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Research on the risk aversion decision model of green supply chain for manufacturing enterprises based on rough set

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ABSTRACT

Implementing green supply chain management is a risky strategy for enterprises, as it puts forward a very high requirement for their risk management and control ability. In this paper we establish the risk decision-making knowledge express system (information system) of manufacturing enterprises green supply chain based on the rough set data mining methods by identifying the key risk factors of green supply chain. This is followed by the building of the risk aversion decision model of green supply chain strategy. In addition, the risk aversion decision-making rules of enterprises green supply chain are studied through the analysis, reduction and reasoning of decision-making table, so as to provide the manufacture enterprises with decision-making measures to avoid the risk for their green supply chain.

KEYWORDS

Green supply chain; Rough set; Risk decision; Knowledge express system.

INTRODUCTION

As a new mode of strategic management, green supply chain management has attracted increasing attention from the government, enterprises and academia. More and more enterprises are actively exploring ways of implementing green supply chain management, although many of them still have considerable concern for it, and in reality only a few companies succeed in implementing the green supply chain management strategy. This shows that the enterprises need to have the ability of risk control and management in order to implement their green supply chain strategic.

In recent years, researches have focused on green supply chain operations model, business relationship and performance evaluation, etc [1-4]. Only a small amount of researches are related to the problems of green supply chain risk qualitative discussion, such as Yan Jiang (2007), which analyses the risk factors of green supply chain management from the asymmetric information, the external environment constraints, choice of distributors, the cultural differences and the enterprise moral combined with electrical home appliances manufacturing enterprises in China, and argues that there exist huge risks in the process of green supply chain management[5]. Zheng Ren (2003) and Ceng Yan (2005) analyse the sources of the green supply chain management risk, and probe into the countermeasures for the green supply chain strategic risk prevention[6]. This paper studies the risk aversion of green supply chain implementation from the enterprises' internal and external factors by the way of building a green supply chain decision model established on the rough set method, and then provides policy recommendations for the green supply chain risk management strategy.

GREEN SUPPLY CHAIN INTERNAL RISK ANALYSIS FOR THE MANUFACTURING ENTERPRISES

Green supply chain technology risk

Green supply chain management needs the support of green technology in materials acquisition, processing, packaging, warehousing, transportation and scrap process. Green technology introduces an abundant amount of uncertainty and risks to the green supply chain management - for instance, the inspection certificates provided by the supplier are not in conformity with the goods in the coming inspection, the delivery goods do not comply with the customer green requirement stipulated before shipment inspection due to high cost of green supply chain technology implementation. In the meantime, besides coordination, all resources that are needed to be integrated into the implementation of the green supply chain are also essential prerequisite for the different enterprises and departments in the enterprises. Therefore, the ability of information integration and management will affect the success of the enterprise green supply chain management implementation.

Economic performance risk

The ultimate goal of the enterprises to implement green supply chain is to acquire core competitiveness and sustainable development ability in market competition, so the enterprises will have to focus on economic performance in the implementation of green supply chain strategy. As a great deal of investment will be put into the green design, green material, green production, green procurement, green inventory management, waste recovery and processing aspects, the production cost of the enterprises will increase, but this investment in green technology won't be necessarily bring green added value in the short term, and the green product market competitiveness is also subject to inspection.

Green enterprises culture

Enterprises' green supply chain management has led to higher requirement for their human resources quality and green culture. Firstly their executives must maintain a high degree of unity regarding the strategic significance of enterprise implementation of green supply chain, and must strongly support the implementation of green supply chain strategy. Disagreement between business executives will affect their staffs' execution of the strategy. The degree of recognition and support from employees to the green culture will also influence the green supply chain management. If employees cannot reach a consensus on green supply chain strategy and don't understand the temporary difficulties, the smooth implementation of green supply chain strategy will be difficult.

Enterprises management ability

Green supply chain management is an example of complicated system engineering, involving various factors and their complex relationship. So the enterprises must have a strong capacity for strategic planning, performance management, risk management ability and innovation ability. They need to be able to fully integrate their resources to adapt to the changes in the implementation of green supply chain management.

GREEN SUPPLY CHAIN EXTERNAL RISK FOR THE MANUFACTURING ENTERPRISES

The strategy implementation of Green supply chain in China's manufacturing enterprises is influenced by green trade barriers, resource constraints, environmental restrictions and external environment factors in aspects of environmental protection product market. All these factors are the pressure and motivation to the green supply chain management. If not handled properly,

they will bring about a lot of uncertainties to the green chain strategy. Meanwhile, due to the fact that a lot of resources will be invested in advance, whether there would be government policy support is an important risk factor.

ROUGH SETS DECISION MATRICES

The rough sets theory, originally proposed by Pawlak[7] in 1982, is a powerful tool concerning working with uncertainty, granularity, and incompleteness of knowledge in information systems. It has become the mainstream of the current research on knowledge processing and data mining methods. The methodology is concerned with the classificatory analysis of imprecise, uncertain or incomplete information or knowledge expressed in terms of data acquired from experience through the analysis of the data and reasoning, discovering the implicit knowledge, revealing the potential regularity, completing the things of judgment, prediction and decision making.

Lower and upper approximation

Let $Y \subseteq R$ be a target set that we wish to represent by using attribute subset R; that is, an arbitrary set of objects Y comprises a single class, and this class will be expressed (i.e., this subset) by using the equivalence classes induced by attribute subset R.

Definition 1: the target set Y can be approximated by constructing the R-lower approximations.

$$\underline{\mathrm{R}}(\mathrm{Y}) = \left\{x \in \mathrm{U} \mid [x]_{\mathrm{R}} \subseteq \mathrm{Y}\right\} \quad \textbf{(1)}$$

Definition 2: the target set Y can be approximated by constructing the R-upper approximations.

$$\overline{\mathrm{R}}(\mathrm{Y}) = \left\{x \in \mathrm{U} \mid [x]_{\mathrm{R}} \cap \mathrm{Y} \neq \phi\right\} \quad \textbf{(2)}$$

Based on prior knowledge to judge, the lower approximation is a the complete set of objects in U/R that can be positively classified as belonging to target set Y, called Y positive region, by $POS(Y)$. According to the collection of existing knowledge that do not belong to the Y object, Y is called the negative domain, denoted as $NEG(Y)$, $NEG(Y) = U - \overline{R(Y)}$. Let $BN(Y)$ represents a collection of X upper approximation and lower approximate difference, if $BN(Y)$ is an empty set, then Y on R is clear; if $BN(Y)$ is not empty, said collections Y as the rough set R.

The Decision Analysis Method based on the rough set

Knowledge expresses system can be described as S=(U, A), U is a non-empty set,called object collection; A is an non-empty finite set, which is called attributes set. Suppose $\mathrm{V_a}$ as the range of $\mathrm{a} \in \mathrm{A}$, a is a mapping of the range $\mathrm{V_a}$ from U to a, C, D is non empty subset of A, $C \cap D = \phi$, the (U, C, D) is called as the decision matrices of (U, A). For the knowledge expresses system S=(U, A), if B is non-zero subset of A, then the binary relation ind(B)= {(x, y)∈U×U : any a∈B, a(x) = a(y)} is as S indiscernible relation. Among them, x, y is the elements of U, the indiscernible relation can be classified as different equivalence class according to the domain.

Knowledge expresses system and decision matrices

In decision matrices, condition attributes are different on different degrees of importance. Some attribute provides a wealth of information, plays an important role in decision making, while some other properties are of the relatively weak influence on decision making. Therefore, on the guarantee of the decision table with the correct classification ability, the condition attribute can be reduced at the same time.

Definition 3: $S = (U, A)$ as an information system, definition

$$k = \gamma(C, D) = Card\,(P_{\mathrm{c}}(\mathrm{D}))/\mathrm{Card}(\mathrm{U})$$

Set D is called relying on the degree of set K on set C, here

$$P_{\mathrm{c}}(D) = \bigcup_{Y \subseteq U/ind(D)} \overline{ind(C)}(Y)$$

Then the C is the positive domain of the D.

Definition 4: (U, C, D) is a decision matrices, the a for set C is an arbitrary element. If $\gamma(C-\{a\}, D)=\gamma(C, D)$,then the a is said reduction, otherwise no reduction. If an arbitrary element in the C can not be reduction, then C is called independent. C' is the C arbitrary nonempty subset, if $\gamma(C', D)=\gamma(C, D)$, and C' is independent, then C' is said to be the condition attribute (U, C, D) simplified.

Definition 5: (U, C, D) is a decision matrices, $x \in U$, $R(x, D, D)$ are a coordination rule of (U, C, D) , $a \in C$; If the $R(x, C-\{a\}, D)$ is coordination, then the c can be removed, otherwise the a is called core properties of $R(x, C, D)$, $a(x)$ is core value of $R(x, C, D)$. If any element in set C can not be deleted, and $R(x, C, D)$ is condition independent, then $R(x, C, D)$ is called simplified.

In addition to condition attribute reduction, the decision matrices reduction also includes the attribute value reduction. The steps of attribute value reduction and decision matrices minimization are as follows:

1) The set of attributes which is common to all reducts is called the core: the core is the set of attributes which is possessed by every legitimate reduct, and therefore consists of attributes which cannot be removed from the information system without causing collapse of the equivalence-class structure. The core may be thought of as the set of necessary attributes-necessary, that is, for the category structure to be represented;

2) If a rule can be used to make decision only by the core, then the core value is only simplifying of the rule;

3) Otherwise, if the non-core condition attribute be added to the core, and the rule is to be coordinated and independent, then a simplification of the rules can be get. Each rule may have multiple simplifies (the choice of such rules is not unique).

4) Repeat with simplified rules from decision table, and extract rule form multiple simplifies to form a category or complex class (simply the sum of all its rules), then select rule with least rules, that is the minimum decision table.

EMPIRICAL ANALYSIS

According to the risk factors analysis of green supply chain management, the key risk factors are of five main kinds: green supply chain technology risk, economic performance risk, green enterprises culture, enterprises management ability and green supply chain external risk., which can be respectively represented as condition attributes a , b , c , d , and e . The condition attribute a , b , c , d , e can be divided into 4 grades respectively (strong, weak, strong, general) with the value 4,3,2 and 1 accordingly. The f is defined as implementation risk of green supply chain. Based on above description, the green supply chain risk knowledge expression system is given as: $S=(U, A)$, where U is the set of objects; $A=C \cup D, C, D \neq \phi, \ C \cap D=\phi$, among them, $C=\{a, b, c, d, e\}$ is condition attribute set, $D=\{f\}$ is decision attribute set. Table 1 is risk assessment discrete data table of enterprise questionnaire survey for Hubei province manufacturing green chain management.

TABLE 1: Green supply chain management strategic risk decision table

U	a	B	c	D	e	F
1	4	1	3	4	4	4
2	1	2	1	3	2	2
3	1	3	1	1	1	1
4	3	1	1	1	2	1
5	4	2	1	1	3	2
6	1	4	1	2	2	2
7	1	3	1	4	3	3
8	1	2	4	4	3	4
9	3	3	1	1	2	2
10	2	1	4	1	3	3
11	1	3	1	2	2	2
12	3	3	3	4	4	4
13	2	4	2	1	2	2
14	1	1	1	2	1	1

15	2	2	3	4	3	3
16	4	2	4	4	3	4
17	3	2	4	4	4	4
18	1	2	1	4	3	3
19	1	2	1	1	2	1
20	1	1	2	1	1	2

According to rough set reduction method and the attribute values given in the paper, the minimum decision is shown as in table 2.

TABLE 2 : The green supply chain management risk decision-making minimal decison table.

U	a	c	D	e	f
1	*	*	*	4	4
2	2	*	1	3	2
3	3	*	*	1	1
4	1	1	*	*	1
5	4	*	*	*	2
6	3	*	*	3	3
7	2	4	*	*	4
8	3	*	*	2	2
9	1	4	*	*	3
10	2	3	*	*	3
11	*	1	4	*	3
12	2	*	*	2	1
13	*	2	*	*	2

From the above the green supply chain management risk decision-making minimal decision table, we can draw the following conclusions.

1) Economic performance risk is an important problem that enterprises have to pay close attention to, which is the key factor in the implementation of green supply chain strategy successfully. Only by establishing a comprehensive performance evaluation system to find out deficiencies in green supply chain management, the sustainable development strategy of green supply chain can be guaranteed.

2) Enterprise management ability is the important guarantee for enterprises to implement green supply chain management. The green supply chain management is a complex system involving complex factors, so the enterprise must have the very high management ability and resources integrating ability in order to adapt to the changes brought about by implementation of green chain management strategy and to ensure the smooth implementation of green supply chain management.

3) Green corporate culture is an important condition for implementing green supply chain management. The identity and support of the corporate executives and employees for the green corporate culture are important risk factors affecting successful implementation of green supply chain management.

4) Green technology factor didn’t play a key risk effect. With the development of modern enterprise cooperation and deep-going of technical support unceasingly, enterprises can solve the problem of green technology from different levels of cooperation. Under the guarantee of the enterprise management capabilities and conditions of the green enterprise culture support, the green technology problem will be resolved in a certain degree.

5) Enterprise external environment factors, such as green barriers, resource constraints, environmental regulations, government support, and environmental protection product market will serve to promote the green supply chain management to some extent. With increasing environmental pressures and resource constraints, the construction of green environment-friendly enterprises has become an urgent task facing China's development of manufacturing enterprises. Green barriers, resource constraints, environmental regulations, environmental protection product market and other external factors are the enterprises of green supply chain management pressure and power.

CONCLUSION

The implementation of green supply chain management is a risky strategy, putting forward a very high request of enterprise risk management. In this paper, the green supply chain risk aversion decision-making model based on the risk key factors analysis of green supply chain implementation has been set up by using the rough set method. Furthermore, countermeasures of green supply chain risk have been analysed in order to assist China's manufacturing enterprises with their implementation of green supply chain strategy.

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