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THEORETICAL MODEL AND EVALUATION INDEX DESIGN OF ENTERPRISE INNOVATION PERFORMANCE UNDER THE FUSION OF TWO CHAINS

Gao Qinuo
[1]School of Management Engineering and Business, Hebei University of Engineering, Handan, Hebei, China [a]228299769@qq.com
[*]Corresponding author

Abstract: Focusing on the layout of the innovation chain in the industrial chain and deploying the industrial chain around the innovation chain are key to improving enterprise innovation performance. This paper, based on the fusion network of the industrial chain and innovation chain, constructs an evaluation index system of innovation performance for equipment manufacturing enterprises, including three primary indicators and fifteen secondary indicators. The Analytic Hierarchy Process (AHP) is employed to determine the weights of the evaluation indicators. The research finds that the innovation subjects, innovation resources, and innovation environment of the fusion network can all affect enterprise innovation performance. Based on the weights of the evaluation indicators, effective strategies are proposed to enhance enterprise innovation performance.
Keywords: Two chain fusion; Innovation performance; Innovation Ecosystem; AHP

1. Introduction

Improving the transformation and industrialization level of scientific and technological achievements is the key to strengthening the integration of science and technology with the economy. The former starts from the innovation chain, and plays a leading role in industrial development. It not only realizes the transformation of scientific and technological achievements, but also promotes upgrading of the industrial chain to optimization; The latter starts from the weak links in industrial development, and it plays a supporting role in the innovation chain. Thus, it helps improve the industrialization to a higher level. It fully reveals the inherent requirements for close connections and collaborative linkage between technological innovation and industrial development. Furthermore, it clarifies the strategic significance of strengthening the position of enterprises as the main body of technological innovation, deepens the understanding of the laws of innovative development, and points out the strategic direction for achieving high-quality economic development.

In recent years, there has been abundant research on the industrial chain and innovation chain, including both theoretical discussions and empirical studies: the bidirectional fusion path of the industrial chain and innovation chain[1], the operating mechanism of the fusion of the industrial chain and innovation chain[2][3], and studies on the synergy of the industrial chain and innovation chain[4]. However, there is still a lack of theoretical analysis and model construction on the fusion network of two chains. Research on equipment manufacturing enterprises mainly focuses on the impact of various factors from different perspectives and backgrounds on the digital maturity of enterprises[5][6], intelligent upgrading[7], and the upgrading of the industrial value chain[8]. There are also some studies involving mode exploration[9], development path analysis and selection[10], and operation mechanism design[11]. However, there are few studies on the innovation performance of equipment manufacturing industry from the perspective of the fusion of two chains. Therefore, this paper constructs an evaluation index system of innovation performance for equipment manufacturing enterprises based on the fusion network of two chains, evaluates relevant case enterprises, and provides suggestions, aiming to provide reasonable means for enterprises to obtain competitive advantages and contribute to the improvement of enterprise innovation performance and economic and social development.

2. Theoretical Analysis and Model Construction of Innovation Performance Evaluation

2.1 Fusion Network of Industrial Chain and Innovation Chain

The concept of the industrial chain originated from the classical economist Adam Smith's discussion of division of labor in "The Wealth of Nations." Based on established technical and economic links, specific logical relationships and spatial layouts, and a dynamic chain system, the industrial sectors exert scale, profitability, systematicness, and transformative effects after the formation of artificial objects through industrial activities, thereby forming a relationship chain of division of labor and cooperation among multiple industrial sectors, ultimately achieving value addition and industrial development objectives. The industrial chain emphasizes the coordination of upstream and downstream enterprises and expands upstream to enter the basic industries and technological research and development links and extends downstream to enter market development and marketing links[12].

The concept of the innovation chain emerged in the 1970s, with its starting point being the incubation of creativity and its end point being industrialization. Guided by market demand, the innovation chain integrates innovation elements such as knowledge and technology through innovation activities to form innovative products and services. It then achieves efficient allocation of innovation resources through market mechanisms, establishes internal connections, value interactions, and mutual coordination, and fully realizes the overall benefits of the innovation chain. The innovation chain can transform basic research into scientific theory, scientific theory into applied research, practical application into products, and products into commodities, thereby transforming them into industrial production[13].

The fusion network of two chains, as an open and systematic innovation platform, is integrated into the research framework of the innovation ecosystem, manifested as close connections among various entities and institutions in the network, emphasizing the interactive relationships between various entities and the coordination and symbiosis of innovation resources, while considering the uncertainty and dynamics of the overall environment, thereby forming an innovative ecosystem of multiple enterprise division of labor, dynamic linkage of various departments, knowledge acquisition, absorption, transformation, and utilization, and ultimately achieving the goal of improving enterprise innovation performance. The development impetus of the industrial chain comes from innovation, and innovation drives the development and value addition of various links in the industrial chain. Similarly, the development of the industrial chain helps to realize the transformation of innovative achievements, support the development of the innovation chain, and ultimately achieve mutual dependence and coordinated development of the industrial chain. The fusion of the industrial chain and the innovation chain constructs an innovative ecosystem interconnected with scientific and technological innovation and industrial development, which can break through the dilemma of critical core technology constraints, effectively overcome industrial bottlenecks, accelerate the transformation of scientific and technological achievements, and improve the level of industrialization, firmly grasping the initiative of innovation development.

2.2 Enterprise Innovation Performance

With the increasing competition in the international market, innovation has gradually become the guarantee for the survival of enterprises. Among them, innovation performance is a very important indicator, reflecting the source of competitive advantages for enterprises, driving force for enterprise development, and the embodiment of the independent innovation capabilities of various industries in a country. Enterprise innovation performance emphasizes the innovation level and results of organizations, reflecting the process from idea generation to the production of new products. Enterprise employees engage in innovative work through the sharing of resources and information and the use of knowledge to achieve purposeful innovation, provide and complete new ideas, produce new methods and products, and obtain actual benefits, reflecting the results of technological innovation and knowledge innovation.

Based on the literature and theoretical analysis at home and abroad, this paper believes that the evaluation of innovation performance of equipment manufacturing enterprises from the perspective of the fusion of two chains

should include three aspects: innovation subjects (research and development institutions, the number of full-time teachers in universities, equipment manufacturing enterprises, and industrial enterprises above designated size), innovation resources (full-time equivalent of R&D personnel, internal expenditure on R&D, fixed asset investment in information technology services industry, and local financial expenditure on science and technology), and innovation environment (per capita disposable income of residents, per capita public budget education expenditure, technology market turnover, and patent applications). Based on this, this paper establishes the evaluation index system of innovation performance of equipment manufacturing enterprises from the perspective of the fusion of two chains. As shown in Figure 1.

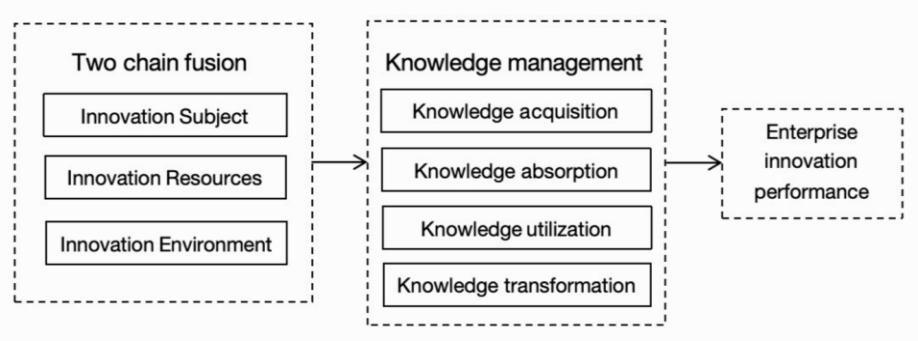

Figure 1: Innovation Performance Theory Model Diagram.

3. Design of Innovation Performance Evaluation Indexes from the Perspective of Fusion of Two Chains

3.1 Construction of Evaluation Index System

Innovation performance evaluation index system is a tool used to measure and evaluate the innovation level and results of enterprises, reflecting the comprehensive strength of enterprise innovation activities. It is the basis and foundation for enterprises to carry out innovation activities and the fundamental guarantee for enterprises to maintain a competitive advantage in the market. The innovation performance evaluation index system from the perspective of the fusion of two chains constructed in this paper includes three primary indicators and fifteen secondary indicators. The primary indicators are innovation subjects, innovation resources, and innovation environment. The secondary indicators are derived from specific indicators. The specific indicators and sources are shown in Table 1.

Table 1: Enterprise Innovation Performance Evaluation Indicators.

Primary indicators	Secondary indicators	References
Innovation subjects	Number of research and development institutions	[14,15,17,18]
	Number of industrial enterprises	
	Regional situation of higher education institutions	
	Number of university science and technology parks	
	Growth rate of enterprise quantity	
Innovation resources	R&D personnel full-time equivalent	[14,15,18,19]
	Internal expenditure of R&D funds	
	Number of patent authorizations	
	Number of scientific and technological papers published	

	Total area of university science and technology park	
Innovation environment	Per capita disposable personal income	[14-16,18,19]
	Per capita public budget for education funding	
	Technology market transaction volume	
	Regional per capita GDP	
	Number of technology enterprise incubators	

3.2 Determination of Indicator Weights

The weight determination of the evaluation index system is a key step in the construction of the evaluation index system, which directly affects the rationality and scientificity of the evaluation results. This paper uses the Analytic Hierarchy Process (AHP) to determine the weights of the evaluation indicators. The specific steps are as follows:

Step 1: Establish the judgment matrix. The judgment matrix is a reflection of the relative importance of the evaluation indicators. Based on the experience and knowledge of the research team, a pairwise comparison is made between the evaluation indicators, and the relative importance of each indicator is scored.

Step 2: Calculate the weight vector. According to the principle of consistency, the maximum eigenvalue and eigenvector of the judgment matrix are calculated, and the consistency ratio is obtained to determine whether the judgment matrix is reasonable and reliable.

Step 3: Check the consistency of the judgment matrix. The consistency ratio is calculated based on the consistency index and the random consistency index. If the consistency ratio is less than 0.1, the judgment matrix is considered consistent and reliable, and the weight vector is used as the weight of the evaluation indicators. If the consistency ratio is greater than or equal to 0.1, the judgment matrix needs to be adjusted until the consistency ratio is less than 0.1.

Step 4: Determine the weight of the evaluation index. The weight of the evaluation index is the normalized eigenvector of the judgment matrix, which represents the relative importance of the evaluation index in the evaluation index system.

3.3 Hierarchical Sorting and Overall Sorting, Consistency Test Results

Table 2: Enterprise Innovation Performance Evaluation Index System.

Primary indicators	Criterion (Primary indicators)	Weight	Objective (Secondary indicators)	Weight
Evaluation indicators for enterprise innovation performance N	Innovation subjects N_1	0.248	Number of research institutions N_{11}	0.253
			Number of industrial enterprises N_{21}	0.285
			Situation of higher education institutions N 13	0.199
			Number of university science and technology parks N14	0.190
			Growth rate of enterprise quantity N_{15}	0.071
	Innovation resources	0.564	R&D personnel full-time equivalent N_{21}	0.121

	N_2		Internal expenditure of R&D funds N_{22}	0.205
			Number of patent authorizations N 23	0.266
			Number of scientific and technological papers N 24	0.299
			Total area of university science and technology park N25	0.105
	Innovation environment N_3	0.188	Per capita disposable personal income N_{31}	0.105
			Per capita public budget for education funding N32	0.085
			Technology market transaction volume N33	0.320
			Regional per capita GDP N_{34}	0.226
			Number of technology enterprise incubators N35	0.261

This study invited experts from industry enterprises, research institutes, and universities in the fields of economics, technology, and financial evaluation to rate the importance of each indicator in the innovation performance evaluation index system established in this article. The Analytic Hierarchy Process (AHP) was used to scale the 1-9 ratio, and a judgment matrix was constructed. After testing, all indicators met the consistency requirements.The weight values of enterprise innovation performance evaluation indicators are shown in Table 2.

Among them, the consistency CR of the judgment matrix for the first level indicator is 0.0036, the weight for the total target is 1.000, and the maximum eigenvalue value is 3.0037; The consistency CR of the judgment matrix for the secondary indicators under the innovation subject is 0.0477, with a total target weight of 0.2297 and a maximum eigenvalue of 5.2138; The consistency CR of the judgment matrix for the secondary indicators under innovative resources is 0.0683, with a total target weight of 0.6483 and a maximum eigenvalue of 5.3060; The consistency judgment matrix of the secondary indicators in the innovation environment has a consistency CR of 0.0431, a total target weight of 0.1220, and a maximum eigenvalue of 5.1930.

Based on the theory and practice of the integration of two chains, relevant experts in the field are invited to provide opinions and suggestions on the composition of innovative performance evaluation indicators established in this article and the weight values determined by the Analytic Hierarchy Process. To ensure the comprehensiveness, representativeness, operability, and comparability of the evaluation index system, the weight of each indicator in the evaluation index system can truly reflect the importance of the indicator in the evaluation of enterprise innovation performance.

3.4 Analysis and Suggestions on the Comprehensive Evaluation Results of Enterprise Innovation Performance

From the analysis of primary indicators, the weights of innovation subjects, innovation resources, and innovation environment are 0.248, 0.564, and 0.188, respectively. It can be seen that innovation resources are the most important for enterprises to improve innovation performance. Therefore, in order to effectively improve the innovation performance of core enterprises in the two chain integration network, the first priority should be to focus on the supply of innovation resources and the construction of infrastructure. Secondly, by optimizing the management decision-making, employee incentives, policy guarantees, and risk monitoring mechanisms of the

two chain integration network, we can create a cooperative environment, learning atmosphere, and integration culture between internal and external organizations of the enterprise, promote the increase of funding and personnel investment in R&D research and development for innovation in the two chain fusion network, increase the number and proportion of patent authorizations and scientific and technological paper publications for innovation in the two chain fusion network, form an innovation ecosystem of organizational integration, management integration, technology integration, and innovation integration, and continuously improve the integration and collaboration capabilities between the various entities in the two chain fusion network. At the same time, by improving the policy planning of the two chain fusion network, enhancing the knowledge management and team learning atmosphere between the two chain fusion networks, and establishing a two chain fusion network platform, the main body size of the two chain fusion network will be continuously increased, and the frequency and intensity of communication between the main body of the two chain fusion network will be continuously increased, thereby effectively improving the innovation performance of enterprises.

From the perspective of secondary indicators, there are five corresponding secondary indicators for innovative entities, with the highest weight being the number of industrial enterprises, followed by the number of scientific research institutions and higher education institutions. Various types of enterprises are the main body of the industrial chain, while universities and research institutions are the main body of the innovation chain. This is consistent with the research content of previous scholars. Based on this, it is necessary to improve the quality of talents in research institutions, teachers and students in higher education institutions, provide a good foundation for the integration network of the two chains, and thus stabilize the superstructure. Innovation resources are the primary factor driving the integration of two chains of innovation, with five corresponding secondary indicators. Among them, the top three weighted indicators are the number of scientific and technological papers published, the number of patent authorizations, and internal R&D expenditure. These three indicators can reflect the output level of academic and technological achievements, as well as the scale of funding investment. Therefore, it is necessary to increase investment in scientific and technological research and development funds, and promote communication and cooperation among various entities in scientific and technological innovation, Overcoming obstacles such as regional and knowledge gap, and accelerating the flow of resources in the two chain fusion network. The innovation environment is one of the factors that prevent enterprises from producing low innovation performance. There are five corresponding secondary indicators, among which technology market transaction volume, the number of technology enterprise incubators, and the weight of per capita GDP in the region are the top three, which can fully measure the cooperation situation in the technology market, the overall economic situation of the region, and the infrastructure of entrepreneurship incubation. Based on this, it is necessary to optimize the allocation of market resources, promote the transformation of innovation achievements, narrow the gap in innovation resource allocation among various entities, promote the aggregation of innovation resources to enterprises, and thus form and improve an innovation ecosystem that can improve enterprise innovation performance.

4. Conclusion and Future Outlook

4.1 Conclusion

Based on the theoretical framework of the fusion of two chains, this paper constructs an evaluation index system of innovation performance for equipment manufacturing enterprises, including three primary indicators and fifteen secondary indicators. The Analytic Hierarchy Process (AHP) is employed to determine the weights of the evaluation indicators. The research finds that the innovation subjects, innovation resources, and innovation environment of the fusion network can all affect the innovation performance of enterprises to varying degrees. Based on the weights of the evaluation indicators, effective strategies are proposed to enhance enterprise innovation performance. Therefore, based on the weight of evaluation indicators, effective strategies to improve enterprise innovation performance have been proposed.

4.2 Future Outlook

In future research, the following aspects can be further explored:

Further improve the evaluation index system of innovation performance from the perspective of the fusion of two chains, expand the scope of the evaluation index, and explore more comprehensive and effective evaluation indicators.

Enhance the pertinence and practicality of the evaluation index system, refine the weight determination method, and explore more scientific and reasonable weight determination methods.

Combine qualitative and quantitative analysis methods, further optimize the evaluation model, and provide a more accurate and comprehensive evaluation method for enterprise innovation performance.

In summary, this paper summarizes the establishment of an evaluation index system of innovation performance for equipment manufacturing enterprises and the determination of indicator weights from the perspective of the fusion of two chains, and proposes strategies to enhance enterprise innovation performance based on the research results. It provides theoretical guidance and practical reference for the innovation and development of equipment manufacturing enterprises.

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