

Research on Risk Management of Technological Innovation in High-Tech Enterprises Based on Project Promotion From Perspective of Innovation Value Chain

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ABSTRACT

Based on the theory of innovation value chain, the technological innovation process of high-tech enterprises can be divided into three stages: technological research and development, product development, and product marketing. This paper identifies the technological innovation risk of high-tech enterprises and constructs the evaluation index system of technological innovation risk of high-tech enterprises based on project promotion. Combined with practical examples, the analytic hierarchy process (AHP) and the fuzzy comprehensive evaluation method are used to evaluate and manage the risk of high-tech enterprises' technological innovation projects. The results show that the project risk is higher, the risk of technology research and development is highest and the risk of product development is lower, the risk of product marketing is higher. Furthermore, some suggestions are put forward on the risk response measures that should be taken by high-tech enterprises in each stage to help them effectively manage and prevent risks.

Keywords: *Innovation value chain, high-tech enterprise, technology innovation, risk management*

1. INTRODUCTION

Development experience shows that high-tech enterprises have played an important role in promoting national economic growth[1]. It has developed rapidly with the increasingly fierce competition in science and technology and the support of the development strategy of building an independent innovation-oriented country. However, projects are faced with various uncertain risks because of the influence of uncertain market demand, unreasonable decision-making, low management level, and financing difficulties. Besides, high-tech enterprises are typical risk-oriented enterprises led by technological innovation and driven by projects. High-tech enterprises are characterized by the coexistence of losses and gains. The decrease of income of general enterprises due to suffering from the risk. However, for high-tech enterprises, such losses can be regarded as a speculative risk, which will not only bring losses to operators but also bring them certain benefits. The risks of high-tech enterprises will be gradually magnified owing to the turbulent external environment and complex project process. Therefore, it is of great practical significance for high-tech enterprises to systematically evaluate the technological innovation project risks, effectively promote the smooth implementation of projects, improve the success rate, and operate efficiency.

The research results of scholars show different perspectives on the risk of technological innovation of enterprises. From the perspective of technological innovation risk sources, Jian-li Luo et al. [2] discussed the risk of technological innovation from internal factors,

technical factors, and external environmental factors. Wu Yunjian et al. [3] believed that there were huge risks in the innovation process, and technology, market, management, and capital were the main sources of innovation risks. Wang et al. [4] divided technological innovation risks into technical risks, marketing risks, organizational and environmental risks. From the perspective of technological innovation risk process, Rothwell [5] pointed out that the innovation process includes seven basic stages-new product creativity, applied research, testing and development, manufacturing, process improvement, market design, and market development. Berglund [6] regards technological innovation as a linear process of applied research, product development, manufacturing, marketing, and promotion.

Technological innovation is a process composed of many discrete behaviors. The processes from the designs of new products to project confirmation, design, and development, production, and marketing are influenced by many variables. The project risks run throughout the project lifecycle. It is still a hot topic to study the process risk of technological innovation. Therefore, this paper will discuss the risks in the development process of enterprise technological innovation projects from a new perspective of the innovation value chain, and consider the main subject as the most dynamic group -- high-tech enterprises. The analytic hierarchy process (AHP) and the fuzzy comprehensive evaluation method are used to study the technological innovation risk projects of high-tech enterprises. It is of a certain value to enrich the risk management theory and broaden the high-tech enterprises in the risk management field.

2. SYSTEM BUILDING

2.1. Analysis Framework of Technology Innovation Risk of Technological Innovation in High-Tech Enterprises

Innovation value chain theory is the combination of technology innovation theory and value chain theory. The opinion of Morten T Hansen & Julian Birkinshaw [7] is the most representative. According to the cyclic process of knowledge acquisition, transformation, development, and utilization, they divided the innovation value chain into three stages: the generation of ideas, the transformation of ideas, and the diffusion of ideas, and systematically analysed the innovation process through the interrelation among the stages. The innovation value chain under the perspective of value realization can well explain the enterprise innovation behaviour in the process from R & D to commercialization.

The technological innovation process of high-tech enterprises is the value realization process of the "innovation value chain". Only through research and development can new technologies be finally transformed into new products and put into the market. Referring to the theory in ref.7 and combining the characteristics of high-tech enterprises, this paper defines the technology innovation process of high-tech enterprises based on project promotion from the perspective of the innovation value chain, including three stages: technology R&D, product development, and product marketing. The technology research and development stage mainly refers to the project decision-making and research and development design stage. Decision-makers need to conduct a feasibility analysis and make project decisions according to internal and external conditions such as the enterprise's own resources, capacity, and market. Enterprises need to organize and allocate corresponding resources to start product design, including product prototype design, process, and technical design, etc. This stage is an essential starting point for project implementation, including new idea generation, requirements analysis, product design, and other work. The product development stage is the production and manufacturing stage of the product, which is also the key to realize mass production and production, including purchasing and manufacturing equipment, organizing the recruitment of workers, purchasing raw materials, and so on. Usually, it requires the enterprise to raise a large number of funds to ensure the smooth implementation of the project. The stage of product sales is the last link for enterprises to carry out technological innovation, and it is an important stage to enter the market circulation to check the effect, too. It is necessary to give full play to the marketing capabilities of enterprises to let consumers accept products and launch new products into the market. In conclusion, this paper defines the technology innovation management framework of high-tech enterprises from the

perspective of the innovation value chain (As shown in Figure 1.)

2.2. Risk Identification of Technology Innovation in High-Tech Enterprises

The technological innovation risk of high-tech enterprises is a multi-factor and multi-stage dynamic system, which is highly related to the uncertainty in the technological innovation development process. We investigate 103 high-tech enterprises, track the IT technology innovation process of related enterprises, and summarize three risks faced by enterprises: technology research and development risk, product development risk, and product marketing risk.

(1) Technology development risk. In the process of research and development, due to the limitations of existing conditions such as the level of knowledge, technical level, scientific knowledge, and so on, although the research and development have made the maximum efforts, there are still related risks that are unpredictable and insurmountable. According to the survey results, the risk is divided into the following seven categories:

- a. Innovation technology risk. Although the technology developed conforms to the scientific principles, it is difficult to complete at this stage due to the big technical difficulty. This risk mainly includes the difficulty of technology development, the inability to acquire technical knowledge, the immaturity of the technology, and the difficulty in the breakthrough of key technologies.
- b. R&D conditional risk. It refers to the risk of insufficient software, hardware resources, and the ability for enterprise research and development.
- c. Future demand risk. The insufficient grasp of market demand and product sales less than expected caused by lacking in-depth market research.
- d. Personnel capacity risk. Such as insufficient personnel scale, weak personnel capacity, and unreasonable talent distribution structure.
- e. Product design risk. It refers to the risk that product design is outdated or too advanced to meet the needs of the market.
- f. Process realization risk. The process design level is not novel enough, which brings risks to the realization of the production process technology.
- g. Subjective decision risk. The subjectivity of decision-makers may lead to the limitation of judgment due to the lack of strict argument.

(2) Product development risk is an unpredictable risk that still occurs in the process of manufacturing products because of an in-depth analysis of market demand and reasonable cost investment. According to the survey results, there are mainly the following risks in this stage:

- a. Tooling equipment risk. It refers to the risk that tooling equipment is inadequate or the quality is not up to standard.

- b. Product quality performance. The final product will not meet consumer needs due to poor quality or inadequate functionality.
 - c. Fundraising risk. It refers to the risk due to the delay in raising funds, the break of the capital chain, or the change of interest rate.
 - d. Raw material supply risk. It refers to the risk of poor quality or insufficient supply of raw materials.
 - e. Market prospect prediction risk. The market forecast in the manufacturing stage determines whether a product will be mass-produced. If the market forecast is not in place, the product will be overstocked.
 - f. Technical transformation scale. The related risk is caused by the difficulty of innovation technology transformation and the failure of enterprises to realize effective and reasonable transformation.
 - g. Organizational management risk. The management and operation risk is caused by an improper organization, coordination, and implementation in the process of production and manufacturing operation.
 - h. Product production scale. The risk of project failure due to insufficient production scale.
 - i. Value-oriented risk. The decision of product development does not conform to the customs and social ethics of consumers.
- (3) Product marketing risk refers to the risk of enterprise damage caused by various uncertain factors that affect marketing activities of enterprises. According to the survey results, the risk mainly includes the following 9 aspects:
- a. Macro policy risks. The risk that changes in macro policies, laws, and regulations will adversely affect the launch of new products.
 - b. Price/performance ratio. It refers to the risk that consumers think the product's performance and price are unmatched.
 - c. Demand change risk. The change of demand will lead to insufficient supply or a surplus of new products.

- d. Market acceptance risk. This risk means consumers accept the product in a low degree or exchange it for a short time.
- e. Market scale risk. The market scale is insufficient or difficult to expand after the launch of new products.
- f. Marketing capability risk. Insufficient product marketing ability (including the choice of marketing strategy and the ability to find customers), and insufficient market analysis ability (including the ability to conduct market research) will cause difficulties in launching new products.
- g. Timing chosen risk. Such as unsalable products caused by improper timing of new products.
- h. Product revenue risk. It refers to the possibility of changes in expected earnings.
- i. Market competition risk. A large number of strong competitive imitators, followers, and even bad competitive behaviours appear in the market.

3. EMPIRICAL ANALYSIS

3.1. Risk Evaluation

Based on the above risk identification analysis, this paper constructs the risk assessment index system of high-tech enterprises' technology innovation, including 1 target layer, 3 first-level indicators (criterion layer), and 25 second-level indicators (factor layer), as shown in Table 1. It is composed of several parameters. The system is complex and multi-level, and some measurement indexes such as product design and marketing capabilities are difficult to be precise and have obvious fuzziness. AHP and fuzzy comprehensive evaluation methods are used to complete the comprehensive evaluation of technological innovation risk of high-tech enterprises.

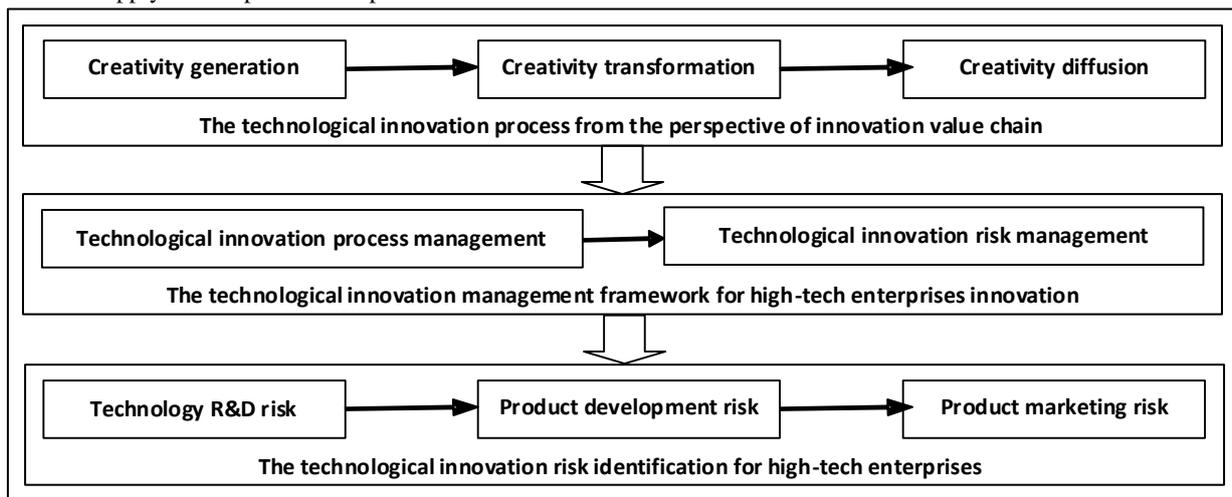


Figure 1 Analysis framework of technology innovation risk of technological innovation in high-tech enterprises based on project promotion from the perspective of the innovation value chain.

High-tech enterprises in different fields face different risks. Even if there is the same enterprise in different technological innovation process, its risk is also different. According to the above analysis on the risk factors of technology innovation of high-tech enterprises, this paper selects H enterprises in Shanghai and takes an IT technology innovation project as an example to evaluate the risks existing in the above three stages. Fifteen senior experts (relevant leaders, engineers, and researchers) are invited to judge the relative importance of IT project risk indicators in the form of questionnaires, and then the weight of each factor is calculated by the judgment matrix. (1) AHP is used to construct the judgment matrix of first-level index and second-level index to determine the index weight:

The first-level indexes include technology research and development risk, product development risk, and product marketing risk. Comparing the three risks in pairs, the relative importance is obtained, and then the judgment matrix of first-level index is established:

$$A_U = \begin{bmatrix} 1.000 & 2.121 & 1.829 \\ 0.471 & 1.000 & 0.989 \\ 0.547 & 1.011 & 1.000 \end{bmatrix}$$

The first-level index weight can be obtained by the root method: $W_U = (0.496, 0.245, 0.259)^T$. According to the formula (1-3), the consistency index is calculated: $\lambda_{max}=3.002$, $CI=0.002$, $RI=0.58$, $CR=0.004<0.1$. Therefore, the judgment matrix satisfies the consistency requirement.

$$\lambda_{max} = \sum_{i=1}^n \frac{(AW)_i}{nW_i} \tag{1}$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{2}$$

$$CR = \frac{CI}{RI} \tag{3}$$

Where λ_{max} is the maximum eigenvalue. n is the number of first-order indicators. RI is the average random consistency index and a fixed constant obtained by experiment. Similarly, second-level index judgment matrix A_{U1} , A_{U2} , and A_{U3} are constructed as follows:

$$A_{U1} = \begin{bmatrix} 1.000 & 3.031 & 2.739 & 4.646 & 3.472 & 2.229 & 2.977 \\ 0.330 & 1.000 & 0.565 & 0.338 & 0.456 & 0.400 & 0.359 \\ 0.365 & 1.770 & 1.000 & 3.584 & 1.490 & 1.713 & 2.580 \\ 0.215 & 2.959 & 0.279 & 1.000 & 0.560 & 0.496 & 0.510 \\ 0.288 & 2.193 & 0.671 & 1.786 & 1.000 & 1.790 & 2.065 \\ 0.449 & 2.500 & 0.584 & 2.016 & 0.559 & 1.000 & 2.433 \\ 0.336 & 2.786 & 0.388 & 1.961 & 0.484 & 0.411 & 1.000 \end{bmatrix} \quad A_{U2} =$$

$$A_{U3} = \begin{bmatrix} 1.000 & 0.376 & 0.508 & 1.605 & 0.475 & 0.525 & 0.469 & 1.792 & 0.490 \\ 2.660 & 1.000 & 0.372 & 0.321 & 0.365 & 0.390 & 0.373 & 0.526 & 1.871 \\ 1.969 & 2.688 & 1.000 & 3.167 & 3.167 & 3.347 & 1.947 & 2.510 & 3.118 \\ 0.623 & 3.115 & 0.316 & 1.000 & 0.601 & 0.497 & 1.540 & 1.837 & 2.449 \\ 2.105 & 2.740 & 0.316 & 1.664 & 1.000 & 0.498 & 2.392 & 1.944 & 1.847 \\ 1.905 & 2.564 & 0.299 & 2.012 & 2.008 & 1.000 & 1.819 & 2.128 & 2.090 \\ 2.132 & 2.681 & 0.514 & 0.649 & 0.418 & 0.550 & 1.000 & 2.201 & 1.836 \\ 0.558 & 1.901 & 0.398 & 0.544 & 0.514 & 0.470 & 0.454 & 1.000 & 2.350 \\ 2.041 & 0.534 & 0.321 & 0.408 & 0.541 & 0.478 & 0.545 & 0.426 & 1.000 \end{bmatrix}$$

$$\begin{bmatrix} 1.000 & 0.502 & 0.489 & 0.413 & 0.432 & 0.405 & 0.448 & 0.336 & 0.360 \\ 1.992 & 1.000 & 0.582 & 0.702 & 0.554 & 0.480 & 0.445 & 0.446 & 2.042 \\ 2.045 & 1.718 & 1.000 & 1.728 & 1.875 & 1.651 & 2.131 & 2.801 & 2.469 \\ 2.421 & 1.425 & 0.579 & 1.000 & 2.206 & 2.153 & 2.961 & 2.674 & 2.528 \\ 2.315 & 1.805 & 0.533 & 0.453 & 1.000 & 1.521 & 2.625 & 2.236 & 2.438 \\ 2.469 & 2.083 & 0.606 & 0.464 & 0.657 & 1.000 & 0.426 & 2.836 & 3.433 \\ 2.232 & 2.247 & 0.469 & 0.338 & 0.381 & 2.347 & 1.000 & 2.642 & 2.708 \\ 2.976 & 2.242 & 0.357 & 0.374 & 0.447 & 0.353 & 0.379 & 1.000 & 2.933 \\ 2.777 & 0.490 & 0.405 & 0.396 & 0.410 & 0.291 & 0.369 & 0.341 & 1.000 \end{bmatrix}$$

Technology R&D risk index weight: $W_{U1} = (0.321, 0.059, 0.180, 0.075, 0.140, 0.132, 0.094)^T$. Similarly, consistency index is calculated as follows: $\lambda_{max} = 7.485$, $CI = 0.059$, $RI = 1.32$, $CR = 0.064 < 0.1$. Product development risk index weight: $W_{U2} = (0.074, 0.068, 0.239, 0.104, 0.130, 0.148, 0.105, 0.072, 0.060)^T$, $\lambda_{max} = 9.951$, $CI = 0.081$, $RI = 1.45$, $CR = 0.056 < 0.1$. Product marketing risk index weight: $W_{U3} = (0.046, 0.074, 0.182, 0.181, 0.139, 0.116, 0.124, 0.084, 0.053)^T$, $\lambda_{max} = 9.891$, $CI = 0.076$, $RI = 1.45$, $CR = 0.053 < 0.1$. Therefore, all judgment matrices meet the requirement of consistency.

Table 1 Technology innovation risk assessment index system

Target layer	Criterion layer	Factor layer
		Innovation technology risk (U ₁₁)
		R&D conditional risk (U ₁₂)
	Technology R&D risk	Future demand risk (U ₁₃)
		Personnel capacity risk (U ₁₄)
	(U ₁)	Product design risk (U ₁₅)
	Technological innovation risks of high and new technology enterprises (U)	Process realization risk (U ₁₆)
		Subjective decision risk (U ₁₇)
		Tooling equipment risk (U ₂₁)
		Product quality performance (U ₂₂)
	Product development risk	Fundraising risk (U ₂₃)
		Raw material supply risk (U ₂₄)
	(U ₂)	Market prospect prediction risk (U ₂₅)
		Technical transformation scale (U ₂₆)
		Organizational management risk (U ₂₇)
		Product production scale (U ₂₈)

	Value-oriented risk(U ₂₉)
	Macro policy risk (U ₃₁)
	Price/performance ratio (U ₃₂)
	Demand change risk (U ₃₃)
Product marketing risk (U ₃)	Market acceptance risk (U ₃₄)
	Market scale risk (U ₃₅)
	Marketing capability risk (U ₃₆)
	Timing chosen risk (U ₃₇)
	Product revenue risk (U ₃₈)
	Market competition risk(U ₃₉)

(2) Comprehensive evaluation by using fuzzy comprehensive evaluation method:

According to the questionnaire survey, we count different risk levels of support number of 15 experts for second-level index on IT project. Risk levels are divided into five grades from high to low (highest risk, higher risk and general risk, lower risk, lowest risk), the corresponding value is V = (5,4,3,2,1). As shown in Table 2.

Through the comprehensive expert evaluation and normalization, the membership degree of each factor is determined, and the fuzzy relationship matrix R₁, R₂ and R₃ of the second-level index are obtained:R₁=

$$R_2 = \begin{pmatrix} 0.07 & 0.13 & 0.27 & 0.33 & 0.20 \\ 0.13 & 0.33 & 0.27 & 0.27 & 0.00 \\ 0.07 & 0.07 & 0.33 & 0.40 & 0.13 \\ 0.07 & 0.20 & 0.33 & 0.27 & 0.13 \\ 0.13 & 0.20 & 0.33 & 0.20 & 0.13 \\ 0.20 & 0.13 & 0.20 & 0.33 & 0.13 \\ 0.07 & 0.33 & 0.20 & 0.33 & 0.07 \\ 0.13 & 0.40 & 0.13 & 0.27 & 0.07 \\ 0.07 & 0.20 & 0.33 & 0.27 & 0.13 \end{pmatrix} \quad R_3 =$$

$$\begin{pmatrix} 0.13 & 0.27 & 0.20 & 0.27 & 0.13 \\ 0.20 & 0.40 & 0.20 & 0.13 & 0.07 \\ 0.13 & 0.33 & 0.33 & 0.20 & 0.00 \\ 0.27 & 0.40 & 0.27 & 0.07 & 0.00 \\ 0.13 & 0.47 & 0.27 & 0.07 & 0.07 \\ 0.20 & 0.27 & 0.40 & 0.13 & 0.00 \\ 0.27 & 0.40 & 0.20 & 0.13 & 0.00 \\ 0.13 & 0.33 & 0.47 & 0.07 & 0.00 \\ 0.07 & 0.33 & 0.33 & 0.20 & 0.07 \end{pmatrix}$$

According to B_i=W_{U_i}·R_i (i=1,2,3), the evaluation result of the second-level index B_i can be obtained:

B₁ = (0.3732, 0.2133, 0.2159, 0.1486, 0.0485)

B₂ = (0.1054, 0.1903, 0.2742, 0.3116, 0.1157)

B₃ = (0.1827, 0.3659, 0.2986, 0.1285, 0.0246)

Therefore, the fuzzy relation matrix of the first-level index is:

$$R = \begin{pmatrix} 0.3732 & 0.2133 & 0.2159 & 0.1486 & 0.0485 \\ 0.1054 & 0.1903 & 0.2742 & 0.3116 & 0.1157 \\ 0.1827 & 0.3659 & 0.2986 & 0.1285 & 0.0246 \end{pmatrix}$$

Similarly, the evaluation result of the first-level index B can be obtained:

$$B = W_U \cdot R = (0.496, 0.245, 0.259) \circ \begin{pmatrix} 0.3732 & 0.2133 & 0.2159 & 0.1486 & 0.0485 \\ 0.1054 & 0.1903 & 0.2742 & 0.3116 & 0.1157 \\ 0.1827 & 0.3659 & 0.2986 & 0.1285 & 0.0246 \end{pmatrix}$$

= (0.2582, 0.2472, 0.2516, 0.1833, 0.0588)

According to the comment set V = (5,4,3,2,1), the overall evaluation value of the project risk can be obtained: P=B·V^T=3.46.

3.2. Risk Assessment Analysis

According to the principle of maximum membership of risk assessment, the risk degree of H enterprise's IT projects is 3.46, which belongs to the evaluation set 3-4, indicating that H enterprise's IT technology innovation projects are facing a higher level of risk. From the perspective of the first-level index (criterion layer), the maximum value of B1 is 0.3732, indicating that the risk level of technology research and development is highest and the membership is 37.32%. The maximum value of B2 is 0.3116, indicating that the product development risk level is lower and the membership is 31.16%. In B3, the maximum value is 0.3659, indicating that the product marketing risk level is higher and the membership degree is 36.59%. To sum up, the risk levels of technology research and development, product marketing risk and product development risk are successively highest, higher and lower.

From the perspective of second-level index (factor layer), among the risks of technology research and development, the risk weight of innovation technology is the highest (0.321), indicating that the maturity and degree of innovation are quite important. The next is the risk of future demand (0.180), indicating that consumer demand is the main factor that guiding technology research and development. Then, it is product design risk (0.140), process realization risk (0.132), subjective decision risk (0.094), personnel capacity risk (0.075), and R&D conditional risk (0.059), respectively.

Table 2 Statistical table of expert collective evaluation

Second-level Index	Highest risk	Higher risk	General risk	Lower risk	Lowest risk
U ₁₁	7	4	2	2	0
U ₁₂	4	3	4	2	2
U ₁₃	5	2	4	2	2
U ₁₄	6	3	3	2	1
U ₁₅	6	4	3	2	0
U ₁₆	4	3	4	4	0
U ₁₇	4	2	5	2	2
U ₂₁	1	2	4	5	3
U ₂₂	2	5	4	4	0
U ₂₃	1	1	5	6	2
U ₂₄	1	3	5	4	2
U ₂₅	2	3	5	3	2
U ₂₆	3	2	3	5	2
U ₂₇	1	5	3	5	1

U ₂₈	2	6	2	4	1
U ₂₉	1	3	5	4	2
U ₃₁	2	4	3	4	2
U ₃₂	3	6	3	2	1
U ₃₃	2	5	5	3	0
U ₃₄	4	6	4	1	0
U ₃₅	2	7	4	1	1
U ₃₆	3	4	6	2	0
U ₃₇	4	6	3	2	0
U ₃₈	2	5	7	1	0
U ₃₉	1	5	5	3	1

For product development risk, from high to low in turn is: fundraising risk (0.239), technical transformation scale (0.148), the market prospect prediction risk (0.130), organizational management risk (0.105), raw material supply risk(0.104), risk of tooling equipment (0.074), the scale of product production (0.072), the product quality performance (0.068) and the value-orientated risk (0.060). Fundraising risk is the main source of product development stage. Whether an enterprise can maintain long-term financial support is the key to the smooth launch of new products. Once the capital chain is broken, it will not only cause the delay for new products to occupy the market, but also destroy the efforts made in the early stage. The innovative technology of enterprises should always follow the market and lead the market to make themselves invincible. The risk with low weight is also an important factor affecting the development of technological innovation projects.

Product marketing risk, which is mainly derived from the risk of demand change (0.182) and the risk of market acceptance (0.181). Consumer demand is the main factor guiding technological innovation and R&D. The next is market scale risk (0.139). The lack of market scale will lead to a decline in the profitability of enterprises and affect their enthusiasm for innovation. The timing chosen (0.124) is very important. If the enterprise does not seize the opportunity in time, its profits will be greatly reduced. Enterprises should still pay attention to marketing capability (0.116), product revenue risk (0.084), price/performance ratio (0.074), market competition risk (0.053), and macro policy risk (0.046). A small defect in marketing services will lead to the abandonment of previous efforts and huge losses.

3.3. Risk Response

According to the IT project risk analysis of H enterprise, the enterprise needs to take effective measures in each stage of technological innovation, to avoid, reduce and share the risk. First of all, enterprises should pay more attention to the technical problems when carrying out the technological innovation project, strengthen the technology prediction, and jointly carry out technical transformation by constantly searching and mining their

own valuable resources and cooperating with powerful enterprise alliances. Secondly, enterprises should try their best to get enough funds in place in time. Finally, enterprises should make more efforts in market research, publicity and marketing to create a good development environment for technological innovation.

4. CONCLUSION

Based on the innovation value chain theory, this paper makes an in-depth identification, evaluation and research on the possible risks in the technological innovation process of high-tech enterprises, and puts forward some measures to deal with these risks. A feasible risk management research framework for high-tech enterprise technology innovation is provided. The main results of this study are as follows:

- (1) The technology innovation risks of high-tech enterprises are distinguished into three stages: technology R&D risk, product development risk, and product marketing risk.
- (2) The first-level risk index of three stages and 25 second-level risk index are proposed for the building of risk assessment index system of high-tech enterprise technology innovation.
- (3) Combined with the examples, the technological innovation project risk of high-tech enterprises is deeply analyzed. AHP and fuzzy comprehensive evaluation method are used to obtain the corresponding level of first-level risk index from high to low, which is the risk of technology research and development, product marketing risk and product development risk, successively. The occurrence of second-level risk index is evaluated and analyzed in each stage and the corresponding risk response method is put forward. Looking forward to providing some help for high-tech enterprises to realize the application of technological innovation and reduce the risk of technological innovation.

ACKNOWLEDGMENT

This work was supported by The 2019 Annual Basic Project of the Party's Political Construction Research Center of the Ministry of Industry and Information Technology (Grant No. 19GZY411)

REFERENCES

- [1] Gupta A.K., Raj S.P., Wilemon D. The R&D marketing interface in high-technology firms[J]. *Journal of Product Innovation Management*, 2(1) (2010) 12-24.
- [2] LUO J L, HU Z H. Risk paradigm and risk evaluation of farmers cooperatives' technology innovation [J]. *Econ Model*, 44 (2015) 80-85.

[3] WU Y J, SUN C F, NIU W X. Analysis of the Technology Innovation Risk Based on High-tech Enterprises [M]. Beijing: China Machine Press, 2008.

[4] Wang, L., Fan, H., 2009. Study about Risk evaluation for enterprise' technology innovation based-on grey hierarchy method. Management and Service Science, 2009. MASS '09. International Conference on.

[5] Rothwell, R. Towards the fifth-generation innovation process. *Int. Mark. Rev.* 11(1994) 7–31.

[6] Berglund, H., Risk conception and risk management in corporate innovation: lessons from two Swedish cases. *Int. J. Innov. Manag.* 11 (2007) 497–513.

[7] Hansen, M.T.B. The Innovation Value Chain[J]. *Research-technology Management*, 50(5) (2007) 71-72.