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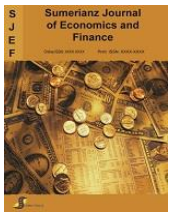

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Technological Innovation Performance: Optimization Strategies for the Evaluation Indicator System of Chinese Enterprises

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Abstract

This study addresses the special characteristics and limitations of Chinese enterprises in innovation performance evaluation, and analyzes in depth the unique needs and challenges of these enterprises in the process of technological innovation. By comparing relevant research and practices at home and abroad, this paper proposes a comprehensive set of enterprise technology innovation performance evaluation index system. This study not only helps the management of enterprises to formulate and adjust their technological innovation strategies, but also promotes the improvement of their internal innovation mechanism and culture. In this way, enterprises can allocate and utilize resources more effectively, optimize products and services, and ultimately enhance their overall technological innovation capability and market competitiveness. The enterprise technological innovation performance evaluation index system constructed in this study not only provides a practical technological innovation evaluation tool for enterprises, but also provides policy makers and academics with a new perspective and methodology for studying enterprise technological innovation. This will help promote the continuous development and progress of Chinese enterprises in technological innovation.
Keywords: Technological innovation; Performance evaluation; Comprehensive evaluation; indicator system.

1. Introduction

In exploring the issue of measuring the technological innovation performance of enterprises, it is widely recognised in academia and industry that there is no globally standardised evaluation system due to the complexity and variability of the technological innovation process (Sarsen *et al.*, 2023). Existing evaluation systems generally have the following limitations: first, the distinction between inputs and outputs is not clear enough, often overemphasising inputs of resources and neglecting the substantive benefits of innovation outputs (Zhang and Aumeboonsuke, 2022); second, evaluation systems tend to measure technological product innovation and under-assess the contribution of technological process innovation (Amponsah and Novák, 2022); and furthermore, most of the existing indicators focus on short-term results and lack the consideration of continuity and depth of the innovation process (Aklobo and Ahodode, 2022).

In view of this, this study proposes a new system of indicators for evaluating the technological innovation performance of enterprises, based on the theoretical foundation of the Handbook of Technological Innovation Survey on the treatment of innovation at the enterprise level, and in conjunction with the core connotations of technological innovation of enterprises and its evolutionary trend in the modern economic environment. The system aims to more accurately reflect the overall performance of enterprise technological innovation, including the construction of innovation management, mechanism and culture, as well as the enhancement of technological innovation capability (Sarsen *et al.*, 2023). Through this system, enterprises can assess their technological innovation status more scientifically, so as to implement innovation management more effectively, optimise

innovation mechanism, cultivate innovation culture, and ultimately improve their technological innovation capability and market competitiveness.

The research results of this paper not only provide enterprises with a scientific tool for evaluating technological innovation performance, but also provide policy makers and academics with new perspectives and strategies for deeply understanding and promoting technological innovation in enterprises. This is of great significance in guiding enterprises to maintain innovation vitality and build lasting competitive advantages in the changing market environment (Amponsah and Novák, 2022).

2. The Design Concept of Enterprise Technology Innovation Performance Evaluation Index System

2.1. The essence of technological innovation

From the perspective of enterprise management, technological innovation is a process that covers the entire process from the conception of an idea to research, development, trial production, manufacturing, and finally commercialization (Plinta and Radwan, 2023). The success of technological innovation is not only reflected in the first commercial application of a technological invention, but also in its ability to meet market demand, which is both the power source of technological innovation and the end point of its value realization (Wu L. and Ding, 2022). Regardless of the type of enterprise, the market orientation of innovative products and the satisfaction of users' needs are its vitality. The concept of "technological genius with business acumen" advocated by Microsoft and Haier's distinction between technological innovation and invention emphasize the importance of integrating technology with the market (Ma *et al.*, 2022).

The uncertainty inherent in technological innovation activities stems not only from the uncertainty of the technology itself, but also involves uncertainty at the market and strategic levels (Wu, 2022). Most cases of technological innovation failure are not due to the technology itself, but rather to deficiencies in market research, sales strategy, and organizational management. Therefore, in order to effectively promote technological innovation, enterprises must achieve close coordination and integration among R&D, market, and production, and strengthen the linkage and interface management among key departments such as research, development, manufacturing, and marketing (Plinta and Radwan, 2023). With the development of science and technology in the direction of integration, the types of knowledge and technology required for technological innovation are increasing, and the comprehensive and complex nature of innovation is also rising. Even enterprises with strong technological strength can hardly satisfy all the knowledge required for technological innovation independently. Under the trend of open innovation, if enterprises want to successfully implement innovation, they must pay close attention to the external environment, strengthen contact and cooperation with the outside world, and make full use of and integrate external innovation resources (Radwan and Plinta, 2023).

The theory of innovation has matured through the combined efforts of economists, statisticians, and other experts, and the Handbook of Technological Innovation Surveys, prepared under the auspices of the OECD, clearly defines innovation as industrial technological innovation, which includes the introduction of new products and processes, as well as significant technological change in products and processes (Wu, 2022). Product innovation refers to the entry of entirely new or technologically significantly changed products into the market, including both the introduction of entirely new products and significant improvements in the performance of existing products. A completely new product is one that differs significantly from previous products in terms of its technical characteristics or use, and these innovations may be based on completely new technologies, new combinations of existing technologies, or the application of new knowledge. Technologically improved products are existing products that offer a significant improvement in performance. Process innovation refers to the use of new or significantly improved production methods and processes, which also includes innovations in the way products are delivered.

2.2. The Limitations and Improvement Space of the Existing Enterprise Technology Innovation Performance Evaluation Indicator System

In international academia, although research on enterprise technological innovation is extensive, the concept of technological innovation performance has been relatively little explored, and existing research has mostly focused on influencing factors and improvement measures, and has yet to form a clear definition of technological innovation performance (Kang and Zhao, 2022). Scholars' understanding of technological innovation performance is mainly centered on input-output efficiency and output results, which are regarded as the outputs of technological innovation activities and the embodiment of their impact on enterprises (Mettang, 2023). Gao (2004), proposed the concept of technological innovation performance for the first time, defining it as the efficiency of an enterprise's technological innovation process, its output results, and its contribution to business success, covering both technological innovation output performance and technological innovation process performance.

Given the complexity of the technological innovation process of enterprises, a unified standard evaluation system of technological innovation performance has not yet been established at home and abroad. The evaluation of enterprise technological innovation performance is still in the exploratory stage, and the existing evaluation index system has many deficiencies, which has not yet been able to give full play to its positive role in promoting enterprise technological innovation activities (Bil and Özdemir, 2021).

The current innovation performance evaluation index system has the following major problems: first, the confusion between input and output indicators leads to over-emphasis on the input of technological innovation

resources and fails to accurately reflect innovation output; second, the existing indicators rely excessively on patent data, which is not fully in line with China's actual situation; third, the evaluation system is biased in favor of product technological innovation, ignoring the performance of process technological innovation; and lastly, the indicators are constructed with short-term effect and superficiality, reflecting only the innovation performance that has been demonstrated, but failing to measure the performance of the innovation process that supports the demonstrated performance, and thus failing to comprehensively reflect the long-term development potential and potential innovation performance of enterprises' technological innovation (Bil and Özdemir, 2021).

In summary, the evaluation of an enterprise's technological innovation performance requires a more comprehensive and in-depth understanding, as well as an evaluation system that can reflect the whole picture of an enterprise's technological innovation. Such a system should be able to identify and measure all aspects of technological innovation, including but not limited to resource inputs, outputs, market impacts, and the efficiency and quality of the innovation process. In addition, the system should be able to adapt to the actual situation in China, taking into account the special environment and market needs of Chinese enterprises, so as to more accurately assess and guide the technological innovation activities of enterprises (Mettang, 2023).

2.2.1 The Current Technological Innovation Performance Evaluation Index System Places TOO Much Emphasis on R&D Resource Inputs

In current academic research and practice, although the number of R&D personnel and R&D intensity are often used as indicators of technological innovation performance, this practice has been gradually questioned (Heij, 2015). In fact, although R&D resource input is a necessary condition for technological innovation, it is not a sufficient condition for innovation output. It is closely related to technological change, but it is not a comprehensive measure of technological innovation performance (Chang, 2022). Especially in an open innovation environment, R&D resources cannot cover all the efforts of firms and governments in technological innovation, such as learning by doing, knowledge and resources external to the firm - including user knowledge, supplier knowledge, and competitors' knowledge (Kim and Jun, 2022).

Therefore, over-emphasis on R&D resource input not only fails to accurately reflect an enterprise's technological innovation performance, but also may lead to a one-sided understanding of the innovation process by enterprise decision-makers, which may mislead the enterprise strategy (Zhang and Aumeboonsuke, 2022). Under the trend of open innovation, improving the technological innovation capability of enterprises should not be limited to increasing internal R&D investment and the number of personnel, but should require the senior leadership of enterprises to completely change the concept of "R&D is equivalent to innovation", and to actively use and integrate internal and external innovation resources, so as to improve the technological innovation capability and innovation performance of enterprises (Lee, 2020).

In summary, the evaluation of technological innovation performance should go beyond the traditional perspective of R&D resource inputs to a more comprehensive and dynamic evaluation of the innovation process. This includes, but is not limited to, internal R&D activities, but should also encompass how enterprises absorb external knowledge, the degree of cooperation with various types of innovation actors, and how this knowledge is transformed into innovative products and services in the market. Such an evaluation system can more accurately reflect the innovation capability and potential of enterprises in the rapidly changing market environment, and provide a more scientific basis for enterprises to formulate innovation strategies (Heij, 2015).

2.2.2. Existing Technological Innovation Performance Evaluation Index System Over-Emphasises Patent Data

In academic research, patent data are often used as an important indicator of the state of technological innovation in a region or enterprise (Svensson, 2021). This is because patent applications usually represent a concrete manifestation of innovative capacity and potential economic value (Ponta *et al.*, 2021). Indeed, the number of patents can reflect an enterprise's technological capability and innovation vigour, but it is not always equivalent to technological innovation output (Liu *et al.*, 2020). The essence of technological innovation lies in its commercial application and the economic benefits it generates, and not all inventions meet this criterion. Many patents may never be converted into innovative products in the market, and therefore patent data cannot be used as the only indicator of technological innovation performance (Kelly *et al.*, 2018).

In China, enterprises' lack of awareness of patent protection and knowledge of patent law, as well as concerns about leakage of technical secrets, have resulted in many inventions with market prospects not being patented (Igami and Subrahmanyam, 2019). In addition, due to the imperfection of China's patent system, some enterprises neglect patent protection in order to quickly capture the market. Therefore, in addition to patent data, indicators such as the number of technical documents, know-how and scientific and technological papers should also be considered to reflect more comprehensively the impact of technological innovation output on the accumulation of technological capabilities of enterprises (Kelly *et al.*, 2018).

At the same time, the number of enterprises participating in or leading the development of new standards is an important indicator of the performance of technological innovation outputs (Igami and Subrahmanyam, 2019). According to the WTO's Agreement on Technical Barriers to Trade (TBT), a standard is defined as a non-mandatory, non-compulsory document approved by a recognised body for the general or repeated use of rules, guidelines or characteristics of products or related processes and production methods. In the era of knowledge-based economy, products with high technological content or technical achievements give new meaning to technical standards. The market has gradually formed a consensus: "third-rate enterprises sell their strength, second-rate

enterprises sell their products, first-rate enterprises sell their technology, and super-first-rate enterprises sell their standards" (Kelly *et al.*, 2018). The development of technical standards based on technical strength, only continuous innovation, improve product quality and level, with independent intellectual property rights of the core technology, enterprises can play an influential role in the field of industry standardisation. Without strong development strength and technological innovation strength, it is difficult for enterprises to participate in the formulation of standards. Through the development of first-class level of technical standards, enterprises can control the frontiers of technological development, firmly grasp the initiative of technological development, so as to maintain a leading position in the domestic and international market competition. Therefore, the number of enterprises participating in or formulating industry standards is a concrete embodiment of their technological innovation performance and an important symbol of their core competitiveness (Ponta *et al.*, 2021).

2.2.3. The Existing Technology Innovation Performance Evaluation System Mainly Focuses On Product Technology Innovation, and Has Not Fully Reflected the Effectiveness of Process Technology Innovation

In the existing technology innovation performance evaluation system, product technology innovation is often given a dominant position, while the performance evaluation of process technology innovation is relatively rare (Lou *et al.*, 2020). Common innovation performance indicators include the number of new products, the share of new product sales, the foreign exchange rate generated by new products, and the profitability of new products, etc., which mainly reflect the results of product technology innovation. However, the contribution of technological innovation in improving production efficiency, lowering costs, reducing resource consumption, easing environmental burdens, and improving product quality is equally important, but these contributions are often difficult to measure through traditional quantitative indicators (Kang and Zhao, 2022).

Technological innovation in processes can replace labor by improving capital efficiency, thereby increasing labor productivity and reducing the cost per unit of product; it may also lead to significant reductions in material and energy consumption, reduce pollution and noise, improve the working environment, and reduce damage to the environment; in addition, technological innovations may improve product quality and shorten the production cycle or delivery time (Rybárová *et al.*, 2021). These economic and social benefits resulting from process technology innovation are extremely significant, but the difficulty of obtaining raw data makes it difficult for these contributions to be adequately captured by current evaluation systems (Yin and Li, 2019).

Therefore, neglecting the performance evaluation of process technology innovation will lead to an incomplete and partial understanding of an enterprise's technological innovation capability (Rybárová *et al.*, 2021). In order to assess technological innovation performance more accurately, new indicators or evaluation methods should be developed to capture the contribution of process technology innovation in terms of improving productivity, saving resources, protecting the environment, and enhancing product quality. These indicators should be able to reflect the long-term benefits and potential value of process innovation, thus providing enterprises with more comprehensive information on technological innovation performance and supporting its application in technological innovation decision-making (Rybárová *et al.*, 2021).

2.2.4. Existing Technological Innovation Performance Evaluation Index System Pays Too Much Attention To Innovation Output And Ignores Innovation Process Performance

In the current field of technological innovation performance evaluation, research has mainly focused on quantitative indicators of innovation outputs, while the evaluation of the innovation process is often not given sufficient attention (Milenković and Petković, 2023). The cultivation and development of an enterprise's technological innovation capability is a dynamic and continuous progress process. The performance of innovation process can show the maturity of enterprises in the management of innovation activities, and predict the potential of future technological innovation (Silva *et al.*, 2023). Excellent innovation results often come from an efficient innovation management process, so a comprehensive technology innovation performance evaluation system should include the measurement of innovation process performance to reveal the long-term development potential and future innovation capability of an enterprise's technological innovation (Das, 2023).

The conceptual model for evaluating technological innovation performance proposed by some scholars emphasises the importance of both innovation output performance and innovation process performance. However, the model fails to provide specific indicators to measure innovation process performance. In order to remedy this shortcoming, indicators that can comprehensively assess the quality of innovation management, teamwork efficiency, knowledge management capability and innovation culture should be developed (Camarinha-Matos *et al.*, 2019). These indicators can not only measure the efficiency of current innovation activities, but also predict the probability of success of future innovations, thus providing enterprises with more in-depth information about their technological innovation performance and supporting their long-term innovation strategic planning and decision-making (Yan-shao, 2012). This evaluation system will help enterprises better understand the complexity of the innovation process, identify improvement points, and promote continuous technological innovation and competitiveness enhancement.

2.3. Design Ideas of Enterprise Technological Innovation Performance Evaluation Indicator System

Technological innovation performance is an important indicator for measuring the effectiveness of enterprise technological innovation activities (Fan *et al.*, 2023). A scientific and comprehensive enterprise technological innovation performance evaluation index system should be able to comprehensively reflect the results of enterprise technological innovation, and maintain the inherent logical connection and mutual complementarity among the indicators (Jiao and Liu, 2022). When constructing such an indicator system, the choice of indicators and the way they are set up not only affects the scientificity and accuracy of the evaluation, but also has a bearing on the effective allocation of enterprise technological innovation resources, as well as the continuous improvement of the enterprise's innovation capacity and innovation mechanism (Sun *et al.*, 2022).

Technological innovation itself is a systematic project, and its stage, diversity and hierarchy determine that the innovation performance evaluation index system must have a hierarchical structure (Saunila, 2017). In view of the many factors affecting the technological innovation performance of enterprises and the complex structure, only through multi-dimensional and multi-level consideration can the actual performance of enterprise technological innovation be comprehensively captured (Shuang, 2020).

Market demand and user satisfaction are key to the success of technological innovation; they are not only the starting point but also the ultimate goal of innovation activities (Jiao and Liu, 2022). The success of new product development and process innovation can bring significant economic returns for enterprises, which constitutes the direct performance of technological innovation (Sun *et al.*, 2022). The success of technological innovation can also enhance the technological level and core competitiveness of enterprises, change the allocation of production factors and improve the social environment through product and process innovation, and create indirect benefits for enterprises and society (Saunila, 2017).

The construction and improvement of an enterprise's technological innovation system depends on the enterprise's internal support system, including technological strategy, organisational environment, resource supply and effective external connections (Shuang, 2020). Therefore, a complete evaluation system of technological innovation performance should include both innovation output performance and innovation process performance (Jiao and Liu, 2022). Figure 1 shows the enterprise technological innovation performance evaluation framework.Technological innovation output performance reflects the direct results of an enterprise's technological innovation activities, while innovation process performance complements the level of an enterprise's innovation management and potential innovation capability (Sun *et al.*, 2022). Excellent innovation results often come from efficient innovation management process, therefore, in-depth investigation of the reasons for good performance is the core task of innovation management (Fan *et al.*, 2023).

As the iceberg model shows, innovation performance is the visible part, while the innovation process is the part hidden under the water (Saunila, 2017). Only by comprehensively evaluating these two parts can we accurately depict the whole picture of enterprise technological innovation (Shuang, 2020). When designing the innovation performance index system, we should closely integrate the essential characteristics of technological innovation, and comprehensively reflect the visible and potential performance of enterprise technological innovation, as well as the economic, technological and social benefits brought by technological product innovation and process innovation (Fan *et al.*, 2023).

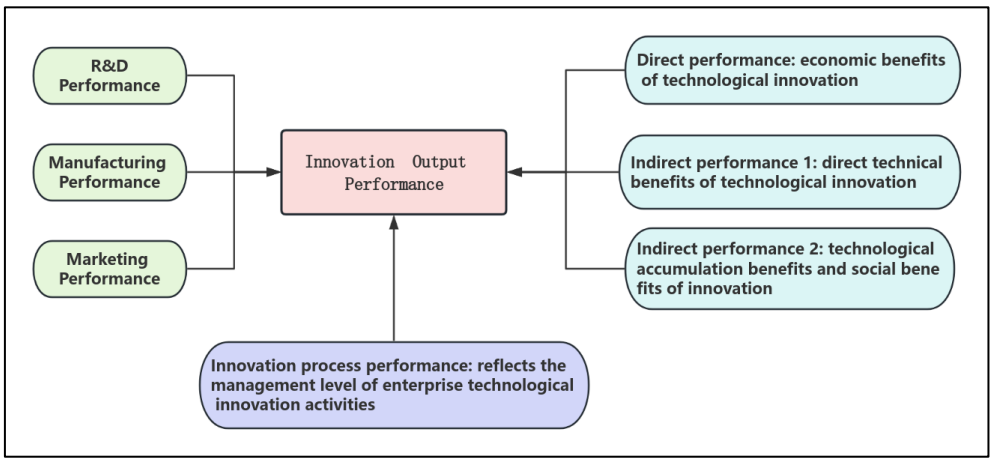

Fig-1. Framework for evaluating enterprises' technological innovation performance

3. The Construction of Enterprise Technology Innovation Performance Evaluation Indicator System

On the basis of an in-depth analysis of the nature, characteristics and process of technological innovation as well as the actual innovation situation of Chinese enterprises, we followed the principles of scientificity, completeness, comparability and operability to tailor a set of technological innovation performance evaluation index system for different types of enterprise innovation characteristics. The system is demonstrated in Tables 1 and 2, in which the weights of the indicators are based on field research and in-depth interviews with enterprises, and the comprehensive judgement derived from the use of hierarchical analysis.

This indicator system aims to provide a multi-dimensional and hierarchical evaluation framework for enterprises to comprehensively measure the effectiveness of their technological innovation. We recognise that technological innovation is more than just the updating of products and processes; it also involves the adaptation of corporate culture, organisational structure, market strategy and the external environment. Therefore, our indicator system includes not only traditional innovation output indicators, such as the number of new products and sales share, but also innovation process indicators, such as project management efficiency, teamwork ability and knowledge conversion rate.

In determining the weights of the indicators, we have particularly considered the industry characteristics, market positioning and innovation resource allocation of the enterprises to ensure the accuracy and practicality of the evaluation results. Our goal is to help enterprises better understand and optimise their technological innovation activities through this indicator system, so as to gain an advantage in the fierce market competition.

Table-1. Evaluation index system of technological innovation performance of enterprises focusing on product innovation

categorisation		**No.**	**norm**	**Dimension weight (%)**	**Indicator weights (%)**
Innovation output performance	economic benefit	1	Sales rate of new products	30	40
		2	New product margins		30
		3	Unit product cost reduction rate		30
	Direct technical benefits	4	Number of new products	30	40
		5	Number of products with significant improvements		30
		6	Number of new standards hosted or participated in		30
	Benefits of technology accumulation	7	Patent Application	20	30
		8	Number of know-how		20
		9	Number of technical documents		20
		10	Number of scientific and technical papers		15
		11	Number of technological innovation proposals		15
Innovation process performance		12	Number of competitive intelligence analysis reports	20	20
		13	Frequency of communication between R&D and customers		10
		14	Frequency of communication between R&D and production		10
		15	Frequency of R&D department exchanges between firms		10
		16	Frequency of exchanges between R&D departments of enterprises and universities and research institutes		5
		17	R&D investment as a percentage of sales revenue		10
		18	Percentage of R&D staff		10
		19	Percentage of technical experts		5
		20	Per capita training costs for enterprise technicians		10
		21	Number of technicians participating in domestic and international training		5
		22	Number of enterprise technology forums		5

Table-2. Evaluation index system of technological innovation performance of enterprises focusing on process innovation

categorisation		No.	norm	Dimension weight (%)	Indicator weights (%)
Innovation output performance	economic benefit	1	Improvement of product sales rate	30	25
		2	Improved product margins		25
		3	Unit product cost reduction rate		50
	Direct technical benefits	4	Number of major process innovations	30	40
		5	Number of products improved		30
		6	Number of new standards hosted or participated in		30
	Benefits of technology accumulation	7	Patent Application	15	20
		8	Number of know-how		15
		9	Number of technical documents		15
		10	Number of scientific and technical papers		10
		11	Number of technological innovation proposals		10
		12	Product quality improvement rate		10
		13	Rate of increase in labour productivity		10
		14	Production cycle time reduction		10
	social benefit	15	Reduction rate of energy consumption per 10,000 yuan of output value	5	50
			Reduction of environmental pollution levels		50
Innovation process performance		12	Number of competitive intelligence analysis reports	20	20
		13	Frequency of communication between R&D and customers		10
		14	Frequency of communication between R&D and production		10
		15	Frequency of R&D department exchanges between firms		10
		16	Frequency of exchanges between R&D departments of enterprises and universities and research institutes		5
		17	R&D investment as a percentage of sales revenue		10
		18	Percentage of R&D staff		10
		19	Percentage of technical experts		5
		20	Per capita training costs for enterprise technicians		10
		21	Number of technicians participating in domestic and international training		5
		22	Number of enterprise technology forums		5

Considering the nature, characteristics, and process characteristics of technological innovation as well as the actual innovation situation of Chinese enterprises, we designed a set of enterprise technological innovation performance evaluation index system, aiming to scientifically and comprehensively reflect the technological innovation achievements of enterprises. The following is an explanation of the specific indicators (Table 3).

Table-3. Explanation of the indicators in the enterprise technology innovation performance evaluation index system

Indicator name	**a concrete explanation**
Number of new products	Represents the total number of new products developed and brought to market during the year. New products are defined as: a. Products whose technical characteristics or uses are significantly different from those of existing products, and which may be based on entirely new technologies, new applications of existing technologies, or the application of new knowledge. b. Existing products with significant performance improvements. c. Product differentiation that does not include minor changes in aesthetics (e.g. appearance, colour, pattern, packaging) or technology only. d. New products in the category of means of production are counted for three years from the start of production, and new products in the category of consumer goods are counted for two years from the start of production.
Number of products with significant improvements	This includes significant improvements in structure, specifications, standards, appearance and materials, as well as innovations in tooling equipment and production processes.
New standard	The number of international, national, provincial and ministerial industry standards that enterprises led or participated in formulating in that year.
Sales rate of new products	The proportion of sales revenue from new products developed in the past three years to the total sales revenue of the enterprise.
Improvement of product sales rate	Proportion of revenue from sales of products with significant improvements in performance to the total sales revenue of the enterprise.
New product margins	The proportion of profits realised from new products developed in the last three years to the total profits of the enterprise in that year.
Improved product margins	The proportion of profits realised from products with significant improvements in performance to the total profits of the enterprise for the year.
Unit product cost reduction rate	Proportion of cost reduction per unit of product resulting from process innovations and equipment improvements.
Number of patent applications	Total number of patents filed during the year, including inventions, utility models and designs.
Number of know-how	Amount of inconveniently patentable technical know-how developed during the year, including technical knowledge, experience and skills under confidentiality.
Number of technical documents	The total number of technical documents completed during the year, covering documents created during product development or process refinement.
Number of scientific and technical papers	The total number of scientific and technical papers published by the enterprise in official journals at home and abroad during the year.
Number of technological innovation proposals	Total number of technological innovation proposals made by employees within the enterprise during the year.
Product quality improvement rate	Proportion of product quality improvement due to process innovation and equipment improvement.
Rate of increase in labour productivity	Proportion of labour productivity gains resulting from process innovations and equipment improvements.
Production cycle time reduction	Reduced production cycle times due to process innovations and equipment improvements.
Reduction in energy consumption per 10,000 yuan of output value	Reduction in energy consumption per 10,000 Yuan of output value due to process innovation.
Reduction of environmental pollution levels	Degree of reduction in environmental pollution due to process innovation.
Number of competitive intelligence analysis reports	Total number of domestic and foreign competitive intelligence analyses related to this industry collected during the year.
Frequency of R&D exchanges	Frequency of communication scores between R&D departments and customers, manufacturing departments, internal departments, and university institutes.
Share of R&D investment	The proportion of technology R&D investment expenses to the total sales revenue of the enterprise in the current year.
Share of R&D staff	The proportion of staff in the technology research and development

	department to the total number of employees during the year.
Number of technical leaders	Total number of experts with outstanding contributions and experts receiving special government allowances.
Number of technical bridge figures	Total number of technical or project managers who act as information bridges.
Technician training costs	The per capita cost of the enterprise for training employees during the year.
Number of participants in technical staff meetings	Total number of domestic and foreign academic or technical seminars attended by technicians during the year.
Number of technical forums	Total number of technology development forums or workshops held during the year.

4. Summary

This study proposes and refines a set of performance evaluation indicators tailored for Chinese enterprises' unique characteristics in technological innovation. The document critiques existing systems that predominantly focus on outputs of product innovation and often overlook the contributions and long-term impacts of process innovations. To address this, the study develops a comprehensive set of indicators that not only measure immediate innovation outcomes but also emphasize the efficiency of the innovation management process, the effectiveness of team collaboration, capabilities in knowledge management, and the cultivation of an innovation culture.

The essence of technological innovation is highlighted as a holistic and systematic endeavor encompassing the entire progression from concept to commercialization. Effective technological innovation is characterized not only by the successful commercial application of a new invention but also by its capability to satisfy market demands and realize value. Consequently, the proposed evaluation system is designed to reflect long-term development potential and actual capabilities in innovation management, mechanism construction, and culture cultivation within enterprises.

5. Discussion

5.1. Complexity and Dynamism in Innovation Evaluation

The research underscores that assessing technological innovation performance should extend beyond traditional output metrics like new product sales rates or profit margins. Instead, a robust evaluation system should incorporate a comprehensive assessment of the innovation process to reveal the maturity of an enterprise's management of innovation activities and the potential for future technological advancements. This includes measuring the quality of innovation management, team efficiency, knowledge management capabilities, and the innovation culture.

5.2. Design Philosophy of the Indicator System

The design of the indicator system should reflect the multi-layered and multidimensional nature of technological innovation. The system proposed in the study not only needs to be scientific and precise but also attentive to the effective allocation of resources within an enterprise and the continuous improvement of its innovation capacity. Additionally, given the diversity in enterprise innovation characteristics, the construction of the indicator system should be flexible and adaptable to accommodate the specific conditions of different types of enterprises.

Recommendations and Implications

To enhance the technological innovation capacity and market competitiveness of Chinese enterprises, it is crucial for policymakers and business managers to focus on and improve the mechanisms for evaluating technological innovation. It is recommended to strengthen the assessment of process innovations and develop new indicators and methods that can capture the comprehensive long-term benefits and potential value of innovation activities. Enterprises should also strive to integrate internal innovation resources more effectively, optimize innovation processes and mechanisms, and establish a technology innovation performance evaluation system that is both scientifically grounded and practically applicable.

In conclusion, the paper offers a novel framework for evaluating the technological innovation performance of Chinese enterprises, aiming to help them accurately assess the effectiveness of their innovation activities and maintain their vitality and competitive edge in a rapidly changing market environment.

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