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The performance evaluation study of low carbon supply chain based on DEA-AHP

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ABSTRACT

DEA - AHP model has a positive effect on the performance evaluation of enterprise low carbon supply chain as well as the scientific evaluation process of all the people involved in the supply. The input and output of the enterprise commodity production has been taken as the breakthrough point, and to be reasonable studied, for the purpose of exploring the inner connection between the input and output of the resource in the process of commodity production to fully express the low-carbon feature. The above is the key factor to improve production efficiency and reduce the input in the operational process, and the DEA - AHP model has played an enormous role in it, promoting the development of enterprise form a good circular model.

KEYWORDS

DEA-AHP model; Supply chain; Low carbon; Performance evaluation.

INTRODUCTION

Performance evaluation of enterprise low-carbon supply chain is familiar to the enterprise organization and manager because of its complex procedure. However, the selection of evaluation model can not be achieved scientific and reasonable. The establishment of evaluation system is the basic condition in the evaluation model, and the elements of evaluation system shall be explored deeply in order to select the evaluation subject, object, aims and methods scientifically, deciding the evaluation model and the evaluation procedure.

This paper has studied two aspects including performance evaluation system and process of the low carbon supply chain and the establishment of comprehensive evaluation model of low carbon supply chain performance. DEA method has been reasonable applied to provide strong theoretical for the process and discussion. What's more, the application of the comprehensive evaluation model of low carbon supply chain performance in the relevant enterprise makes the practical value of the study fully embody.

PERFORMANCE EVALUATION SYSTEM AND PROCESS OF THE LOW CARBON SUPPLY CHAIN

The basic components of low carbon supply chain performance evaluation system

As for the process of enterprise performance evaluation system, the elements of supply chain performance evaluation shall be thought scientifically. To be specific speaking, it is to know what is to evaluate in the supply chain and how to solve the problems of the evaluation as well as how to establish the process of evaluation and etc. From the perspective of comprehensive three-dimensional building, the evaluation subject shall be served as object in the enterprise supply chain performance evaluation and the evaluation aims shall be decided scientifically. At the same time the evaluation standards are needed to be selected to pick up the scientific evaluation method. See the frame of evaluation system in picture 1.

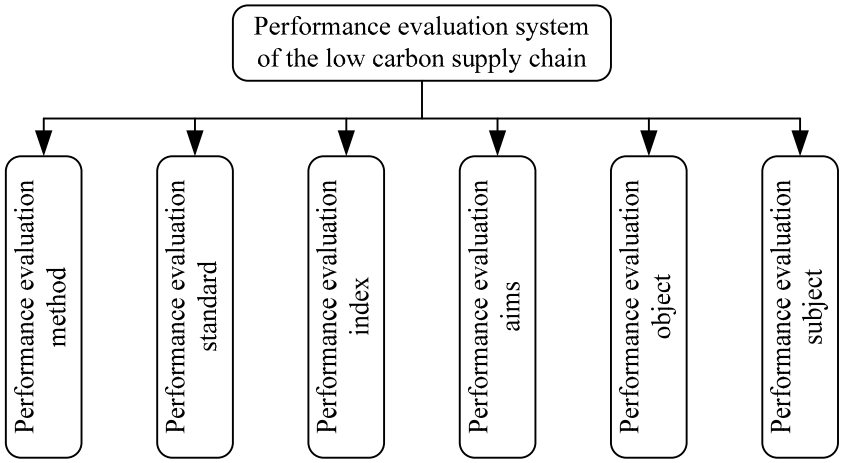

Figure 1 : Performance evaluation system of the low carbon supply chain

The supply chain performance evaluation subject

The evaluation subject mainly refers to the manager and organizer of the enterprise, and they are responsible for the construction of evaluation system. Then the evaluation subject also refers to the following aspects such as the selection of the evaluation model, the construction of the evaluation index system, the determination of evaluation method and the establishment of the evaluation standard. Profit maximization of the relevant person involved in the supply chain is taken as the basic starting point, while the leading role of the organizer in the process of rating system can not be effectively decided. When it comes to evaluation subject, initiator in the evaluation process of supply chain shall be served as core leader and different levels of enterprises are able to participate in it, and the strategic objectives shall be explicated, aiming to the establishment of performance evaluation system of the supply chain through multilateral coordination.

Supply chain performance evaluation object

Supply chain performance evaluation object usually refers to all the people involved in the supply chain, and initiator in the evaluation process of supply chain shall be served as core leader to decide the evaluation object in the evaluation subject. What is said above is usually abstract, and the effect of the measurement can not be reflected clearly. So effective measures shall be carried out after the corresponding decomposition in order to effectively analyze and synthesize the factors of the evaluation results, obtaining overall performance of the supply chain.

Supply chain performance evaluation aims

The making of supply chain evaluation aims are usually regulated according to the specific commodity production ability. It has played an important role in measurement during the process of performance evaluation. In different goods

supply systems, there are corresponding gap in the process of the performance evaluation. Due to the various strategies adopted by the enterprise organizers, their objectives of the business will be difference, too. All these factors will have some influence the performance evaluation aims of the commodity production.

Supply chain performance evaluation index

As for the establishment and selection of supply chain performance evaluation index, the first is to give relevant evaluation about the whole system. And this process is an important part of the performance evaluation activity and also the foundation. The argument of the evaluation index low carbon is carried out in order to reflect the feature and make the supply chain keep in the low carbon level. In the process, not only the situation of the enterprise's certain node is evaluated, but also inner link of every node is conducted effectively evaluation. Therefore, the meaning of low carbon in the evaluation index and supply chain shall be carried out effective analysis to give full expression of the low carbon characteristic.

Supply chain performance evaluation standard

The definition of performance evaluation index of low carbon supply chain is that it is the main standard to evaluate the objects performance good or bad, and has huge impact, and the reflected situation is more objective. The so called measurement refers to the important content of evaluation indexes and has some effect on the achievement of the aims. Therefore the establishment of the performance evaluation index firstly should further explore its stability, and only in this way the process of supply chain performance evaluation can meet the development of enterprise.

Supply chain performance evaluation method

As for the process of enterprise supply chain performance evaluation, the scientific evaluation method and its effective form and the process of implementation have played an important part in the process. They are used to decide whether scientificity and rationality of the evaluation model-building can reach a certain standard. According to the features of low carbon supply chain performance evaluation, the evaluation methods are rationally selected for the purpose of the evaluation process achieving objective and fair, and also the much authenticity of reflecting the problem.

Performance evaluation procedure of low carbon supply chain

In the process of supply chain performance evaluation, the analysis of elements shall be focus on to make sure the rationality of the procedures. The Performance evaluation procedure of low carbon supply chain can be divided into several parts. Firstly, the evaluation index system shall be established effectively. Secondly, the standard of evaluation index shall be decided and the index weight, data collection and processing shall also be considered effectively. Finally, the performance of low carbon supply chain shall be carried out effectively evaluated and the corresponding improvement strategies needed to put forward. See the specific procedure in Figure 2.

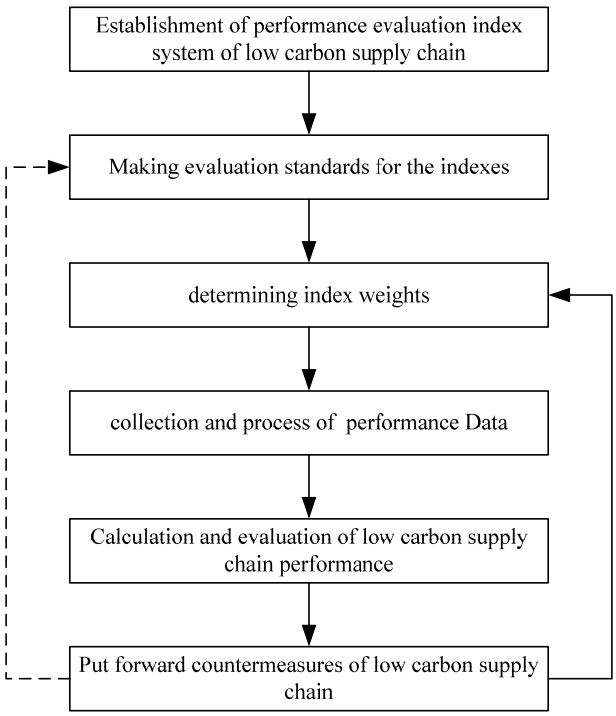

Figure 2 : Performance evaluation procedure of low carbon supply chain

COMPREHENSIVE EVALUATION MODEL OF LOW CARBON SUPPLY CHAIN PERFORMANCE

Summary of data envelopment analysis method

The Data Envelopment Analysis based on concept of relative efficiency is put forward by famous operational researchers including Charne1 A and Cooper W and others. It is a nonparametric estimation method to evaluate the effective of the same type of input and output Decision Making Unit. The method adopts weight coefficients to evaluate the Decision Making Unit on the basis of input and output of the observed data. Since the appearance of the first and most important representative C^2R of DEA model, it has formed a complete theory, method and DEA research field of model based on the concept of efficiency, production possibility set, production frontiers and etc.

Basic principle and the 2CR model

The basic principle of DEA model

Assuming two aspects of resources needed to inject into a production activity, and X1 and X2 are used to represent the two aspects of resources. And the letter Y is adopted to represent yield goods. However, under the condition of maintaining goods consistent, the processes of the two resources injecting have five combinations. The letters including A, B, C, D and E are used to substitute them. See them in picture 3. However, in the Decision Making Unit, the four combinations of A, B, C and D are located above production frontiers and the effective conclusion can be obtained. While the combination E is enveloped, so it will be different from the other four combinations and the acquired DEA is useless. If drawing a straight line between the original point and the location point, it will intersect with frontier D.

In the production of the same commodity, the resources combination D is proved using the least amount of resources, while the resources combination E has certain resources waste. And in the process, OD⁄OE value can be used to show the adjusted size of the resources combination E, and maintain the goods input at the same. See the detail in Figure 3.

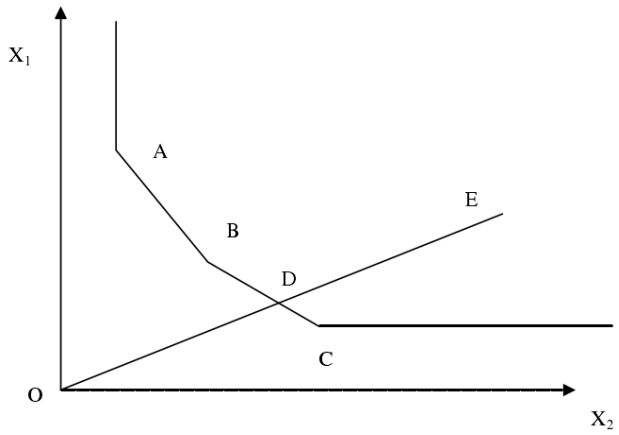

Figure 3 : The principle of data envelopment analysis efficiency evaluation

The process of data envelopment analysis is based on the above ideas, through the effective evaluation of Decision Making Unit and analysis of the difference among the production frontiers, and linear programming model is concluded. The evaluation process of the Decision Making Unit can be ensured high production efficiency, and the resource input of production process can be kept in the most scientific and ideal state. The above is the simple process of data envelopment analysis, and the principle is also brief.

C^2R model of the DEA method

jC^2R model, also called constant return model, is one of the most application model and DEA method is served as the foundation of model building. Supposing in the process of production, there are several Decision Making Units and the letter n is used to represent them. But there is strong comparability between the decision making units of the relevant departments. What's more, each decision making unit has many ways of recourse output (X is usually used to represent), and different types of output indicators (Y is usually used to represent). However, in this paper, the theory of input and output needed to be proved is the decrease of input process and at the same time to keep the output increasing, so the value maximization of the commodity production can be realized. See the input and output formula of the decision making unit in Figure 4.

The decision making unit J is DMU_j, $1 \leqq j \leqq n$; $x_{ij} = DMU_j$ represents the inventory of the I input; $y_{rj} = DMU_j$ represents the inventory of the r output;

v_i= equals to the weight of the I input; u_j= equals to the weight of the r output, , $i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$; $r = 1, 2, \ldots, s$. As a matter of convenience, it is expressed as below:

$X_{ij} = (x_{1j}, x_{2j}, ..., x_{mj})^T, j = 1,2,...,n; Y_{ij} = (y_{1j}, y_{2j}, ..., y_{sj})^T, j = 1,2,...,n;$

$v = (v_1, v_2, ..., v_m)^T; u = (u_1, u_2, ..., u_s)^T$

$$\begin{bmatrix} x_{11}x_{12}...x_{1j}...x_{1n} \\ x_{21}x_{22}...x_{2j}...x_{2n} \\ ..... \\ x_{m1}x_{m2}...x_{mj}...x_{mn} \end{bmatrix} \quad \begin{bmatrix} y_{11}y_{12}...y_{1j}...y_{1n} \\ y_{21}y_{22}...y_{2j}...y_{2n} \\ ..... \\ y_{m1}y_{m2}...y_{mj}...y_{mn} \end{bmatrix}$$

Figure 4 : The input and output of each decision making units

The known data Xj and Yj can be adopted by former materials and statistical data; variable v and u are the corresponding weight vectors of m input and s output. The evaluation indicators of the weight coefficient v, u and the decision making unit *j* are as follows:

$$h_j = \frac{\sum_{i=1}^{r} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}, 1 \le j \le n$$

Supposing the weight coefficient v and u is always suitable, meeting the condition $h_j \leqq 1$, $1 \leqq j \leqq n$

The meaning of efficiency evaluation index: the ratio of input and output, on the condition that weight coefficient is less than v and u, the input is $v^{'}X_j$, and the output is $u^{'}Y_j$.

The question of DMU_k efficiency evaluation: take DMU_k efficiency evaluation index as target,

$$h_k = \frac{\sum_{i=1}^{r} u_r y_{rk}}{\sum_{j=1}^{m} v_j x_{ik}}, 1 \le j \le n$$

And efficiency index of all decision making units including DMU_k are taken as constraints.

$$h_j = \frac{\sum_{i=1}^{r} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}, 1 \le j \le n$$

Fractional programming question is formed as below:

$$\max h_k = \frac{\sum_{i=1}^{r} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}}, 1 \le j \le n$$

The above is the C^2R model of DEA, and it has applied the definition of science, engineering efficiency into occasion that has more input and output systems. The original C^2R is fractional programming and not conducive to solving, so it can be transformed into corresponding linear programming model through C^2 changing. Therefore, making

$$t = \frac{1}{v^{'}X_k}, w = tv, \mu = t\mu$$

the corresponding linear programming model is :

$$s.t.\begin{cases}\max \mu' Y_k \\ w' X_j - \mu' Y_k \geq 0, j = 1,2,...,n \\ w' X_k = 1 \\ w \geq 0, \mu \geq 0\end{cases}$$

We can see that the above formula is linear programming, and relevant theorem can prove that the two formulas are equivalent. Using the formula above is not directly to estimate the effectiveness of the decision making unit. If θ is the corresponding dual variable and λ_i is the relevant slack variable, through dual transformation and the introduction of the Archimedes dimensionless, the following model can be acquired.

$$\min\left[\theta - \varepsilon\left(\sum_{i=1}^{r} S_i^+ + \sum_{i=1}^{r} S_i^-\right)\right]$$

$$s.t.\begin{cases}\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{rk}, x = 1,2,...,m \\ \sum_{j=1}^{n} \lambda_j y_{ij} - S_i^+ = y_{rk}, r = 1,2,...,s \\ \lambda_j \geq 0, j = 1,2,...,n \\ S_r^+ \geq 0, S_i^- \geq 0, r = 1,2,...,s, i = 1,2,...,m\end{cases}$$

The above formula shows that the application of this model is frequently. The advantage of using this model lies in that the model application can be realized through simple computer software processing. While in the process of research and discussion, relevant operations based on this formula of model is carried out. The value rang of ε is 10^{-6} and the optimal solution of the formula is as below.

If the value rang is set at 1 and while the sum value is 0, the DEA of the 10th decision making unit can be efficient. And the k decision making unit for efficiency of DEA can be shown in two aspects. The first is scale efficiency and the second is technology efficiency. In the process of inference, the production element combination of the k decision making unit is proved much more scientific, forming scientific ratio of the resource input and output to maximize the economic benefit in the process of production process.

If the value rang is set at 1 and that of greater than 0. so the k decision making unit for the related decision making units can only achieve weak efficient, and the effective has certain disequilibrium, it can be technology efficiency or scale efficiency. As for the k decision making unit, X_k can be decreased correspondingly in the case of the original production maintaining unchanged. Or the product output is increased on the condition that the X_k invested in advance unchanging. From the process we can see that the evaluation results can provide positive guidance for the direction of input and output and effectively control the size of adjustment, for the purpose of highlight the advantage of DEA method.

If the value rang is set less than 1, the relationship of the k decision making unit and others will be invalid in the DEA level. And it also proves that this decision making unit is invalid both in scale and technology in the economic system. On the condition of the output Y_k maintaining the same, while reducing the input of the k decision making unit and keep around at times.

From the above discussion, we can conclude that: If the value rang is set at 1, the DEA is valid. If the value is less than 1, the DEA is invalid, and the relationship between the valid and invalid is not clearly distinguished.

CONCLUSION

From the traditional point of view, the development of enterprise supply chain decides its own prospect, and relevant performance evaluation of the supply chain can give full expression to the low carbon character. The relationship of input and output of the enterprise commodity production will gradually reach the ideal level. This topic is discussed on the basis of DEA-AHP model, and through the model building and application, the inner link between the input and output of enterprise commodity production is further studied, providing foundation for the scientificity of low carbon supply chain performance evaluation.

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