# Research on Evaluating Science and Technology Trust Degree of Innovative Enterprises

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**Abstract**　Innovative enterprise, as a main innovation part, is an important force to build an innovation-oriented country. Its trust in science and technology is one of the key factors to determine whether it can complete innovation projects and innovation research successfully. Based on systematic analysis, comparison and comment of the research actuality in both domestic and overseas, this paper analyses the factors which impact the trust degree in the scientific and technological evaluation. From the result of the literature study, expert investigation, and the qualitative and quantitative analysis, it establishes evaluation index system of innovative enterprises' trust in science and technology. At the same time, it introduces the fuzzy comprehensive evaluation method that was used in the evaluation of science and technology.
**Key words**　Innovative enterprise; Trust degree in science and technology; Evaluation index system; Fuzzy comprehensive evaluation

## 1 Introduction

Building an innovative country is one of the strategic objectives and tasks of building a socialist harmonious society. Innovative enterprise is an important force for technological innovation. To building an innovative country should improve independent innovation capability of enterprises and reduce the risks, so it's necessary to strengthen our innovative enterprise management and evaluation. And the level of trust in business is a more important index of evaluating a company.

In the era of market economy, it'll be an inevitable trend to consider each other's trust when choose partner or trading account. The higher index of enterprise's trust degree, indicating the greater the possibility of completing projects and tasks, the smaller risk of commission, the greater benefit can be acquired. Innovative enterprises occupy an important position in the social development, economic growth, so we need to establish a complete and reliable evaluation index system of trust degree in science and technology. Currently the research on trust mainly focused on individuals, teams, enterprises, listed companies, financial reporting etc, and it needs be further explored because the research methods and evaluation factors have not yet formed a complete system. The researches both at home and abroad among the comprehensive evaluation methods of trust degree are: fuzzy comprehensive evaluation method, AHP, artificial neural network, genetic algorithm, close value method, factor analysis procedure and so on. However the research on innovative enterprises' trust degree is rare. Referencing the study result of the literature in domestic and international, and using the Delphi method, this paper will establishes evaluation index system of innovative enterprises' trust in science and technology. And then it uses AHP (Analytic Hierarchy Process) to implement the fuzzy comprehensive evaluation.

## 2 Establish the Evaluation Index System

### 2.1 Innovative enterprises' characteristics

Innovative enterprises have a significant historical responsibility on the full realization of the goal of building a moderately prosperous society. Compared with the traditional business, innovative enterprises have different characteristics which decide that we should build a new technology trust evaluation system for these enterprises.

Most founders of innovative enterprises are technology researcher original, who possess high quality and the reform spirit, and have courage and insight to lead the companies to open up the domestic and foreign markets. These enterprises pay attention to personnel training, have strong independent innovation talents teams, and establish good talent management systems. They own autonomous intellectual property of core technology and technology innovation system, so their overall technological level is in the advanced position in the industry. They also have high-tech products and technology transfer capabilities. In the development of practice, most of them formed a unique system of operating mechanisms: dynamic mechanism of spiritual civilization and creating material wealth,

technological innovation mechanism of adhering to independent research and development, and changing technological achievements into productive forces, independent decision-making mechanism, market-oriented operation mechanism, behavior mechanism of self-accumulation and self-restraint, and people-oriented corporate culture mechanism etc.

**2.2 Evaluation index system**

To evaluate the credibility of innovative enterprise technology assessment is a comprehensive evaluation process, which needs to consider comprehensive, objective and concrete measures of various influential factors that contain the influence of both internal and external environment and the policy factors. Through the reference of innovative enterprise technology at home and abroad on the theory and practice of credibility assessment results, the evaluation index system is formed by qualitative and quantitative index, including 6 primary indices and 21 secondary indices.

In selecting business confidence indices we have two steps: first, make a preliminary selection according to the basic theory of knowledge and expert experience, then make a further selection according to the contribution of each index of enterprise credibility. Screening for index is the main method of statistical analysis of enterprise credibility, eliminate the index that has little contribution and that provides repeated information, and then we can form trust evaluation index system of the innovative enterprise technology though finding out the main influencing factors. Enterprise technology trust evaluation index system is a comprehensive index collection, which concerns researching ability and basic qualities of enterprise, and external macroeconomic environment and so on. This research is made according to the survey by experts firstly, and then we fix the initial index by analyzing and arranging the experts' choosing results. After that, we offer the results to every expert and get their marks so that they can make a second correction for their decision, which will lay a foundation for fixing the index. Also, we can decide whether choose a certain index or not by co relational analysis and discriminating analysis. We do this for times until all the experts' ideas tend to concentration, eventually form the evaluation index system of this research, as the following table 1.

**Table 1   Innovative Enterprise Technology Trust Evaluation Index System**

| | Primary indicators | Secondary indicators |
|---|---|---|
| Innovative Enterprise Technology Trust Evaluation Index System | R & D capabilities | Intensity of investment in research and development funds |
| | | The intensity of investment in research and development personnel |
| | | Degree of scientific and technological projects completed |
| | | Equipment renewal rate in recent 3 years |
| | Technology Transfer ability | The transformation technology projects average annual production nearly 3 years |
| | | New product development and intellectual property ownership |
| | | The technical level of main products |
| | | Relativity between projects and enterprises |
| | Financial situation | Return on net assets |
| | | Ratio of external financing |
| | | Asset turnover |
| | Company Market Positioning | Market share |
| | | Brand Awareness |
| | | Product quality |
| | | Price advantage |
| | Basic quality of enterprise | Enterprise management |
| | | Corporate reputation and performance status |
| | | Business-related work experience |
| | An external macro-environment | Industry characteristics |
| | | The industry average growth rate of value |
| | | Impact of macroeconomic policy |

# 3 The Fuzzy Comprehensive Assessment

Many factors need to be considered in the evaluation and research of trust degree in science and technology in innovative enterprise. It refers to many complex phenomena and interactions between several factors and some of them cannot be evaluated quantitatively, such as corporate reputation, the level of management, it needs qualitative indices to measure, so we choose the method of fuzzy

comprehensive assessment to establish the evaluation model. Base on the system of evaluation, questionnaire survey and expert scoring situation we determine the index weight, then evaluate it.

**3.1 Establish set of evaluation factors**

Establish set of evaluation factors X, its target for the evaluation of the various factors affecting the composition of the set. Resolve these various factors related into several levels beginning at the top in accordance with different attributes, the same level of various factors subordinate to the upper level of the factor or affect it. Various factors relating to different attributes in accordance with the decomposition into a number of top-down hierarchy, subordinate to the same level of various factors on the upper level of the factor or factors that affect the same time under the control of the lower layer of the factors or by the role factors .While under the control of the lower layer of the factors or affected by the role factors.

Correlation analysis of hardiness indices means to judge whether there is relevance and of the size of the relevance between the two indices .According to the correlation analysis of indices, we can exclude some of the larger correlation coefficient evaluation, eliminate results of duplication of information on the evaluation .The formula for calculating the correlation coefficient:

$$r = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2(y_i - \overline{y})^2}} \tag{1}$$

We use the method of repeatedly survey analyze the results of each time on the correlation, removing the larger relevance of indices, and then feedback to the expert, repeat investigation and analysis of the indices, to finalize the evaluation index system.

**3.2 Establish set of indices weights**

Analytic hierarchy process is a combination of qualitative and quantitative, systematic, hierarchical analysis method. In dealing with complex decision, it can make on the issue of practicality and effectiveness. The basic idea is: comparing the effect of a number of factors to the same goal, determine their proportion in the target. Analytic hierarchy process can process the determined weights; try to eliminate the subjective composition, making it accordance with the objective facts. Calculated by AHP comprehensive evaluation index system of weights is as a simple method to solve the non-quantitative evaluation of the quantitative analysis of the incident, is also an effective method to do on people's subjective judgments and objective description. Using this method to determine the weights, can reflect the actual situation, and make a high practical value to evaluate the result. We obtain the comparison matrix through the expert investigation and the allocation, and then determine the evaluating indicator weight of innovation enterprise science and technology trust degree by the method of analytic hierarchy process:

$$W = \{w_1, w_2, w_3, w_4, w_5, w_6\}, w_1 = \{w_{11}, w_{12}, w_{13}, w_{14}\}, \ldots\ldots, \quad w_6 = \{w_{61}, w_{62}, w_{63}, w_{64}\}$$

**3.3 Determine the membership degrees**

If we use a simple mathematical indicator to limit the classifications of the enterprises' trust degree of science and technology, it will cause the fact that boundaries on both sides are divided into different grade. For example, evaluation results define the 90 points as excellent, but 89 points are defined as good. In fact, as the enterprises' trust degree is a fuzzy concept, so we use the membership concept to describe the grade boundaries of fuzzy trust degree. The degree of membership is a level of things that belongs to a standard, such as when the evaluation result is 95, it's 100% attached to the excellent level; if result is 89, it's 92% attached to excellent level. In determining the membership function, we should pay attention to distinguish between qualitative and quantitative indices.

3.3.1 Membership function of qualitative indices

Membership function of qualitative indices is to make the experts judge which grade a certain evaluation index belongs to. Then we calculate the proportion of the number of people whose evaluation is in some level of the total number of evaluation people as $v_i$, and get the membership vector of the index. The formula is as follows:

$$v_i = \frac{\sum v_{ik}}{n} \tag{2}$$

In equation (2), $v_i$ is the membership degree of a index belongs to the level $i, i = 1, 2, 3, \cdots n, v_{ik}$ is the evaluation values of the evaluators $k$ of a index belongs to the level $i$ , the evaluation value is 0 or 1, $n$ is the number of experts.

3.3.2 Quantitative Indices of Membership Function

In the evaluation index system, the forms, units, dimensionles, orders of magnitude are different, so it's not conducive to calculation. It needs the dimensionless treatment to eliminate units and magnitude

differences in order to make the results comparable. This paper uses linear interpolation method for the nondimensionalization. For a index $U_y$, the average expert rating is $d_y$, supposing the maximum of $U_y$ is $d_y^{\max}$ and the minimum is $d_y^{\min}$, then dimensionless score of $U_y$ is calculated as follows:

For the indices of the smaller numerical value the better: $M_y = \dfrac{d_y^{\max} - d_{ij}}{d_y^{\max} - d_y^{\min}} \times 100$ .

For the indices of the bigger numerical value the better: $M_y = \dfrac{d_{ij} - d_y^{\min}}{d_y^{\max} - d_y^{\min}} \times 100$ .

The dimensionless average score of $u_y$ $M_y \in [0,100]$ . In order to avoid some index's dimensionless average score $M_{ij}$ at the edge of its score interval causes irrational phenomena that similar scores have different review levels, we should make $M_{ij}$ fuzzy to get bottom index's subjection degree.

$$v_1 = \begin{cases} 1; M_{ij} \geq 95 \\ (M_{ij} - 85)/10; 85 \leq M_{ij} < 95 \\ 0; \end{cases} \quad v_2 = \begin{cases} (95 - M_{ij})/10; 85 \leq M_{ij} < 95 \\ (M_{ij} - 75)/10; 75 \leq M_{ij} < 85 \\ 0; \end{cases} \quad v_3 = \begin{cases} (85 - M_{ij})/10; 75 \leq M_{ij} < 85 \\ (M_{ij} - 65)/10; 65 \leq M_{ij} < 75 \\ 0; \end{cases}$$

$$v_4 = \begin{cases} (75 - M_{ij})/10; 65 \leq M_{ij} < 75 \\ (M_{ij} - 55)/10; 55 \leq M_{ij} < 65 \\ 0 \end{cases} \quad v_5 = \begin{cases} (65 - M_{ij})/10; 55 \leq M_{ij} < 65 \\ (M_{ij} - 45)/10; 45 \leq M_{ij} < 55 \\ 0; \end{cases}$$

Based on index system, we determine the subjection degree of indices belong to remarks set. $v_{ij}$ is the subjection degree of number $i$ index belongs to number $j$ grade in some target level. $0 \leq v_{ij} \leq 1, \sum_{j=1}^{5} v_{ij} = 1$ , $i = 1,2,3,...,m$ , $j = 1,2,3,4,5$ Then we'll get comparative subjection degree matrix:

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix}$$

### 3.4 Establish remarks set

In evaluating science and technology trust degree of innovative enterprises, the remarks set is $R = \{r_1, r_2, r_3, r_4, r_5\}$ , $r_1, r_2, r_3, r_4, r_5$ they represent "excellent, good, general, passable, poor". The relations between remarks sets and score ranges are in Table 2.

**Table 2　The Relations Between Remarks Sets and Score Ranges**

| Remarks set | excellent | good | general | passable | poor |
|---|---|---|---|---|---|
| Score range | 100～90 | 90～80 | 80～70 | 70～60 | 60～0 |

### 3.5 Fuzzy comprehensive evaluation

We use $M(\bullet, +)$ to make fuzzy comprehensive evaluation. $B$ is comprehensive evaluation, $W$ is weight coefficient matrix, $V$ is index subjection degree matrix.

$$B = W \bullet V = [w_1, w_2, w_3, ..., w_m] \bullet \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix}$$

Make $B$ normalized get $B'$. Then we evaluate the result according to the principle of maximum subjection degree which is estimating the review owns maximum subjection degree. The evaluation result score of this grad: $G = B' \bullet R^T$ . Through rock-bottom $B'$ forms higher grade's matrix $V = \begin{pmatrix} B_1' \\ B_2' \\ \cdots \\ B_n' \end{pmatrix}$ .

Repeat the above calculation for every grade. At last acquire comprehensive evaluation matrix $B^*$ , make it normalized get $B^{*'}$ , the final evaluation result is: $G^* = B^{*'} \bullet R^T$ .

## 4 Conclusions

Innovative enterprises play an important role in technology transformation, when government management department give the main projects to enterprises instead of research departments or universities gradually. So it improves the technology transformation and independently innovative capabilities of these enterprises. However, not all innovative enterprises have the capability to undertake significant projects; the internal and external conditions will limit the enterprises development and impact the projects. Thus, science and technology management departments should evaluate the trust degree of innovative enterprises according to science and technology projects' types, features, and the conditions required for project implementation etc, and then base on the evaluation result determine the enterprise which undertakes the project.

It can greatly reduce the risks of technology project management and ensure the projects completed successfully. This paper's study may be not adequate, there are other methods and models in further studies in trust degree evaluation of innovative enterprises.

## References

[1] Chen Weidong, Xu Jingyi. Study on the Evaluation Index System of Innovative Enterprises[J]. Statistics and Decision, 2007, (22):181-183 (In Chinese)
[2] Han Guowen. Study on the Establishment of Personal Credit System in China[J]. China Soft Science, 2001, (6): 122-124 (In Chinese)
[3] Ning Xiaoqiu. The Principles and Methods of Fuzzy Math[M]. Xuzhou: China University of Mining Publishing House, 2004: 203-208 (In Chinese)
[4] Sun Minghua. Study on the Features and Functions of Innovative Enterprises[J]. Market Modernization, 2007, (15): 97-98 (In Chinese)
[5] Wang Yongfei, Chen Liuping, Chen Aimin, Study on the Evaluation Index System and Evaluation Model of Innovative Enterprises[J]. Statistics and Decision, 2007, (9): 81-82 (In Chinese)