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Evaluation of Logistics Resource Allocation Efficiency in Chemical Industry Base

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In order to verify the effect of logistics resource allocation efficiency on the production efficiency of chemical enterprises, the logistics resource allocation index system of chemical base is established by analyzing the logistics system and logistics resources of chemical base. Data envelopment analysis (DEA) is used to establish the evaluation model of resource allocation efficiency of logistics system in chemical base. Taking a large chemical industry base as the research object, the resource allocation efficiency of the chemical base is analyzed by using the evaluation system and model of the logistics resource allocation efficiency. The results show that the research on resource allocation efficiency of logistics system in chemical base can reduce resource redundancy. By adjusting the input structure of resources, the cost can be saved, and the benefit and industrial demonstration effect of chemical base can be improved.

1. Introduction

Because the normal production of the project in the chemical base needs a lot of raw and auxiliary materials, the logistics cost accounts for a high proportion of the total production cost of the base (Thomas, et al., 2013). At the same time, the chemical base logistics system is a multi-input and multi-output system with dynamic, complex and specific. The rational allocation of logistics resources is of great significance to guarantee the efficient operation of the base production organization, optimize the industrial system, reduce the cost, and improve the demonstration effect of the chemical base (Kazuyo and Tetsuya, 2015). In the evaluation of chemical production logistics system, some scholars have applied AHP (Ozsakalli et al., 2014) and fuzzy mathematics methods (Thies et al., 2017), but these evaluation methods have strong subjectivity. The comparison and judgment process are rough and the precision is poor. However, the DEA method does not need the weight hypothesis. It can exclude the subjective factors with strong objectivity (Qiong et al., 2014). This method can solve the problems of diversification of input and output indexes, difficulty of homogenization and difficulty to be measured with unified standards.
The evaluation model of resource allocation efficiency of logistics system in chemical base is established by using DEA method. Through empirical research, the effectiveness of resource allocation in different chemical bases is tested, which provides theoretical support for efficient resource allocation of logistics system in chemical base.

2. Construction of evaluation model of logistics resource allocation efficiency in chemical base

2.1 Analysis and construction of evaluation index

Although the raw materials and auxiliary materials of chemical base are relatively single, the supply and logistics system have higher stability. However, the logistics process of chemical base is a flow with complex multi -link and multi-process, and the resources needed to be invested are more complex. Because of the large equipment used in the production of chemical projects, the cost is high and the operation is complicated. The process is closely connected, the operation continuity is strong, and the requirement of time condition is high. Therefore, the import of major raw materials and fuels is particularly important (Yong et al., 2017). Based on the full analysis for logistics resources of chemical bases, the transportation resources, storage resources, loading and unloading resources and circulation processing resources of the chemical base logistics input link are taken as input indexes, while the demand for coal is taken as output index. The detailed division is shown in table 1.

Table 1: Evaluation Index System of Logistics Resource Integration in Chemical Industry Base

Indicators		Data sources
Resource input	Transport resources	Calculated
	Storage resources	Calculated
	Loading and unloading resources	Calculated
	Circulation processing resources	Calculated
Logistics output	Resource demand	Calculated

2.2 Application steps of DEA

DEA is used to build evaluation model of logistics resource allocation efficiency in coal chemical industry base. First, the application steps of DEA method need to be defined, and the general application process is shown in figure 1.

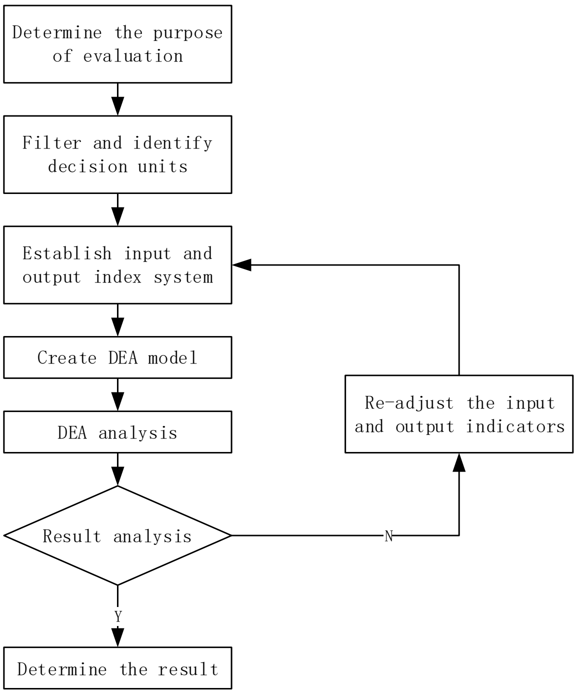

Figure 1: DEA general application flow chart

Through the research on the general application framework of DEA, the systematic analysis steps for evaluating the efficiency of logistics resource allocation in coal chemical industry base by using DEA are obtained:

Clear analysis purpose: DEA analysis technology is used to analyze the allocation of logistics resources among the various projects in the coal chemical industry base, and the overall re planning of the logistics resources of the base is carried out according to the analysis results (Martha, et al., 2016). DEA is used to reevaluate the efficiency of logistics resource allocation after overall planning and the optimal allocation strategy of logistics resources in the base are summarized.

Determine the decision-making unit: According to the different purposes of each evaluation, the decision-making units including common external conditions, common input and output indicators are selected, such as each coal chemical project, different time periods.

Establish an input / output index system: The input/output index system relies on DEA technology, so the definition of input and output should be defined. A specific analysis is carried out according to the logistics resources involved in the base logistics circulation. Combined with the particularity of the base logistics, the

key resources are screened so that the evaluation can be more meaningful. Usually, the scarce resources are the input, and the measure of the actual product or the achievement of the target is the output.
Determine the DEA model: Because there are many models in DEA, different problems should be chosen according to the purpose of the research and the characteristics of each model.
Analyze the result: According to the analysis results, the improvement direction and degree of non-priority DMU are obtained, so as to provide decision-making reference for base management.

2.3 Construction of DEA evaluation model

The basic idea of establishing the resource allocation evaluation model of the logistics input system in the coal chemical industry base is: The logistics input system of each coal chemical project is regarded as a decision-making unit. Through the comprehensive analysis of input and output indicators with different dimensions, the model is established with the input and output index weights as variables, and then the validity of the allocation of resources is tested by comparison.
Assuming that there are n coal chemical projects, the logistics input system of each coal chemical project has m types inputs and s types output. Among them, the i-th input of item j is represented by xij, and the r-th output is represented by yrj. vi denotes the weight coefficient of the input quantity of the i-th resource, and ur denotes the weight coefficient of the r-th output. The efficiency evaluation index hj of the j-th DMU is:

$$h_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}, j = 1,2,\ldots,n \tag{1}$$

Efficiency evaluation (1≤j0≤n) is carried out for the j0-th logistics input system of coal chemical project. The weight coefficient v and u are taken as the variable, and the efficiency of the j0-th decision-making unit is taken as the main goal. The efficiency coefficient of all DMUs is less than 1 for the constraint. An optimization model of relative efficiency evaluation is as follow:

$$(C^2R)\begin{cases} \max h_{j_o} = \dfrac{\sum_{r=1}^{s} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i y_{ij_0}} \\ s.t. \dfrac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i y_{ij}} \leq 1 \\ j = 1, 2, \ldots, n; u \geq 0; v \geq 0 \end{cases} \tag{2}$$

The model of formula (2) is a fractional programming problem. In order to solve the problem conveniently, the Charnes-Cooper transform is carried out (Luisa, et al., 2017), and the input relaxation variable s- and the output relaxation variable s+ (Cui and Song, 2017) are introduced respectively according to the dual theory of linear programming. The inequality constraints of formula (2) are transformed into equality constraints, and the following models are obtained:
The logistics input system of n project in a chemical base is selected. vi is the input of i logistics resources of chemical project logistics system. ur is the r output (Ewa and Joanicjusz, 2017) of the logistics system of chemical projects. According to table 1, the DEA model of logistics resource allocation in coal chemical industry base is set up, and the specific division is shown in table 2.

$$(D_\varepsilon)\begin{cases}\min\left[\theta-\varepsilon\left(\hat{e}^T s^- + e^T s^+\right)\right]=V_{D_\varepsilon}\\ \sum_{j=1}^{n}\lambda_j x_j + s^- = \theta x_0\\ s.t.\sum_{j=1}^{n}\lambda_j y_j - s^+ = y_0\\ \lambda_j, s^-, s^+ \geq 0\\ j=1,2,\ldots,n\end{cases} \tag{3}$$

Table 2: Coal chemical industry logistics input system resource integration evaluation DEA model

Project 1	Project 2	······	Project n	Weights
x_{11}	x_{12}	······	x_{1n}	Transport resources v_1
x_{21}	x_{22}	······	x_{2n}	Storage resources v_2
x_{31}	x_{32}	······	x_{3n}	Loading and unloading resources v_3
x_{41}	x_{42}	······	x_{4n}	Circulation processing resources v_4
y_{11}	y_{12}	······	y_{1n}	Resource demand u_1

To sum up, firstly, through analyzing the logistics input system of each project of coal chemical industry base, it is abstracted as the research object (decision-making unit), and then the C2R model of DEA is transformed through linear programming. According to the dual theory of linear programming, the input relaxation variables s- and the output relaxation variable s+ are introduced respectively. The evaluation model of logistics resource allocation suitable for coal chemical industry base is constructed.

3. Case study and analysis

Taking a large chemical base in Northwest China as an example, the base was started construction in 2004 and covers an area of 25 square kilometers. By 2020, the base plan has invested 260 billion yuan.

3.1 Analysis of existing input logistics resources capability in chemical industry base

Transportation resource capacity. The railway transportation of the logistics system in the coal chemical industry base is based on the local railway of a local professional railway company and the special line in the base. It is responsible for transporting the coal from the mining area to the coal chemical industry base. At present, the comprehensive transportation capacity of the professional railway company is 36 million tons / year, and the daily transportation capacity is 110 thousand tons, amounting to 1818 vehicles. There are 17 diesel locomotives and 581 owned open-wagons operated by the company.
Storage resource capability. At present, the coal chemical base has built 3 coal bunkers with 60 thousand tons capacity, and the coal storage capacity is 180 thousand tons.
Loading and unloading resource capacity. The coal chemical base uses the double tandem dumper system to unload the coal. The system is equipped with dumper platform and electronic control system. At present, the coal chemical base has 2 sets of double tandem dumper system, and the unloading capacity is 5000 tons per hour. If it works 16 hours a day, the average daily unloading capacity can reach 80000 tons.

Table 3: Analysis of Input Logistics Resource Capability in Coal Chemical Industry

	Day capacity	Logistics equipment
Transport resources	110000	Gondola
Storage resources	180000	Warehouse
Loading and unloading resources	80000	Tipping machine
Circulation processing resources	110000	Coal washing plant

Circulation and processing resource capability. At present, the coal chemical base has been built into a coal preparation plant with a design capacity of 36 million tons per year. The plant can produce 330 days a year and 16 hours a day. Its daily handling capacity is 110 thousand tons, and the processing capacity is 6818.18 tons per hour.

As shown in table 3, through the analysis of the existing input logistics resources in the coal chemical industry base, the analysis table of the input logistics resources capacity in the coal chemical industry base is obtained.

3.2 Evaluation and analysis of input logistics resource allocation efficiency of base projects

According to the input logistics traffic statistics data and the current logistics resources in the base, the basic data of the logistics resources and the daily coal demand of each project are obtained in table 4 (Holden, et al., 2016). According to the model established by (3), MATLAB software programming is used to analyze the logistics resource allocation efficiency of the logistics input system of each project planning. The results of analysis and calculation are shown in table 5:

Table 4: Item Input / Output Indicator Raw data

Decision unit	Input resources				Output
	Transport resources	Storage resources (%)	Loading and unloading resources(min)	Circulation processing resources(min)	Resource output (t)
DMU_1	37	1.24	27	21	2234.85
DMU_2	103	3.44	75	56	6199.3
DMU_3	264	8.80	190	144	15848.49
DMU_4	32	1.05	23	17	1890.91
DMU_5	1028	34.27	740	558	61688.18
DMU_6	44	1.46	31	24	2623.03
DMU_7	709	23.65	511	385	42570.91
DMU_8	1028	34.27	740	558	61688.18
DMU_9	44	1.46	31	24	2623.03

Table 5: The results of resource allocation evaluation of logistics input system of chemical industry

Decision unit	θ^*	S_1^{-*}	S_2^{-*}	S_3^{-*}	S_4^{-*}	S_1^{+*}
DMU_1	1.000	0.000	0.000	0.000	0.000	0.000
DMU_2	1.000	0.000	0.000	0.000	0.000	0.000
DMU_3	1.000	0.000	0.000	0.000	0.000	0.000
DMU_4	1.000	0.000	0.000	0.000	0.000	0.000
DMU_5	1.000	0.000	0.000	0.000	0.000	0.000
DMU_6	1.000	0.000	0.000	0.000	0.000	0.000
DMU_7	1.000	0.000	0.000	0.000	0.000	0.000
DMU_8	1.000	0.000	0.000	0.000	0.000	0.000
DMU_9	1.000	0.000	0.000	0.000	0.000	0.000

According to the DEA calculation results shown in table 5, the comprehensive efficiency of all decision units is $\theta^*=1$ and $S^{-*}=0$, $S^{+*}=0$. This shows that the logistics resources input of each project according to the existing logistics resources of the base is effective (Venus, et al., 2015). Its input resources have been more efficient use, that is, the effectiveness of the individual planning of logistics resources allocation is DEA.

4. Conclusion

The DEA evaluation model for logistics resource allocation efficiency in chemical base is established, and the logistics input system of a large chemical industry base is taken as the research object to analyze the example. First of all, by analyzing the logistics input system of each project of coal chemical industry base and abstracting it as the research object, the evaluation model of logistics resource allocation efficiency suitable for coal chemical industry base is constructed. Then, the data of each project logistics input system are obtained by sorting out the planning data of each base project. Then, the logistics resources of each project logistics input system are analyzed and calculated by using MATLAB software. The calculation results show that the input of logistics resources and the logistics demand of each project is matching when each project is planned separately.

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