Establishment of AHP-Fuzzy Model for Risk Assessment of High-tech Start-ups

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Abstract: **High-tech start-ups play an increasingly important role in the growth of national economy and are the source of modern economic growth. On the basis of risk identification and analysis of high-tech start-ups, this paper establishes a risk assessment index system for high-tech start-ups, then this paper proposes a risk assessment model of high-tech start-ups based on AHP-Fuzzy, which provides theoretical guidance for high-tech enterprises to conduct risk assessment scientifically. At the end of this paper, the application of this model in practice is illustrated by empirical analysis.**

Keywords: High technology; Start-up enterprises; Analytic hierarchy process; Fuzzy comprehensive assessment; Risk assessment.

I. INTRODUCTION

With the rapid growth of the national economy, technology has been one of the main drivers of economic development, and high-tech start-ups have played an important role in promoting technological advancements in the industry, adding jobs and so on. However, high-product added-value, high technology content and short life-cycle features of high-tech start-ups make it a typical high-risk enterprise. Therefore, how to reduce the risk of enterprises effectively and extend the life cycle of enterprises has become an inevitable practical problem.

Scholars at home and abroad have conducted a lot of detailed studies on entrepreneurial risks [1-5], the research content mainly focuses on the identification of entrepreneurial risk factors, risk assessment and risk assessment and so on. Different scholars give different opinions on the risks faced by high-tech start-ups [6-10]. But in terms of existing research, although many scholars have made detailed analysis on the risks of technology, market and human resources of high-tech enterprises, the risk factor analysis at the enterprise level is still insufficient, and there is no in-depth exploration on the risk assessment of high-tech start-ups.

On the basis of risk analysis of high-tech start-ups this paper uses field investigation method and Delphi method to identify key indicators. Then this paper constructs a risk assessment system for high-tech start-ups, and combines AHP with Fuzzy technology to construct a comprehensive risk assessment model for high-tech start-ups. The case study shows that the model is not only scientific and reliable, but also simple and practical.

II. THE ESTABLISHMENT OF RISK ASSESSMENT INDEX SYSTEM FOR HIGH-TECH START-UPS

In order to make the constructed index system meet the requirements of science, system optimization, practicability and objectivity we adopt the method of combination of literature analysis and expert investigation. First of all, according to domestic and foreign relevant literature, the preliminary formulation of high-tech start-up companies risk assessment index system, ask experts in related fields to correct the index system, and then modify the indicator system according to the opinions of experts, and invite experts to correct, get a scientific and reasonable index system, as shown in TABLE I.

TABLE I. THE RISK ASSESSMENT INDEX SYSTEM OF HIGH-TECH START-UP ENTERPRISES

Grade I Indexes	Grade II Indexes
Environmental Risk X_1	Political and legal environment X_{11}
	Macroeconomic environment X_{12}
	Sociocultural environment X_{13}
Technical Risk X_2	Technical maturity X_{21}
	Technical applicability X_{22}
	Technology life cycle X_{23}
	Loss of vulnerability X_{24}
Production Risk X_3	The composition of production technicians X_{31}
	Production equipment and technology level X_{32}
	Supply of raw materials X_{33}
Market Risk X_4	Product competitiveness X_{41}
	Marketing ability X_{42}
	Market prospect X_{43}
	Industry competition situation X_{44}
Financial Risk X_5	Financing ability X_{51}
	Debt paying ability X_{52}
	Earning capacity X_{53}
Management Risk X_6	The quality and ability of entrepreneurs X_{61}
	The management system is reasonable X_{62}
	Identification of decision-making X_{63}
Human Resource Risk X_7	Liquidity risk X_{71}
	Human resources moral hazard X_{72}
	Entrepreneurial team cooperation status X_{73}

III. THE CONSTRUCTION OF AHP-FUZZY MODEL FOR RISK ASSESSMENT OF HIGH-TECH START-UP ENTERPRISES

Analytic hierarchy process (AHP) is an analytical method of hierarchical weight decision proposed by American operational research scientist Thomas L. Saaty in the early 1970s. It is a hierarchical weight decision analysis method combining qualitative and quantitative analysis. AHP

analyzes complex problems by constructing hierarchical structures. AHP digitizes the thought of evaluation and has wide application basis. Fuzzy sets were proposed by American operational research experts L.A.Zadeh in 1965 to represent fuzzy problems mathematically. It is a method of comprehensive evaluation of various indicators of things by means of the concept of fuzzy mathematics. In the following, we combine the AHP [11-12] and the fuzzy evaluation method [13] to process the data to evaluate the risk of high-tech startups.

A. The Determination of Index Weight Coefficient

There are many factors in the risk evaluation index system of high-tech startups and the factors are related to each other. Therefore, we choose the analytic hierarchy process (AHP) to determine the weight of indicators. The basic steps include: First of all, establish a judgment matrix, use the two-by-two comparison method, and ask the experts to measure the relative importance of each index element according to the principle of 9 scale and form a judgment matrix; Then, use the normative column average method to calculate the eigenvalues of each indicator and perform consistency checking; Finally, after obtaining the weight vector of each factor on the upper level indicator, the overall importance of each index element on the overall level can be calculated from top to bottom. At this point, you can get the weight of all indicators.

B. The Risk Classification of High-tech Start-ups

According to the characteristics of the high-tech start-up industry, we divide the degree of risk into five levels. The assessment set consists of high to low comments:

V={Low risk，Lower risk，Moderate risk，Higher risk，High risk}={Ⅰ,Ⅱ,Ⅲ,Ⅳ,Ⅵ}={V_1,V_2,V_3,V_4,V_5}

Graded by Experts Mark, with a score of 10, the higher the score, the stronger the ability of the relevant parties and the smaller the risk. The classification inserts 4 equidistant points a1、a2、a3、a4 between the best and worst critical values. The risk index rating table of high-tech start-ups is obtained, as shown in TABLE II.

TABLE II. THE RISK INDEX CLASSIFICATION OF HIGH-TECH START-UPS

Index level	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ
Score	[8,10]	[6,8)	[4,6)	[2,4)	[0,2)

C. The Calculation of Membership Function Value

All the experts (n experts) involved in the evaluation are asked to rate the evaluation indicators according to the assessment methods presented in table 3-1 and take the average score s_{ij} of a certain index as the index score. According to the method judged above, all indicators are effective indicators, that is, the bigger and better. At this point, the membership degree of the indicator x_{ij} belonging to the rank at is:

$$x_{ij}^{1}=\begin{cases}1 & x_{ij}\ge a_5\\ (x_{ij}-a_4)/d & a_4\le x_{ij}<a_5\\ 0 & x_{ij}<a_4\end{cases} \quad (1)$$

$$x_{ij}^{(t)}=\begin{cases}0 & x_{ij}\ge a_{6-t+1}\\ (a_{6-t+1}-x_{ij})/d & a_{6-t}\le x_{ij}<a_{6-t+1}\\ (x_{ij}-a_{6-t-1})/d & a_{6-t-1}\le x_{ij}<a_{6-t}\\ 0 & x_{ij}<a_{6-t-1}\end{cases} \quad (2)$$

$$x_{ij}^{5}=\begin{cases}1 & x_{ij}<a_0\\ (x_{ij}-a_0)/d & a_0\le x_{ij}<a_1\\ (a_2-x_{ij})/d & a_1\le x_{ij}<a_2\\ 0 & x_{ij}\ge a_2\end{cases} \quad (3)$$

Among them, t=2, 3, 4 ; d=(a_5-a_0)/5; X_{ij} is the actual value of the index x_{ij}. X_{ij}^{t} represents the membership of the indicator x_{ij} to the rank at.

In this way, we can obtain an evaluation matrix R compose of that indicator layer's subordinate function value X_{ij}^{t}.

D. The Comprehensive Risk Assessment for High-tech Start-ups

The single index evaluation was conducted for each index of factor layer Xi, and the evaluation matrix $R_i=(x_{ijt})^{n*p}$ n*p was obtained. The fuzzy judgment set S was obtained through the fuzzy transformation of weight coefficient matrix W and evaluation matrix R.

$$S=W\circ R=(\omega_1\ \ \omega_2\ \ \dots\ \ \omega_m)\circ\begin{bmatrix}X_{11} & X_{12} & \dots & X_{1n}\\ X_{21} & X_{22} & \dots & X_{2n}\\ \dots & \dots & \dots & \dots\\ X_{m1} & X_{m2} & \dots & X_{mn}\end{bmatrix}=(s_1,\ s_2,\ \dots,\ s_n) \quad (4)$$

After evaluating m elements of X, the total evaluation matrix is obtained:

$$A=(S_1,\dots,S_m)^{T} \quad (5)$$

The comprehensive evaluation value is

$$S=WOA \quad (6)$$

Finally, according to the principle of maximum membership, a comprehensive evaluation conclusion can be made on the risk of high-tech start-ups. Thus, the risk level of high-tech start-ups can be obtained, and the risk level of various elements can be obtained, so as to facilitate the identification of key risks.

IV. THE EMPIRICAL ANALYSIS

In May 2015, a graduate of Stanford University, has served in the well-known technology companies of the world's top 500

of the returnees entrepreneurial teams in Shenzhen founded RY technology company. Risk assessment of RY Technology Company is conducted as follows:

1) Establish the risk assessment index system of RY company, as shown in TABLE I.

2) The general process of determining the weight coefficient of evaluation indicators is as follows:

First of all, the relevant experts were asked to compare the relative importance of elements according to the 1-9 scale

method to obtain the judgment matrix. Then, the sum method was used to calculate the characteristic values and conduct the consistency test, requiring the consistency ratio CR=CI/RI<0.1. According to the expert opinion, the corresponding normalized weight vector can be obtained.

At this point, we can obtain the relative weight direction scale of the indicator layer, as shown in TABLE III.

TABLE III. RELATIVE WEIGHT DIRECTION SCALE

（X_1, X_2, X_3, X_4, X_5, X_6, X_7）	（0.024, 0.413, 0.091, 0.246, 0.034, 0.063, 0.129）
（X_{11}, X_{12}, X_{13}）	（0.648, 0.230, 0.122）
（X_{21}, X_{22}, X_{23},	（0.272, 0.482, 0.088, 0.158）
（X_{31}, X_{32}, X_{33}）	（0.633, 0.260, 0.106）
（X_{41}, X_{42}, X_{43},	（0.494, 0.148, 0.291, 0.067）
（X_{51}, X_{52}, X_{53}）	（0.539, 0.164, 0.297）
（X_{61}, X_{62}, X_{63}）	（0.283, 0.643, 0.074）
（X_{71}, X_{72}, X_{73}）	（0.581, 0.110, 0.309）

3) Calculate the membership function value.

Experts were asked to grade according to the actual situation, take the average score, and calculate the membership function value according to the formula (3.1-3.3).We can get the evaluation matrix R composed of the value of each indicator membership function x_{ijt} in the indicator layer. X_{ijt} represents the membership function value of the j_{th} index under the i_{th} element under the rank at. For example, the fuzzy evaluation matrix R1 of environmental risk indicator layer is:

$$R_1 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0.75 & 0.25 & 0 & 0 \\ 0 & 0.45 & 0.55 & 0 & 0 \end{bmatrix}$$

4) According to the formula (3.4-3.6), the comprehensive evaluation vector of the target layer and the criterion layer can be obtained. Taking the environmental risk index as an example, according to the formula, the fuzzy evaluation vector of environmental risk is:

$$s_1 = w_1 \cdot R_1 = (0.648,\ 0.230,\ 0.122) \cdot \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0.75 & 0.25 & 0 & 0 \\ 0 & 0.45 & 0.55 & 0 & 0 \end{bmatrix}$$

$$= (0,\ 0.875,\ 0.125,\ 0,\ 0)$$

According to the principle of maximum membership, the comprehensive evaluation grade of various elements of RY enterprise can be obtained, as shown in TABLE IV.

TABLE IV. COMPREHENSIVE RISK ASSESSMENT RESULTS OF RY START-UP ENTERPRISES

The evaluation object	Comprehensive assessment results	Grade
Environmental Risk	（0, 0.875, 0.125, 0, 0）	II
Technical Risk	（0.204, 0.524, 0.245, 0.027, 0）	II
Production Risk	（0, 0.027, 0.396, 0.447, 0.13）	IV
Market Risk	（0.034, 0.404, 0.415, 0.074, 0.074）	III
Financial Risk	（0, 0.662, 0.041, 0.297, 0）	II
Management Risk	（0, 0.396, 0.605, 0, 0）	III
Human Resource Risk	（0, 0.581, 0.11, 0.309, 0）	II
RY Comprehensive Risk	（0.093, 0.462, 0.296, 0.120, 0.03）	II

From the comprehensive evaluation result table 4-2, it can be seen that the risk of the enterprise comprehensive evaluation for "II", in a state of low risk. However, the company's production capacity is poor, the overall evaluation is only grade IV, and it is in a relatively high-risk state. Therefore, it is necessary to take immediate pre-control measures, otherwise it is very likely to have a great impact on the company. There are also poor market and management capabilities, and they are in Class III. They are in a general state of risk and should improve their capabilities.

V. CONCLUSION

With the advent of knowledge-based economy, high-tech entrepreneurial activity has gradually become the main reason to drive China's economic growth. Whether there is a scientific and reasonable assessment of risk, is directly related to the success of high-tech start-ups. By constructing AHP-Fuzzy risk evaluation model of high-tech start-ups, this paper makes a quantitative analysis of the risks faced by high-tech start-ups. It makes up for the lack of systematisms, comprehensiveness and practicability of the previous evaluation methods, and provides a reference for high-tech start-ups to solve relevant risk problems.

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