

RESEARCH ON THE COST OPTIMIZATION OF COAL ENTERPRISES BASED ON THE INTERNAL VALUE CHAIN OPTIMIZATION

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ABSTRACT. *The value chain optimization of the coal enterprise plays an important role in reducing its cost and improving its core competitiveness. This article explores the basic method of value chain optimization and establishes a fuzzy linear programming model with the aid of fuzzy linear programming method by utilizing both dynamic cost analysis and marginal cost analysis through in-depth analysis of the connotation of the value chain and the organization structure of coal enterprises' interior value chain. Taking an example of Shanxi Coking Coal Group Co., LTD. (Company Limited), the value chain optimization model of the company is established in this article which concludes the optimal cost of coal enterprise value chain by utilizing the method of operational research, as well as verifies the accuracy and scientific nature of the value chain optimization model.*

Keywords: Value chain optimization, Quantitative analysis, Coal enterprise, Cost optimization

1. Introduction. The world economic crisis does not change the trend of China's rapid economic growth. Moreover, China's economy will step into a long period of 'rapid economic growth period'. In the new economy period, energy is still the focus of the industry. Since the eighteenth century, coal has been one of the most commonly used energy that human has used. Under the pressure from advanced energy and from both the domestic and international market, traditional cost control mode cannot adapt to the need of cost control and management of modern coal enterprises. Value chain analysis method decomposes the enterprise into many interrelated activities, such as design, production, marketing and service, which will determine the enterprise's core competitive advantage through analyzing its cost and differentiation advantage [1]. The value chain covers inside and outside value added activities. The enterprise can strengthen its cost advantage and realize its sustainable development through reengineering of the organization process and optimal allocation of resources by means of optimizing the value chain. Thus, in-depth analysis of the transition of coal enterprise value chain structure is of great significance to optimize the value chain and promote the enterprise's core competitive advantages. Many domestic scholars have utilized quantitative analysis to the enterprise value chain optimization model [2], for example, Z. Qiao and Y. Li have set up a value chain optimization model on the basis analysis of customer value realization degree and internal resource conditions and made an empirical analysis of car enterprise value chain structure to verify its scientific nature [3]; H. Dong and S. Fang have put forward an enterprise value chain management – class production function of this new value chain management model by using the value chain and the production function theory and carried out quantitative and optimization analysis on the value chain [4]; Y. Guo and X. Li have used value chain method to analyze cost management problems from the perspective of the connotation of the value chain method, trying to improve the competitiveness of the coal enterprises [5].

2. The Connotation of Enterprise's Value Chain. The concept of value chain was first put forward by Harvard University professor Michael Porter in his book *Competitive Advantage* [6] and summarized it as: each enterprise's value chain is combined with procurement, production, marketing, delivery, finance, human resource management as well as all kinds of auxiliary activities for the product. In the process of value formation, series of value activities compose a activity cost chain with the increase of the investment and value [6]. Value chain analysis divides the value added activities both inside and outside into basic activities and auxiliary activities. Basic activities include production, sales, feed logistics, shipping logistics, after-sales service and auxiliary activities include the personnel, finance, planning, research, development and purchasing, etc. These different but interrelated production and business operation activities constitute the value creation activity, as known as value chain. Value chain lists the value activities and profit. Profit is the difference between the total value and the total cost that engaged in all kinds of value activities. Value chain analysis method organizes the collaboration of production resources and logistics process to be the lowest and the most efficient supply chain. It makes each node in the value chain to have common value orientation through coordinating the relationship between the work nodes of the value chain and utilizing the information shared, so as to realize the maximum value and the purpose of "multi-win".

Coal enterprises' value chain is a process from mining, coal processing to sales and after-sales customer service. Analyzing the internal value chain and reducing internal cost will make the coal enterprises continue to occupy competitive advantages and obtain an impregnable position in the fierce market at home and abroad.

3. The Quantitative Analysis Method of the Value Chain Optimization. Quantitative analysis method is the basic method of management science, whose basic theory is the application of mathematical statistics and operations research. The application of mathematical statistics consists of discrete and continuous probability, statistical sampling, parameter test, hypothesis testing, regression analysis and other contents. Operational research includes decision theory, linear programming, integer programming and network planning, etc. Quantitative analysis method combining with the value chain analysis and setting up value chain optimization mathematical model can make quantitative analysis of the value chain optimization and evaluate enterprise's cost advantage scientifically. First, this paper applies the AHP (Analytic Hierarchy Process) to determining the index weight and uses the practical factors fuzzy linear programming method to study the systematic structure of the internal value activity, which creates a systematic, dynamic, practical value chain optimization method for long-term profit and the core advantages [7].

Compared with the coal enterprise optimization methods such as work cost method, accounting, business process reengineering and the fuzzy programming method, the value chain analysis method quantifies the factors influencing the value of the coal enterprises, which will show the efficiency and results of the cost optimization. The goal of the coal enterprise value chain optimization is to further optimize the cost of coal enterprise value chain in view of the internal resources conditions of the enterprise's core product. Therefore, the objective function should reflect the cost of each value chain and internal resource conditions.

Contribution of each value activity in the coal enterprise value chain to the enterprise determines the objective function of value chain optimization model. In the article, coal enterprise value chain is divided into four main value activities, namely coal mining, coal processing, coal marketing and customer service. Assuming that factors related to coal enterprise value are S_{jk} ($j, k = 1, 2, 3$), namely mining cost S_{11} , processing cost S_{12} , sales cost S_{13} , customer service cost S_{21} , R&D (Research and Development) cost S_{22} , logistics cost S_{23} , inventory cost S_{31} , human resources cost S_{32} , and financial cost S_{33} .

Set a_{jk} as the proportion of S_{jk} contributing for coal enterprise value. According to the value of a_{jk} , it calculates the synthetic weight w_i using AHP, namely the degree of contribution to the enterprise value of each value activity, whose meaning is the proportion that the amortization cost of each value chain in the year t converts into enterprise value. The greater the value is, the higher the utilization rate of capital (capital utilization = profit/total capital) is and the greater the value of enterprises is. Set a value on the value chain activities into the first t year enterprise value amortization cost value of x_i^t , the $w_i \times x_i^t$ for the value activities in the first year t creates value for the enterprise. So the value created by coal enterprise can be measured as follows,

$$f(x_i^t) = \sum_{i=1}^9 w_i x_i^t \tag{1}$$

The objective function of the fuzzy linear programming model for value chain optimization is

$$Max f(x_i^t) \tag{2}$$

Namely

$$Max f(x_i^t) = Max \left(\sum_{i=1}^9 w_i x_i^t \right) \tag{3}$$

Marginal cost refers to increment of total produced by cost per unit new products or purchased products, which shows that each unit's product cost is related to the total quantity of products. On the value, the marginal cost is equal to variation of total cost divided by output variation. According to the marginal analysis method, only when the marginal cost changes from positive to negative, corporate profit is the biggest, so marginal cost should be the smallest in the year t [8]. Set Q_t as the production value and x^t as the cost value in the year t , thus the MPP (Massively Parallel Processor) is $Q_t - Q_{(t-1)}$ and the total marginal cost is

$$C_m^t = \lim_{Q_t \rightarrow Q_{(t-1)}} \left(\left(\sum_{i=1}^9 x_i^t - \sum_{i=1}^9 x_i^{(t-1)} \right) \div (Q_t - Q_{(t-1)}) \right) \tag{4}$$

The constraint condition which can make marginal cost to be the smallest is

$$0 \leq C_m^t \leq C_m^{(t-1)}, \quad C_m^t = \min_{0 \leq i \leq t} C_m^i \tag{5}$$

After being fuzzy processed, it is

$$\sum_{i=1}^9 x_i^t \lesseqgtr t \sum_{i=1}^9 x_i^1 - (t-1) \sum_{i=1}^9 x_i^0 \tag{6}$$

In coal enterprise value chain analysis, we always consider that the total cost is the sum cost of all the factors related to the enterprise value. Assuming x_i^t is the amortized cost of the value activity i and C_t is the total cost in the year t . So the total cost constraint condition in the year t is

$$\sum_{i=1}^9 x_i^t \lesseqgtr C_t \tag{7}$$

Prediction of the enterprises to the cost allocation of each value activities in the year t is based on the present value of cost allocation. So we can approximately give the cost of the lower limit in the year t and carry on the reasonable allocation to the extent permitted. So the cost allocation of each constraint is as follows:

$$x_i^t \geq x_i^0 \quad (i = 1, 2, 3, 4, 5, 6, 7, 8, 9) \tag{8}$$

The fuzzy form is

$$-x_i^t \lesseqgtr -x_i^0 \quad (i = 1, 2, 3, 4, 5, 6, 7, 8, 9) \tag{9}$$

After clearing the objective function and constraint conditions, the fuzzy comprehensive evaluation model of coal enterprise value chain optimization can be obtained. The model is as follows:

$$\begin{aligned}
 \text{Max } f(x_i^t) &= \text{Max} \left(\sum_{i=1}^9 w_i x_i^t \right) & (10) \\
 \text{st } \begin{cases} \sum_{i=1}^9 x_i^t \lesssim t \sum_{i=1}^9 x_i^1 - (t-1) \sum_{i=1}^9 x_i^0 \\ \sum_{i=1}^9 x_i^t \lesssim C_t \\ -x_i^t \lesssim -x_i^0, \quad i = 1, 2, 3, 4, 5, 6, 7, 8, 9 \end{cases}
 \end{aligned}$$

4. The Case Study. Set Coking Coal Group Co., LTD. in Shanxi for example, combining its cost condition with the coal enterprise internal value chain optimization of fuzzy linear programming model, we can test the effect of value chain analysis theory for coal enterprises.

Through the analysis of the coal enterprise internal value chain, we can determine the enterprise value chain, understand the process of value, clarify the value-added and non value-added activities and facilitate the enterprise to take measures to control the cost and improve its core competitive advantage. Value chain analysis method is to examine the enterprise activities and their relationships among each other by using a systemic method so as to find out the value activities which have more competitive advantages and can allocate resources more reasonably. According to Porter’s value chain theory, activities in enterprise value chain can be divided into basic activities and auxiliary activities. In terms of the basic operation process of coal enterprises, the basic activities are divided into four main links, namely coal mining, coal processing, coal sales, and customer service, while the auxiliary activities are divided into five major links, namely enterprise infrastructure, human resource management, research and development, purchasing management and financial management.

The value chain structure of the coal enterprise is shown in the table below.

TABLE 1. The value chain of coal enterprises

<i>Auxiliary activities</i>	<i>Enterprise infrastructure</i>				<i>profits</i>
	<i>Human resources management</i>				
	<i>Research and development</i>				
	<i>Procurement management</i>				
	<i>Financial management</i>				
<i>Basic activities</i>	<i>Coal mining</i>	<i>Coal processing</i>	<i>Coal sales</i>	<i>Customer service</i>	

Compared with Porter’s value chain model, the value chain in coal enterprises has added financial management link, which mainly includes finance, budget management, cost control, internal control, etc. This kind of value chain structure has broadened the connotation of the value chain and is more appropriate to the coal enterprise production and operation business situations. It is advantageous for the optimization of coal enterprise internal value chain analysis. Utilizing the cost data of the company in the last four years (2009 ~ 2013), the article uses the value chain optimization model to analyze the method of realizing the value chain optimization. Supposing that the requirement is the cost data of the coal enterprise in the next five years, then t is 5.

The contribution degree of each value activity in the value chain of the coal company calculated by AHP is shown in Table 2.

The value and proportion of the initial cost allocation values are shown in Table 3.

TABLE 2. The contribution degree of each value chain

Value activities	Infrastructure	Human resources	R&D	Procurement	Financial	Mining	Processing	Sales	Service
Weight	0.13	0.12	0.08	0.06	0.05	0.19	0.17	0.09	0.11

TABLE 3. The value and proportion of the initial cost allocation values

Value activities	Infrastructure	Human resources	R&D	Procurement	Financial	Mining	Processing	Sales	Service
Allocation values	12812	9000	1652	5476	4379	35823	29012	15613	5741
Proportion	10.72	7.53	1.38	4.58	3.66	29.98	24.28	13.06	4.80

Assume the total cost is 150,000 CNY in the year t and the total cost is 130,000 in the first year. According to the above analysis, the fuzzy linear programming model of the coal enterprise value chain optimization is as follows:

$$\begin{aligned}
 \text{Max } f(x_i^t) &= \text{Max} \left(\sum_{i=1}^9 w_i x_i^t \right) \tag{11} \\
 \text{st } \begin{cases} \sum_{i=1}^9 x_i^5 \lesssim 171968 \\ \sum_{i=1}^9 x_i^5 \lesssim 150000 \\ -x_i^5 \lesssim -x_i^0, \quad i = 1, 2, 3, 4, 5, 6, 7, 8, 9 \end{cases}
 \end{aligned}$$

The optimal cost allocation value of each value activity in the year of 2014 and its proportion in total cost can be calculated through this model. Enter the model with the optimal solution, it can get the profit $f(x)$ is 22,574.6 and the total cost of all value activities combined for optimal cost is 150,000. By using the value chain optimization, the coal enterprise had realized the optimization of the coal value chain.

5. Conclusion. In this article, it studies the problems of coal enterprise cost by introducing the characteristics of coal enterprise cost optimization and the basic principle of the value chain. It has put forward a model that can show the most optimal cost consumption of each value activity in the value chain. It has also set a coal enterprise in Shanxi as an example for empirical study and discussed the implementation mechanism of the perspective of value chain cost optimization, which is of great significance to the cost optimization of coal enterprises. In addition, the research on the using of value chain optimization analysis for coal enterprises' cost optimization is still at an early stage, so enriching the theory and developing its application in practice constantly are the focus of future research.

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