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Cost-Effective Control Model for Chemical Industry

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Chemical industry as an important support for the economic development in our country creates a huge value economically, but along with this, it also has a negative impact on the environment and even spoils the life of the people. To achieve a healthy and sustainable development, chemicals manufacturers shall exercise effective cost management. This paper completely expounds the cost supervision and control of those manufacturers in the chemicals industry with the fuzzy AHP (Analytic Hierarchy Process) and other relevant theories on the account of real case, for example, a chemicals manufacturer in Langfang, Hebei. The findings show that the main business cost and the financial expenses of the chemicals manufacturers in China are so far roaring year by year. A system will be built for cost control indicators on five fronts such as financial data, internal production, employees, customers and environment. It turns out from computation that the cost control effect for the chemicals manufacturer M reaches a composite score 82, and the evaluation result is better. Among them, financial data and customers contribute more, and employees and environmental factors should be improved.

1. Introduction

China has witnessed the rapid development of chemicals manufacturers over the past few years, bringing with it inevitable pollution in domestic environment while creating great value economically (Berente et al., 2010). Facing the great pressure of the ecological environment, the chemicals manufacturers shall strengthen their own cost control and management to realize a sustainable development, thereby to improve their competitiveness (Perry et al., 2006). However, up to now, there are still a series of problems in the cost management of chemicals manufacturers, and more reasonable evaluation method has never been developed. All of these defects have a negative impact on the cost management optimization process. From the perspective of social responsibility, it is of great significance to intensify the investigation on the cost control of chemicals manufacturers (Goodale et al., 1949; Jing and Liu, 2018). For the business cost control, a numerous experts and scholars at home and abroad have done a lot of works in this regard. Their efforts have borne fruits, mainly including: the cost management theory (Matsui, 2009; Huang and Wu, 2014); the cost management process and methods (Acosta et al., 1981; Chen et al., 2015); the cost control effect (Connor et al., 1995; Wasim et al., 2013). This paper uses the relevant theory of fuzzy AHP and takes a chemicals manufacturer in Langfang, Hebei as the study object, and discusses the cost control and management of chemicals in an all-round way, which has strong practical instruction significance.

2. Relevant theories

2.1 Cost control theory

The business cost can be composed of fixed and variable costs, in which the fixed cost attributes to fixed expenditure, which will not be subjected to change with output. If a manufacturer intends to seek profits, its sales revenue should exceed the cost. The M is the BEP (Break-Even Point) of business. When the sales revenue of a business exceeds the sum of fixed and variable costs, manufacturer starts to make profits.

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2.2 Fuzzy AHP

The fuzzy AHP is to decompose the general goal of the multi-target evaluation problem based on its hierarchies and properties in order to build a ladder hierarchy from the bottom up (Haq and Kannan, 2006). It has filled the gaps of the traditional AHPs, for example, it has a better reliability and stability of decisions (An et al., 2011). The concrete analysis process mainly includes the following four dimensions:

2.2.1 Analyze the problems

The relationship between the various factors in the system shall be clarified, and multilayer recursion model shall be also built (Samvedi et al., 2012).

2.2.2 Establish fuzzy judgement matrix

At a level, the pairwise comparison is performed based on the elements above this level, and the relative importance is determined according to the standard. Then a fuzzy judgment matrix is built, as shown below:

$$\mathrm{A} = (a_{ij})n \times n \quad (1)$$

Its properties are:

$$a_{ii} = 0.5, \mathrm{i} = 1,2,\cdots,\mathrm{n} \quad (2)$$

$$a_{ij} + a_{ji} = 1, \mathrm{i}, \mathrm{j} = 1,2,\cdots,\mathrm{n} \quad (3)$$

2.2.3 Calculate the weight

The weight of fuzzy judgment matrix is derived and solved by the formula with a relatively less calculated quantity, so it has been widely applied in practice (Mikaeil et al., 2011), as shown below:

$$W_i = \frac{\sum_{j=1}^{n} a_{ij} + \frac{n}{2} - 1}{n(n-1)} \quad (4)$$

2.2.4 Check the consistency

To determine whether the weight obtained by formula (4) is effective, consistency check shall be required. If there is a too large deviation from the consistency, which suggests that the calculation result is not reliable. It is derived that that the consistency principle is tested using the compatibility of fuzzy judgement matrix.
Assume a matrix $\mathrm{A} = (a_{ij})n \times n$ and $\mathrm{B} = (b_{ij})n \times n$ are fuzzy judgement matrices, and the compatibility indicator for A and N is:

$$\mathrm{I(A, B)} = \frac{1}{n^2} \sum_{j=1}^{n} \sum_{i=1}^{n} a_{ij} + b_{ij} - 1 \quad (5)$$

Assume $\mathrm{W} = (W_1, W_{2,} \cdots W_n)^T$ is the weight vector of the fuzzy judgment matrix, where, $\sum_{i=1}^{n} W_i = 1$, let $W_{ij} = W_i W_i + W_j$, the specific matrix of the judgment matrix is:

$$\mathrm{W} *= (W_{ij})_{n \times n} \quad (6)$$

For decision makers, if the compatibility indicator I(A, W)≤A, the judgement matrix is considered to be satisfactory. The less the A, the higher the consistency of the fuzzy judgment matrix as the decision maker requires, in general, A=0.1.
In the practical application process, in general cases, a number of experts give the pairwise comparison judgement matrix on the set X of same factors:

$$A_k = (a_{ij}^{(k)})_{n \times n} \quad (7)$$

The sets of weights $W^{(\mathrm{k})} = (w_1^{(k)}, w_2^{(k)}, \cdots, w_n^{(k)})$ are respectively obtained, perform the fuzzy complement judgement and consistency check on the matrix.
The weight vector expression is:

$$\mathrm{W} = (W_1, W_{2,} \cdots W_n) \quad (8)$$

Where $W_i = \frac{1}{n} \sum_{k=1} W_i^{(k)}$.

3. Cost control methods of chemical companies

At present, the main business costs and financial expenses of China's chemical companies build up year by year. As of 2017, the main business cost in the chemical industry has reached RMB 7522.94 billion, an increase of 5.2% year-on-year, as shown in Figure. 1.

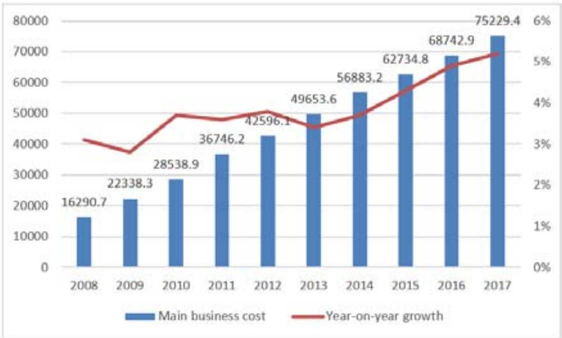

Figure 1: The main business cost and growth rate of China's chemical enterprises

Cost control analysis on chemical company M

Herein we take chemical manufacturer M in Langfang, Hebei, as an example for cost control analysis. First, set up a cost control indicator system from five dimensions, i.e. financial data, internal production, employees, customers, and the environment. See Table 1 for details.

Table 1: Evaluation index system of cost management

Target layer	Standard layer	Index layer
Evaluation index system of cost management (A)	Financial data (B1)	Net profit margin (C1) Cost profit margin (C2) Unit product cost (C3) Growth rate of operating income (C4)
	Internal production (B2)	Qualified product rate (C5) Manufacturing cycle (C6) Unit product cost change rate (C7)
	Staff (B3)	Employee satisfaction (C8) Employee's sense of social responsibility (C9) Social responsibility training fee (C10)
	Customer (B4)	Market share (C11) Market share of green products (C12) Customer retention rate (C13) New customer acquisition rate (C14) Customer satisfaction(C15)
	Environmental Science (B5)	Energy utilization ratio (C16) Environmental cost rate (C17) Recycle utilization rate of three wastes (C18)

Table 2: Judgment matrix of standard layer elements

	B1	B2	B3	B4	B5
B1	1	3	2	4	1/3
B2	1/3	1	3	2	1/4
B3	1/2	1/3	1	3	1/5
B4	1/4	1/2	1/3	1	1/3
B5	3	4	5	3	1

In the way of expert scoring, the experts in the industry are invited to rate the relevant indicators, and the scoring results are collated to establish a two-by-two judgment matrix. The judgment matrix for the five indicators at the criterion level is shown in Table 2.

In the same way, the judgment matrix for the indicator layer can be obtained, as shown in Tables 3 - 7.

Table 3: The judgment matrix of the financial index layer

	C1	C2	C3	C4
C1	1	2	5	3
C2	1/2	1	2	4
C3	1/5	1/2	1	2
C4	1/3	1/4	1/2	1

Table 4: The judgment matrix of the internal production index layer

	C5	C6	C7
C5	1	3	2
C6	1/3	1	1/2
C7	1/2	2	1

Table 5: The judgment matrix of employee index layer

	C8	C9	C10
C8	1	3	3
C9	1/3	1	3
C10	1/3	1/3	1

Table 6: The judgment matrix of customer index layer

	C11	C12	C13	C14	C15
C11	1	3	2	4	1/3
C12	1/3	1	3	2	1/4
C13	1/2	1/3	1	3	1/5
C14	1/4	1/2	1/3	1	1/3
C15	3	4	5	3	1

Table 7: The judgment matrix of the index layer of environmental responsibility

	C16	C17	C18
C16	1	3	2
C17	1/3	1	3
C18	1/2	1/3	1

With the above judgment matrix, its eigenvalue can be calculated and then perform the consistency test at an indicator CI calculated by the formula:

$$\mathrm{CI} = \frac{\lambda_{max} - n}{\mathrm{n-1}} \quad (9)$$

The test coefficient is CR=CI/RI. The values of the average random consistency indicator RI are shown in Table 8.

Table 8: Average random consistency index RI

Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.54	0.89	1.13	1.26	1.31	1.43	1.47

In general, if CR ≤ 0.10, the judgment matrix has a consistency; if CR > 0.10, the judgment matrix needs to be adjusted until CR ≤ 0.10.

Perform the consistency check on the above judgment matrix, the results are CR_A=0.0094, CR_A=0.0085, CR_A=0.0214, CR_A=0.0129, all of which satisfy CR≤0.10. Therefore, the above matrices are all consistent.

After the consistency check, the weight coefficient can be calculated for each indicator. W represents the weight at criteria layer; W_i(i=1,2,…,5) represents the weight at the indicator layer. Weight of each indicator is listed in Table 9.

Table 9: Indicator weights

Target layer	Standard layer	Weight	Index layer	Weight
A	B1	0.4238	C1	0.3259
			C2	0.1468
			C3	0.0965
			C4	0.4308
	B2	0.1596	C5	0.5691
			C6	0.1537
			C7	0.2772
	B3	0.0983	C8	0.5106
			C9	0.2885
			C10	0.2009
	B4	0.2574	C11	0.3992
			C12	0.2743
			C13	0.1126
			C14	0.0738
			C15	0.1401
	B5	0.0636	C16	0.2896
			C17	0.4917
			C18	0.2187

Table 10: Evaluation set interval scores and grade scores

Evaluation grade	Very good	Good	Commonly	Bad	Very bad
Percentile interval	[90,100]	[80,89]	[60,79]	[40,59]	[0,39]
Grade score	95	85	70	55	15

Table 11: The membership of each index

Standard layer	Index layer	V_1	V_2	V_3	V_4	V_5
B1	C1	0.1	0.6	0.3	0	0
	C2	0.1	0.7	0.2	0	0
	C3	0	0.8	0.1	0.1	0
	C4	0	0.6	0.2	0.2	0
B2	C5	0.4	0.2	0.3	0.1	0
	C6	0.3	0.2	0.3	0.1	0.1
	C7	0.2	0.2	0.3	0.1	0.2
B3	C8	0.3	0.4	0.2	0.1	0
	C9	0.1	0.4	0.2	0.1	0.2
	C10	0.5	0	0.1	0.3	0.1
B4	C11	0.3	0.1	0.2	0	0.4
	C12	0.1	0.5	0.2	0.1	0.1
	C13	0.2	0.2	0.2	0.4	0
	C14	0.7	0.1	0	0.1	0.1
	C15	0.5	0.3	0.1	0.1	0
B5	C16	0	0.3	0.4	0.1	0.2
	C17	0.1	0	0.7	0.1	0.1
	C18	0.6	0.2	0	0.1	0.1

The evaluation effects of the company's cost control are classified into five levels, i.e. very good, good, general, poor, and very bad. To enable a more intuitive evaluation on the business cost control, the evaluation vector is converted into a percentage system, see Table 10 for details. The evaluation set is expressed by V=(95,85,70,55,15)T.

The experts in the industry are invited to evaluate the cost management effects reflected by the company's various indicators, from which, the evaluation results are based to determine the fuzzy evaluation matrix Ri

(i=1, 2,… 5) of each indicator at the appropriate layer. Assume that S is the evaluation result vector, use matrix operation for comprehensive evaluation. First, a first-level evaluation is performed for the indicator layer to calculate a fuzzy comprehensive evaluation vector Si=(Si, S2, S3, S4, S5), where Si= Wi×Ri×V (i=1,2,… 5). Then the second level evaluation is performed on the target layer, and the calculation formula is S=W×Si, thus finally calculate the synthesis score of the cost management in this company.
The degree of membership of each indicator is determined based on the number of people as chosen in the indicator comments for each level, listed in Table 11, the membership vectors are further obtained to constitute five fuzzy evaluation matrices.

4. Conclusions

The main business cost and financial expanses of chemicals manufacturers in China hike up year by year. As of 2017, the primary business cost in the chemical industry has reached 7522.94 billion, an increase of 5.2% YoY. Take the chemicals manufacturer M in Langfang city, Hebei province as an example, the system is built for cost control on five fronts such as financial data, internal production, employees, customers and environment. The results from calculation show that the cost control effect of chemicals manufacture M has a composite score 82, and the evaluation result is better. Among them, financial data and customers contribute more, but employees and environment remain to be improved.

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