence need to reduce the factors of the original system.

2.2. The Construction of City Taxi "Matching Supply And Demand" Degree Evaluation Information System

The construction of city Taxi "matching supply and demand" Degree Evaluation Information System is converting the evaluation system to information systems. Rough Set mainly use two-dimensional information table to represent knowledge and information, dimensional information table was defined as the Comprehensive Assessment Information System in rough set, generally use following shorthand $S=\langle U,R,V,f\rangle$ or $S=\langle U,R\rangle$ to represent the Comprehensive Assessment Information System.

Corresponding to evaluation system, U in The City Taxi "matching supply and demand" Assessment Information System refers to the evaluation of a collection of objects (evaluation) $U=\{u_1,u_2,u_3\cdots,u_n\}$. R represents a set of attributes $R=\{r_1,r_2,r_3\cdots,r_n\}$. V represents that each index the set of values of corresponding impact factors. We construct Taxi "matching supply and demand," the degree of evaluation information systems through correspondence explanation.

Evaluation system factors in both quantitative factors, as well as qualitative factors. Quantitative factors corresponding attribute value V_r, you can consult Transport Statistical Yearbook, Statistical Yearbook or visit the official website to get. The qualitative factors are obtained through expert scoring method.

2.3. The Value of Affecting Factors Normalized and Discrete

① The value of affecting factors normalized

Firstly, dimensionless processing the indicators of various factors, this paper uses linear non dimensionalization to dimensionless process the indicators of various factors.

② Factors value discrete

Equal interval is equally divided the continuous property range into $k(k\in N)$ Interval. It contains the same amount of measured values within each interval. So this article selection method for each interval factors discrete processing. We use mathematical (1.3.1) express each factor. Among them k represents the corresponding value of each factor.

$$k=\begin{cases}1 & 0\le k<a\\ 2 & a\le k<b\\ 3 & b\le k\le c\end{cases} \tag{1.3.1}$$

2.4. The Construction of Factors Screening Model Based On Equivalence Relations

This step is the key step of the factors evaluation based on rough set. In factors evaluation information system we can divided the evaluation of a collection of objects into a plurality of equivalence classes based on any factors. Set of equivalence classes is an equivalence relation. We can also divided the evaluation of collection of objects into a plurality of equivalence classes based on multiple factors. We can also obtain an equivalence relation. We will all be able to get an equivalence relation based on a subset of arbitrary factors, this equivalence relation is expressed as $\mathrm{IND(R)}$,

$$\mathrm{IND(R)} = \bigcap_{r \in R} \mathrm{IND}(\{r\}) \tag{1.4.1}$$

Among them, $\forall r \in R$, $\mathrm{IND(R)}$ equivalence relations are all subsets of R Intersection.

The build process of factors evaluation information system reduction model is shown as Figure 1.

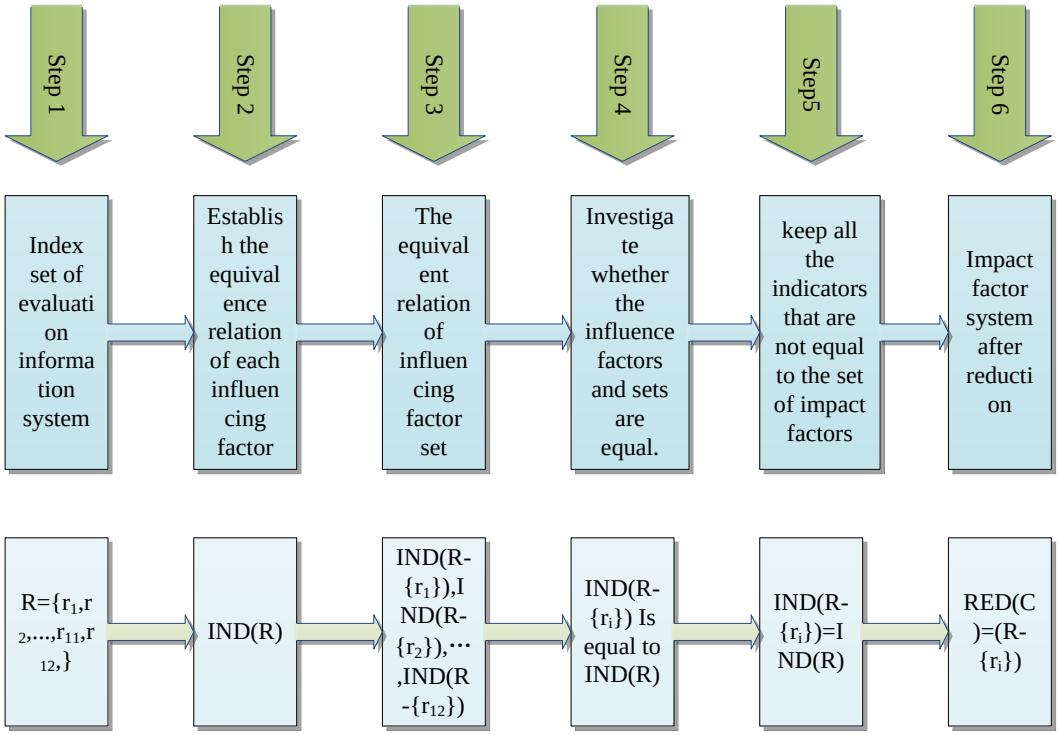

Figure 1. Flow Chart of Reduction Model of Impact Factor Evaluation Information System

2.5. Determine and Evaluate the Weight of Influencing Factors

In order to make the right to a more reasonable weight factors, we determine the weight and also consider the objective weights and the weight of experience. In factors system objective weight of each factor correspond to the importance of each factor the comprehensive assessment information system. We use information entropy to indicate each factor weight in factors system. Information systems $S = \langle U, R, V, f \rangle$, including:

$$U / R = (X_1, X_2, X_3, ..., X_{14})$$

Then the system $\mathrm{U/R}$ information entropy is

$$H(R) = -\sum_{i=1}^{m} p(\mathrm{X_i}) \ln p(\mathrm{X_i}) \tag{1.5.1}$$

$$p(\mathrm{X}) = \frac{|\mathrm{X}|}{|\mathrm{U}|}, X \in U / R$$

Among them, .The importance of each factor in factors systems is

$$S(R) = \left|H(R - \{r\}) - H(R)\right| \quad (1.5.2)$$

We use the value of $\mathrm{S(r)}$ shows the influence of factors of weight, the weight is the objective weights. We use linear weighted method to deal with the weight calculated by rough set and the weight given by experts to obtain the weight value of final factors.

$$\omega^* = \alpha \cdot \omega_1 + (1-\alpha) \cdot \omega_2 \quad (1.5.3)$$

In formula (1.5.3), ω_1 is objective weight, ω_2 is subjective weight. We calculate the weight of each index, and the corresponding values of various factors, obtained using linear weighted index values. According to the evaluation model based on rough set of index system for processing obtain "matching supply and demand" the corresponding evaluation factors value. We sort these values, excluding the factors does not meet the performance and combine the remaining three evaluation factors, as a taxi "matching supply and demand" comprehensive evaluation index level.

3. The Practical Application of Rough Set

(1) According to the degree of "supply and demand matching" of taxi, primary election of influencing factors of evaluation index

① Construction of influencing factors system

The above factors system is regarded as the initial evaluation index system that evaluates the degree of the taxi "supply and demand".

② Data to determine the impact factor system

Evaluation index set that evaluates the degree of the taxi "supply and demand" is $\mathrm{U} = \{\mathrm{u}_1, u_2, \cdots, u_{12}\}$. The quantitative factors in the system of influencing factors can be obtained by referring to the relevant literature, on the other hand, qualitative factors are obtained through expert scoring. In all factors, r_7 and r_8 are qualitative factors, meanwhile, although r_1 is a quantitative factor, owing to the data is not easy to query, still it to assign. Qualitative index fuzzy quantitative numerical corresponding table is shown in Table 2.

Table 2. Numerical Value of Qualitative Factors Blurred and Quantified

qualitative description	1	2	3
data	bad/little	commonly	good/more

Through access to relevant literature to obtain the impact factor data from a taxi company, fuzzing quantification of qualitative information, then construction index evaluation original data information table.

③ Correlation analysis

To establish the relationship between the three indicators and the 12 Factors, going to establish the relationship between the two sets of data. Firstly, the data must be standardized and dimensionless, in order that there is no difference between the dimensions of the data, after that, correlation analysis to establish the relationship between the data. Correlation analysis of the data to get the relationship data of Table 3.

Table 3. The Relationship between the Three Indicators and the 12 Factors

	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
x_1	-0.103	-0.075	0.083	0.121	0.005	-0.153	0.140	-0.087	0.140	0.372	0.005	-0.036
x_2	0.323	0.449	0.329	0.170	0.497	0.349	0.326	0.034	0.211	0.115	0.270	0.472
x_3	0.179	0.169	-0.495	-0.618	0.068	0.502	0.357	-0.198	0.121	-0.578	-0.661	0.262

④ Information table discretization

According to the equal interval method, discretizing the numerical value of the influence factors in the information table. The 12 sets of data are discretized, in accordance with the discretization standard of the formula (2.1).

$$k=\begin{cases}1 & 0\le k\le 0.333\\ 2 & 0.333\le k\le 0.666\\ 3 & 0.666\le k\le 1\end{cases} \tag{2.1}$$

After that the absolute value is taken, the specific value of each influence factor is obtained.

⑤ Influencing factors of reduction information table

According to the method of general reduction, influencing factors of reduction information table. Data discrete table by the above factors, drawing the conclusion.

$IND(R)=IND(r_1,r_2,r_3,...,r_n)=\{\{r_1\},\{r_2\},\{r_3\},...,\{r_n\}\}$

Calculated separately:

$IND(R-\{r_1\})=IND(r_2,r_3,...r_{12})$;

$IND(R-\{r_2\})$; $IND(R-\{r_3\})$; $IND(R-\{r_4\})$; $IND(R-\{r_5\})$; $IND(R-\{r_6\})$; $IND(R-\{r_7\})$; $IND(R-\{r_8\})$; $IND(R-\{r_9\})$; $IND(R-\{r_{10}\})$; $IND(R-\{r_{11}\})$; $IND(R-\{r_{12}\})$;

So the information table is obtained after reduction, then transforming into simple information table 4.

Table 4. Information Result after Reduction

	r_3	r_4	r_6	r_7	r_{10}	r_{11}
x_1	0.083	0.121	-0.153	0.140	0.372	0.005
x_2	0.329	0.170	0.349	0.326	0.115	0.270
x_3	-0.495	-0.618	0.502	0.357	-0.578	-0.661

According to the data in Table 4, performing factor analysis, then it can extracting a

component.

$$Q = -0.865x_1 + 0.934x_2 + 0.807x_3$$

Subsidy programs are mainly divided into cash subsidies, red subsidies and bonus points [9-11]. Subsidy program will have a certain impact on the extent of the use of taxi passengers and drivers related software, but the extent of the use of software and taxi drivers taxi software and the extent of the software will mainly function in two factors including the level of consumption of residents r_7 and driver's single month revenue r_{10}, acting on the mileage utilization, taxi million ownership, vehicle load factor, ultimately affect the degree of matching supply and demand. Comparing before and after the different subsidies from the degree taxi passengers and drivers to use software taxi software level, these changes affect the mileage utilization, taxi million ownership, vehicle load factor, thereby affecting the ultimate degree of matching supply and demand.

According to the data before and after the subsidies, using the formula $Q = -0.865x_1 + 0.934x_2 + 0.807x_3$, finding before and after indicators of subsidies Q_1 and Q_2, comparing the size of the two values. After the data infinitude and frame on the table, drawing the graph shown in Figure 2:

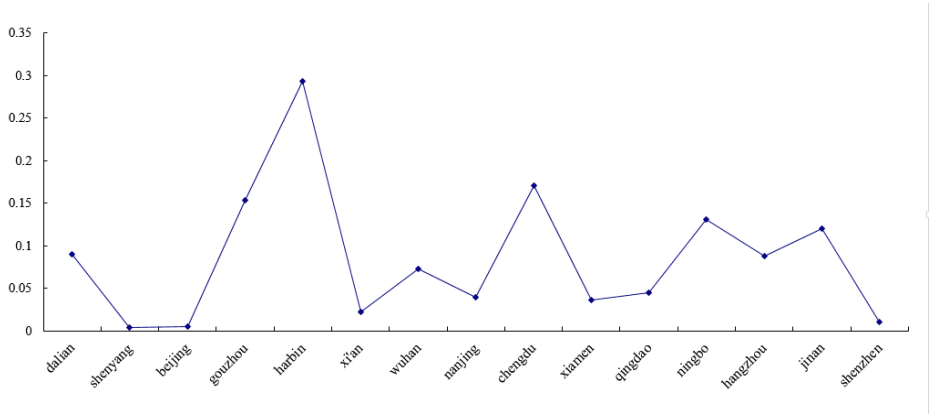

Figure 2. The Difference between Before and After the Subsidy Integrated Indicators

Getting a taxi subsidy program to ease the taxi difficult to have some help from Figure 2, but the help is not too great in some of the cities mentioned, especially Shenyang and Beijing, taxi difficult situation has almost no change.

Acknowledgments

This work was supported by National Scientific and Technological Support Projects (no. 2012BAE09B00), the National Natural Science Foundation of China (no. 51274270,51274081, 51504080), and the National Natural Science Foundation of Hebei Province (no. E2013209215).

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