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Investment Risks Evaluation of High-tech Projects Based on Analytic Hierarchy Process

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***Abstract*—The paper firstly proposed an evaluation index system for high-tech projects investment risks from six aspects, and then built the investment risks evaluation model of high-tech project based on Analytic Hierarchy Process (AHP). Through the analysis, we obtained the weights of each risk index, which provided basis for decision-making.**

Keywords-high-tech projects; investment risks evaluation; analytic hierarchy process

I. INTRODUCTION

High-tech industry which is the main prop of knowledge economy society needs capital support for its development. Therefore, investment into high technology industry acts as important power in economic growth. However the investors must take prudent action because of the extremely high risks in this field. Besides conventional feasibility analysis, the investors should judge the risk factors in detail to determine the investment value of a particular high technology project [1, 2]. Based on this requirement, this paper presents a comprehensive indicator system for venture evaluation of investment into high technology projects from the angels of technology, manufacture, market, management, finance and environment. The paper first proposes an evaluation index system for high-tech projects investment risks from six aspects, and then builds the investment risks evaluation model of high-tech project based on Analytic Hierarchy Process (AHP).

II. THE EVALUATION INDEX SYSTEM OF HIGH-TECH PROJECTS INVESTMENT RISKS

In the investment process of high-tech projects, risk assessment results basically decide the success of the projects. For the risk assessment of corresponding projects, in the use of certain assessment methods and models, it is necessary to establish a certain risk evaluation index system in order to reasonably reflect the degree of project risks. The risk evaluation index for high-tech projects investment should consider each side of project risks and at the same time classify the risks in accordance with a certain standard. Combined with China's national conditions and domestic high-tech industries, the investment risks of high-tech projects can be divided into six aspects: R&D risks, technology risks, production risks, management risks, market risks and environmental risks [3, 4].

(1) R&D risks. R&D risk refers to the uncertainty of the expected R&D goal because of the changes in the R&D activities, including theoretical foundations, human resources, information resources and R&D conditions.

(2) Technology risks. Technology risks mean the risks caused by the own deficiencies of new ideas and scientific researches (that is, the technologies themselves are imperfect) and the emergence of other new alternative technologies, including technology maturity, technology practicality, technology matching and technology life cycle.

(3) Production risks. Production risks refer to the uncertainties caused by the changes the level of production equipment, production personnel constitution, raw material supply and so on. It runs through the entire production process from beginning to end.

(4) Market risks. Market risks refer to the uncertainty of market competition advantages lead by a variety of internal and external factors including market prospects, product competitiveness, potential competitors, marketing abilities, and so on.

(5) Management risks. Management risks refer to the risks caused by whether the leadership has uniform agreement on high-tech projects investment or not and the non-applicability of managers and staff quality, which include managers' quality and experiences, the rationality of project organization, the scientificity of decision-making and project management mechanisms so on.

(6) Environmental risks. Environmental risks refer to the risks caused by market demand fluctuations as a result of social, political (policy and legal), natural and economic environment, involving in national industrial policies, macroeconomic environments, and natural environments.

In addition to the above several risk aspects, high-tech project investment also face financial risks, financing risks, intellectual property risks, credit risks and so on [5]. For investment risk assessment on high-tech projects, the focus should be concerned about technology risks, market risks and management risks and so on. Based on the above analysis of risk factors, we can accordingly build the investment risk evaluation index system of high-tech projects, as shown in Table I.

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TABLE I. THE INVESTMENT RISK EVALUATION INDEX SYSTEM OF HIGH-TECH PROJECTS

The goal	The criterion layer	The index layer
G Risk evaluation of high-tech projects investment	C_1 : R&D risks	I_{11} : theoretical foundations
		I_{12} : human resources
		I_{13} : information resources
		I_{14} : R&D conditions
	C_2 : technology risks	I_{21} : technology maturity
		I_{22} : technology practicality
		I_{23} : technology matching
		I_{24} : technology life cycle
	C_3 : production risks	I_{31} : the level of production equipment
		I_{32} : production personnel constitution
		I_{33} : raw material supply
	C_4 : market risks	I_{41} : market prospects
		I_{42} : product competitiveness
		I_{43} : potential competitors
		I_{44} : marketing abilities
	C_5 : management risks	I_{51} : managers' quality and experiences
		I_{52} : the rationality of project organization
		I_{53} : the scientificity of decision-making
		I_{54} : project management mechanisms
	C_6 : environmental risks	I_{61} : national industrial policies
		I_{62} : macroeconomic environments
		I_{63} : natural environments

III. ANALYTIC HIERARCHY PROCESS

The Analytic Hierarchy Process (AHP) is a structured technique for helping people deal with complex decisions. rather than prescribing a "correct" decision, the AHP helps people to determine one. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. The AHP provides a comprehensive and rational framework for structuring a problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. It is used throughout the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education.

Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently [6]. The elements of the hierarchy can relate to any aspect of the decision problem—tangible or intangible, carefully measured or roughly estimated, well- or poorly-understood—anything at all that applies to the decision at hand. Once the hierarchy is built, the decision makers systematically evaluate its various elements, comparing them to one another in pairs. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations. The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques. In the final step of the process, numerical priorities are derived for each of the decision alternatives. Since these numbers represent the alternatives' relative ability to achieve the decision goal, they allow a straightforward consideration of the various courses of action.

VI. INVESTMENT RISKS EVALUATION OF HIGH-TECH PROJECTS BASED ON AHP

The paper prepared and carried out questionnaires to relevant experts, high-tech industry manager and first-line personnel of risk assessment. 35 copies of questionnaires are sent and 31 withdrawn, with 88.6 percent response rate. According to the established investment risk evaluation index system of high-tech projects in Table l, the paper applied AHP, on the basis of withdrawn questionnaire, to determine the weights of all indexes. Among them, for the indexes in the same criteria layer, we apply 1-9 proportional scaling method (as Table II shows) to determine the relative weights of each index, and calculate the Eigenvectors (i.e., weights) and the largest eigenvalue of judgment Matrix. For example, in the criterion layer, there are six criterions: R&D, technology, production, market, management and environment, their pair-wise judgment matrix relative to the goal is shown in Table III. From Table III, we can calculate the Eigenvectors of the judgment matrix:

$$C = (C_1, C_2, C_3, C_4, C_5, C_6) = (0.2900, 0.2901, 0.0942, 0.1726, 0.1017, 0.0441)$$

Where the largest eigenvalue $\lambda_{\max} = 6.0693$, the consistency index CI =0.0139<0.1, the relative consistency index CR =0.0112<0.1, which all meet the consistency test, so the eigenvalues can be directly taken the weights of each criteria [7, 8].

TABLE II. 1-9 PROPORTIONAL SCALING METHOD

$a_{ij} = 1$	u_i is as important as u_j
$a_{ij} = 3$	u_i is a little more important than u_j
$a_{ij} = 5$	u_i is obviously more important than u_j
$a_{ij} = 7$	u_i is strongly more important than u_j
$a_{ij} = 9$	u_i is extremely more important than u_j

Note: 2, 4, 6, 8 are the medians of above judgment

TABLE III. THE PAIR-WISE JUDGMENT MATRIX OF CRITERIONS RELATIVE TO THE GOAL

G	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	1	3	2	3	5
C_2	1	1	3	2	3	5
C_3	1/3	1/3	1	1/2	1	3
C_4	1/2	1/2	2	1	2	4
C_5	1/3	1/3	1	1/2	1	3
C_6	1/5	1/5	1/3	1/4	1/3	1

TABLE IV. THE WEIGHTS OF EACH INDEX IN VARIOUS LAYER

The goal	The criterion layer	Criterion weights	The index layer	Membership weights	Synthetic weights	The consistency test
G Risk evaluation of high-tech projects investment	C_1 : R&D risks	0.2900	I_{11} : theoretical foundations	0.5318	0.1542	$\lambda_{\max}$ =4.1142 CI =0.0381 CR =0.0423
			I_{12} : human resources	0.2702	0.0784	
			I_{13} : information resources	0.1221	0.0354	
			I_{14} : R&D conditions	0.0760	0.0220	
	C_2 : technology risks	0.2901	I_{21} : technology maturity	0.3909	0.1134	$\lambda_{\max}$ =4.1232 CI =0.0411 CR =0.0457
			I_{22} : technology practicality	0.3638	0.1055	
			I_{23} : technology matching	0.1596	0.0463	
			I_{24} : technology life cycle	0.0857	0.0249	
	C_3 : production risks	0.0942	I_{31} : The level of production equipment	0.5278	0.0497	$\lambda_{\max}$ =3.0536 CI =0.0300 CR =0.0462
			I_{32} : production personnel constitution	0.3325	0.0313	
			I_{33} : raw material supply	0.1396	0.0132	
	C_4 : market risks	0.1739	I_{41} : market prospects	0.1013	0.0176	$\lambda_{\max}$ =4.2411 CI =0.0804 CR =0.0893
			I_{42} : product competitiveness	0.2242	0.0390	
			I_{43} : potential competitors	0.1633	0.0284	
			I_{44} : marketing abilities	0.5112	0.0889	
	C_5 : management risks	0.1077	I_{51} : managers' quality and experiences	0.3000	0.0323	$\lambda_{\max}$ =4.0000 CI =0.0000 CR =-3.290
			I_{52} : the rationality of project organization	0.3000	0.0323	
			I_{53} : the scientificity of decision-making	0.3000	0.0323	

		I_{54} : project management mechanisms	0.1000	0.0108	
C_6 : environment risks	0.0441	I_{61} : national industrial policies	0.4791	0.0211	$\lambda_{\max}$ =3.0020
		I_{62} : macroeconomic environments	0.4583	0.0202	CI =0.0046
		I_{63} : natural environments	0.0626	0.0028	CR =0.0079

TABLE V. THE SIMPLIFIED INVESTMENT RISK EVALUATION INDEX SYSTEM OF HIGH-TECH PROJECTS

C_1 : R&D risks	I_{11} : theoretical foundations	C_4 : market risks	I_{42} : product competitiveness
	I_{12} : human resources		I_{43} : potential competitors
	I_{13} : information resources		I_{44} : marketing abilities
	I_{14} : R&D conditions		
C_2 : technology risks	I_{21} : technology maturity	C_5 : management risks	I_{51} : managers' quality and experiences
	I_{22} : technology practicality		I_{52} : the rationality of project organization
	I_{23} : technology matching		I_{53} : the scientificity of decision-making
	I_{24} : technology life cycle		
C_3 : production risks	I_{31} : the level of production equipment	C_6 : environmental risks	I_{61} : national industrial policies
	I_{32} : production personnel constitution		I_{62} : macroeconomic environments

Similarly, we can construct pair-wise judgment matrices of the indexes in the index layer relative to corresponsive criterion in the criterion layer, and calculate the membership weights of each index relative to its criterion, and the synthetic weights relative the goal, concrete results as Table VI shows.

As the *CR* value of each judgment matrix is less than 0.1, you can think that they meet the consistency test, and then calculate the membership weights and synthetic weights of various indexes, as shown in Table VI. We remove the indexes whose weights are less than 0.02, so four indexes: I_{33} , I_{41} , I_{54} and I_{63} are excluded. The simplified investment risk evaluation index system of high-tech projects is shown as Table V. On the one hand, the exclusion can guarantee the contribution rate of the cumulative weight of the remaining 18 indexes is more than 90%, which will not affect the degree of risk assessment; on the other hand, the number of indexes is reduced from 22 to 18, the simplification range 18.18%.

V. CONCLUSIONS

High-tech projects investment occupying large funds and with many uncertainties, in the investment process many unpredictable risks are there, so some enterprises have suffered huge losses in the projects investment process due to ignorance of risk assessment or using improper evaluation methods. Therefore, it is essential to apply scientific risks evaluation methods to analyze and evaluate the risks of high-tech projects. In terms of the qualitative analysis of the risks investment on high-tech projects, many literatures at home and abroad are mostly focused on the description of evaluation index system, no works to explore and integrate those risk factors theoretically and in-depth. While the quantitative analysis on high-tech projects risk has also accumulated a certain amount, and become an important research direction. The paper first proposes an evaluation index system for high-tech projects investment risks from six aspects, and then builds the investment risks evaluation model of high-tech project based on Analytic Hierarchy Process (AHP). Through the analysis, we obtain the weights of each risk index, which provides basis for decision-making.

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