

The Application of Analytic Hierarchy Process in Risk Management of Enterprise Groups -- Take XX Group Company as an Example

Zirui Wang

Economics School of Jilin University, Changchun, Jilin Province, China

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Abstract: This paper states the risk management theory and risk management tools of the world's mainstream enterprises, and points out the rationality of applying analytic hierarchy process to the risk management of enterprise groups. This paper makes a theoretical interpretation of the analytic hierarchy process, and takes the risk management practice of XX group company as an example to illustrate how analytic hierarchy process conducts practical operations such as model construction, risk assessment and risk sequencing in the risk management of enterprise groups. At the same time, this paper analyzes the advantages and limitations of analytic hierarchy process. It also summarizes the enlightenment and experience of risk management theory and evaluation technology to risk management practice, and puts forward some suggestions to optimize the application of risk management theory.

1. Introduction

Risk management is an important subject concerned by modern enterprises. Enterprise groups is the advanced organization form of modern enterprises. Risk management at the group level is of great significance to improve the overall management level and anti-risk ability of enterprises, and enhance competitiveness and promote development. However, modern enterprise groups are often large scale. There are a lot of internal management levels and large individual differences. The distribution of member units is also wide. It is difficult to identify the overall risk of an enterprise by risk assessment technology aiming at a single enterprise or specific risk, and it is difficult to quantify the risk management at the group level. This paper takes XX group company as an example, applies the analytic hierarchy process (AHP) to construct models in enterprise group risk management which is supplemented with questionnaire statistical method. By combining qualitative and quantitative methods, the risk information is collected accurately and efficiently, evaluated scientifically, and the major risks and their key causes are ranked. It can provide scientific basis for enterprise group risk prevention, early warning and decision making.

2. Risk Management Theory and Risk Assessment Techniques

2.1 Risk management theory

Risk management has been studied in depth internationally. For example, according to the theory of risk management, the UK has put forward the principle of "As Low As Reasonably Practicable" (ALARP), which holds that to confirm a certain risk meets the minimum reasonable feasibility, it is necessary to prove that the cost of further risk reduction is far greater than the benefit after risk reduction. In order to reduce the risk to zero, enterprises may invest unlimited resources, thus enterprise risk management must consider the management investment and management effect, which is instructive for the selection of enterprise risk assessment technology. Meanwhile, France has put forward the principle of integrated optimal (GAMAB). According to this principle, if an enterprise already has an "acceptable" measure, other new risk management measures should at least have the same effect on overall risk control as this measure. This principle can be used as the implementation principle of risk management, but it is difficult to quantify the risk. According to the characteristics of safety management, Germany proposed the principle of minimum endogenous

mortality (MEM). This theory is mainly used in the field of security risk control, but not in the whole enterprise risk assessment. In addition, there are also risk management theories such as the minimum safety equivalence principle (MGS) which is mainly used for security risk management, the maximum tolerable limit principle (NMAU) which is mainly used for equipment risk management, and the land use planning standard (LUP) which is mainly used for land risk management.

2.2 Risk assessment techniques

With the increasing popularity of risk management, Australia, Britain, Holland, Norway, Germany, the European Union, China and other countries and regions have respectively issued risk management guidelines or developed risk management standards. ISO 31000:2009 -- risk management principles and guidelines issued by the international organization for standardization is a typical representative, and has gradually formed the mainstream standard in the international risk management field. According to these risk management standards, a large number of risk management techniques and theoretical methods have emerged. These methods or tools are called risk assessment techniques. Risk assessment techniques can be classified into qualitative, semi-quantitative, quantitative or comprehensive techniques according to different structural attributes of assessment. The selection of appropriate risk assessment methods and techniques is helpful for enterprises to obtain assessment results timely, economically and effectively. In practice, risk assessment activities vary in complexity and details, so the form and output of risk assessment must be suitable for the enterprise's own situation.

2.3 Brief introduction of analytic hierarchy process

Analytic hierarchy process is a modeling and analysis method applied in the fields of society, economy, science and technology, planning, etc., which is suitable for decision-making of multi-objective, multi-level and multi-factor complex system. The basic principle is to decompose a complex problem into its constituent elements, and group these elements according to the governing relationship, so as to form an ordered hierarchical structure from top to bottom. It can compare and judge the relative importance of any two factors at the same level, and quantify them. Through calculation, it can judge the relative importance of elements at each level, integrate them under an evaluation target, and then rank them out.

Analytic hierarchy process has moderate requirements on enterprise resources and capabilities and is suitable for the uncertainty and complexity of any type of risks. It can quantify the results of risk assessment and make the results of risk analysis comparable. Analytic hierarchy process is an ideal method for enterprise group risk management because of its strong relevance and applicability.

3. The Application of XX Enterprise Group

XX group co., ltd. is a large state-owned enterprise group in China. It has more than 50 subsidiaries and direct management units, which are distributed in 20 provinces, cities and autonomous regions in China. It has four business segments: military products, civilian products, strategic resources and financial circulation. In the process of risk management, the company uses the analytic hierarchy process to realize the combination of qualitative and quantitative risk assessment process which playing a good management effect. The process is as follows:

3.1 Calculating the risk database

The annual risk evaluation index of the group is the three-level risk index system. The first level is the group risk, the second level is five business risks, and the third level is each specific risk item. Risk assessment is completed from the bottom up within the group, and the group calculates the annual risk event database composed of several three-level risks.

3.2 Screening key risks

In the specific risks assessed by its member units, the group company selects key risks. The

number of the risks is usually about 30. Key risks are calculated by weighting according to the occurrence frequency of specific risks and the integration with the risk contribution of each unit. The risk contribution degree is to measure the relative risk contribution of member units to the group by observing the enterprise life cycle and development strategy and selecting corresponding indicators. XX group chooses “profit ratio”, “asset ratio” and “income ratio” as three indicators and assigns weights to calculate the degree of risk contribution of member units to the group.

3.3 Applying analytic hierarchy process for risk assessment and ranking

3.3.1 Construct the judgment matrix

Risk indicators were comprehensively considered from the two dimensions of occurrence probability (Table 1) and influence degree (Table 2) to construct the risk judgment matrix. The risk factor judgment scale adopted a 9-level scale.

Table 1 Quantitative Statement of Risk Occurrence Probability

Grade	Possibility	Statement
5	Extremely high	This risk is almost certain to occur at least once in the next 12 months.
4	High	This risk is likely to occur once in the next 12 months.
3	Medium	This risk could occur once in 2 to 10 years.
2	Low	This risk is likely to occur at least once in the next 10 to 100 years.
1	Extremely low	This risk is likely to occur less than once in the next 100 years.

Table 2 Quantitative Table of Influence Degree

Grade	Degree of damage	Statement
5	Disaster	It deprives the ability of the cooperation to continue operating. (or accounts for 20% of pre-tax profits)
4	Severe	It has a significant impact on the achievement of its strategic plans and goals. (or accounts for 5% to 10% of pre-tax profits)
3	Medium	To some extent, it hinders enterprises' efforts to achieve their strategic plans and goals. (or accounts for up to 5% of pre-tax profits)
2	Slight	It has only a slight impact on the achievement of its strategic plans and goals. (or accounts for up to 1% of pre-tax profits)
1	Negligible	The effect is extremely slight.

The judgment matrix represents the relative importance of the various risks associated with a given risk at a higher level. Assuming risk Ak in level A is related to risk B1, B2..., Bn in the next level, then the judgment matrix of level A is constructed.

3.3.2 Calculating the weight of evaluation index

Calculating the eigenvector of risk judgment matrix at each level as follows:

a) Calculating the product of each row of elements in the judgment matrix M_i :

$$M_i = \prod_{j=1}^n a_{ij}, i = 1, 2, \dots, n \dots\dots(1)$$

b) Calculating the n-th root of the number M_i : \bar{W}_i :

$$\bar{W} = [\bar{W}_1 \quad \bar{W}_2 \quad \bar{W}_3 \quad \dots \quad \bar{W}_n]^T \dots\dots\dots(2)$$

c) Normalizing vector \overline{W} :

$$W_i = \frac{\overline{W}_i}{\sum_{j=1}^n \overline{W}_j}, i = 1, 2, 3, \dots, n \dots \dots \dots (3)$$

$W = [W_1 \ W_2 \ W_3 \ \dots W_n]^T$ This is the eigenvector of matrix A.

3.3.3 Consistency check

For the judgment matrix of order 1 and order 2, RI is only formal. The judgment matrices of order 1 and order 2 are always identical. When the order is greater than 2, the ratio of CI, the consistency index of the judgment matrix, and RI, the average random consistency index of the same order, is called the random consistency ratio of the judgment matrix, named CR, that is:

$$CR = \frac{CI}{RI} \dots \dots \dots (4)$$

$$\text{And } CI = \frac{\lambda_{\max} - n}{n - 1} \dots \dots \dots (5)$$

RI is shown as below:

Table 3 The Comparison between RI and The Order of The Judgement Matrix

The Order of the judgement matrix	1	2	3	4	5	6	7	8	9
<i>RI</i>	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

When $CR < 0.10$, the judgment matrix has a satisfactory consistency and the weight vector W is acceptable. Otherwise, the judgment matrix needs to be adjusted.

3.3.4 Examples of risk assessment calculation

Taking the first-level risk of the XX year of the group company as the assessment object, the analytic hierarchy process is used to evaluate the process as follows:

According to the actual situation of the group company and the experience grade given by the risk management assessment group, A comprehensive analysis judgment matrix A of hierarchical 1 is constructed, as shown in Table 5.

Table 4 The Judgment Matrix of Hierarchical 1

Group risk	Strategic risk	Market risk	Financial risk	Legal risk	Operational risk
Strategic risk	1	2	3	2	4
Market risk	$\frac{1}{2}$	1	2	1	2
Financial risk	$\frac{1}{3}$	$\frac{1}{2}$	1	$\frac{1}{3}$	3
Legal risk	$\frac{1}{2}$	$\frac{1}{5}$	3	1	3
Operational risk	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	1

After normalizing the judgment matrix, the upper triangular matrix is obtained:

The upper triangular matrix of Hierarchical 1 risk $A = \begin{pmatrix} 1 & 2 & 3 & 2 & 4 \\ & 1 & 2 & 1 & 2 \\ & & 1 & 1/3 & 3 \\ & & & 1 & 3 \\ & & & & 1 \end{pmatrix}$,

Calculating eigenvector $W = (0.374 \ 0.198 \ 0.121 \ 0.233 \ 0.073)$,

Eigenvalue of maximum $\lambda_{\max} = 5.168$, $CI = \frac{\lambda_{\max} - n}{n - 1} = 0.042$, $RI = 1.12$,

Consistency check $CR = \frac{CI}{RI} = 0.038 < 0.1$, pass the consistency check.

Table 5 Risk Ranking of Hierarchical 1

Risk ranking	1	2	3	4	5
Weight	0.374	0.198	0.121	0.233	0.073
Risk name	Strategic risk	Market risk	Financial risk	Legal risk	Operational risk

Similarly, the comprehensive analysis judgment matrix of each risk at the first hierarchical is constructed respectively, namely the two-level judgment matrix: B_i

By using the results of single ranking of all levels in the same level, all the weights of the risk significance in this level can be calculated for the last level, that is, the total ranking of the level. The overall ordering of the hierarchy needs to be done layer by layer from top to bottom.

3.3.5 Risk management effectiveness

In its risk management practice, XX group has made comprehensive use of the analytic hierarchy process to build an information model of risk assessment and achieved positive results. This assessment process quantifies and concretizes risks, reduces the randomness and subjectivity of risk identification to a large extent, and improves the pertinence and accuracy of risk management. This process can collect all kinds of risk information at all levels of management, prompt major risks, and form risk management reports at the company level. After years of data accumulation, XX group has realized the function of historical analysis and future prediction of important risk indicators. Since the use of the risk assessment technology, XX group has been developing continuously and has not experienced any major risk events at the company level.

4. Conclusion

4.1 Revelation

As a mature theory and scientific method, risk management is widely used in enterprise risk management practice. Analytic hierarchy process reflects the idea of combining qualitative and quantitative analysis of system engineering, which can make the qualitative thinking process of risk assessors mathematical and modelled, and help to maintain the consistency of thinking process. When applied to enterprise group risk management, it can make risk assessment more scientific, applicable and effective. However, analytic hierarchy process also has some limitations, mainly manifested in: It depends on the assessor's experience to some extent and is greatly influenced by the assessor's subjective factors. It can only exclude the serious inconsistency in the thought process. It can't exclude the serious one-sidedness which may exist in the decision-maker personally. Moreover, the process of comparison and judgment is rough, so it can't be used for risk assessment and decision making with high precision.

4.2 Suggestions

All parties involved in risk management should make corresponding improvements to promote

risk assessment techniques including analytic hierarchy process to play a greater role in enterprise risk management practice. Firstly, the state should further promote the publicity, implementation and application of risk management standards, accelerate the formulation of industry and segmentation of risk management standardization process, promote enterprises to get familiar with the concept, principles and methods of risk management as soon as possible so that they can effectively carry out risk assessment activities. Secondly, Enterprises should build and form a standardized internal control system, establish a thorough risk warning system, and cultivate a unified risk management culture. The last but not the least, in designing and selecting risk assessment techniques, risk management professionals should pay more attention to the comparability of techniques and outputs in integrating the results of different studies.

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