Logistics Outsourcing Risks Evaluation Based on Rough Sets Theory

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Abstract: There are a variety of risks because of many factors’ influences in the process of logistics outsourcing. The logistics outsourcing risks are taken as the objects of study, based on rough sets model, the initial decision table is made reduction using Johnson Reducer algorithm, the weight coefficient of each risk index is determined by calculating the importance of attributes in the decision table after reduction, and a model of logistics outsourcing risks evaluation based on rough sets is proposed in the paper. The model can effectively overcome the subjectivity of determination of weight coefficient in current evaluation model and serve as the decision basis for enterprises to carry on logistics outsourcing risks evaluation and its prevention. Evaluation to 6 logistics enterprises in Handan City just verifies the validity of the evaluation model, providing the measurable basis for the enterprises’ logistics outsourcing risks and a set of scientific logistics outsourcing decision system for the enterprises’ managers.

Keywords: Logistics outsourcing, Rough sets, Risks evaluation, Index system

1 Introduction

1.1 Study subject and background
Logistics outsourcing has rapidly become a kind of new enterprises operation strategy with its advantages including reducing operating costs and strengthening the core competitiveness, speeding up organization reconstruction, and improving enterprises’ reaction speed. However, enterprises’ logistics outsourcing is experiencing a variety of risks because of the influences of many factors such as the uncertainty of the external environment, changes in the market, and enterprise risks decision ability and risks management ability. Therefore, how to carry out the decision of effective logistics outsourcing for enterprises becomes a research subject which need be immediately solved. To ensure the successful completion of logistics enterprises’ outsourcing, logistics outsourcing risks must be correctly evaluated.

1.2 Literature review
Harry L. Sink and C. John Langley (1997), on the basis of the core competence theory and the industrial organization theory, proposed a management frame of logistics outsourcing, with divided into five steps: identification of outsourcing logistics demand, development of potential suppliers, evaluation and selection of suppliers, the implementation of service and service evaluation. Study made by Wynstrad (2001) and others shows that there is a certain conflict between outsourcing enterprise and logistics providers, that is, objective utility function between both cooperating parties of logistics outsourcing is inconsistent. Jharkharia and Shankar (2007), through sorting out the literature, put forward a more complete method of selecting the third-party logistics service providers, which is easy to be understood by decision-makers. They divided the selection process into two parts, namely, the establishment of the initial frame of selecting the third-party logistics service providers, evaluating and making choices to the service suppliers through ANP (network hierarchy analytic method). Isiklar and Alptekin (2007) established the multi-system integration decision support model of selecting the third-party logistics service providers, through processing the problem of selection and decision of the third-party logistics service providers under the environment of uncertain and imprecise decision based on case-based reasoning, rule-based reasoning and compromised compiling technique,
and it can be easy to cope with the change of logistics business demands, shorten the decision time and accurately select service providers. In China, Wei Zhong and others studied the risks of logistics outsourcing and their forming mechanism, grouping them into four categories \cite{3}; Ning Yun-cai, using the method of the fuzzy evaluation, succeeded in evaluating the risks of logistics outsourcing \cite{4}. By investigating many domestic companies, in the enterprises circle, it is found that the logistics outsourcing risks evaluation carried out by many companies mainly relies on the experience of the relevant personnel in the enterprises and the credibility of the logistics service providers to evaluate risks, they lack a complete risks management system and methods. After analysis, it can be seen that the theory circle and the enterprises circle, at present, has a clear understanding of the existing risks of logistics outsourcing, but has limited study on logistics outsourcing risks evaluation and its management.

Logistics outsourcing risks are identified, on the basis of qualitative analysis of logistics outsourcing risks evaluation, the index system of logistics outsourcing risks evaluation is established, the model of logistics outsourcing risks evaluation based on Rough sets Theory is explained, the weight coefficient of each risk index is determined by calculating the importance of attributes in the rough sets, and then the comprehensive evaluation value is worked out according to the index score of each evaluated object, and the logistics outsourcing risks evaluation is carried on to the valuated objects, finally by evaluation to 6 logistics enterprises in Handan City, the evaluation results are obtained that conforms to the common practice and which verify the validity of the evaluation model.

2 Establishment of Logistics Outsourcing Risks Evaluation Index System

Identification of the logistics outsourcing risks is the process in which the project managers identify the origin of the risk, determine the conditions of its occurrence, describe its characteristics and evaluate its influences, which is the premise and the foundation of risks evaluation. At present, in the process of Handan’s logistics enterprises’ business outsourcing, its risks identification mainly includes as follows:

1. Risks in customer relationship management. In the cooperation with the third-party logistics service, who has the most direct contact with customers is usually the third-party logistics enterprises. Meanwhile, they also have the comprehensive customers information, even including those potential customers information. Therefore, there exist at least two kinds of risks in the customer relationship management: risks of weakening the tie with the customers and risks of leaking the customers’ information.

2. Risk of leaking the companies’ confidential strategy. The third-party logistics usually has a very deep understanding to the customer enterprises’ company strategies. From the adjustment of the purchasing channels to the market strategies, from the present situation of operation to the future anticipation, from the products’ reform to the customer service strategies, the third-party logistics enterprises have an opportunity to obtain the relevant information. To those companies whose information-handling capacity is quite strong, the information they acquire through the data mining technology is often unknown to the customers themselves. Therefore, logistics outsourcing greatly increases the risk of revealing the core strategies.

3. Risk of economic fluctuation. Rapid growth of economy tends to cause shortage of market logistics supply, and affects the normal logistics service of the enterprises, while economic depression will lead to rise of products’ inventory costs. In addition, some other unpredictable factors also affect the normal operation of the logistics supply chain including some accidents, such as traffic accidents, custom blockage, cut of the water and power supply and some big ones such as political factors, the war, etc.

4. Information risk of the principal-agent mechanism. Because of information’s asymmetry and incompleteness, the principal (the cargo owner) is often in a more disadvantageous position than the agent (the third-party logistics enterprise), therefore, this inevitably brings certain information risks to the principal, for example: moral hazard and adverse selection, etc.
5. Reduction of the opportunities for a company to study and to develop its core competitive power. At present, many enterprises, during the practice of “the outsourcing” may only obtain the short-term competitive advantages, but may lose the opportunities to acquire the key skills and to construct the future core competitive power.

6. Risk of decreasing the control power to logistics. In the process of the logistics outsourcing, the third-party logistics enterprises will involve itself in the customer enterprises’ purchasing, production, distribution, and after-sales service, and become the logistics manager of the customer enterprises. The customer enterprises’ ability to control logistics greatly reduces, so when both sides have trouble in coordinating, it may occur that logistics is out of control, namely, the third-party logistics enterprises cannot fully understand and accomplish the logistics business according to the customer enterprises’ requirements, thus the customer service index is reduced.

7. Problems in the enterprise culture. Different enterprises generally have their own enterprise culture and this may give rise to different views to the same problem, cause different standpoints, and affect the stability of the logistics supply chain; because of shortage of their acknowledgement degree and coordinating degree to the supply chain, the supply chain cannot fully play its due role in the course of its running.

The index system of logistics outsourcing risks evaluation is proposed in this paper according to the above analysis, as is shown in Figure 1.

Figure 1: Logistics outsourcing risks evaluation index system

3 Rough Sets Evaluation Model

3.1 Rough sets Theory
Rough sets Theory\(^{(3)}\), as a new achievement in the data mining technology, was first introduced by the Polish scientist, Professor Z.Pawlak. Since 1990, Rough sets Theory has received increasing widespread attention from many research fields for its unique superiority in processing incomplete data
and in dealing with the imprecise knowledge. The main idea of the Rough sets Theory is to use the knowledge in the known knowledge database to approximately describe the imprecise and indefinite knowledge and it is actually a process of discovering knowledge. According to the methods of Rough sets Theory, the data mining is to work out all the smallest decision algorithms that accord with its knowledge, given the condition attribute and the policy-making attribute of the knowledge expressing system. Its main idea is to divide the universe of problems according to the existed knowledge to the given question; work out the rules for the classification of concepts and the major factors influencing decision through seeking core, knowledge reduction, determination of the conditional attribute weight on the premise of keeping the ability of classification invariable. In the practical application, a knowledge expressing system is usually a two-dimensional information form (decision table). In the table, the column stands for the attribute and the row stands for the object discussed (sample), each row represents the attribute value which the corresponding sample has.

3.2 Some important concepts
1. Upper approximation, Lower approximation and Positive region. Suppose \( U \) is the given universe, suppose \( R \) is the family of the equivalence relation of \( U \), then \( K = (U, R) \) is a knowledge database, suppose \( X \subseteq U \), when it can be represented as the union in some \( R \), \( X \) is called definable; otherwise \( X \) is called indefinable. The definable set of \( R \) is called the precise set, the indefinable set of \( R \) is called the rough set. It is described by upper and lower approximation, which is respectively shown as follows\(^6\):

- R-lower approximation of \( X \):
  \[
  \underline{R}X = \{ Y \mid Y \in U / R | Y \subseteq X \},
  \]

- R-upper approximation of \( X \):
  \[
  \overline{R}X = \{ Y \mid Y \in U / R | Y \nabla X \neq \Phi \},
  \]

- R-positive region of \( X \):
  \[
  pos_R(X) = \underline{R}X.
  \]

2. Degree of dependence. In the knowledge database \( K = (U, R) \), suppose \( C, D \subseteq R \), degree of dependence \( D \) to \( C \) is:

\[
\gamma_C(D) = \frac{|pos_C(D)|}{|U|} \quad (1)
\]

In this formulation, \(|U|\) represents the cardinal number of \( U \).

3. Information expression system. An information system can be expressed as:

\( S = (U, A, V, f) \)

\( U \) is the set of the objects, \( C \cup D = A \) is the attribute set, the ir-related subset \( C \) and \( D \) are respectively called the conditional attribute and the decision attribute, and \( V \) is the set of the attribute values \( f : U \times A \rightarrow V \) is an information function, which specifies each object’s attribute value in \( U \).

4. Knowledge reduction and attribute importance. Knowledge reduction is one of the central contents in Rough sets Theory. It is to delete the ir-related or unimportant knowledge in it by on the condition of keeping the ability of knowledge classification invariable. In the decision table, the different attribute may have the different importance. In order to find the importance of the attribute set, our method is to remove some attributes from the table and then consider how the classification will change without these attributes. If the change of the corresponding classification is great, after removing the attribute, this shows that the intensity of this attribute is strong, namely, the importance is high; otherwise, this indicates that the intensity of the attribute is weak, namely, the importance is low.
C and D are separately called the conditional attribute and the decision attribute, the importance of the attribute subset $C' \subseteq C$ to D is defined as:

$$\sigma_{CD}(C') = \gamma_C(D) - \gamma_{C-C'}(D)$$  

(2)

In particular, when $C' = \{a\}$, the importance of the attribute $a \in C$ to D is:

$$\sigma_{CD}(a) = \gamma_C(D) - \gamma_{C-\{a\}}(D)$$  

(3)

### 4 Application Case

Logistics outsourcing risks evaluation index system identified in Part 2 in this paper is selected to be used here including 12 indexes: weakening customer relationship; leaking customer information; leaking company confidential strategies; shortage of logistics supply; rise of the product inventory cost; moral hazard of the logistics enterprises; reversed choice of the logistics enterprises; reducing study opportunities of companies; loss of opportunities of developing the core competitive power; reduction of ability to control logistics; reducing the customer service level; enterprises culture conflicts.

#### 4.1 Establishment of the decision table of logistics outsourcing risks evaluation index

The risk level of the above-mentioned 12 indexes is identified by 10 logistics experts using Delphi method in this paper, that is, using the risk matrix method to divide degree of the risk influence into five levels: critical, serious, moderate, minor and negligible; represented respectively by 4, 3, 2, 1 and 0, thus, the decision table of logistics outsourcing risks evaluation index is obtained, as is shown in Table 1.

<table>
<thead>
<tr>
<th>Sample attribute value C</th>
<th>Decision attribute value D</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1  F2  F3  F4  F5  F6  F7  F8  F9  F10  F11  F12</td>
<td></td>
</tr>
<tr>
<td>X1  3   4   1   2   2   2   4   2   3   3   2   3   3</td>
<td></td>
</tr>
<tr>
<td>X2  2   3   2   2   2   1   3   2   2   3   1   2   1</td>
<td></td>
</tr>
<tr>
<td>X3  3   3   2   3   1   0   4   1   3   3   2   3   3</td>
<td></td>
</tr>
<tr>
<td>X4  3   3   2   2   1   1   4   2   2   4   2   3   2</td>
<td></td>
</tr>
<tr>
<td>X5  3   4   1   2   0   1   3   2   2   4   1   3   2</td>
<td></td>
</tr>
<tr>
<td>X6  3   4   1   1   1   0   3   1   3   3   1   2   1</td>
<td></td>
</tr>
<tr>
<td>X7  3   4   2   2   0   1   3   1   2   3   2   3   2</td>
<td></td>
</tr>
<tr>
<td>X8  2   3   1   1   2   1   4   1   3   3   2   2   3</td>
<td></td>
</tr>
<tr>
<td>X9  3   4   3   2   1   1   4   2   2   4   1   3   2</td>
<td></td>
</tr>
<tr>
<td>X10 3   3   2   2   1   1   4   2   2   4   1   3   3</td>
<td></td>
</tr>
</tbody>
</table>

#### 4.2 Attribute reduction of the decision table of logistics outsourcing risks evaluation index

By using the ROSETTA software and adopting the reduction algorithm of Johnson Reducer, the decision table reduction can be worked out as: $\{F1, F3, F4, F11\}$.

#### 4.3 Calculation of degree of dependence and importance of the attribute after reduction.

By using the ROSETTA software, from the reduced decision table, it can be seen [7, 8]:

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\[ \sigma_{CD}(F1) = \gamma_C(D) - \gamma_{C-F1}(D) = 1 - 8/10 = 0.2 \]
\[ \sigma_{CD}(F3) = \gamma_C(D) - \gamma_{C-F3}(D) = 1 - 4/10 = 0.6 \]
\[ \sigma_{CD}(F4) = \gamma_C(D) - \gamma_{C-F4}(D) = 1 - 7/10 = 0.3 \]
\[ \sigma_{CD}(F11) = \gamma_C(D) - \gamma_{C-F11}(D) = 1 - 3/10 = 0.7 \]

Use the formula:

\[ \omega_i = \frac{\sigma_{CD}(F_i)}{\sum \sigma_{CD}(F_i)} \quad (4) \]

The weight of each index after normalizing the importance of the index \( i \) is worked out, specifically as follows:

\[ \omega_1 = \frac{\sigma_{CD}(F_1)}{\sum \sigma_{CD}(F_1)} = \frac{0.2}{0.2 + 0.6 + 0.3 + 0.7} = 0.111 \]
\[ \omega_3 = \frac{\sigma_{CD}(F_3)}{\sum \sigma_{CD}(F_3)} = \frac{0.6}{0.2 + 0.6 + 0.3 + 0.7} = 0.333 \]
\[ \omega_4 = \frac{\sigma_{CD}(F_4)}{\sum \sigma_{CD}(F_4)} = \frac{0.3}{0.2 + 0.6 + 0.3 + 0.7} = 0.167 \]
\[ \omega_{11} = \frac{\sigma_{CD}(F_{11})}{\sum \sigma_{CD}(F_{11})} = \frac{0.7}{0.2 + 0.6 + 0.3 + 0.7} = 0.389 \]

4.4 Case evaluation of logistics outsourcing risks

Logistics outsourcing risks of six logistics enterprises in Handan City are evaluated in this paper, as is shown in Table 3.

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Score of each index given by the experts</th>
<th>Score of comprehensive evaluation ( V = \sum \omega_i y_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>78 60 70 85</td>
<td>73.393</td>
</tr>
<tr>
<td>E2</td>
<td>80 80 65 80</td>
<td>77.495</td>
</tr>
<tr>
<td>E3</td>
<td>75 65 30 65</td>
<td>60.265</td>
</tr>
<tr>
<td>E4</td>
<td>60 50 56 70</td>
<td>59.892</td>
</tr>
<tr>
<td>E5</td>
<td>55 45 78 40</td>
<td>49.676</td>
</tr>
<tr>
<td>E6</td>
<td>20 56 80 45</td>
<td>51.733</td>
</tr>
</tbody>
</table>

Therein, \( \omega_i \) is the weight of each index after normalizing the importance of the index \( i \). The lower is the score of comprehensive evaluation to each enterprises, the less is the risk, on the contrary, the more it is, as can be seen from Table 3, the comprehensive score of E1, E2, E3, E4, E5 and E6 is: 73.393, 77.495, 60.265, 59.892, 49.676 and 51.733, the degree of the logistics outsourcing risk of each enterprise is also shown.

5 Conclusion

In the process of the enterprises’ logistics outsourcing, the outsourcing enterprises and the third-party logistics supplier achieve co-ordination through the contractual means. The information asymmetry
between the outsourcing enterprises and the cooperative enterprises, the culture differences, the uncertainty of market and some logistics service suppliers’ too focusing on the short-term benefits, all contribute to a variety of risk.

1. The logistics outsourcing risks are identified, and a index system of logistics outsourcing risks evaluation which contains 12 indexes is established.

2. The attribute reduction is made to the established logistics outsourcing evaluation index system by using rough sets, according to the index weigh processed by the importance normalization, it can be concluded that reducing the customer service level and leaking company’s confidential strategies, among 12 risks, is the most important, followed by shortage of logistics supply and weakening customer relationship.

3. Combined with 6 logistics enterprises in Handan, its logistics outsourcing risks are evaluated.

References


