Risk evaluation of oversea investment of Chinese enterprises based on fuzzy-AHP

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Abstract

This paper is aimed at studying risk evaluation of overseas investment of Chinese enterprises with the application of fuzzy comprehensive analytic hierarchy process (AHP). In order to complete this task, this paper constructed the index evaluation system from three aspects that were macro, meso and micro to assess the risk of foreign investment of Chinese enterprises, the risk factor was divided into three main factors and eleven subfactors. The weight of each factor was defined by means of AHP. On this basis, this paper assessed the risk of direct investment of enterprise S in country X by means of fuzzy comprehensive evaluation, and the result is a high risk rating. The results show that fuzzy comprehensive analytic hierarchy process is good at the risk evaluation of oversea investment of Chinese enterprises, and it provides a reference for oversea investment of Chinese enterprises.

Keywords: overseas investment, risk, analytic hierarchy process (AHP), fuzzy comprehensive evaluation

1 Introduction

Since the 1990s, China has encouraged direct foreign investment of qualified enterprises. Especially after joining the WTO, Chinese government put forward the strategy of "going out" to stimulate foreign investment. According to Chinese Ministry of Commerce statistics, China's non-financial direct foreign investment has increased 37.61 times from $2 billion to $77.22 billion during the ten years from 2002 to 2012. The investment extended to 4,425 enterprises distributed in 141 countries and regions all over the world. In the first quarter of 2013, Chinese investors invested directly in 1,621 enterprises worldwide. Total non-financial direct investment accumulates $23.827 billion with year increase of 44%. The internationalization of Chinese enterprises has entered a new phase. Direct foreign investment surge the export of capital goods such as machinery and equipment, which promote rapid development of China's economy. In addition, it can alleviate domestic contradiction of the short supply of some resources by making good use of foreign resources, which played a positive role in adjusting domestic industrial structure and upgrading the enterprise's international competitiveness. However the enlargement of China's overseas investment is accompanied with economic slowdown and financial unrest over world. Chinese enterprises are confronted with a variety of risks under the pressure from international competition and investment environment. Ignorance of investment risk will be a fatal mistake for enterprises. Therefore, identifying the risks correctly and evaluating the risks objecting is important for the enterprises.

In order to assess the risks of overseas investment of Chinese enterprises we must construct index evaluation system in the first. On this basis we must adopt a reasonable and objective evaluation method to assess the risk justly and effectively.Fuzzy comprehensive evaluation method is such a quantitative mathematical methods combined with qualitative analysis, which can make effective evaluation of the investment risks of enterprise overseas.

2 Construction of the index system of overseas investment risk

2.1 THE STRUCTURE OF THE INDEX SYSTEM

Identifying the risk factors is the first thing in constructing the system of indicators of risk assessment. Identifying risk is analyzing the sources of risk, classifying the risks and describing the characteristics of the risks. The risks of direct foreign investment of Chinese enterprises are sorted into three categories based on their source, namely macro environment risk, industry environment risk and enterprise internal risk.

2.1.1 Macro environment risks

Macro environment risks consist of political risk, macroeconomic risk and cultural risk. Political risk refers to the risk caused by the war, the revolution, the coups or the policy change of the host country. Macroeconomic risk means the risk due to the change of economic, inflation, exchange rate or interest rate change. Cultural risk refers to the risk due to the differences in language, custom, habit, religious belief or values.

2.1.2 Industry environment risk

Industry risk includes four factors, namely industry competition risk, product market risk, technology risk and industry system risk. Industry competition risk refers to the risk caused by the fluctuations of product price and raw material due to potential competitors' state, and market competition. Product market risk refers to the risk from changes of consumer preference, substitute availability and the scarcity of complements. Technology risk refers to the risk caused by the changes in industry labor productivity, technology development level and technology transfer speed. Industry system risk refers to industry rules fomulated by the host country government, industry association or industry leading companies. Ignoring these rules, multinational companies may suffer boycott and lawsuit from industry peers, even punishment from relevant departments.

2.1.3 Enterprise internal risk

Internal risk contains four factors that is operational risk, financial risk, human resource risk as well as social responsibility risk. Operational risk refers to the risk resulting from ill- control in the whole process of production and sale. Financial risk refers to the risk of financial activities which includes financing, fund utilization, capital recovery and income distribution. Human resource risk refers to the risk caused by personnel flow, the quality of the employees, working status, values and the change of labor productivity. Social responsibility risk means the responsibilities of the enterprises on product safety, environment protection, staff benefit and safety production during production and sale.

Based on the above analysis, the system of indicators of the risk of overseas investment is showed in the following Table 1.

TABLE 1 The system of indicators of the risk of oversea investment

Target layer	Principle layer: main factors of the risk evaluation	Weight	Sub-principle layer: secondary factors of the risk evaluation	Weight
The risk of the direct oversea investment and management risk	U_1 macro environment risk	0.0880	U_{11} political risk	0.0227
			U_{12} macroeconomic risk	0.0561
			U_{13} cultural risk	0.0092
	U_2 industry environment risk	0.2426	U_{21} industry competition risk	0.0946
			U_{22} product market risk	0.0946
			U_{23} technology risk	0.0370
			U_{24} industry system risk	0.0165
	U_3enterprise internal risk	0.6694	U_{31} operational risk	0.3782
			U_{32} financial risk	0.1755
			U_{33} human resource risk	0.0787
			U_{34} social responsibility risk	0.0370

2.2 THE WEIGHT OF THE INDEX

Analytic hierarchy process is used to determine indicator weight. Affiliation between the upper and lower l is determined since the hierarchical structure is constructed. The upper layer dominates the lower layer as a rule. First, we must compare the importance of the indicators of the lower layer in accordance with the rule of the upper layer. According to the comparison results we can construct the judgment matrix.

The weight vector of each factor is determined by eigenvector of the judgment matrix. Consistency test would be needed. If consistency indicator is less than 0.1, the judgment matrix is inconsistent which is acceptable. Otherwise the judgment matrix is inconsistent and requires to be weighted again until through the consistency check. In the end, the weight of the risk factors of the principal layer is $A = (0.0880, 0.2426, 0.6694)$;In the secondary layer, the weight of the macro environment risk is $A_1 = (0.0227, 0.0561, 0.0092)$, the weight of the industry environment risk is $A_2 = (0.0946, 0.0946, 0.0370, 0.0165)$ and the weight of the enterprise internal risk is $A_3 = (0.3782, 0.1755, 0.0787, 0.0370)$.

3 Fuzzy-AHP comprehensive evaluation model of overseas investment risk

Fuzzy comprehensive evaluation is a method developed from fuzzy mathematics, which was first put forward by Chinese scholar Wang Peizhuang. Its fundamental idea is to describe the degree of subordination of evaluation objects quantitatively based on the theory of fuzzy transition.

3.1 ONE-LEVEL FUZZY COMPREHENSIVE EVALUATION MATHEMATICAL MODEL

Step 1. Determine the set of assessment $U = \{u_1, u_2, \cdots, u_m\}$ including m factors of the object and the set of comment $V = \{v_1, v_2, \cdots, v_n\}$ including comments from a high level to a low level.

Step 2. Construct the vector of weight allocation of m factors $A = \{a_1, a_2, \cdots, a_m\}$.

The weight is on behalf of the status and importance of each factor in the "evaluation target", namely the different proportion of each factor in the comprehensive evaluation. Analytic hierarchy process is used to determine the weight of each indicators (see Table1).

Step 3. Obtain the matrix R of fuzzy comprehensive evaluation through fuzzy evaluation of each factor. The matrix R is as follows:

$$R = \begin{vmatrix} R_1 \\ R_2 \\ \vdots \\ R_m \end{vmatrix} = \begin{vmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{vmatrix}. \quad (1)$$

Since $R_i = (r_{i1}, r_{i2}, r_{i3}, \cdots, r_{in})$ is the evaluation of the ith factor u_i, r_{ij} stands for the frequency distribution of the ith $(1 \le i \le m)$ factor on the jth $(1 \le j \le n)$ comment, which is typically normalized to meet $\sum_{j=1}^{n} r_{ij} = 1$.

Step 4. Get the result of comprehensive evaluation through compound operations:

$$B = A \cdot R1. \tag{2}$$

$B = (b_1, b_2, \cdots, b_n)$ and b_j means the degree of comment v_j, namely the degree of belonging of v_j to fuzzy set *B*. The membership degree of the objective is determined by the theory of maximum. The hierarchy of the comment with the maximum membership degree is that of the evaluation object.

3.2 MULTI-LEVEL FUZZY COMPREHENSIVE EVALUATION MATHEMATICAL MODEL

We divide the set U of factor into a couple of groups:

$$U = \bigcup_{i=1}^{p} U_i \cdot (U_i \cap U_j = \Phi \quad and \quad i \ne j). \tag{3}$$

Set $U_i = \{u_{i1}, u_{i2}, \cdots, u_{im_i}\}$, so

$$U = \{u_{11}, \cdots, u_{1m_1}, u_{21}, \cdots, u_{2m_2}, \cdots, u_{p1}, \cdots, u_{pm_p}\}. \tag{4}$$

The comparison of each set get the multi-level fuzzy comprehensive evaluation model. The steps are as follows:

Step 1. Following the one-level fuzzy comprehensive evaluation mathematical model, we evaluat each factor in the group of *i*th $U_i = \{u_{i1}, u_{i2}, \cdots, u_{im_i}\}$ of the second layer we can get evaluation matrix R_i. Weight is allocated to all factors in U_i, that is $A_i = \{a_{i1}, a_{i2}, \cdots, a_{im_i}\}$.Through fuzzy transition we get the evaluation result of factor U_i:

$$B_i = A_i \cdot R_i (i = 1, 2, \cdots, p). \tag{5}$$

Step 2. Set B_i for the factor evolution of U_i, we get the fuzzy relation comprehensive evaluation matrix of the second layer:

$$R = \begin{vmatrix} B_1 \\ B_2 \\ \vdots \\ B_p \end{vmatrix} = \begin{vmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & & & \vdots \\ b_{p1} & b_{p2} & \cdots & b_{pn} \end{vmatrix}. \tag{6}$$

The allocation of weight to $U = \{U_1, U_2, \cdots, U_p\}$ is in $A = \{a_1, a_2, \cdots, a_p\}$. Through fuzzy transition, we get the final result of comprehensive evaluation $B = A \cdot R$.

The comprehensive evaluation including two layers is called two-level fuzzy comprehensive evaluation model. Likewise, it can be extended to multi-level fuzzy comprehensive evaluation model.

4 Empirical assessment

In conformity with its own developing strategy, Chinese enterprise S intends to invest in country X directly in order to enhance international competitiveness. In order to make up the lack of the knowledge on political, economic, cultural, legal and social conditions of the host country, and in order to avoid losses caused by blind investment, enterprise S invited 20 experts to score all factors in Table 2. And the fuzzy hierarchical comprehensive evaluation model was applied to comprehensively evaluate the risk of oversea investment in host country. The steps are as follows:

4.1 DIVISION OF THE SET OF EVALUATION FACTOR

According to the index system of the risk of oversea investment (Table 1), the set of the risk factor can be divided into three main factor sets $U_1 1$, U_2 and U_3:

$$U = \{U_1, U_2, U_3\}. \tag{7}$$

U_1, U_2 and U_3 can further be divided into several secondary subsets such as

$$U_1 = \{U_{11}, U_{12}, U_{13}\},\ U_2 = \{U_{21}, U_{22}, U_{23}, U_{24}\},$$

$$U_3 = \{U_{31}, U_{32}, U_{33}, U_{34}\}.$$

4.2 DETERMINATION OF RISK EVALUATION HIERARCHY DOMAIN OF DISCOURSE

The risk is categorized into five degrees, that is higher, high, average, low and lower, that is

$$V = \{V_1, V_2, V_3, V_4, V_5\}. \tag{8}$$

In the set of V, V_1, V_2, V_3, V_4 and V_5 stands for each according layer.

4.3 FUZZY COMPREHENSIVE EVALUATION

4.3.1 One-level fuzzy comprehensive evaluation

In the first, 20 experts are asked to make fuzzy judgment on the risks of subsets U_1, U_2 and U_3. The result is shown in Table 2.

In Table 2 NP and F refer to "Number of people" and "Frequency" respectively.

The fuzzy relation matrixes of U_1, U_2 and U_3 can be obtained from the fuzzy evaluation results in Table 2.

$$R_1 = \begin{vmatrix} 0.15 & 0.3 & 0.5 & 0.05 & 0 \\ 0.05 & 0.3 & 0.4 & 0.25 & 0 \\ 0.25 & 0.6 & 0.15 & 0 & 0 \end{vmatrix},$$

$$R_2 = \begin{vmatrix} 0.05 & 0.2 & 0.6 & 0.15 & 0 \\ 0.05 & 0.5 & 0.4 & 0.05 & 0 \\ 0.2 & 0.55 & 0.25 & 0 & 0 \\ 0.15 & 0.15 & 0.65 & 0.05 & 0 \end{vmatrix}, \qquad R_3 = \begin{vmatrix} 0.15 & 0.65 & 0.15 & 0.05 & 0 \\ 0 & 0.6 & 0.35 & 0.05 & 0 \\ 015 & 045 & 0.3 & 0.1 & 0 \\ 0 & 0.3 & 0.5 & 0.2 & 0 \end{vmatrix}.$$

TABLE 2 Expert Fuzzy Evaluation Results

Hierarchy / Factors		Higher (V_1)		High (V_2)		Average (V_3)		Low (V_4)		Lower (V_5)	
		NP	F	NP	F	NP	F	NP	F	NP	F
U_1	U_{11}	3	0.15	6	0.3	10	0.5	1	0.05	0	0
	U_{12}	1	0.05	6	0.3	8	0.4	5	0.25	0	0
	U_{13}	5	0.25	12	0.6	3	0.15	0	0	0	0
U_2	U_{21}	1	0.05	4	0.2	12	0.6	3	0.15	0	0
	U_{22}	1	0.05	10	0.5	8	0.4	1	0.05	0	0
	U_{23}	4	0.2	11	0.55	5	0.25	0	0	0	0
	U_{24}	3	0.15	3	0.15	13	0.65	1	0.05	0	0
U_3	U_{31}	3	0.15	13	0.65	3	0.15	1	0.05	0	0
	U_{32}	0	0	12	0.6	7	0.35	1	0.05	0	0
	U_{33}	3	0.15	9	0.45	6	0.3	2	0.1	0	0
	U_{34}	0	0	6	0.3	10	0.5	4	0.2	0	0

One-level fuzzy comprehensive evaluation is carried out according to $B_i = A_i \cdot R_i (i = 1,2,3)$, so we can receive the evaluation results of U_1, U_2 and U_3 as shown in Table 3.

TABLE 3 One-level fuzzy comprehensive evaluation results

Factor set	Weight vector	One-level fuzzy comprehensive evaluation
U_1	$A_1 = (0.0227, 0.0561, 0.0092)$	$B_1 = A_1 \cdot R_1 = (0.0085, 0.292, 0.0352, 0.0152, 0)$
U_2	$A_2 = (0.0946, 0.0946, 0.0370, 0.0165)$	$B_2 = A_2 \cdot R_2 = (0.0193, 0.0890, 0.1146, 0.0197, 0)$
U_3	$A_3 = (0.3782, 0.1755, 0.0787, 0.0370)$	$B_3 = A_3 \cdot R_3 = (0.0685, 0.3976, 0.1603, 0.0430, 0)$

4.3.2 Two-level fuzzy comprehensive evaluation

One-level fuzzy comprehensive evaluation results B_1, B_2 and B_3 can form U 's fuzzy relation matrix R as

$$R = \begin{vmatrix} 0.0085 & 0.292 & 0.0352 & 0.0152 & 0 \\ 0.0193 & 0.0890 & 0.1146 & 0.0197 & 0 \\ 0.0685 & 0.3976 & 0.1603 & 0.0430 & 0 \end{vmatrix}.$$

The vector of the weights of main factors is $A = (0.880, 0.2426, 0.6694)$. Two-level fuzzy comprehend-sive evaluation is then carried out based on $B = A \cdot R$ to obtain the comprehensive risk evaluation result of direct investment of enterprise S in country X as

$B = (0.0513, 0.2904, 0.1382, 0.0349, 0)$

4.4 ANALYSIS ON FUZZY COMPREHENSIVE EVALUATION RESULTS

Fuzzy comprehensive evaluation result B is a vector. The principle of maximum membership degree is used to determine risk level. The corresponding hierarchy of the biggest component in vector B is that of the comprehensive evaluation of investment risk.

Fuzzy comprehensive evaluation result B show that its membership degrees to the five risk levels of "higher, high, average, low, lower" are respectively 0.0513, 0.2904, 0.1382, 0.0349 and 0, with the largest membership degree of 0.2904. It can be inferred that the comprehensive risk evaluation result of direct investment of enterprise S in country X is "high". Therefore, enterprise S shall be cautious in the investment.

5 Conclusion

The direct overseas investment of Chinese enterprise is confronted with many uncertainties, which is the resource of risks that Chinese enterprises face. Fuzzy comprehensive evaluation method is an appropriate method to assess the risk of oversea investment, which use mathematical language to describe dynamic, fuzzy and difficult problems. It is worth noting that fuzzy hierarchical comprehensive evaluation fails to adjust weight automatically on new information, so it fails to adapt to the uncertainty of the evaluation object. Besides factors which cause risks changes constantly, risk comprehensive evaluation should integrate static evaluation and dynamic evaluation and adjust the index system constantly.

Conflict of Interest

The authors confirm that this article content has no conflicts of interest.

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