PAPER • OPEN ACCESS

Supplier Evaluation and Selection Method Based on Multi-attribute Granulation

Supplier Evaluation and Selection Method Based on Multi-attribute Granulation

Feng Zhan*

Engineering College, Fujian Jiangxia University, Fuzhou, China

*Corresponding author e-mail: fzhan_84@163.com

Abstract. Enterprise plays the role of resource amplifier or resource converter in production activities, whose function is often closely related to the activities in a value chain. The procurement activity of the enterprise is one of the key links in a value chain. Supplier evaluation and selection in the procurement activity is critical to the quality of the final product. To deal with the problem that multiple attribute decision was there, determination of attribute weights was uncertain, and fast computation could not be achieved in traditional supplier evaluation and selection research. The granular computing is applied to supplier evaluation and selection research, which a multi-attribute based on bit granular matrix is used to study supplier evaluation and selection problem in a value chain. The attribute redundancy of evaluation index in mixed information is solved in this paper by using the knowledge reduction method of granular computing theory. The attribute weight matrix is calculated by the calculation method of attribute index weight based on knowledge, which is used to evaluate the importance of attributes. The experimental results show that this method can provide the reference for enterprises to select suppliers quickly and efficiently.

1. Introduction

Modern industries must choose suppliers who meet their own needs to survive and develop. It can achieve cost reduction, efficiency enhancement, quality improvement, and service quality. Therefore, how to effectively evaluate and select suppliers has become an important issue in all industries [1].

The earliest systematically study of supplier evaluation was done by Dickson [2]. In 1966, he studied a large number of questionnaire feedback data and then proposed 23 evaluation indicators for supplier evaluation. On this basis, Weber studied 74 literature on supplier selection from 1976 to 2000, and then found that the key indicators of supplier evaluation and selection were price, quality and delivery [3]. Price has long been a major factor in supplier evaluation and selection. With the development of science and technology and the increasingly fierce competition in domestic and foreign markets, the competition among suppliers is no longer the traditional "low price winner". That is to say, when selecting the right supplier, not only the price should be considered, but also factors such as product quality, historical service, and maintenance ability should be considered [4]. With the increasing pressure of resources and environment, the concept of environmental protection is deeply rooted in people's minds, and it is imperative to develop green suppliers [5].

In the actual supplier evaluation and selection, there is a multi-attribute decision [6]. However, it is difficult to achieve the optimization of multiple objectives at the same time. For example, the optimal service of the supplier and the lowest price are a pair of possible conflicting goals. The buyer wants to get the best service from the supplier at the lowest price. In fact, to improve the supplier's service level, it needs to increase its construction or operation cost, and it may increase exponentially with the improvement of service level.

The study of supplier evaluation and selection has gone through three stages: qualitative method, quantitative method, and combination method [7-10]. In recent years, many scholars have adopted rough sets to deal with the fuzzy, incomplete and objective nature of attribute weight in supplier evaluation and selection, and achieved certain results [9-10]. However, the above researches on supplier evaluation and selection based on rough set have some problems such as lack of focus, inability to evaluate rapidly, etc.

Granular computing is one of the knowledge discovery and data mining, to imitate the human way of thinking to solve the problem of a complex [11]. It can be viewed from different angles, analyze problems. It is used to grasp the connotation and essence of things by decomposing problems into different levels. Further, the hidden key information is mined. The solution to the problem is obtained by dividing the complex multi-attribute problem into a simple one. Many scholars have done a lot of research and obtained gratifying research results, in data mining, knowledge discovery, information decision, pattern recognition and other aspects [11-13]. Therefore, grain calculation is a solution method for complex problems [14].

In this paper, granular computing is applied to the supplier evaluation and selection. It is used to study and solve the redundancy of evaluation index attribute, and realize the supplier evaluation and selection of multi-attribute decision based on the focus. It can provide the right supplier for the enterprise to consolidate the position of enterprises in the supply chain, which is conducive to control the cost of enterprises, improve customer satisfaction, and further enhance the core competitiveness of enterprises. Therefore, it is a matter of great theoretical and practical significance to construct an effective supplier evaluation and selection system.

2. Basic information of supplier evaluation and selection

As a pillar industry of Fujian Province, the construction industry has made important contributions to the economic and social development, urban and rural construction and improvement of people's livelihood in Fujian province. However, the construction industry has also become an industry with high energy consumption and heavy pollution (air pollution, noise pollution, and et al.). The government pay a great importance attention to the reform and development of the construction industry and has vigorously developed the green construction industry. Among them, choosing the right green supplier is an effective way to achieve this goal. Therefore, six candidate suppliers of a practical green building project in Qingdao is used to the research object in this paper [10].

Table 1. Green building supplier selection evaluation form.

Supplier candidate	Product superiority *C1*	Operations management *C2*	Cooperative potential *C3*	Green management *C4*	Users' satisfaction *D*
1	Good	Great	General	Great	Dissatisfied
2	Great	Good	Great	Good	Satisfied
3	Great	Great	Great	Good	Very satisfied
4	Great	Great	Good	General	Satisfied
5	Great	Good	Great	General	Very satisfied
6	General	General	General	Great	Dissatisfied

According to the appointment in paper [10], the supplier selection criteria and decision attributes in the rating table are numerically normalized according to the three-point system.

Table 2. Green building supplier selection knowledge base.

Supplier candidate	Product superiority *C1*	Operations management *C2*	Cooperative potential *C3*	Green management *C4*	Users' satisfaction *D*
1	2	3	1	3	1
2	3	2	3	2	2
3	3	3	3	2	3
4	3	3	2	1	2
5	3	2	3	1	3
6	1	1	1	3	1

3. Basic concept of multi-attribute granulation knowledge evaluation

Definition 1: Supplier selection is defined as an information system, S=<U, C, D>, supplier selection decision table T=(U, A, C, D), where U is the non-empty set which is a collection of all the supplier information that needs to be discussed, and A is A non-empty evaluation attribute set, which is composed of supplier evaluation attribute set C and supplier decision attribute set D. The equivalent class of $IND(C)$ is the conditional class of supplier evaluation. The equivalent class of $IND(D)$ is the decision-making class of supplier selection.

Definition 2: Define a supplier selection knowledge base K=(U, G). G is a set of equivalent relation of U. An arbitrary non-empty set $S(S\subseteq G)$ is given, where equivalence class $U/IND(S)=\{Y_1, Y_2, \ldots, Y_i, \ldots, Y_m\}$ ($1\leq i\leq m$) is called knowledge granular G. Each knowledge granular G is represented by a binary number, whose binary number is l. l is the potential of U. If the $u_k\subseteq Y_i$($1\leq k\leq l$), the binary number corresponding to the i bit is 1, otherwise 0.

Definition 3: Attribute dependency k describes the compatibility of supplier selection system, that is the dependence of supplier decision attribute D and supplier condition attribute C. When k=1, the supplier selection decision table is consistent; otherwise, the supplier selection decision table is inconsistent.

In a supplier selection decision table, decision attribute D is denoted as k dependent on condition attribute C, which is expressed as follows:

$$k=\gamma_C(D)=\frac{card(pos_C(D))}{card(U)} \tag{1}$$

Where, $pos_C(D)$ is the condition attribute C-positive region of decision attribute D, $card(\bullet)$ is the potential of supplier selection set, $card(pos_C(D))=\sum_{NE(i)=1} c_{ij}$, $NE(i)=c_i$ is the number of non-zero elements in c_i.

Definition 4: Attribute index weight, which refers to the importance degree of each supplier condition attribute in supplier selection system relative to supplier decision attribute.

The weight of a supplier's condition attribute is calculated. This condition attribute is deleted from the supplier selection decision table, and the classification ability of the supplier selection decision table is calculated, which is then reduced by attribute dependency k.

$$\omega_{c_i}=\gamma_C(D)-\gamma_{C-c_i}(D) \tag{2}$$

Attribute weight is used to set the attribute weight of supplier condition attribute.

Definition 5: Definition $\{\mathbf{Y}_{m\times l}, \mathbf{X}_{n\times l}, \mathbf{C}_{m\times n}\}$ as Bit Granular Matrix(BGrM) [15], where

$$\mathbf{C}_{m\times n}=\mathbf{C}_{\mathbf{YX}}=\mathbf{Y}\times\mathbf{X}' \tag{3}$$

Where, Matrix $\mathbf{C}_{m\times n}$ reflects subordinative relation of equivalent classes Y_i and X_j. $\mathbf{Y}$ and $\mathbf{X}$ represent the equivalence classes which is derived from supplier condition attribute C and supplier decision attribute D.

IOP Conf. Series: Materials Science and Engineering **490** (2019) 042029 doi:10.1088/1757-899X/490/4/042029

$$\mathbf{Y}_{m\times l} \overset{\Delta}{=} \mathbf{Y} = \begin{pmatrix} Y_1 \\ \dots \\ Y_m \end{pmatrix} = \begin{pmatrix} a_{11} & \dots & a_{1l} \\ \dots & \dots & \dots \\ a_{m1} & \dots & a_{ml} \end{pmatrix} \tag{4}$$

$$\mathbf{X}_{n\times l} \overset{\Delta}{=} \mathbf{X} = \begin{pmatrix} X_1 \\ \dots \\ X_n \end{pmatrix} = \begin{pmatrix} b_{11} & \dots & b_{1l} \\ \dots & \dots & \dots \\ b_{n1} & \dots & b_{nl} \end{pmatrix} \tag{5}$$

Definition 6: According to the existing supplier's selection of knowledge base K=(U, G), where a condition attribute $g \in G$, if $IND(G)=IND(G-\{g\})$, condition attribute g is the redundant attribute. The data of this attribute is not required to be collected in the supplier evaluation. Otherwise, condition attribute g is required knowledge of G.

4. Supplier selection and evaluation method based on multi-attribute granulation

The supplier selection and evaluation method based on multi-attribute granulation can be divided into the following five steps:

Step 1: The attributes of each indicator system is determined according to the evaluation needs.

Step 2: The conditional attribute matrix and decision attribute matrix of supplier selection are constructed, and the initial supplier selection knowledge base is established.

Step 3: According to the actual situation, the supplier selection knowledge base is preprocessed to generate the supplier selection knowledge base.

Step 4: Information granulation is carried out by using knowledge of multi-attribute granulation, and the weight of attribute index of condition attribute is calculated.

Step 5: The evaluation value of each supplier is calculated according to the attribute index weight of the condition attribute and the conditional attribute value of each supplier, and the best supplier can be selected according to the descending order.

4.1. *Data granulation*

According to Definition 2, the supplier selected of the knowledge base after data preprocessing is carried out by the corresponding information granulation, that is, the binary matrix is constructed by binary code.

The green construction supplier selection knowledge base shown in table 2 is taken as an example. Decision attribute can be decomposed into binary information granular of 3 objects, d1={100001}, d2={010100}, d3={001010}, and their granularity is 1, 2 and 3 respectively. The steps are as follows:

① Decision Attribute BGrM

② for each *D*

③ if equal flag=1;

④ else flag=0;

⑤ end for

The binary information granular of conditional attribute can also be obtained according to the definition and the above steps.

4.2. *Merged the same rule*

In the supplier selection decision table, line by line scan is adopted. If the same rules occur, the same decision rules are merged.

4.3. *Attribute index weight of condition attribute*

In view of the disadvantages of setting the attribute weight based on experience, the importance of the evaluation index is obtained objectively by extracting the attribute importance method with the help of the multi-attribute decision-making idea.

The attribute index weight of each supplier selection decision table is calculated. The steps are as follows:

Step 1: Attribute dependency k of decision attribute D on condition attribute C in the supplier selection decision table is calculated according to Definition 3.

Step 2: Attribute index weight ω_{c_i} ($\omega_{c_i} = \gamma_C(D) - \gamma_{C-c_i}(D)$), which the importance degree of each condition attribute c_i relative to supplier decision attribute D is calculated according to Definition 4.

4.4. Knowledge reduction method of granular computing theory

According to Definition 6, knowledge reduction method of granular computing theory to simply the information collection work is constructed and the subsequent evaluation work of the supplier is simplified.

5. Supplier selection and evaluation example

This paper takes six candidate suppliers of a practical green building project in Qingdao as the research object. The steps are as follows:

Step 1: The attributes of supplier selection and evaluation are determined according to the survey results [10].

Step 2: Supplier selected condition attribute matrix C and decision attribute matrix D is constructed.

Step 3: Following the data preprocessing method [10], the supplier selection knowledge base is generated and the green construction supplier selection knowledge base is obtained in table 2.

Step 4: Information granulation is carried out by using knowledge of multi-attribute granulation, and the weight of attribute index of condition attribute is calculated.

$$w = \begin{pmatrix} 0 & 0.3333 & 0 & 0.3333 \end{pmatrix}$$

Step 5: It can be known that operation management c_2 and green management c_4 are the minimum attribute reduction by using the knowledge reduction method of granular computing theory.

The conclusion which green management c_4 is an important attribute is consistent with the result calculated by knowledge entropy [10].

6. Conclusion

In this paper, a supplier selection and evaluation method based on multi-attribute granulation is proposed. Bit Granular Matrix is used to extract attribute index weight to achieve the objective evaluation of supplier condition attribute weight. The fast knowledge reduction algorithm based on granular computing theory is implemented to simplify the workload of the follow-up supplier evaluation. Reference is provided for enterprises to select suppliers. Therefore, the method proposed in this paper is feasible and efficient in supplier selection and evaluation. In the next stage, the application of Bit Granular Matrix in supplier evaluation and selection is further explored.

Acknowledgments

This work was financially supported by Education and Research Foundation for Young and Middle-aged Teachers of Fujian Province(JT180581), Youth Scientific Research Personnel Training Foundation of Fujian Jiangxi University(JXZ2017003), Monographic Research Foundation of Fujian Jiangxi University(JXZ2018008). We gratefully acknowledge the financial aid for this research.

References

[1] Rajesh R, Ravi V. Supplier selection in resilient supply chains: a grey relational analysis approach[J]. Journal of Cleaner Production, 2015, 86: 343-359.

[2] Dickson G. An Analysis of Vender Selection System and Decisions[J]. Journal of Purchasing, 1996, (2): 5-17.

[3] C.A. Weber, J.R. Current, W.C. Benton. Vendor selection criteria and methods[J]. European Journal of Operational Research, 1991, (50): 2-18.

[4] Beauchamp H, Novoa C, Ameri F. Supplier Selection and Order Allocation Based on Integer Programming[J]. International Journal of Operations Research & Information Systems, 2015, 6(3): 60-79.
[5] Bakeshlou E A, Khamseh A A, Asl M A G, et al. Evaluating a Green Supplier Selection Problem Using a Hybrid MODM Algorithm[J]. Journal of Intelligent Manufacturing, 2017, 28: 1-15.
[6] Shukla N, Kiridena S. A fuzzy rough sets-based multi-agent analytics framework for dynamic supply chain configuration[J]. International Journal of Production Research, 2016: 1-13.
[7] Hayden Beauchamp, Clara Novoa, Farhad Ameri. Supplier Selection and Order Allocation Based on Integer Programming[J]. International Journal of Operations Research and Information Systems, 2015, 6(3): 60-79.
[8] Yuan Yongbo, Liu Lixia, Zhang Mingyuan. Material Supplier Selection in Construction Based on DEA and TOPSIS[J]. Journal of Civil Engineering and Management, 2016, 33(1): 7-11,17.
[9] Wang Lei, Ye Jun, Zhang Hong-li. Rough Set and Analytic Hierarchy Process-based Approach on Supplier Selection[J]. Computer Science, 2014, 41(3): 80-84.
[10] Xu Qian, Zhang Lin, Yue Guangfei. Diagnosis of the Value of Green Building Suppliers Based on Rough Set. Journal of Shandong Jianzhu University, 2013, 28(4): 371-374.
[11] Lin T Y. Granular Computing[C]. Announcement of the BISC Special Interest Group on Granular Computing, 1997.
[12] Liang Jiye, Qian Yuhua, Li Deyu, et al. Theory and Method of Granular Computing for Big Data Mining[J]. Science China: Information Science, 2015, 45(11): 1355-1369.
[13] Yiyu Yao. A triarchic theory of granular computing[J].Granular Computing,2016, 1(2):145-157.
[14] Miao Duoqian, Zhang Qinghua, Qian Yuhua, et al. From Human Intelligence to Machine Implementation Model: Theories and Applications Based on Granular Computing[J]. CAAI Transactions on Intelligent System, 2016, 11(6): 743-757.
[15] Chen Zehua, Lin T Y, Xie Gang. Knowledge Approximations in Binary Relation: Granular Computing Approach[J]. International Journal of Intelligent Systems, 2013, 28(9): 843-864.
[16] Zhan Feng. SDG Fault Diagnosis System Based on Information Granulation Theory and its Simulation Platform[D]. Taiyuan: Taiyuan University of Technology, 2010.