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Research on the performance evaluation of road transportation supply chain based on interval DEA method

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ABSTRACT

In order to solve the uncertainly problem in supply chain management of road transportation, and achieve performance evaluation. Indexes of performance evaluation in road transportation supply chain management were built. Ten road transport enterprises were chosen as decision-making units. The data was collected and interval DEA method combined with C2R model was used to be efficiency range of every decision-making unit. The result provides decision-making for supply chain management of road transportation.

KEYWORDS

Road transportation;
Supply chain management;
Interval data envelopment analysis method;
Performance evaluation.

INTRODUCTION

Road transportation involves multiple cargos handing operation in ways of using cars to transport passenger and freight on the highway. Road transportation can be defined a series of process from the starting place to the ultimate customer. Its service can be equal to the enterprise products[1]. The supply chain management of road transport is individuation solution for the road transportation objects by efficiently linking the each aspect of the road transportation enterprises supply chain. In the supply chain management of road transportation, the supply chain performance evaluation is of great significance for measuring the realization degree of the supply chain objective and providing the operation decision support. In addition, the indeterminacy is of great influence for the transportation enterprises. This indeterminacy can be showed through input and output which can be got in the stage of plan, purchase, production, distribution and customer satisfaction. Therefore, how to provide decision support for the supply chain management by ways of aiming at the uncertainly problems and realizing the performance evaluation in the process of the supply chain management of road transportation is the problem which should be solved urgently.

At present, the research literatures with respect to the supply chain management and performance evaluation focus on the basic framework and network design of the road transportation supply chain. Zhu Wenying[1] has established road freight transportation enterprise value chain and put forward relevant optimizing strategy from the perspective of value chain, then the significance of balance and harmonious among enterprises finance and customer relations has been emphasized; Wu Yue[2] has put forward the method of purchasing road construction materials under the guidance of supply chain management and the reality; Ma Xiaofeng[3] has explained the main performance indicator in detail for the supply chain and established systematic supply chain performance evaluation system according to the

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supply chain performance management research domestic and overseas; Zhong Zuchang[4] has studied demand uncertainty and output uncertainty in the supply chain management by means of applying the probability density function and risk factor to the traditional DEA model, then established the supply chain performance evaluation model in the case of the output indeterminacy. These papers above have provided important reference value for evaluation of the road transportation supply chain performance. On the basis of the performance evaluation factor for the road transportation supply chain, the indeterminacy which exists in the supply chain of road transportation will be evaluated and optimized through the interval DEA in this paper.

THE INTERVAL DEA C^2R MODEL CONSTRUCTION

On the basis of the relative efficiency, the data envelopment analysis which is put forward by Charnel A and Cooper W is a nonparametric estimation method and is used to evaluate the validity of the multiple inputs and multiple outputs decision making unit with the same type[5]. In the traditional DEA, the efficiency of the DMU is evaluated on the basis of certain input and output data, but in the realistic management process of the road transportation supply chain, the specific data of the every factor is difficult to collect accurately because of the external environment transformation, incomplete information and technology limitation. Thus, a series of blurry data or estimated value which can be translated into interval data can be got frequently. Then, the interval DEA can solve this problem[6].

Set the j-th DMU_j ($1 \le j \le n$) with the same input and output type possess m input and s output, the input and output vector quantity can be show as following.

$$X_j = \left(x_{1j}, x_{2j}, \cdots, x_{rj} \cdots x_{mj}\right)^T > 0 \quad (j = 1, \cdots, n) \tag{1}$$

$$Y_j = \left(y_{1j}, y_{2j}, \cdots, y_{rj} \cdots y_{mj}\right)^T > 0 \tag{2}$$

Among these formulations, $x_{ij} = \left[\underline{x_{ij}}, \overline{x_{ij}}\right]$ can be showed the i-th interval input in the j-th DMU; $y_{rj} = \left[\underline{y_{rj}}, \overline{y_{rj}}\right]$ can be showed the r-th interval output in the j-th DMU. $\left(X_j, Y_j\right)$ can be showed the j-th DMU.

Let $x_{ij}^{'} \in \left[\underline{x_{ij}}, \overline{x_{ij}}\right]$, $y_{rj}^{'} \in \left[\underline{y_{rj}}, \overline{y_{rj}}\right]$, and $\left(i = 1, \cdots, m, r = 1, \cdots, s, j = 1, \cdots, n\right)$.

$$X_j^{'} = \left(x_{1j}^{'}, x_{2j}^{'}, \cdots, x_{ij}^{'}, \cdots x_{mj}^{'},\right)^T,$$

$$x_{ij}^{'} \in \left[\underline{x_{ij}}, \overline{x_{ij}}\right] (i = 1, \cdots, m) \tag{3}$$

$$Y_j^{'} = \left(y_{1j}^{'}, y_{2j}^{'}, \cdots, y_{rj}^{'}, \cdots y_{sj}^{'},\right)^T,$$

$$y_{rj}^{'} \in \left[\underline{y_{rj}}, \overline{y_{rj}}\right] (r = 1, \cdots, s) \tag{4}$$

Definition 2.1: $\left(x_j, y_j\right)$ is defined a projective point of the j-th DMU. And $x_j \in \left[\underline{x_j}, \overline{x_j}\right]$, $y_j \in \left[\underline{y_j}, \overline{y_j}\right]$.

Definition 2.2: $\left(\underline{x_j}, \overline{y_j}\right)$ is defined the best projection point of the j-th DMU and $\left(\overline{x_j}, \underline{y_j}\right)$ is called the worst projection point of the j-th DMU.

Definition 2.3: A set of all the best projection points of the DMU is defined the reference set of the DUM, and denotes $T^{'}$.

$$T^{'} = \left\{\left(x_j, y_j\right) \middle| \underline{x_j} \le x_j \le \overline{x_j}, \underline{y_j} \le y_j \le \overline{y_j}, j = 1, \cdots, n\right\} \tag{5}$$

A set is got by the reference set of the DMU.

$$MT = \left\{(x, y) \middle| \sum_{j=1}^{n} \overline{y_j} \lambda_j \ge y, \sum_{j=1}^{n} \underline{x_j} \lambda_j \le x, \lambda_j \ge 0, j = 1, \cdots, n\right\} \tag{6}$$

The formula (6) is the maximum experience production possible set, the maximum production possibility set for short[7].

On the basis of the maximum production possibility set, the interval DEA (C^2R) linear programming model for the k-th DMU is established.

$$P_{(x_k, y_k)} \begin{cases} \max \mu^T y_k \\ s.t. \begin{cases} \omega^T \underline{x_j} - \mu^T \overline{y_j} \ge 0, j = 1, \cdots, n \\ \omega^T x_k = 1 \\ \mu \ge 0, \omega \ge 0 \end{cases} \end{cases} \tag{7}$$

This formula's optimal value is called $\theta(x_k, y_k)$ and is the projection efficiency of the projection point (x_k, y_k) for the *k*-th DMU.

If $\theta(x_k, y_k)$=1, the *k*-th DMU corresponding to the projection point (x_k, y_k) is valid in DEA. Otherwise, the projection point (x_k, y_k) is invalid and the numerical value of the projection efficiency is between the best projection point and the worst projection.

THE SUPPLY CHAIN PERFORMANCE EVALUATION CONSTRUCTION FOR THE ROAD TRANSPORTATION

In the road transportation supply chain management, the road transportation enterprises are the core part, the upstream enterprises are component suppliers and oil companies and the downstream enterprises is each site. Among these enterprises, the component suppliers provide various transport vehicles and subsequent parts, the oil companies provide fuel for the road transportation enterprises. As shown in Figure 1.

In order to analyze simply, the performance of the road transportation enterprises is used to represent the performance of the whole supply chain. Meanwhile, because the fuzzy interval DEA model is used in this pa-

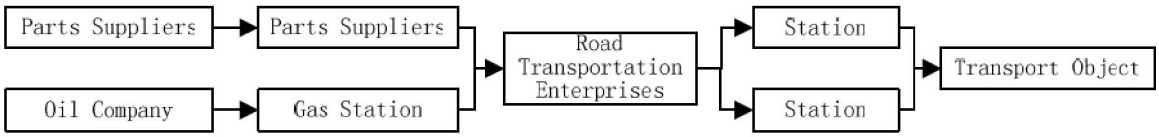

Figure 1 : The road transportation supply chain

TABLE 1 : The index system to evaluate supply chain performance of the road transportation

Index Type	Definition	Description
Input Index	The actual total assets	Tangible assets are fixed and intangible assets are uncertain, so the total assets are change and have upper limit and lower limit.
	The base number of cars	$S_{used} = \frac{2nl/v + 2nt_{pb}}{18}$, in this formula, S_{used} is everyday vehicle group number; n is the vehicle number which can running from two lands every day; l is the revenue passenger kilometers which every vehicle cover; v is the speed target value; t_{pb} is the reentrant time which the vehicle spent on the journey.
	Number of staff and workers	Road transportation is service enterprises for the customer typically; the number of staff and workers is one of the most important indexes for the performance.
Output Index	Annual turnover	The total cost is got from the service and assets include transportation expenses, other income and taxes and so on within one year.
	Customer coverage rate	Because the more service objects, the more income which the road transportation enterprises get, the customer coverage rate is an important index.
	Customer satisfaction index	The CSI is got from evaluation on the service quality of road transportation enterprises. This index is an economic index which measure customer satisfaction and an important index which can influence then the new customer number by ways of influencing the service image of road transportation.

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per, the parameters and value should be got from the road transportation enterprises. According to the need in the process of the operation, the interval number is used to express fuzzy index and can reflect actual situations and meet the need of the model. The supply chain performance evaluation index for the road transportation can be shown in TABLE 1.

NUMERICAL EXAMPLE AND RESULT ANALYSIS

In this paper, ten road transportation enterprises are chose as DMU. Every road transportation enterprise is analyzed as one supply chain. Because of the great influence which the core enterprise has on the supply chain, in this paper, the performance of core enterprise will be used to represent the performance of whole supply chain.

The input and output data can be shown according to the road transportation enterprises data and C^2R model.

Input index:① The actual total assets (x_1): the enterprise's total assets are got by ways of multiplying the total assets from the statement by the relevant adjustment coefficient, and the adjustment coefficient can be got from the situation changes of the total assets. The unit is one hundred million Yuan. ②The base number of the cars(x_2): the value of this index can be got from the distances and relevant parameters and assume that every day is same and the number is certain. The unit is one hundred. ③ Number of staff and workers(x_3): this index can reflect the number of employers which one enterprise own and is assumed a certain value. The unit is ten thousand.

Output index: ①Annual turnover (y_1): the annual turnover is influenced by various factor, so the value is within a certain range. The unit is one hundred million Yuan. ② Customer coverage rate(y_2): The customer coverage rate is certain basically unless the great change from important activities or long-standing business dealings, therefore, the value of this index is certain. The unit is percent. ③Customer satisfaction index(y_3): The value of customer satisfaction index can be influenced by the service quality, and because of different service

TABLE 2 : The input-output data of performance evaluation of supply chain

Company number	Input index			Output index		
	The actual total assets (x_1)	The base number of cars (x_2)	Number of staff and workers (x_3)	Annual turnover (y_1)	Customer coverage rate (y_2)	Customer satisfaction index (y_3)
1	[512.1,520.4]	39.1	10.1	[26.9,27.1]	79.4	[76.2,86.1]
2	[403.4,409.9]	37.2	9.7	[11.9,12.1]	81.6	[78.4,88.9]
3	[597.2,606.9]	43.7	10.4	[29.9,30.2]	82.7	[81.3,87.6]
4	[762.8,775.1]	48.2	11.9	[23.9,24.1]	83.1	[84.3,87.9]
5	[747.2,759.3]	47.9	11.4	[32.8,33.2]	82.4	[81.7,85.8]
6	[793.7,806.5]	54.3	11.2	[119.4,120.6]	83.2	[83.5,89.4]
7	[533.9,542.5]	41.5	9.4	[28.9,29.2]	91.3	[86.7,93.4]
8	[676.4,687.3]	45.7	10.9	[41.8,42.2]	83.4	[82.9,88.2]
9	[861.6,875.5]	57.9	11.7	[61.7,62.3]	82.9	[81.4,86.3]
10	[868.2,882.3]	56.7	12.7	[17.9,18.1]	81.7	[82.8,87.4]

TABLE 3 : The performance efficiency interval of supply chain

Number	1	2	3	4	5
Efficiency interval	[0.8755,0.9124]	[0.8354,0.8837]	[0.8529,0.8978]	[0.8237,0.8761]	[0.8601,0.8932]
Number	6	7	8	9	10
Efficiency interval	[0.9764,1.0000]	[0.8297,0.8765]	[0.8831,0.9247]	[0.8973,0.9421]	[0.9126,0.9637]

expectation, the value will have certain deviation. Therefore, the value is assumed an interval value [0,100]. The input-output data of performance evaluation of supply chain for ten road transportation enterprises is shown in TABLE 2.

$\theta(j)$ is represented the DEA efficiency interval of the *j*-th project, the efficiency interval of every DMU which is got form the model and the LINGO procedure operation is shown in TABLE 3.

As is shown in TABLE 3, the maximum production possibility set MT is got form the input and output index of ten road transportation enterprises. The projection efficiency of the sixth enterprise is not less than 0.9764, and the projection efficiency of other nine enterprises is not more than 0.9637. Therefore, the sixth enterprise's DEA efficiency evaluation is best among ten enterprises. That is to say, the business of the sixth enterprise is effective and the ratio of input and output is reasonable. For the other nine road transportation enterprises, because of different interval number, the efficiency interval is repeated. From the TABLE 3, the DEA evaluation of the ninth and tenth enterprise is better than the second enterprise, seventh enterprise and eighth enterprise. And these numbers illustrate that the business efficiency of the second, seventh and eighth enterprise is lower. There are wasteful resources and poor management in these enterprises. Therefore, these existing problems from every link of enterprise management should be found and solved.

CONCLUSIONS

The specific strategy and method of the road transportation supply chain management is in a fledging stage, the interval DEA C^2R model is established on the basis of the uncertain problems which exist in the process of the road transportation business operation combining the supply chain management theory. And at last, the performance of road transportation enterprises is evaluated and the results provide reference to the supply chain management.

REFERENCES

[1] Zhu Wenying, Ma Tianshan; Research on the supply chain theory and optimizing strategy of the road transportation enterprises. Wuhan University of Tehnology (Social Science Edition), **01**, 77-81 **(2010)**.

[2] Wu Yue, Cao Bin; The road construction material purchasing based on supply chain management. Modern Business Trade Industry, **07**, 168-169 **(2013)**.

[3] Ma Xiaofeng, Luo Wenping; Research on the analysis and application of supply chain performance evaluation index. Logistics Sci-Tech., **01**, 26-29 **(2011)**.

[4] Zhong Zuchang, Chen Gongyu; Research on the supply chain performance evaluation method and application based on web DEA. Logistics Sci-Tech., **04**, 29-32+77 **(2006)**.

[5] Yang Yinsheng, Zhang Liying; Research on the net interval DEA model and application based on inner-enterprise performance evaluation. Jilin University Journal Social Sciences Edition, **06**, 111-117+156 **(2010)**.

[6] Zhou Qin, Wang Yingming; Research on the interval DEA model. Forecast, **20(01)**, 78-80 **(2001)**.

[7] Wang Quanwen, Wu Yuhua, Luo Yunling, Wang Yanchen; Research on the two-stage DEA method for the decision-making unit rank. Statistics and decision, **23**, 160-162 **(2008)**.