

# Research on the Evaluation Index System of Technological Innovation of Technology-Based SMEs

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**ABSTRACT.** *In the era of 'mass entrepreneurship and innovation', the status of Technology-based SMEs in innovation-driven entities is increasing. Technology-based SMEs still need to enhance technological innovation continuously to gain competitive advantage, expand their position in market competition, and rely on external resources and capabilities to seek rapid business development. This article takes Technology-based SMEs as the research object, analyzes the dynamic mechanism of their technological innovation, and constructs a set of technological innovation evaluation index system from the aspects of innovation input, research and development capabilities, core output and environmental support, and proposes the development path of Technology-based SMEs on the basis of the above.*

**KEYWORDS:** *Evaluation Index System, Technological Innovation, Technology-Based SMEs*

## 1. Introduction

Technological innovation is an important cornerstone of national progress and a path for national prosperity. From the perspective of international economic development trends, technology-based SMEs have become increasingly prominent in the world economic structure, and their role in improving market activity, increasing employment, upgrading industrial structure and sustainable economic development has become increasingly prominent. Due to the constraints of the environment and resources, the past reliance on material elements to promote economic development is difficult to sustain. The "Thirteenth Five-Year Plan" takes scientific and technological innovation as an important driving force for the transformation of economic development mode. It points out that my country's economic development has entered a new stage, and the economic development model has changed from extensive development to innovation-driven development.

After recent years of development, technology-based small and medium-sized enterprises have become the most attractive market entities with the best development prospects in economic development. An important force in national economic and social development has been receiving extensive attention from theoretical and practical circles. The analysis of the innovation driving factors, the evaluation of innovation ability and the exploration of the development path of technology-based SMEs have become the focus of attention of the government, scholars and enterprise managers. They hope to build an innovation-driven ecology to promote the rapid development of technology-based SMEs by exploring the root motive force of technological innovation. Therefore, this article uses technology-based SMEs as the research object to analyze the dynamic mechanism of technology innovation of technology-based SMEs and the evaluation index system, hoping to promote the development of innovation capabilities of technology-based SMEs from the micro level.

## 2. Literature Review

In 1912, the Austrian economist Joseph Schumpeter first proposed the concept of 'innovation theory'. He pointed out that modern economic development should be based on innovation. Since there are certain potential benefits in society, obtaining such potential benefits is the root of innovation. Follow-up scholars carried out extensive and in-depth research on innovation theory along the lines of Schumpeter. Nicolas O Regan et al. (2006) compared the technological innovation of small and medium-sized enterprises and large enterprises, and found that small and medium-sized enterprises surpassed large enterprises in the speed of R&D and improvement innovation. Alexander Kaufmann (2002) used domestic small and medium-sized enterprises as a sample of research in Australian and found that small and medium-sized enterprises are higher than large enterprises in terms of the ratio of technological innovation investment, and conducted empirical analysis on the correlation between R&D investment and technological innovation. Yao Hongyi (2006) started from the essence of the definition of technological innovation, through the combination of theoretical innovation and practice, carried out a statistical analysis on the technological innovation of small and medium-sized enterprises, put forward the main factors influencing technological innovation and proposed solutions for its research content. Li Shuangjie (2008) used relevant measurement software to conduct an empirical analysis on the efficiency of technological innovation in the allocation of resources in the manufacturing industry, and concluded that the allocation efficiency of technological innovation has a clear gap in the allocation efficiency of different industries in the manufacturing industry.

Regarding the evaluation of technological innovation capabilities, scholars have also carried out extensive research and established various evaluation index systems for enterprise technological innovation. Foreign scholars Scheirer and Mansfield (1992) obtained the functional relationship respectively through the study of technological activities and output:  $P=a+bI+cx$ . The functional relationship shows that there is a linear correlation between enterprise R&D investment  $I$  and enterprise

technological invention P, which also shows that R&D investment can effectively measure technological innovation capabilities. Clark (1990) proposed that technological innovation capability can be measured from two aspects: process innovation capability and product innovation capability. Among them, process innovation capability is measured by three aspects: enterprise production process equipment mold development capability, experimental production capability, and mass production capability. Comprehensive manifestation; and product innovation capability is measured from three aspects: enterprise industry development cycle, product development efficiency and comprehensive product quality. Ransley and Rogers (1994) studied the evaluation indicators of corporate technological innovation capabilities from seven aspects: technology strategy, project selection and management, corporate core capabilities, effectiveness, external awareness, technology transfer and personnel.

Domestic scholar Wang Hui et al. (2008) established an evaluation index system from the aspects of innovation decision-making capabilities, management capabilities, research and development capabilities, and manufacturing capabilities embodied in the process of enterprise technological innovation. Liu Weiling and Li Haiping (2008) believe that enterprises mainly introduce or develop new technologies to enable them to meet or create market demands and enhance their competitiveness. Therefore, they decompose their technological innovation capabilities into innovation management capabilities, innovation resource investment capabilities, and R&D. Manufacturing capabilities, innovative marketing capabilities and innovation realization capabilities. Haiyun Liu (2010) established a two-tier hierarchical decision-making model evaluation index system by systematically analyzing the components of enterprise technological innovation capabilities. The first level is the basic elements that affect innovation capabilities, and the second level is the specific innovation capabilities. Indicator items. Wang Jian and Wang Haishan (2000) proposed that technological innovation capability is a comprehensive capability, which is embodied in innovation input capability, innovation output capability, innovation activity capability, and innovation support capability.

Looking at the above research by scholars, it can be seen that there are many factors affecting technological innovation. Different scholars have summarized the evaluation index system from different angles, but there are still some shortcomings. First, the existing index system does not have a unified standard, and evaluators cannot evaluate the company's scientific and technological innovation capabilities through unified indicators, making the evaluation results difficult to be horizontally comparable; Second, there are some indicators that are difficult to quantify in the existing index system. Indicators often affect the accuracy of evaluation results; Third, most of the existing indicators are used to evaluate the existing innovation status at this stage, and few more classic indicators can predict the future technological innovation of enterprises.

### **3. Analysis on the Dynamic Mechanism of Technological Innovation in SMEs**

Innovation power mechanism is the source and mode of action of innovation, a mechanism that can promote innovation to achieve high-quality and efficient operation and provide incentives to achieve predetermined goals. There are some more classic models for the research on the innovation motivation mechanism of SMEs. For example, the demand-capital theory believes that the imbalance between capital and demand will create a gap, thereby stimulating and promoting innovation and development. The technical specification-orbit model believes that capital power and market power play a selective role in a large number of technological directions, and technology automatically advances within the range determined by the technical orbit. Based on this, we also analyze the technological innovation power of technology-based SMEs from the internal and external aspects of technological innovation.

#### **3.1 Internal Dynamics**

The internal driving force of enterprise technological innovation mainly comes from the entrepreneur's own innovation consciousness, the human and financial resources invested thereby, and the innovative atmosphere in the corporate culture.

Entrepreneur's sense of innovation. Schumpeter pointed out that entrepreneurs are adventurous and are managers or organizers of innovative businesses. Among the internal driving forces of enterprise technological innovation, the entrepreneur's awareness of innovation ranks first. For small and medium-sized enterprises, the entrepreneur's awareness of innovation determines the development direction of the enterprise to a certain extent, and directly affects the production and operation of the enterprise. Entrepreneurs with a strong sense of innovation are often able to grasp the direction of technological development of the times and lead their enterprises to success.

Enterprise innovation investment. For small and medium-sized enterprises to have high-level innovation capabilities, they must ensure investment in research and development, including investment in scientific and technological talents and financial resources. Connie Zheng (2007) pointed out that the core of technology-based small and medium-sized enterprises is innovative talents. Enterprises should introduce and retain talents through various methods, and cultivate talents through corporate training, and put forward the core values of corporate talents. Stephen Roper (2008) conducted a comparative study on product innovation of SMEs in Britain, Germany and Ireland and found that the ability of talent innovation plays an important role in the growth of technological SMEs. It seems vital. The importance of R&D investment in promoting scientific and technological innovation and economic development has been reached in all countries in the world. It is generally believed that increasing R&D financial and material investment can strengthen the position of enterprises as the mainstay of innovation and stimulate their innovation potential. Enterprises are the main carriers of market innovation. If high-tech SMEs

want to strengthen their competitiveness, they must increase R&D investment and enhance their innovation capabilities.

Corporate culture construction. In addition to increasing investment in innovation, corporate innovation is also crucial to whether the company has a very strong innovation soil and atmosphere, which is mainly reflected in the innovation of corporate culture. At this stage, the competition among high-tech SMEs is fierce. How companies can maximize their talent and technical advantages, the construction of corporate culture is particularly important. An enterprise has a good atmosphere for innovation, which can directly affect the innovation vitality of all employees of the enterprise, and also help to form cohesion among employees, enhance their happiness and satisfaction in the work process, and then affect the overall efficiency of the enterprise.

### **3.2 External Power Mechanism**

Enterprise innovation is not only internally driven, but also has a strong external innovation environment, including: market momentum, technological development, and the government's "visible hand" and other driving mechanisms.

Driven by market mechanisms. The market power of enterprise innovation includes two elements: market demand and market competition. One is market demand. Keynesian theory points out that demand drives supply and demand is in a dominant position. Small and medium-sized enterprises mainly occupy the buyer's market. Market demand-oriented innovation is the development direction of high-tech small and medium-sized enterprises. How to innovate on the existing basis and stimulate new demands is the ultimate goal of innovation for high-tech small and medium-sized enterprises. The second is market competition. The majority of small and medium-sized enterprises are in a fiercely competitive market. How to stand out from the role of many suppliers requires that enterprises must do a good job in product innovation or service innovation. Enterprises must face this kind of market competition. Healthy competition can often promote enterprises Redevelopment.

Driven by technological development. The development of science and technology is the strongest driving force for social and economic development. SMEs are the main subjects engaged in technological research and development, production of technology-intensive products and technological services. The direction and trend of future scientific and technological development is an important direction and source of power for technological innovation of SMEs. High-tech small and medium-sized enterprises are often able to quickly grasp development opportunities and achieve greater development due to their sharp market sense, fast information feedback, and flexibility.

Driven by the 'visible hand' of the government. The development of technology-based SMEs often faces constraints such as large R&D investment, unstable market demand, financing channels, and limited human resources. Therefore, the government also needs to increase policy incentives for technology-based SMEs, and do a good job in policy guidance, finance and credit. Support, build an

information feedback channel for market demand and technological development. At the same time, it is necessary to continuously improve the property rights protection system to promote its higher research and development enthusiasm.

Then, the collected information is uploaded to the PC; at the same time, processing software running on PC processes the acquired information and calls the target tracking algorithm to obtain the coordinate position of moving target. Moreover, the trajectory of moving target is real-time rendered to the display interface for monitoring the working state of each sensor node. The overall structure of the system is designed as shown in Figure 4.

#### **4. Construction of the Evaluation Index System for Technological Innovation of SMEs**

According to the 'High-tech Enterprise Certification Scoring Standards and Rules' issued by the Ministry of Science and Technology and other departments in 2016, the technological innovation of high-tech enterprises covers four aspects: core independent intellectual property rights, transformation of scientific and technological achievements, enterprise organization and management level, and enterprise growth. It has certain guiding significance for the evaluation index system of technological innovation ability of technology-based small and medium-sized enterprises. In 2017, the Ministry of Science and Technology and other three departments issued the "Measures for the Evaluation of Technological SMEs", pointing out that the evaluation indicators of technological SMEs cover three aspects: scientific and technical personnel, scientific and technological investment and scientific and technological achievements. In addition, Pan Sha (2009) started research from the "Excellent Performance Evaluation Criteria" and found that the "Excellent Performance Evaluation Criteria" has been universally recognized internationally and has strong authority. The evaluation criterion attaches importance to the process of enterprise innovation, and the process guarantees the results of innovation; it is a comprehensive and systematic evaluation criterion that can improve the company's comprehensive performance management capabilities and help the company achieve sustainable development. The guidelines focus on the importance of technological innovation and the degree of capital investment, the efficiency and effect achieved in the implementation of technological innovation, and the quality of the final innovative products. It has a good reference for technological innovation of SMEs.

In this paper, according to the national Ministry of Science and Technology and the evaluation index system, based on outstanding performance evaluation criteria, and on the basis of reference Zhang Dongliang (2010), Wang Yuanyuan (2015) and other scholars research literature, build a set of suitable for small and mid-sized enterprise technology innovation ability evaluation index system, starting from the process of production operation, from the capital investment, innovation process, innovation output and environment four aspects, innovation of the enterprise to conduct a comprehensive evaluation of the system. The specific indicator system is shown in Table 1:

Table 1. Evaluation Index System of Technological Innovation of Technology-based SMEs

First level indicators	Second level indicators	Third level indicators
Innovation investment capacity	Human Resources	Number of scientific researchers
		Research personnel structure
		The proportion of scientific researchers in the total number
	Financial resources	Research and innovation investment
		Research and innovation investment structure
		Research and innovation investment as a proportion of sales
	Infrastructure	Experimental equipment construction
Information database construction		
Innovative research and development capabilities	Organizational skills	Organization of enterprise R&D
		Support for R&D from other departments
	Innovation quality	Variety structure of innovation achievements
		Cost difference between innovation and alternatives
Innovation output capacity	Market recognition	Market share of innovation
		Customer satisfaction and loyalty of innovation
	Financial output	Innovative sales revenue
		Innovation achievement profit
		Asset contribution rate of innovation achievements
Innovative environment support	Internal environment	Entrepreneur leadership style
		Enterprise innovation incentive
	External environment	Government R&D expenditure input rate
		Industry-University-Research Cooperation Degree

## 5. The Path of Technological Innovation of Technology-based SMEs

Technology-based SMEs rely on their own desire to promote technological SMEs to improve their innovation capabilities. They cannot do without the company's own innovation motivation and government-level incentives and guidance. Therefore, this paper will discuss the countermeasures and suggestions to promote the development of technology-based small and medium-sized enterprises from the two dimensions of enterprise itself and government.

### 5.1 Enterprise Countermeasures

Increase corporate R&D investment. Technological innovation is a high-cost economic activity, which is not only reflected in the capital investment in

technological research and development, but also in talent investment. Talents are the source of power for technological innovation, and a strong R&D team is the foundation to ensure that an enterprise has lasting innovation. The enterprise should establish a R&D team with strategic vision, innovative courage, and strong skills and innovative spirit.

Cultivate the innovation ability of managers. The development of an enterprise is often the direction set by the enterprise manager, and the employees follow the direction set by the management. The innovation ability of the manager often represents the innovation ability of the enterprise. The structure of technology-based SMEs is simple. Operators are often the organizers of innovation activities and the bearers of innovation risks. Their knowledge literacy and innovative concepts are often decisive for enterprises. Therefore, this requires managers not only to possess professional knowledge, but also to be innovative.

Strengthen the construction of corporate organizational culture. The actual controllers of technology-based SMEs tend to devote more energy to enterprise technological innovation, leading to management becoming a shortcoming of the enterprise, which leads to inefficient operation of the enterprise. To change this situation, the actual controller of the enterprise must pay attention to the important role of management in the development of the enterprise in the modern enterprise competition, and promote the more efficient and rapid development of the enterprise by strengthening the construction of enterprise organizational culture.

## **5.2 Government Countermeasures**

Establish a sound policy support system. In view of the problems that may arise in the development of technology-based SMEs in terms of R&D, funding, talents, operations, management, etc., the government should first establish sound laws and regulations to improve the business environment of technology-based SMEs and provide guarantees for SMEs' technological innovation. Secondly, the government should also establish a sound technology service system to provide assistance and guidance for technology-based small and medium-sized enterprises in terms of management and operation; Finally, the government should also increase incentives, reduce taxation standards, and guide technology-based small and medium-sized enterprises to conduct technological innovation.

Provide a good financing environment. High-tech SMEs often need a large number of innovations to support their own development, but due to the limitation of the size of the enterprise, SMEs often do not have enough funds to meet R&D investment. At this time, the government needs to be able to open up diversified financing channels, improve corporate guarantee mechanisms, and help companies connect with financial fund compensation such as small and medium financial institutions, commercial banks, and venture capital for entrepreneurship. It should improve the credit guarantee system for technology-based SMEs, and set up a dedicated financing institution for technology-based SMEs.



Establish a systematic and standardized scientific and technological innovation platform. The technology innovation platform can provide a good development space and information channels for technology to SMEs. The government should establish a systematic and standardized technology innovation platform for technology SMEs. With the gradual improvement of platform functions and the gradual clarity of entrepreneurs' understanding of the platform, if technology-based SMEs can make full use of platform resources, they can reduce the financial pressure in the initial stage of enterprise development and help enterprises grow more smoothly.

As a hot research technology, moving target tracking technology has been widely used in various fields. With the help of low cost, low power consumption, self-organization and high error tolerance of wireless sensor networks, moving target tracking based on wireless sensor networks also has broad application prospects.

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