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Study on Partner Selection of Virtual Logistics Alliance Based on DEA

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Abstract: In this study, we construct a evaluation system including qualitative as well as quantitative indexes. The qualitative indexes include corporate image, the compatibility of culture and management, team spirit and development potential. The quantitative indexes include cost control, service level, technology level, financial performance and information level. Finally, we estimate and select the partners of virtual logistic alliance using DEA method.

Key words: Partner selection, virtual logistic alliance, DEA

INTRODUCTION

Virtual logistic alliance was a organization forms which between logistics enterprise and market. To managing Virtual logistic alliance efficiently, it is essential that seeking a balance mechanism between the two extreme mechanisms. This balance mechanism is establishing a long-term cooperation to eliminate waste and enhance the rapid response capability of market opportunity. As shown in Fig. 1, compared with tradition cooperation and Virtual enterprise other industries, Virtual logistic alliance give priority to mutual trust, long-term dynamic cooperation, information sharing, achieving shared vision and common goal.

CONSTRUCTION OF EVALUATION SYSTEM

Principles of construct evaluation system: This study applies the method of quantitative combined with qualitative in constructing index system. The main principles include integrity, simplicity, objectivity, comparability, measurability.

Evaluation index system for choice of partners: Qualitative index includes enterprise image, compatibility of management and culture, cooperation spirit and development potential. Quantitative index includes cost control, service level, technology level, management benefit, informatization level.

Implication of quantitative index is shown as fellow:

Cost control: it is the index of describe Costs in the process of logistics services. Low cost is the inevitable choice of enterprise obtained competitive advantage. The logistics cost include the aspects as shown in Fig. 2.

Service level: The service level of customer perception determines customer loyalty and direct influences market share. Customer satisfaction has been the indicator of external performance of virtual logistic alliance. Customer satisfaction includes rapid treatment of customer complaint rate, rapid response capability, on time delivery rate, order form satisfying rate, anti-risk ability, communication ability and feedback ability.

Innovation ability and operation applicability: Innovation ability and operation applicability is a key determinant of quality level of the backup cooperation partners provide logistic service. This study selected the typical technical index, such as innovation ability of process, innovation ability of service, innovation ability of management, advancement of information system and matching degree of information system.

Management benefit: Management benefit is imperative that choice of cooperation partners. It includes asset-liability ratio, market share, ratio of sales, inventory turnover, turnover of fixed assets.

BASIC THEORY OF DEA

Data envelopment analysis is a nonparametric method in operations research and economics for the estimation of production frontiers by Charnes and Cooper (1978). It is used to empirically measure productive efficiency of decision making units (or DMUs). The guiding principle is to determine the DMU: Its

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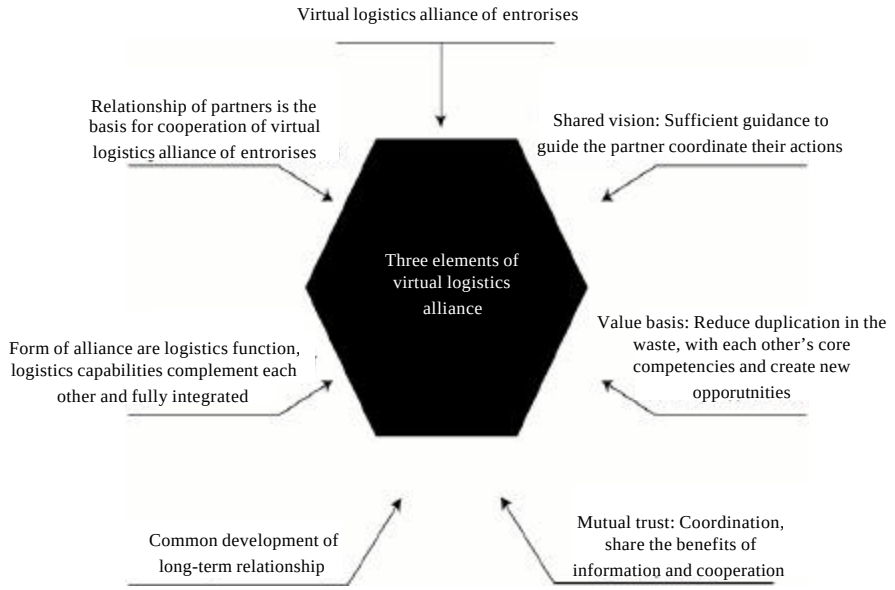

Fig. 1: Virtual logistic alliance

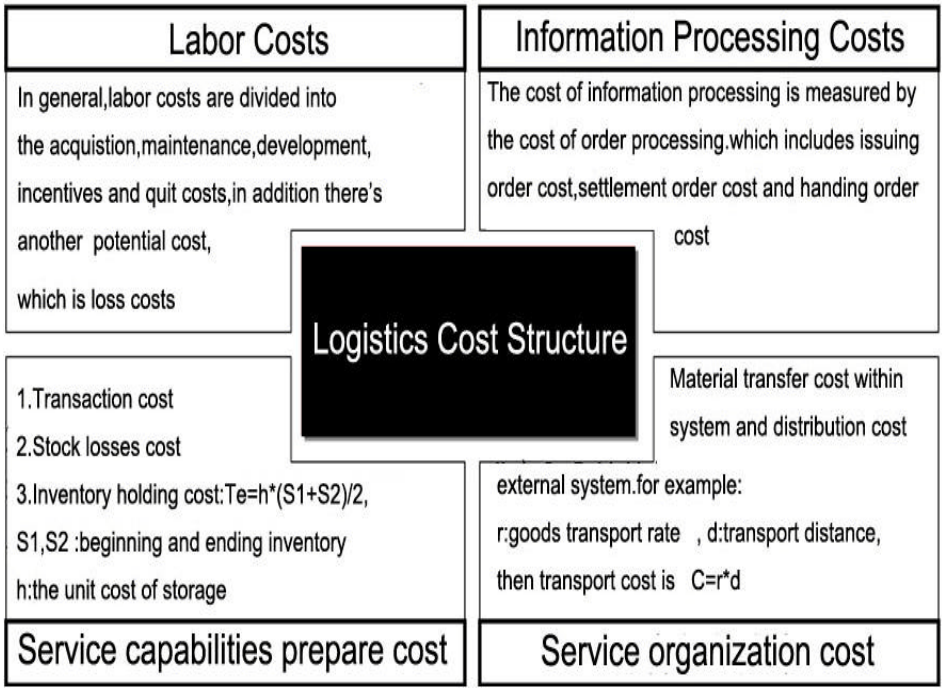

Fig. 2: Logistics cost structure

"consuming resources" and "products", each DMU can be seen as the same entity, that is, a perspective, each DMU has the same input and output. Through a comprehensive analysis of the input and output data, DEA can draw a number of indicators of each DMU efficiency. Accordingly to each DMU grading queue, to determine the effective (ie, relatively high efficiency), DMUandpointed out that the DMU non-valid reasons for and extent of management information to provide the competent authorities. DEA can also determine the scale of the inputs of each DMU is appropriate, given the adjustment of each DMU into the right direction and extent of the scale. DEA to promote the concept of the engineering efficiency of single-input single-output in the

evaluation of the effectiveness of multiple input multiple output similar decision-making unit DMU, no pre-set any weight, to avoid subjective factorsandgreatly simplifies the algorithm.

Decision making units: Since the output is the result of the decision-making, this unit is called decision making units DMU. Therefore, each DMU representatives or show some economic significanceandthe basic characteristics is multiple input and output. And in the process of transform input into the outputandthe DMU strive to achieve its own decision-making goals. In the DEA, the most use is the same type of DMU. The same type DMU collection has the following three characteristics: the same goals and tasks; the same external environment; the same input and output indicators.

Basic type of DEA model: It using a fixed scale assumptions as well as estimate the production boundary of the alternative partners by linear programming methodsandthen measure the relative efficiency of each decision making unit. For a given the specific DMU0 (enterprise), the efficiency values calculated by the following mathematical programming.

The j DMU with i input de noted by x_{ij}, j DMU with r output denoted by y_{rj}. u_r and v_i is weights. The efficiency value is compare efficiency of resources invested, so it called input orientation efficiency.

In order to avoid innumerable solutions, adding constraint condition:

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

according to Charnes-Cooper transform. The new CCR module shown as follow:

$$\begin{aligned}
&\max_{u,v} h_0(u,v) = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \\
&\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, j = 1, 2, \cdots, n \\
&\text{s.t. } u_r \ge 0, r = 1, 2, \cdots, s \\
&\quad v_i \ge 0, i = 1, 2, \cdots, m
\end{aligned}$$

According to the principle of duality, the above equation can be transformed into the dual model.

The optimal value θ^* obtained by the above linear programming problem is called CCR efficiency value. If

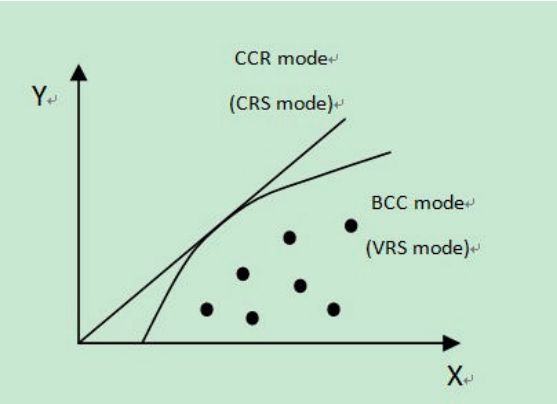

Fig. 3: Convex of the BCC model

$\theta<1$, the DMU is efficiencyandits inputs existence of waste, must proportionally reduce its inputs, reduce the proportion is $1-\theta$; If $\theta = 1$, the DMU is efficient.

BBC module: The DMU may be in a state of increasing returns to scale or decreasing returns to scale, therefore, DMU inefficiency comes from their own input-output configuration is inappropriateandmay also be due to the factors of their scale. Grasping the returns to scale of each DMU can contribute to policy makers to do scale adjustment, thus achieving efficient operation. Banker *et al.* (1984) *et al* increase of a convex constraint:

$$\sum_{j=1}^{n} \lambda_j = 1$$

The CCR model the BCC model:

$$\begin{aligned}
&\max_{u} z_0 = \sum_{r=1}^{s} u_r y_{r0} \\
&\quad \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, j = 1, 2, \cdots, n \\
&\text{s.t.} \sum_{i=1}^{m} v_i x_{i0} = 1, u_r \ge 0, r = 1, 2, \cdots, s \\
&\quad v_i \ge 0, i = 1, 2, \cdots, m
\end{aligned}$$

As shown in Fig. 3 the convex of the BCC model of cross-interface more closely than the CCR model inclusive of data points, the value of technical efficiency is higher than or equal to the value of using the CCR model obtained. The efficiency of value obtained by the BCC model is pure technical efficiency, the BCC model of the observation point closer to the efficiency frontier.

However, there are some defects in the measure of Scale Efficiency, that is, regarding the invalid scale of the industry, it could not be seen by the efficiency value

whether the evaluated industry is in the increasing area of scale pay or the decreasing area of scale pay, so the role of the scale efficiency analysis will be reduced.

Coelli (1996) put forward that the inspected units of scale is judged in the increasing area or in the decreasing area through solving the DEA of NIRS. Comparing the model of NIRS with VRS can obtain the efficiency value that could judge the evaluation industry in the area. When TENIRS is not equal to TEVRS, it shows that the evaluation industry is in the increasing area of the scale pay. The invalid scale results from the too small scale. It can expanding the scale to improve the efficiency. When TENIRS is equal to TEVRS, it indicates that the evaluation industry is in the decreasing area of the scale pay. The too large scale of the industry leads to the invalid scale. It needs to lessen the scale to improve the efficiency.

Advantage of DEA: The logistics system is a complex system which contains lots of links and multi-levels and there are some great correlation and influence among the subsystem. It can avoid the mutual effect and relationship influence through the method of DEA. By confirming the effective of the evaluated enterprise in the aspect of the effective, the economic benefits of the logistics system in a enterprise can be evaluated effectively. Because the logistics system is a dynamic system, the economic benefits need to be evaluated from the different aspects and index and those index cannot often use the same dimension. The method of DEA need not consider the problem of the same dimension. So, the economic benefits can be evaluated more accurately and efficiently. The model of DEA is the best method of evaluating lots of index in the world today (Liu *et al*., 2005). Applying this method can comprehensively consider the various factors. Also it can avoid the more subjective factors disturbed. DEA has the outstanding advantages that helps the supplier of the logistics serves to solve some problem (Weber *et al*., 1991; Liu *et al*., 2005).

Comparing to the other evaluating method, DEA is particularly applied to the complex system which has multiple-input and multiple-output. It has some Characteristics. First, DEA regards the input and output data of decision making units as variables. This point of view can evaluate the decision making units better and avoid to determine the weight of each index under the priority meaning. Second, assuming each input is related to one or more output and the input and output has some relations actually, so DEA unnecessarily determine the expression of this kind of relationship. The partners of the alliance enterprise are evaluated in order to choose the best enterprise partner that is suitable for the enterprise mostly. So the Input-output ratio of the optional enterprise is a more appropriate evaluating standard and the evaluating index of the optional enterprise can be divided into the input index and output index. Using DEA is to comprehensively analyze the input and output data and obtain the quantitative index of each evaluation objects' relative efficiency. So it can judge which optional enterprise is the most reasonable input and gain maximal profit. In conclusion, this article chooses the DEA method as the evaluating method for alliance enterprise partners to evaluate and analyze.

COOPERATIVE PARTNER SELECTION OF VIRTUAL LOGISTICS AND ALLIANCE ENTERPRISE

This article will use the CCR and BBC model that put forward by Banker (1984) to choose the cooperative partner of virtual logistics and alliance enterprise through the method of linear programming. Evaluating the qualitative indexes according to comments and the corresponding relation between each comment Wj and the quantitative score Cj ($C_j \in [0, 1]$) is shown in Table 1.

Through the qualitative index data processing, it can obtain the evaluating value of each index. Then determine the one class index value of the optional partner by the method of AHP and evaluating the input and output efficiency of the optional enterprise by the method of DEA model. Finally, select the partner that is the most suitable for the enterprise. The specific process is shown on the Fig. 4.

DEA evaluating model can obtain the effective partner and the qualitative analysis of some result as follows. Firstly, considering the operation cost, when the Performance level of the optional partner has reached the operation requirements of the alliance enterprise, it can select the company which is the lowest operation cost among the effective DEA of the optional company as the partner. Secondly, from the aspect of a high performance that the union hope to reach, it can select the high performance relatively as the partner. Thirdly, under the consideration of the long-term development, it is very important to supply the quality service for customer. Whether the logistic service of the Partners is good or not that will directly affect the level of the customer service of the alliance enterprise. Therefore, enterprise should not only consider the operation cost. They should consider the overall service performance and comprehensive quality and select the high overall service performance and comprehensive quality company as their partners.

Table 1: Evaluation set quantitative score

Evaluation set Wj	Very nice	Bette r	General	Poor	Very poor
Quantitative score Cj	0.90	0.70	0.50	0.30	0.10

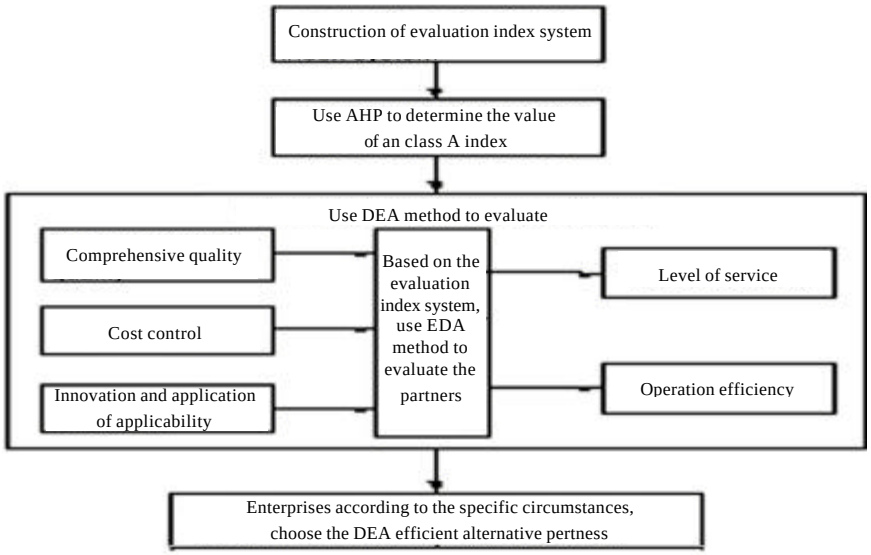

Fig. 4: Cooperative partner selection of virtual logistics and alliance enterprise

Table 2: Indicator value of the optional suppliers

Optional partners	Comprehensive quality	Cost control	Service level	Technical level	Operation benefit
A	0.40	0.35	0.25	0.30	0.25
B	0.35	0.30	0.20	0.40	0.40
C	0.45	0.65	0.35	0.30	0.25
D	0.20	0.15	0.30	0.50	0.40
E	0.55	0.35	0.40	0.20	0.20
F	0.45	0.50	0.35	0.25	0.20
G	0.15	0.30	0.35	0.40	0.30
H	0.30	0.35	0.55	0.35	0.50
I	0.65	0.20	0.30	0.30	0.25
J	0.40	0.30	0.15	0.30	0.20

Table 3: Evaluating results

Optional partners	Technical efficiency	Pure technical efficiency	Scale efficiency	Scale efficiency characteristics
A	1.000	1.000	1.000	-
B	0.843	1.000	0.843	Irs
C	0.742	1.000	0.742	Irs
D	0.333	0.833	0.400	Irs
E	0.769	1.000	0.769	Irs
F	1.000	1.000	1.000	-
G	0.656	1.000	0.656	Irs
H	0.622	0.800	0.778	Irs
I	1.000	1.000	1.000	-
J	0.624	1.000	0.624	Irs

irs: Means the industry is in the increasing area of Scale returns, drs means the industry is in the decreasing area of Scale returns, -: Means the region that the scale of the industry is effective and scale returns unchanged

Example analysis: The following is using the specific examples to state the evaluating process of partner selection by the method of DEA model based on AHP for virtual logistics and alliance enterprise. A union enterprise actively seek its partners, there are ten optional enterprises which is A, B, C, D, E, F, G, H, I and J. A. AHP analysis: At first using the method of AHP to work out the one class index for this optional enterprise. It will obtain the performance value of these ten suppliers based on these five indicators that is comprehensive quality, cost control, service level, technical level and operation benefit as shown in the Table 2.

Partners selection based on DEA: According to the Table 3 showing the indicator system that comprehensive quality, cost control and the level of technology are regarded as cost indicator, service level and operation performance as efficiency indicator. The cost indicator and efficiency indicator are respectively considered as the input and output elements of DEA and evaluate the optional partner. The evaluating results are shown on the Table 3.

From the analysis result of the Table 3, we can see the effective alternative suppliers that is A, F and I, the other seven companies are in the increasing area of scale return. If the company would expand its scale further, it will help the company to improve the competitive power of enterprise. For the three effective suppliers, alliance enterprise can choose them according to the practical situation. If the alliance enterprise pay more importance to the technology level and operation benefit, they can choose A. If the alliance enterprise pay more importance to the cost control level and the service level, they can choose I. If the alliance enterprise pay more importance to the comprehensive quality, they can choose F.

CONCLUSION

Through evaluation and analysis, we can come to the following conclusion. Firstly, using DEA to evaluate, it

not only takes into account the qualitative indicator of the virtual logistics and alliance partners, such as enterprise image, potential development and so on, but also considers the practical operation performance of the partners and realizes the comprehensive evaluation. Secondly, using DEA evaluation model, it overcomes the shortcomings of AHP, for example, when meeting the sort of weight is closer each other, it is difficult to determine the final choice object. The method of AHP is affected by subjective factors of experts and it should consider more qualitative indexes, etc. But the DEA evaluation model can better solve the problems. Thirdly, the input and output indicators are considered and it can better meet the actual needs of alliance enterprise. Fourthly, using DEA have more optional object according to the evaluation results. Aiming at this circumstance, we can integrate with the actual situation and refer to the evaluation results by AHP from the aspect of enterprise operation cost, performance level expected and strategic development to consider the final selection result of the company.

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