TELKOMNIKA, Vol. 11, No. 12, December 2013, pp. 7295~7301
e-ISSN: 2087-278X

Rough Set and DEA of Strategic Alliance Stable Decision-making Model

Yi Zhang
Economics and Management School, Nanjing University of Science and Technology, Nanjing, Jiangsu, China, 210094
Corresponding author, e-mail: flying_tracy@hotmail.com

Abstract

This article uses rough set theory for stability evaluation system of strategic alliance at first. Uses data analysis method for reduction, eliminates redundant indexes. Selected 6 enterprises as a decision-making unit, then select 4 inputs and 2 outputs indexes data, using DEA model to calculate, analysis reasons for poor benefit of decision-making unit, find out improvement direction and quantity for changing, provide a reference for the alliance stability.

Keywords: *rough set, data analysis, DEA model, stability of alliance*

1. Introduction

Today's society is a rapid develop and economic globalization society. Under the condition, the number of strategic alliances, which are mutual cooperation, competition and complementary with each other surge [1, 2]. However, due to dramatic changes in the market environment, developments of strategic alliances have high instability. So explore a scientific and rational approach for stability evaluation of strategic alliances' selection and cooperation is a very meaningful and important work.

Stability of strategic alliances can be studied from different angles, using different criteria. So there are many criteria and indexes for alliance stability analysis and evaluation selection[3]. And indexes redundancy is inevitably [4]. This paper is based on the combination of rough set and DEA model. This new combined model on the one hand can optimize indexes, on the other hand can carry out relatively efficiency evaluation for multi-input and output objective decision-making [5, 6]. And illustrate validity and practicability of the model through examples.

2. Construction of Strategic Alliance Stable Decision-making Combined Model

The combined model based on rough set and DEA specifically manifested in two aspects: first, the strategic alliance selectivity, based on rough set theory, uses data analysis method for reducing redundant and related indexes, obtains leaner strategic alliance stability evaluation index system [7]; Second, in terms of the strategic alliance, uses multiple-input multiple-output problem of multi-objective decision making DEA method for strategic alliances to conduct relative efficiency evaluation for the economic phenomena which in the amount of input and output factors strategic alliance have put, and then make economic decision so as to enhance stability of strategic alliances.

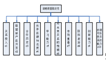
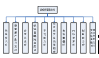
2.1. Algorithm and Examples of Rough Sets Reduction Model

In general, the information system S = (X, A, V) is a decision table. Where X is a non-empty finite set called global, global elements of X are called objects or instances; $A = C \cup D$, C is the condition attribute set, which are characteristics of the object; D = {d} is the decision attribute set, called for the classification of objects; V is the set of attribute value. Rough set is an effective data reduction tools. It removes some redundant attributes of decision table, not only did not change the classification or decision-making capacity of a decision table, but also improve the processing speed and efficiency.

Received June 15, 2013; Revised July 28, 2013; Accepted August 12, 2013

This paper studies the use of data analysis theory of rough reduction set model for model algorithm. The so-called data analysis, its basic idea is that in the decision table S of information system, according to formula requirements to delete attribute of attributes set A one by one, and check decision table after deleting attribute, according to whether the consistency of decision table before and after deleting attribute changed to determine whether it can be deleted [8-10]. If the decision tables can be expressed as S1 → a1, S2 → a2, while a1 ≠ a2 and S1 ≠ S2, then the decision table is consistent; if a1 ≠ a2 and S1 = S2, then the decision table is inconsistent. In other words, find the evaluate items to be deleted that resulting classification is not uniform from evaluation parameter set, and further to delete non-essential classification parameters of other categories, the last remaining parameters constitute the reduction evaluation parameter set.

2.1.1. Models' goals:

This decision table is defined X = {X1, X2, ..., Xn}, n is total number of samples; characteristic set C = {C1, C2, ..., Cm}, m is the number of items of condition attributes; category set D = {d1, d2, ..., dk}, k is the number of decision attributes; value of sample x_i at the items of condition attribute is , and in d decision attribute category. Specific models's goals are as fellows:

Input: a set of sample data set X, each sample consists of m alliance condition attribute values u and a classification category d;

Output: evaluation parameter set Y after reduction (Y initially set to an empty set);

2.1.2. Modeling steps:

Step 1: Indicator discretization, the condition of each sample was converted to the corresponding attribute value u feature set C, where a (0,1) represents index attribute with (Ⅰ, Ⅱ, Ⅲ) represents the decision attribute. Programming the following formula:

```
for(int i=1;i<=n;i++)
{for(int j=1;j<=m;j++)
{Cj(Xi)=Uj(Xi);}}
```

Step 2: Find parameters needs to be reduct, to be placed in the table d; programming equation:

```
for(int j=1;j<=n;j++)
{i=VD(Xj);
Table(i).insert(Xj);}%Classify samples
Select * from table where same classification but different values of parameter items
for(int j=1;j<=m;j++)
{all samples of table(i)
If(Cj is different in items' classification)
Dtable.insert((Cj, di));
}%find out evaluation parameters have same classification but different values of parameter items
```

Step 3: parameter reduction; programming equation:

```
Int index=0;
While (dtable!=null)
{Var Cx=dtable.row[index]; % Take out a record in table d
Var dx=Cx. % Reduction parameters to be recorded as Cx, classification categories denoted as dx
If(bj(Cx)=true) %bj is a sign of whether to reduct
For(int j=1 ;j<= n;j++)
{if (VD(Xj)!=dx)
If( VCx(Xj)>=VD(Xj)) %Cx can be deleted if it's not the main sample classification parameter
{bj(Cx)=false; }%Remove the record from table d
}
Index++;%Take out next record in table d;
}
```

Step 4: If d table is not empty, remove evaluation parameter corresponds to each record in the Y that is formation of evaluation parameter set after reduction.

2.1.3. Application of Examples

There are many affecting factors for strategic alliance stability indicators, from the management ability to capacity can be converted, from input and output capabilities to relative range factors capability. This paper constructs a strategic alliance stability evaluation index system, shown in Figure 1:

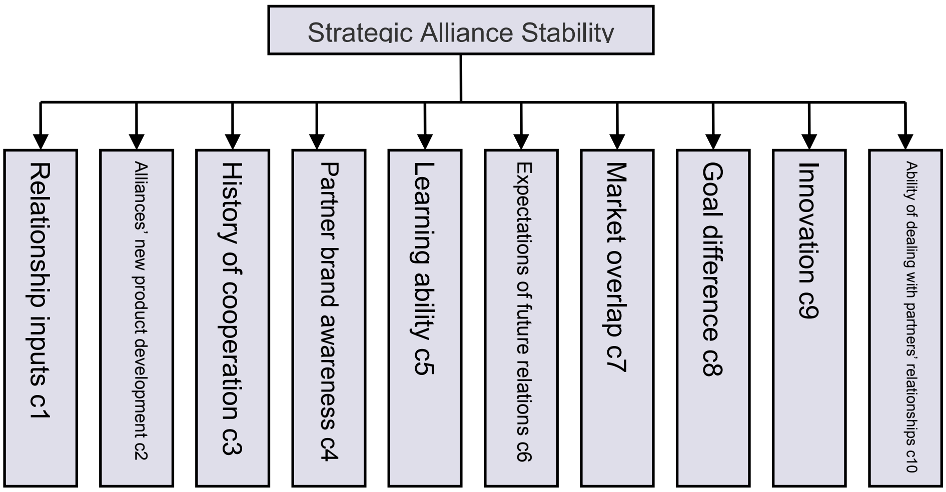


Figure 1. Structure Diagram of Strategic Alliance Stability Evaluation Index System

10 indicators attributes: Relationship inputs c1, alliances' new product development c2, history of cooperation c3, partner brand awareness c4, learning ability c5, expectations of future relations c6, market overlap c7, goal difference c8, innovation c9, and ability of dealing with partners' relationships c10.

A decision attribute: Strategic alliance stability degree.

Select 6 samples, 10 indicators attributes a decision attribute shown in Table 1 below:

Table 1. Information Table of Strategic Alliance Stability Evaluation Index

	Attribute A										
	Indicators attributes C										Decision attribute D
Sample X	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	d
1	Low	Strong	Long	Strong	Strong	Good	Less	Less	Great	Strong	Medium
2	High	weak	Short	Strong	Weak	Bad	Less	Great	Less	Weak	Small
3	High	Strong	Short	Weak	Weak	Good	More	Great	Great	Strong	Medium
4	Low	Strong	Long	Strong	Strong	Good	More	Great	Great	Strong	Big
5	High	weak	Short	Strong	Weak	Bad	Less	Great	Less	Weak	Small
6	High	Strong	Long	Weak	Weak	Good	Less	Great	Great	Strong	Big

In accordance with modeling step 1, data obtained from discredited indexes is shown in Table 2.

Table 2. Information Table of Evaluation Index after Discretion

	Attribute A										
	Indicators attributes C										Decision attribute D
Sample X	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	d
1	0	1	1	1	1	1	0	0	1	1	II
2	1	0	0	1	0	0	0	1	0	0	I
3	1	1	0	1	0	1	1	1	1	1	II
4	0	1	1	0	1	1	1	1	1	1	III
5	1	0	0	1	0	0	0	1	0	0	I
6	1	1	1	0	0	1	0	1	1	1	III

Table 2 lists 10 evaluation parameters and alliance stability level (mark as I, II, III) of the six samples. In accordance with steps of the algorithm, reduct the remaining parameters, draw alliance stability levels that c1, c4 and c8 in class I are non-reduction parameters, c2, c4, c6, c9 and c10 in class II are non-reduction parameters, and c2, c3, c6, c8, c9 and c10 in class III are non-reduction parameters. Screen out parameters to be reducted and find that after further reduction, c3, c5 and c7 are not decision parameters of other types, can be reducted. Final evaluation parameter set is C = {c2, c4, c6, c9, c10} that affecting strategic alliance stability evaluation parameters can be reducted as: new product development, partner brand awareness, expectations of future relations, innovation, and ability of dealing with partners' relationships.

2.2. Algorithm and Examples of DEA Model

DEA is a multi-input multi-output system analysis method.

2.2.1. Data Definition and Algorithm

Assume that strategic alliance has k stages, each stage has n types of input indicators X and m types of output indicators Y. x_0 and is input and output vector respectively at some stage; v_i is a weight of the i-th input, V = [v_1, v_2 … v_i], u_j is a weight of the j-th output, U = [u_1, u_2 … u_j]; (i = 1,2 ... n; j = 1,2, … m; r = 1,2, ... k). Input indicators X and output indicators Y are known data, input weight U and output weight V are variable data. The input data and output data of DEA evaluation model is shown in Table 3.

Table 3. Decision Units' Inputs, Outputs Data

Stage	Weight of input	Input factors				Output factors				Weight of output
1	v_1	x_{11}	x_{12}	…	x_{1n}	y_{11}	y_{12}	…	y_{1m}	u_1
2	v_2	x_{21}	x_{22}	…	x_{2n}	y_{21}	y_{22}	…	y_{2m}	u_2
…	…	…	…	…	…	…	…	…	…	…
k	v_k	x_{k1}	x_{k2}	…	x_{kn}	y_{k1}	y_{k2}	…	y_{km}	u_k

When determining a relative efficiency of decision-making unit, we assume that the input and output indicators weighting coefficient v and u are such variables: under the conditions of all decision-making units' efficiency is not greater than 1, they enable efficiency value of decision-making units maximization. This maximum is also known as the relative efficiency of decision making units. Accordingly, we can form the following optimization model:

$$\max\ p_r = \sum_{j=1}^{m} U_j y_{jr} / \sum_{i=1}^{n} V_i x_{ir}$$

$\sum_{j=1}^{m} U_j y_{jr} \leq \sum_{i=1}^{n} V_i x_{ir}$, $U_j \geq \varepsilon \geq 0$. Duality appropriately in above nonlinear fractional programming, transform it into equivalent dual form of linear programming: Let dual numbers of each constraint as θ, the input-output coefficients is λ_i, s^+, s^- are slack variables), ε is non-Archimedean infinitesimal, then the optimal solution for programming is λ_i, s^-, s^+, θ, transformed model formula is:

$$\min\left[\theta - \varepsilon\left(e^{\mathrm{T}}s^- + e^{\mathrm{T}}s^+\right)\right]$$

Condition: $\sum_{i=1}^{n} \lambda_i x_i + s^- = \theta x_0 \quad \sum_{j=1}^{m} \lambda_j y_j - s^- = y_0$

The model equations have following analysis: first, the alliance efficiency DEA efficient, on conditions that θ = 1, and s^- = 0, s^+ = 0, indicates that output obtained on the basis of original investment have been optimal; Second, alliance efficiency weakDEA inefficient, condition is θ = 1, and s^- ≠ 0, s^+ ≠ 0, indicates that the origin output remains unchanged original investment can be reduced or original investment remains but raise output; Third, alliance efficiency non-DEA efficient, condition is 0 <θ <1, and the value θ smaller, the lower their relative effectiveness. If the unit r is a non-DEA efficient introduce the remaining inputs Δx_0 and outputs deficit Δy_0, wherein: $\Delta x_0 = (1-\theta)x_0 + s^-$; $\Delta y_0 = s^+$; when adjusting x_r to θ x_r - s^-, adjusting y_r to y_r - s^+, the unit become DEA effective.

Analysis whether the use of evaluating input factors in DEA method is effective by calculating the value λ: If $\sum_{i=1}^{n} \lambda_i$ = 1, then corporate earnings does not change, reaches a maximum output; if $\sum_{i=1}^{n} \lambda_i$ > 1, corporate earnings increas and gains increasing trend is inversely proportional to the value, which indicates that on the basis of companies invest x_0, appropriate increase investment, a higher proportion of output will increase; if $\sum_{i=1}^{n} \lambda_i$ <1, enterprise diminishing returns, and the trend of diminishing returns is proportional to the value, which indicates that on the basis of enterprise invest x_0, decision-making units' additional investment is unnecessary.

2.2.2. Instance Specification

Table 4. Evaluation Input, Output Indicators of Alliance Collaboration

Indexes type	Indexes name	Variable	Unit
Input indicators	Number of employees	x_1	Person
	Yearly average balance of circulation funds	x_2	10 thousands
	Immobilisations	x_3	10 thousands
	Net value of fixed assets	x_4	10 thousands
Output indicators	Product output	y_1	10 thousands of pieces
	Product excellent-good rate	y_2	%

Based on analyzing literatures about strategic alliance performance evaluation indexes, combine with indicators' representativeness and availability, this paper select number of employees, yearly average balance of circulation funds, fixed assets and net value of fixed assets as input indicators, and chooses the product output, product excellent-good rate as output indicators, select 6 alliances' data for statistical analysis. Detail is shown in Table 4 and Table 5.

Table 5. Data of Alliance Enterprises Input, Output Indicators

Decision-making unit(Enterprises)	Input Value				Output Value	
	x_1	x_2	x_3	x_4	y_1	y_2
Z1	900	2100	50000	3000	8000	92
Z2	1050	3000	80000	4500	6000	90
Z3	850	1800	60000	2000	10000	89
Z4	700	1500	45000	1500	5000	91
Z5	1100	3200	85000	4500	6000	88
Z6	600	1600	50000	4000	7000	90

According to data in Table 5, calculated values of θ, s^-, s^+, $\sum\lambda$ based on DEA model. The result is shown in Table 6**.**

Table 6. Based on the DEA Model Alliance Benefit Calculation Results

Decision-making unit(Enterprises)	θ	s^-	s^+	Effectiveness	$\sum\lambda$	Scale merit
Z1	0.75	67.5	2.6	Inefficient	1.03	Increase
Z2	1	0	0	Efficient	1	Invariant
Z3	1	0	0	Efficient	1	Invariant
Z4	0.79	45.7	1.5	Inefficient	0.97	Decrease
Z5	1	0	0	Efficient	1	Invariant
Z6	0.95	5.8	0.6	Inefficient	1.01	Increase

From Table 6, we can see that the three companies Z2, Z3, Z5 input elements achieve the best combination, and draw the maximum output, and technical efficiency is at its best. Other companies exist in varying degrees the redundancy of resources, both in size and technique. These results give corresponding decisions for the choice of pre-and post alliance enterprises and modify inputs, outputs in the process of alliance collaboration in later stage. Accordingly to further stabilize the strategic alliance cooperation.

4. Conclusion

This paper studied a strategic alliance stable decision-making model. For strategic alliance partners selection, based on rough set theory, uses data analysis method for quantitative analysis, scientifically reduces redundancy and related indicators, highlighting principal contradiction, drawn optimized evaluation, thereby enhances the alliances' stability; for multi-input multi-output problems of alliance cooperation, uses DEA model to obtain a stable intelligent model of alliance cooperation performance evaluation, through case studies illustrate the combined model is feasible and effective.

References

[1] Das TK. The Dynamics of Alliance Conditions in the Alliance Development Process. *Journal of Management Studies*. 2002; 39(5): 725-745.
[2] Harrigan KR. Bases of interorganization cooperation: Propensity, Power, Persistence. *Journal of Management Studies*. 2010; 27: 417-434.
[3] Zhang Xingyuan. A model of the appraisement about the capability of logistic development based on DEA. *China Water Transport*. 2007; 10: 131-132.
[4] Liu Manzhi, Zhou Meihua, Yang Juan. Urban Logistics Based on DEA Efficiency Evaluation Model and Empirical. *Statistics and Decision*. 2009; 6: 50~52.
[5] CHEN Zhi, SHAN Mi-yuan, GU Hen-ping. An Empirical Analysis on the Efficiency of Enterprise Supply Logistics Systems Based on DEA. *Journal of Hunan University (Social Science)*. 2005; 11: 68-71.
[6] Zhao Huijuan, Luo Jiemin. Attribute Value Reduction Algorithm Based on Rough Set. *Science & Technology Information*. 2007; 10: 141-142.
[7] SHI Cheng-dong, LI Su-ling. Performance decision-making of oil supply chain enterprise based on heuristic reduction and DEA. *Computer Engineering and Applications.* 2008; 31: 211-213.
[8] Yin Yunqiang, Huang Xiaokun, Zhang Zhenliang. Decision Algorithm for Finding Reduct Based on Inter-information of Rough Set. *Journal of Yunnan Nationalities University (Natural Sciences Edition)*. 2006; 1: 12-14.
[9] Fang Ying. Air Quality Evaluation Method Based on Rough Set and BP Neural Network. *Henan Science*. 2010; 4: 432-435.
[10] SHI Cheng-dong, CHENG Jun-mo, YU Lan-lan. Application research of rough sets in logistic alliance stability decision-making. *Computer Engineering and Applications*. 2008; 18: 197-199.