Research of Evaluation Mechanism of Petrochemical Informatization Projects Based on AHPP

Feng'an Wen

Chongqing Academy of Social Sciences

Abstract

To address unreasonable planning process and imbalanced budget for informatization projects of petrochemical enterprises, this paper designs an informatization projects evaluation model. Analytic Hierarchy Process (AHP) is introduced to provide theoretical support. First, this paper conducts a hierarchical analysis to the decisive project factors in the informatization construction by constructing judgment set for the ladder-type hierarchical mode. Then, it calculates the weight for each factor and makes reasonable decision, which provides guidance to the implement of the informatization projects of petrochemical enterprises.

Keywords: Informatization; Project AHP; Evaluation Structure Model; Petrochemical Industry

1. Introduction

With the development of computer technology, informatization construction of petrochemical enterprises has attracted attention of relevant authorities. Limitations in project construction in traditional stated-owned enterprises as well as the limitations of defective framework pose many problems to the evaluation work of informatization projects, including the unreasonable planning project and imbalanced budget distribution. Thus, these petrochemical enterprises call for a feasible, efficient and scientific evaluation mechanism for informatization projects. This paper designs an informatization projects evaluation model based on Analytic Hierarchy Process (AHP) and produces a set of project decision-making information. It provides guidance to the implementation of informatization projects of petrochemical enterprises.

2. Researches About AHP

AHP is in the decision-making system. It decomposes elements related to decision into target, rule and scheme. Qualitative and quantitative analysis are based on it. AHP was proposed in the early 70s by Professor T.L.Saaty, an operational expert from University of Pittsburgh. It was first applied to the project of Ministry of Defense to "distribute electrical power according to the contribution of each industrial department to the whole nation".

AHP uses a small amount of quantitative information to mathematize the decision-making process based on an in-depth analysis of the nature of complicated decision questions. It provides simple and convenient decision-making method to address complicated decision questions with multiple targets, multiple rules and unclear structures. It in particular suits to those decision questions that are less likely to be calculated accurately. AHP is more efficient than other decision analysis method mainly in the following ways [1]:

1) Systematic analysis method: AHP takes the research objects as a whole system. It is an important analysis method following mechanism analysis and statistical analysis. The

thought of system lies in that the influence of each factor on the result is related to each other. The weight of each layer will affect the result directly or indirectly. The influence of each factor in each layer is quantified and clear. This method is conductive to those systems with multiple targets, multiple rules, multiple periods and uncertain structures.

2) It doesn't require much information. AHP mainly starts from evaluators' understanding of the nature and factors of the evaluated question. It prefers qualitative analysis and judgment. AHP simulates the decision-making process of human brain and leaves the judgment of relative importance to it. It only retains the impression of factors and does the calculation with simple weights. This method can solve many problems that seem possible to traditional ways.

3) Clear and practical. AHP combines both qualitative method and quantitative method. It decomposes the complicated system, mathematizes and systemizes the thinking process of human kind. It turns questions to decide with multiple targets and multiples rules to those with multiple layers and singe target. It determines the relationship between the factor in the same layer and that in the upper layer by comparison of every two factors. It ends with a simple calculation. AHP is easy to learn for one even with a middle education.

AHP consists of the following steps. (1) Construct ladder-type hierarchical mode. (2) Construct the judgment set. (3) Calculate the relative weight of a factor under certain standard based on the judgment set. (4) Calculate the combination weight of a factor under certain standard based on the judgment set.

2.1. Construct Ladder-type Hierarchical Mode

The hierarchical mode is the first step of AHP decision-making. Completeness and integrity should be given a priority. These complicated items are treated as factors and put into different layers according to their characteristics. The standard scale layer has the controlling power over the lower layer, namely, decision layer. And it is subject to the control of father standard scale layer. The hierarchical mode is shown in Figure 1.
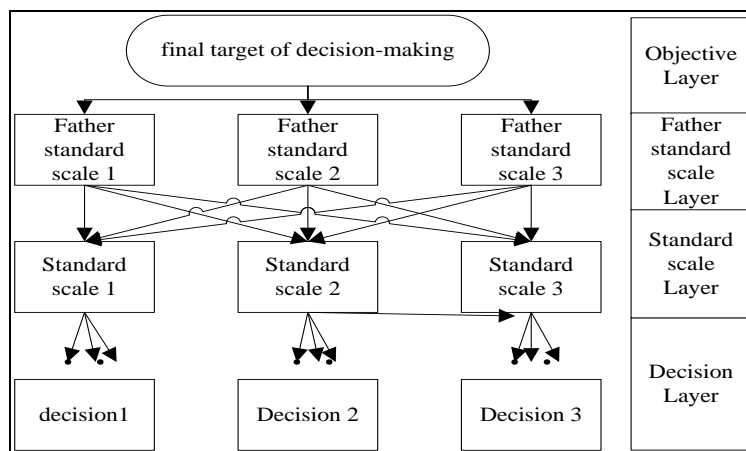

Figure 1. Ladder-type Hierarchical Mode

2.2. Construct the Judgment Set

AHP hierarchical mode makes it clear the relationship between layers. If factor Cm belongs to the father standard scale layer, it has controlling power over a set of factors T1,T2,...,Tn. Based on the hierarchy, T1,T2,...,Tn are given different weight. In the process of

decision-making analysis, one should answer the same question repeatedly. In other words, one should compare every two factors in the same layer and judge which factor is more valuable and give them weight according to their importance.

The importance of a factor should be considered from multiple perspectives. The decision result is labeled by several identifications [2], such as "importance degree a", "importance degree b", "importance degree c", "importance degree d", etc. Table 1 shows the comparison results of the importance degree of factors.

Table 1. Comparison Results of the Importance Degree of Factors

Value	Definition
1	Equal Importance
3	Importance a
5	Importance b
7	Importance c
9	Importance d
2,4,6,8	Median {1,3,5,7,9}

Note: importance degree a<b<c<d

2.3. Calculate Relative Weight of a Factor in the Standard Scale

For a set of factors T1,T2,...,Tn, calculate the judgment set T. The process is parallel to the decomposition of characteristic root $Tw = \lambda_{max} w$. λ_{max} exists and has the uniqueness. W is a parameter value decided after quantitative analysis and has uniqueness. The importance degree of all factors can compose a set, namely, the comparison judgment set, added with unification identification. The relative weight is calculated according to the following steps:

(1) Calculate the unification identification CI:

$$CI = \frac{\lambda_{max} - n}{n - 1} (n \in 1,2,3,4\ldots\ldots \quad)$$

n: The layer that the set is in

(2) Acquire random identification RI through random distribution. RI of different layers is shown in Table 2.

Table 2. Parameters from Unification Identification RI

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.01	0.23	0.88	1.23	1.25	1.44	1.47	1.52	1.55

(3) Calculate the ratio of random identification to unification identification CR: $CR = \overline{CI}$, if CR<0.2,the unification of the judgment set meets the standard; if CR>=0.2,repeated calculation is needed until the standard is met.

2.4. Calculate the Combination Weight of Factors between the Standard Scale Layers

It is the time to calculate the combination weight of factors between standard scale layers and apply them to unification test for judgment set.

If the father standard scale layer C controls factor T1,T2,...,Tm, then the combination weight is CT1,CT2,...,CTm. The standard scale layer D below C controls factor T1,T2,...,Tn. Then, the ordered weight of factor Tj in father standard scale layer is B1j,B2j,...,Bnj. When

Dk has no relationship with Tj, Bkj is 0. Calculate the combination weight vector of layer D
d=(d1,d2,...,dn)^T .There is: $d_k = \sum\limits_{j=1}^{m} B_{kj} CT_j$. In the expression, k=1,2,...,n; $d = B \bullet C$ and
$B = (B_{ij})_{n \times m}$.

For a ladder-type hierarchical mode with r layers, the factor of the top layer is p. The
combination weight of target layer to p is $w = B_r B_{r-1} \cdots B_2 P_1$ (Owing to the uniqueness of the
top layer factors, it can be assumed that p1=1).

The unification test for judgment set [6] is based on CI. If the weight vector for layer k-1 is
known as tk-1=(t1k-1,t2k-1,...,tmk-1)T (m is the number of factors in the layer) and CIk-
1,RIk-1,CRk-1 are also known, then the corresponding identifications for layer k is:

（1） $CI_k = (CI_k^1, CI_k^2,..., CI_k^m)t^{k-1}$;

（2） $RI_k = (RI_k^1, RI_k^2,..., RI_k^m)t^{k-1}$;

（3） $CR_k = CR_{k-1} + CI_k / RI_k$;

When CRk<0.20, it can pass the unification test. And layer k meets the standard.

3. Design Project Evaluation Model

According to analysis judgment of experts and scholars, three indexes are confirmed and
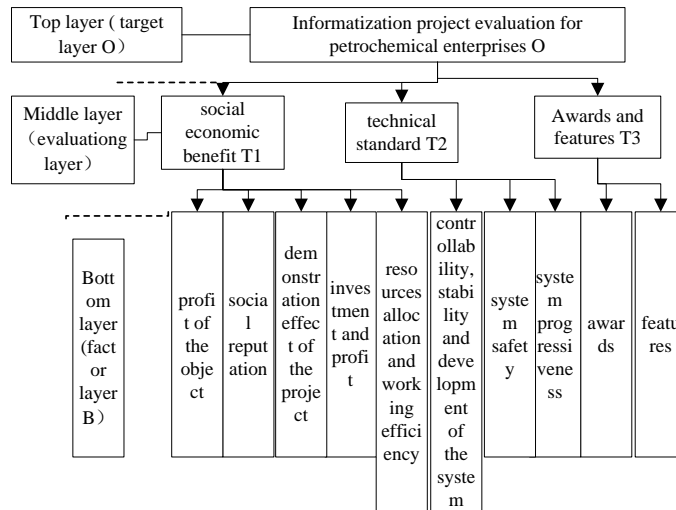each has around 10 factors. The detailed evaluation structure is shown in Figure 2.

**Figure 2. Informatization Project Evaluation Model for Petrochemical
Enterprises**

4. Determination of Factors' Weight

4.1. Determination of the Weight of Factors in the Same Layer

Establish the judgment set based on importance degree of factors in the same layer. For
example, the importance degree of T,T1,T2,T3 in the middle layer to the top layer O can be
available by judgment analysis of experts and scholars. Then, rank the factors of the judgment
set and calculate their corresponding weights, as is shown in Table 3.

Table 3. Calculation of the Judgment Set and Weight for Top Layer O

O	T1	T2	T3	w
T1	1	7	3	0.656
T2	1/7	1	5	0.134
T3	1/3	1/5	1	0.056

$\lambda_{max} = 2.563$, unification identification $CI = \frac{\lambda_{max} - n}{n - 1} = 0.027 \ (n = 3)$. Refer to Table 2, RI=0.23. Therefore, $CR = CI / RI = 0.08 \leq 0.1$, which meets the standard. Since w=(0.656, 0.134, 0.056)^T, the weight of three indexes in layer T is able to be calculated.

4.2. Determination of the Weight of Factors under the Middle Layer

By the same way, the weight of factors in the middle layer (the third layer to the second layer) is shown in Figure 4-6.

Table 4. Judgment Set for Evaluation Index T1

T1	B1	B2	B3	B4	B5	w
B1	1	5	3	1	5	0.548
B2	1/5	1	2	1/5	1/4	0.094
B3	1/3	1/2	1	1/5	1/2	0.089
B4	1	5	3	1	1	0.247
B5	1/5	4	2	1	1	0.234

Calculate T1 according to the table and there is $\lambda_{max} = 6.343$, $CI = \frac{\lambda_{max} - n}{n - 1} = 0.007$, $CR = CI / RI = 0.028 \leq 0.1$,suggesting that judgment set T1 meets the standard of unification.

Table 5. Judgment Set for Evaluation Index T2

T2	B6	B7	B8	w
B6	1	1/2	1/3	0.144
B7	2	1	1	0.565
B8	3	1	1	0.421

The calculation of T2 is the same as Ta. There is $\lambda_{max} = 4.233$, $CI = 0.008$, $CR = 0.041 \leq 0.1$, suggesting that judgment set T1 meets the standard of unification.

Table 6. Judgment Set for Evaluation Index T3

T3	B9	B10	w
B9	1	4	0.7
B10	1/4	1	0.3

The calculation results of T3 is $\lambda_{max} = 2$, $CI = 0$. T3 only has two factors and both meet the standard of unification.

4.3. Determination of the Combination Weight of Factors in the Bottom Layer

The bottom layer is the decision layer. The purpose of calculating the combination weight of all factors in bottom layer B is to calculate the ordered weight of each factor, there is:

$$B_i = \sum_{i=1}^{3} B_{ij} t_j .$$

In the expression j=1,2,3,...,10, $w^{(3)}$=(0.257, 0.08, 0.024, 0.197, 0.231, 0.045, 0.064, 0.078, 0.087, 0.028)^T. According to the unification test, there is $CI^{(3)}$=0.057,$RI^{(3)}$=0.894,$CR^{(3)}$=0.069<0.1,suggesting that the ordered weight meets the standard of unification. The decision analysis can be adopted.

Based on the abovementioned steps, we can rank the importance of projects of petrochemical enterprises according to the weight. The rank of the project code is {B3,B6,B8,B1,B2,B9,B7,B10,B5,B4}.

5. Conclusion

This paper uses Analytic Hierarchy Process (AHP) to address problems presented in informatization projects of petrochemical enterprises. It determines the weights of evaluation factors in an effective and scientific way and makes reasonable decision. It provides guidance to the implement and development of informatization projects of petrochemical enterprises.

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Author

Feng'an Wen, He obtained his master's degree at China University of Geosciences. Now he is a professor as well as the vice minister of Chongqing Academy of Social Sciences