

Selection of Supply Chain Partners for Small and Medium-Sized Manufacturing Enterprises

Tongjuan Liu^{1,a}, Lanqing Yang^{2,b*}

¹Beijing WUZI University, China

²Beijing WUZI University, China

^altj7905@163.com, ^b532629916@qq.com

Keywords: Selection of Cooperation Partner. Supply Chain. Analytic Network Process. Data Envelopment Analysis

Abstract : Supply Chain Partnership means a strategic relationship which is reached a long-term cooperation agreement between upstream and downstream entities in the same supply chain. Establishing a good supply chain partnership help to reduce the cost, shorten the reaction time and create the new market value and so on, and to successfully build supply chain strategic partnership, one of the key aspects is to choose partners. Through analyzing the problem that is selecting the small and medium-sized manufacturing enterprises partners (upstream parts suppliers), the full text will establish a reliable supplier evaluation system and a mathematical model using the analytic network process (ANP) / data envelopment analysis (DEA) method, and will derived the basic theory and methods adapted to the small and medium-sized manufacturing enterprises partners selection to help companies better implement supply chain management.

Introduction

In today's competitive international environment, competition between enterprises has transformed the competition between supply chains. The traditional view is that choosing the right partner is mainly to reduce procurement costs, so as to achieve the purpose of reducing expenses. But now the choice of partners was transformed into a strategic activity, choosing the right partner is to establish stable relations of cooperation, so as to stabilize the entire supply chain. It is becoming the problem had to think is that manufacturing companies how to make itself as the core, to build the enterprise supply chain adapted itself and to choose its enterprise partners. Based on this, this paper puts forward the supply chain partner selection model, and accordingly raise the new supply chain partner selection method - based on two-stage supply chain partners selection method of data envelopment analysis and network analysis, and provides reference for the implementation of supply chain management integration and the reasonable choice of supply chain partners.

DEA Supplier Selection Efficiency Evaluation System

A. Identify Indicators

This paper selects some of indicators which are more readily available and relatively stable, and take the smaller, the better indicators as input variables and the bigger, the better indicator as output variables.

1. Input Indicators: This article will input four indicators: price, the level of on time delivery, the average rate of customer complaints, after-sales service, these indicators are the small, the better indicators and easier available.

1) Price X_1 : indicates weighted average price which is used by batch and weight given by shipments, P represents the weighted average price, W_i is the price when the number of the supply goods is X_i , and the formula is expressed as follow: $P = \sum_{i=1}^n W_i X_i / \sum_{i=1}^n W_i$

2) The Level of On-Time Delivery: It means the enterprise in accordance with the requirements of the goods delivered on time, inputting on the basis of the late number of the supply goods.

3) The Average Rate of Customer Complaints: The average rate of customer complaints= (the number of enterprises given negative evaluation/ cooperation with the vendor of business partner confession) $\times 100\%$

4) After-Sales Service: the respond days of suppliers received service requests \times the average number of items rework

2. Output Indicators: In this paper, these output indicators will be act as three indicators: quality level, the emergency supply capacity and supply history, these indicators are the bigger, the better for suppliers when they were quantified.

1) The Level of Quality Y_1 : It means the number of the qualified product of the arrival products.

2) The Emergency Supply Ability Y_2 : This indicator is that suppliers can provide the number of qualified products in a unit of time, and the number can be quantified by the enterprise temporary ordered expected-time and the on-time delivery. This indicator reflects the comprehensive inspect of suppliers' production and supply capacity, storage capacity, mobility capacity, coordination of action and other capabilities. In a dynamic market environment, it also is reflect the ability of suppliers in response to the changing economic situation and the performance of the supply chain agility, and it can also test supplies' ability of emergency response when the economic situation changes.

3) Supply history: By Availability to reflect the history of the total shipments. Trading success is the vendor's products in all respects to meet the business requirements, and the entire process is satisfactory to both sides.

B. Based on the DEA Model to Construct C^2R Model Supplier Efficiency Assessment

1. The Model Process: Suppose there are W suppliers to efficiency assessment, each vendor has a input terms and b output terms (in this article a = 4, b = 3), DMU_k is the k supplier in W suppliers, a terms referred to as an input credited to: X_i^k ($i = 1, 2, 3, 4$), b output terms credited to: Y_j^k ($j = 1, 2, 3$). Efficiency evaluation is the ratio of total output to the total input. DEA mathematical programming model is based on the goal of maximize the efficiency E_k of the decision-making unit DMU_k , finding the most favorable weight combination for the right DMU_k of inputs and outputs, and forcibly the total investment set to 1 for the sake of calculating easier, converting the general

linear programming model then the formula CR mode is: $\max h_k = \sum_{j=1}^b u_j^k Y_j^k$

$$s.t. \begin{cases} \sum_{i=1}^a v_i^k X_i^k = 1 \\ \sum_{j=1}^b u_j^k Y_j^r - \sum_{i=1}^a v_i^k X_i^r \leq 0, r = 1, 2, \dots, W \\ v_i^k \geq \varepsilon > 0, i = 1, 2, 3, 4 \\ u_j^k \geq \varepsilon > 0, j = 1, 2, 3 \end{cases}$$

(Among them X_i^r, Y_j^r are the actual input-output data and the unknown variable weights are u_j^k, v_i^k , it is not a given but a calculated, and it is the favorable weight of investment and production under the target of maximize the efficiency.)

In order to facilitate the validation of DEA, according to the linear programming duality theory, introducing slack variables S^+, S^- and the non-Archimedes infinitesimal ε , and θ means efficiency value for the vendor DMU_k , the greater θ means the higher efficiency of the j decision making unit and the more rationalize to allocation of resources the state, the smaller θ means the lower the efficiency of the j decision making unit and its values range is [0, 1].

$$\max h_k = \theta - \varepsilon \left(\sum_{i=1}^a S_i^- - \sum_{j=1}^b S_j^+ \right)$$

$$s.t. \begin{cases} \sum_{r=1}^w I_r Y_i^r - \theta X_i^k + S_i^- = 0, i=1,2,3,4 \\ \sum_{r=1}^w I_r Y_j^r - S_j^+ = Y_j^k, j=1,2,3 \\ S_i^-, S_j^+ \geq 0, i=1,2,3,4, j=1,2,3 \end{cases}$$

2) Economic Meaning of C^2R Model Analysis:

a) When $q^* = 1$, and $S_j^{+*} + S_i^{-*} = 0$, it means DMU_k is DEA effective, and its efficient frontier surface formed is constant returns to scale, and DMU_k is effective scale and technology, good allocation of resources and no waste loss.

b) When $q^* = 1$, $S_j^{+*} \neq 0$ or $S_i^{-*} \neq 0$, it represents DMU_k is weak DEA efficient, and this supplier is close to the best allocation of resources, and in the original output unchanging, it can reduce some investment, or on the contrary.

c) When $q^* < 1$, it is considered DMU_k is DEA invalid, invalid technical or invalid scale, and allocation of resources did not achieve the best state, so certain improvement should be made for the allocation of resources, such as changing the input to the original θ times.

Based on ANP Evaluation System of Supply Chain Index

A. Determining the Indicators

Based on principle of index system establishment and the guiding ideology, this paper had established four layer indicators, namely business performance evaluation, business capability evaluation, the cooperation between enterprises ability evaluation and enterprise environments; 5 second indicators, namely quality, cost, responsiveness, enterprise cooperation ability, communication ability. As a control layer, assuming that they are independent of each other, and the 16 index layer below the second layer indexes is non-independent (between certain factors are relevant) and we call it the network layer in Table I.

Table I
Quantitative values and quantitative methods of evaluation index

The target layer	Rule layer		Index layer	Indicator quantitative values	The index type	Indicator quantitative methods
The evaluation index system of supply chain	The product competition evaluation A1	Quality B1	The rate of qualified products C1	Qualified products accounted for the ratio of total output products	Quantitative	Formula calculate
			Quality system C2	The quality system with the consistency of the enterprise requirement	Qualitative	Experts assess
		Cost B2	Product price C3	Product unit price (weighted)	Quantitative	Formula calculate
			The rate of cost efficiency C4	The ratio of profit and loss cost	Quantitative	Formula calculate
		Responsiveness B3	Product flexible C5	On time delivery number, total	Quantitative	Formula calculate

				number of delivery		
			EmergencyC6	In a certain time of delivery ability	Quantitative	Historical data
	Business ability evaluation A2	Financial situation B4	The rate of capital turnover C7	The ratio of sales income and total assets	Quantitative	Formula calculate
			The rate of profit growth C8	The ratio of the profits and profits last year added value and the profits last year	Quantitative	Historical data
		Business situation B5	The rate of on time delivery C9	The ratio of on time delivery number and the total number of delivery	Quantitative	Formula calculate
			The rate of order completion C10	Reflect product orders	Quantitative	Formula calculate
	The cooperation between enterprises ability evaluation A3	Enterprise cooperation compatible B6	The strategic target consistency C11	Goals are or not consistent between enterprises	Qualitative	Experts assess
			Information platform compatibility C12	Between information system can be or not compatible	Qualitative	Experts assess
		Communication ability B7	Communication degree C13	The degree of communication with the partners	Qualitative	Experts assess
			Information level C14	The degree of information sharing	Qualitative	Experts assess
		Evaluation enterprise environments B8	Public relations C15	Relationship with the media, community, government and the public	Qualitative	Experts assess
			The competitive environment C16	The competitive position in the industry	Qualitative	Experts assess

B. Based on ANP Supply Chain Evaluation Model Construction

1. The main factor layer' weight matrix

Determining the element groups is determining the main factor layer' weight matrix, which is the degree of mutual influence structuring between the network layer element groups, that is to say, it is the relative importance of each element in the target group to B_i ($i = 1, 2, 3, 4, 5, 6, 7$). If an element has no effect on the other elements in the ANP comparison matrix its value is 0, that is different from the AHP, and the corresponding feature vector values is also 0, the other are normalized.

B_i	$B_1 \cdots B_n$	The normalized feature vector
B_1	Comparison matrix	a_{11}
\vdots		\vdots
\vdots		\vdots
B_n		a_{ni}

The last column normalized is gained by the algorithm based on the feature vector in AHP, all the normalized feature vector can composite matrix which is a weighted matrix A: (in that place $n = 7$, A is a non-negative matrix and its column sum is 1.)

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & \mathbf{L} & a_{1n} \\ a_{21} & & \mathbf{L} & a_{2n} \\ \mathbf{M} & \mathbf{M} & \mathbf{L} & \mathbf{M} \\ a_{n1K} & a_{n2} & \mathbf{L} & a_{nn} \end{bmatrix}$$

2. Secondary factor layer's super matrix

B_i is providing secondary factor $C_{i1}, C_{i2}, \dots, C_{ini}$, $i = 1, 2, \dots, n$, the impact of elements C_{jk} ($k = 1, 2, \dots, n_i$) of B_j element set is gain by the pairwise comparison, constructing comparison matrix structure.

C_{jk}	$C_{i1} \dots C_{ini}$	The normalized feature veltor
C_{i1}	Comparison matrix	W_{i1}^{jk}
\vdots		\vdots
\vdots		\vdots
C_{ini}		W_{ini}^{jk}

The relative influence of all elements in the C_i to all elements in the C_j in comparison matrix to calculate the normalized feature vector and make the matrix W_{ij} , as is shown in the below:

$$W_{ij} = \begin{bmatrix} W_{i1}^{j1} & \dots & W_{i1}^{jni} \\ W_{i2}^{j1} & \dots & W_{i2}^{jni} \\ \vdots & \dots & \vdots \\ \vdots & \dots & \vdots \\ W_{ini}^{j1} & \dots & W_{ini}^{jni} \end{bmatrix}$$

The column vector of W_{ij} is the influence degree arrange elements of the C_i elements to C_j elements. If it is an element of C_i , then $W_{ij} = 0$, and it can be obtained a super matrix in B_i guidelines.

3. Calculate the Weighted Super Matrix

Weighted matrix constructs the mutual influence degree between the element group, and super matrix constructs the mutual influence degree between each element under element group, then the real impact relationship degree which is a dependent and feedback relationship of analysis network process (ANP) between elements can be represented through the weighted super matrix. Each element of the weighted matrix in step 1 multiply the blocks of super matrix in step 2 can constitute a weighted super matrix. Weighted super matrix reflects the control effect of the main factor to the second factor and the feedback effect of the second factor to the main factor, weighted super matrix $\bar{W} := \bar{W} a_{ij} * W_{ij}$

4. Solve the Index Weight

The elements of super matrix \bar{W} are W_{ij} , then the size of W_{ij} reflects the effect of element to element j , and it also is the degree of dominance. The degree of dominance of element i to element j can be got by $\sum_{i=1}^n W_{ik} W_{kj}$, and it is the second degree of dominance. It is the element of \bar{W}^2 which is column normalization.

When $\bar{W}^\infty = \lim_{t \rightarrow \infty} \bar{W}^t$ exists, the j column of \bar{W}^∞ is the limits corresponding vector of each element in the network layer under the B_i to the element j .

Because of the complexity of the ANP algorithm, this paper will adopt the SD (super decisions) decision making software to calculate this model.

A Company Partner Selection Evaluation Example

This section will use the DEA and the ANP mathematical model aforementioned to solve the problem of selecting partners for an office equipment manufacturing limited company, and the supplier will be selected as the target evaluation assessment (as DMU), and be done specific calculations. As the company continues develop, the conflict between the M company and suppliers are increasingly fierce, and the suppliers are increasingly unable to meet the company's needs. Company executives believe that this issue must be put agenda, and the partners has become the biggest obstacle currently impeding the company forward.

Firstly, M company listed the deficiencies existing suppliers and the hope to build partnerships shown in Table II .

Table II
The deficiencies existing and hope to building partnerships

	The service content	Stability	The market reaction speed	Information communication	The consistency of quality	The timeliness of delivery	Number of suppliers
Deficiencies existing suppliers	Product	Frequent changes	Slow	Privileged Information	Bad	Bad	
Hope to build partnerships	Products and strategic cooperation	Long-term and close cooperation	Fast	Information sharing	Excellent	Excellent	Fewer but better

In summary, we can conclude that M company has been decided to re-select partners, because the relationship between the company and its partners were mainly "buy - sell" relationship. The major factor of selection partners is price, and if only one person to make a choice, it is inevitably existing empiricism, subjective judgment and personal factors doping, which will inevitably lead to more friction that appears in the process of cooperation partners with the company and can't reach an agreement in some important issues, such as data and information sharing, partners on product quality and response speed of assuring, which are directly bound by the M company's growth and development, and it also go against establish their own service characteristics on the opponent diverse markets .Next, this article will propose constructive solutions to solve the actual situation of the M company.

A. Supplier Efficiency Evaluation

a. Original Data Processing

Table III
A parts supply data

The candidate suppliers number	Price level	Quantity of late distribution (kg)	The enterprise of given negative evaluation	The number of cooperative enterprises	Quant ity of returns (kg)	Quantity of response days	The level quality	The emergency supply ability (kg)	Supply history
1	21.4/20.4/22.5/21.9	3.0	2	33	6	2	40.3	590	10.9/9.5/9.6/11.5
2	19.6/21.3/21.9/22.0	30.0	5	25	28	7	30	260	4.5/8.3/7.0/10.5
3	22.7/22.5/23.7/24.0	21.0	4	25	10	5		290	7.8/6.0/8.0/9.4
4	20.0/19.3/20.1/21.4	6.0	1	50	8	1	25	550	5.0/7.0/6.0/7.0

5	20.6/22.2/22.3/23.1	7.0	1	20	19	1	30	400	8.0/7.0/7.0/9.0
6	19.9/20.1/21.6/23.5	48.0	2	20	17	3	4.8	200	1.0/1.5/1.0/1.4
7	20.2/22.5/25.0/22.3	40.0	2	22	9	1	30.2	100	7.2/6.7/8.0/8.5
8	22.4/22.7/23.1/22.9	15	4	23	20	1		210	7.0/5.5/8.3/7.8

Table IV
The processed data

The candidate suppliers number	Price (I)	Level of on time delivery (I)	The average rate of customer complaints (%) (I)	After-Sales service (I)	The level of quality (O)	The emergency supply ability (O)	Supply history (O)
1	21.56	3.0	6	12	40.3	590	41.5
2	21.43	30.0	20	196	30.0	260	30.3
3	23.31	21.0	16	50	31.0	290	31.2
4	20.25	6.0	2	8	25.0	550	25.10
5	22.07	7.0	5	19	30.0	400	31.0
6	21.34	48.0	10	51	4.8	200	4.9
7	22.12	40.0	9	9	30.2	100	30.4
8	22.79	15	17	20	28.3	210	28.6

Note: In the table, (I) denotes input item, (O) denotes output item, and then using DEAP2.1 software inputs data. Calculating as follows:

Wherein Guidance Document command:

logistic.dta DATA FILE NAME

logistic.out OUTPUT FILE NAME

8 NUMBER OF FIRMS

1 NUMBER OF TIME PERIODS

3 NUMBER OF OUTPUTS

4 NUMBER OF INPUTS

0 0=INPUT AND 1=OUTPUT ORIENTATED

0 0=CRS AND 1=VRS

0 0=DEA (MULTI-STAGE), 1=COST-DEA, 2=MALMQUIST-DEA, 3=DEA (1-STAGE), 4=DEA (2-STAGE)

b. DEA Model Results

Table V
Candidate vendor analysis

The candidate suppliers number	C ² R model	
	Relative efficiency	Ranking
1	1.000	1
2	0.749	5
3	0.711	6
4	1.000	1
5	0.813	4
6	0.342	8
7	0.999	3
8	0.664	7

c. Analysis Calculation Results

As we can see from Table V, supplier 1 and supplier 4's efficiency is 1 in C²R model, indicating that both enterprise scale and technique are effective, and its efficient frontier is formed constant

returns of scale, which is a species ideal state that is good allocation resources, not wasteful, appropriate input and output, and it should be based on this keeping continue.

At this time, two suppliers' relative efficiency is 1, and it should be the next step, using ANP method to evaluate the two vendors supply chain.

B. Evaluate Supply Chain

a. Original Data

1. Supplier 1's rate of qualified product is 97%, and annual sales income is 20 million yuan in which the total annual profit is 380 million yuan, and the total cost is 16.2 million, and total assets is 56.5 million yuan. The supplier has a large size and has produced more products, and this supplier adding much new services and products for the special needs of customers. Its kinds of products in 2008 is increasing from 9 to 13, the rate of on time delivery is 92.5%, and the rate of order completion is 99.5%. Merging profit statement of supply companies and offsetting the internal transaction can obtain supplier 1's profit growth throughout the supply chain. According to the data can gain profit growth in the current year is $PRA_{2008} = 25\%$.

2. Supplier 4's rate of qualified product is 94%, and annual sales income is 96.3 million yuan in which the total annual profit is 13.2 million yuan, and the total cost is 8310 yuan, and total assets is 168,356,700 yuan. In 2008, this supplier's products kinds from six series of eight kinds increase to seven series of 10 kinds, develops new markets to meet customers' need. Due to fierce market competition, supplier 2 has greatly improved in responsiveness and punctuality, and the rate of on time delivery is 97%, and order fulfilment rate is 100%. With the growing competition, the slowing production and sales grow, the prices continue to decline, and the growing original material prices and other factors, the industry profit growth is decline, but the goal of supply chain with its improving sales service, quality management makes profit growth and its' profit growth rate is 30%.

b. Supply Chain Evaluation Data Processing

1. Index System: This case uses analytic network power (ANP) process to evaluate suppliers in the supply chain after the primary election, the following steps is calculating according to the ANP.

1) Control layer elements: By analyzing the control layer of quality, cost, responsiveness, financial situation, business conditions, business cooperation compatibility, communicate ability and the business environment, its correlation between these enterprises is not large, so we can conclude that they are mutually independent.

2) Network layer elements: the rate of qualified products C1 and quality system C2 of elemental focus quality with product price C3 and the rate of cost efficiency C4 of elemental focus cost are influenced each other, using double arrow express. Responsive element set has influenced on the cost element set, using a single arrow express (the more responsiveness sensitive, the response cost often rises), and product flexible C5 and emergency C6 of responsive element set's internal elements is influenced each other. The rate of capital turnover C7 and the rate of profit growth C8 of pecuniary condition element set is influenced each other, and it is independent element. The rate of on time delivery C9 and the rate of order completion C10 of business condition set is influenced each other (the higher on time delivery rate, the higher order completion rate). The strategic target consistency C11 of enterprise cooperation compatibility concentrated has influenced on information platform compatibility C12, so it is independent with each other. Communication degree C13 of communication ability set and information level C14 is influenced each other, the high information level is good for communication, and information level is also affect the information platform compatibility. Two factors of business environment set is influenced each other, but the correlation is not very big. In order to objectively evaluate the supply chain, this paper is assumed that they are independent with each other.

According to M company's supplier requirements, it has established supplier evaluation system shown in Fig 1,

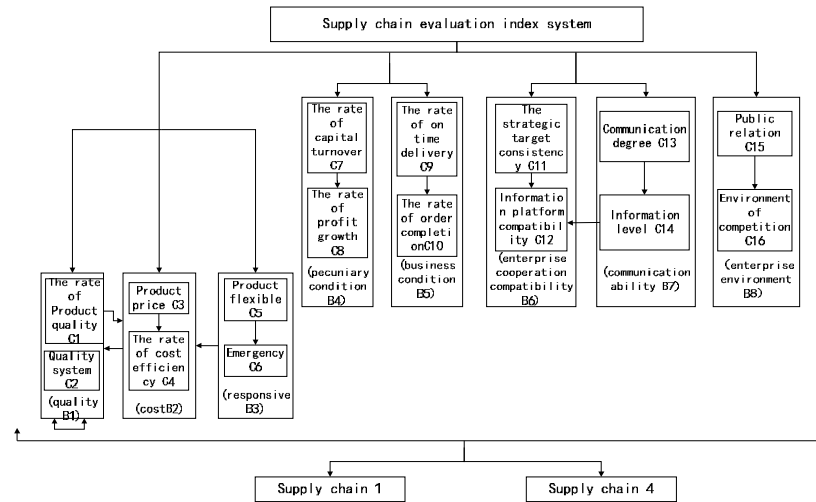


Fig.1 Supplier evaluation system

2. Establish Supply Chain Evaluation Model: Model has been established in accordance with the order which is first the control layer and then the sub-rule layer, according to the forth large sections' model ideas in turn set up, and then according to Fig.1 and Table I dependency relationship between the factors of determining the relationship between element set. This paper use SD (super decisions) software model and calculation. The model is that correlation between the modules of the model and the elements between the modules also are interconnected.

By determining the weight of index factors and determining the weights of various factors in the evaluation index system of supply chain (detailed steps can be reference for the implementation of the analytic hierarchy process (AHP) to determine the weight, not repeat them here), then by the model which is depended on elements make the index weight of the primary and secondary factors in accordance with the SD software prompts inputting step by step, and then it can be obtained the unweighted super matrix, the weighted matrix, and the limit super matrix.

W_{ij} of unweighted super matrix table shows the effect degree of i element to j element, for example, $W_{56} = 0.75$ indicating the response degree of flexibility product C5 affecting emergency C6 is 0.75.

Weighted matrix has different meaning from unweighted super matrix which represents the interaction degree between the elements of the systems and also is the result of the main factor and the secondary factors, such as $W_{56} = 0.1875$, and its value is different from the unweighted super matrix.

Limit super matrix table is the final output shown in Fig.2. The weight of each sub-criterion layer can be calculated corresponding results, such as the C2 quality system weight is 0.1341.

		Index layer															
Main layer	Sub-layer	The rate of Product quality C1		Product price C3		Product flexible C5		The rate of capital turnover C7		The rate of on time delivery C9		The strategic target consistency C11		Communication degree C13		Public relation C15	
		Quality system C2	(quality B1)	The rate of cost efficiency C4	(cost B2)	Emergency C6	(responsive B3)	The rate of profit growth C8	(pecuniary condition B4)	The rate of order completion C10	(business condition B5)	Information platform compatibility C12	(enterprise cooperation compatibility B6)	Information level C14	(communication ability B7)	Environment of competition C16	(enterprise environment B8)
The rate of Product quality C1	Quality system C2	1.00	0.17	0.10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	(quality B1)	0.17	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Product price C3	The rate of cost efficiency C4	0.10	0.05	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	(cost B2)	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Product flexible C5	Emergency C6	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	(responsive B3)	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
The rate of capital turnover C7	The rate of profit growth C8	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	(pecuniary condition B4)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
The rate of on time delivery C9	The rate of order completion C10	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	(business condition B5)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05	0.05	0.05
The strategic target consistency C11	Information platform compatibility C12	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05	0.05
	(enterprise cooperation compatibility B6)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05	0.05
Communication degree C13	Information level C14	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05	0.05
	(communication ability B7)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05	0.05
Public relation C15	Environment of competition C16	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00	0.05
	(enterprise environment B8)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1.00

Fig.2 Limit super matrix

c. Result Analysis

Seen from the limit super matrix, supply chain 1 and supply chain 4's weight index respective is: 0.1796, 0.1562, and its normalized results is: 0.5348, 0.4652. As can be seen from the data supply

chain, supply chain 1 is superior to supply chain 4, so companies should choose superior 1 as the best provider, and also be used as a long-term close strategic partner.

Conclusion

This paper were researched the supply chain partners of small and medium-sized manufacturing enterprises. Selecting Suppliers is a multi-criteria problem that is combine qualitative factors with quantitative factors. On the basis of research status, this article creative combines the data envelopment analysis DEA with network analysis methods ANP. First using the DEA method established the efficiency evaluation model and index system of suppliers, and then using the ANP method established the evaluation model and index system of supply chain on which vendors located. DEA method is a quantitative method, and it can research the rationality of the supplier's resource allocation, make the primary election to the suppliers, and overcome the subjectivity of the AHP and other methods determining the index weight. Indicators are affected by each other between ANP method which is overcoming the shortcomings of AHP index that it only has the vertical hierarchical mutually independent. Combination of both methods is a combination of qualitative and quantitative, and breaking the status quo of the traditional supplier selection and supply chain evaluation phase separation. Using horizontal and vertical cross-evaluation is a new method of program evaluation.

Acknowledgment

This work was supported by funding project for Youth Talent Cultivation Plan of Beijing City University Under the grant number (CIT&TCD201504051), supported by Beijing WUZI University Cultivation Fund Project (GJB20143006), supported by Beijing Key Laboratory(NO:BZ0211) and Beijing Intelligent Logistics System Collaborative Innovation Center.

References

- [1] Jafar Rezaei. A two-way approach to supply chain partner selection [J].International Journal of Production Research, 2015, 53(16):4888-4902.
- [2] Chong Wu,David Barnes. Partner selection in agile supply chains: a fuzzy intelligent approach [J]. Production Planning and Control, 2014, 25(10):821-839.
- [3] Dubow, Mark. Evaluate business plans, select strategic partners by taking a 10-step approach [J]. Health Care Strategic Management, 2006, 24(10):1-16.
- [4] Zhang Feng, Song Xiaona, Yin Xiuqing. Based on AHP and TOPSIS method of evaluation and selection of supply chain partners [J].Industrial economic BBS, 2015, (2):95-104.
- [5] Guo Siqu. Analyses how to evaluate supply chain partners [J].Brand, 2015, (10):95.
- [6] Qiu Zengjian. The improved AHP method in the analysis of application of international project risk assessment [J].Jiangsu building materials, 2016, (1):57-60.