*Corresponding Author's Email: yanfengc@nuaa.edu.cn
Proceedings of the International Conference on Applied Research in Management, Business and Economics,Vol. 2 Issue. 2, 2025, pp. 01- 10
DOI: https://doi.org/10.33422/icarbme.v2i2.1597

ISSN: 3030-1149 online

Diamond Scientific Publishing

Research On Measuring the Integration Level of High-Tech Manufacturing Industry Chain and Innovation Chain in Jiangsu Province in China

Chu Yanfeng*, and Xie Lian

Nanjing University of Aeronautics and Astronautics, Nanjing 211100, China

Abstract

The integration of industrial and innovation chains serves as a critical guarantee for the high-quality development of the high-tech manufacturing industry in Jiangsu Province, as the synergistic effects derived from their coupling and coordinated development outweigh the independent contribution of each individual system. From the perspective of coupling coordination, this study constructs an evaluation index system for industrial-innovation chain integration and systematically estimates and assesses the coupling coordination degree of dual-chain integration for Jiangsu's high-tech manufacturing industry from 2013 to 2022. The empirical results reveal that, despite an overall upward trend in the coupling coordination level of the innovation chain, the comprehensive dual-chain coordination degree remains at a relatively low level, implying that interactive collaboration and mutual adaptation between the two chains require further enhancement. Accordingly, this paper proposes targeted policy recommendations, including the establishment of specialized dual-chain cooperation platforms and the introduction of high-end innovative talents, to facilitate deeper dual-chain integration and high-quality industrial development.

Keywords: High-tech manufacturing industry, industry chain, innovation chain, degree of coupling coordination

1. Introduction

The integration of industrial and innovation chains is a dynamic and intricate process. In this process, a single participant is unable to independently lead or fully meet the complex demands of technological and industrial innovation integration. In contrast, diversified cooperation helps form a well-organized organic system that facilitates resource transfer across different departments and sectors. Multi-stakeholder collaboration enables participants to integrate their respective superior resources and build a coordinated and complementary operational system. Such synergistic collaboration not only gives full play to the complementary advantages of all participants but also maintains a balanced match between technological innovation and industrial development capabilities, as well as efficient docking between technology research and market demand. Therefore, industrial–innovation chain integration can be regarded as a multi-agent synergistic process, in which all participants contribute heterogeneous resources

and capabilities to jointly promote technological progress and achieve high-quality industrial development.

Although the high-tech manufacturing industry in Jiangsu Province presents an obvious agglomeration and growth trend, and preliminary coupling between industrial and innovation chains has been realized in prefecture-level cities, significant regional and industrial heterogeneity still exists. The industry is currently plagued by insufficient core technologies, weak industrial foundational capabilities, and inadequate independent research and development capacity. These problems lead to mismatched and fragmented development between industrial and innovation chains and restrict the efficiency of scientific and technological progress. Against this backdrop, this study aims to promote high-level and in-depth integration of industrial and innovation chains in Jiangsu's high-tech manufacturing sector.

2. Literature Review

Research on industrial chains

The industrial chain is defined as a multi-functional chain-like network composed of multiple embedded links. It covers the whole process from raw material procurement and resource allocation to production and operation, creates value for upstream and downstream sectors and affiliated enterprises, and ultimately forms market-oriented products and services recognized by end users (Liang et al., 2023). Jiang et al. explored the role of standard alliances in facilitating upstream and downstream synergistic cooperation within industrial chains. Li et al. investigated how technological innovation drives the iterative upgrading of industrial chains. Based on input–output linkages, Hirschman constructed the theoretical framework of industrial chains by defining forward and backward industrial linkages across sectors.

Research on innovation chains

The concept of the innovation chain originates from the industrial chain theory proposed by Roper et al. Xing further adopted this theoretical perspective to explain how innovative entities form chained and goal-oriented innovation behaviors through knowledge linkages. Zhang systematically examined the transformation process from scientific research outputs to practical applications driven by industry–university–research collaboration. In addition, Bititci established a knowledge-sharing framework to promote the widespread application of research and development (R&D) achievements.

Research on industrial–innovation chain integration

Han pointed out that the integration of industrial and innovation chains mainly follows two interactive paradigms: the innovation chain empowers the expansion and upgrading of the industrial chain, and the industrial chain provides practical scenarios and market traction for innovative iteration. From the perspective of industrial–innovation–financial triple-chain integration, Yuan et al. sequentially analyzed the current status and evolutionary characteristics of dual-chain integration. Liu et al. further evaluated the co-innovation performance of industrial chains from multi-dimensional perspectives, including industrial input, environmental conditions, and policy support.

Research on the measurement of industrial–innovation chain integration level

In terms of quantitative measurement, Wang et al. adopted the coupling coordination degree (CCD) model to explore the interactive relationship between innovation chains and technology intermediary service chains. Domestic and foreign scholars have widely applied multiple

empirical models to identify the influencing factors and integration mechanisms of dual-chain development, including the absorptive capacity (AC) model (Hensena & Ahr, 2020), logit model (Bergeseno, 2019), DEA-LCV model (Li et al., 2015), SEM model (Okea, 2013), and capability maturity model (Di et al., 2018).

Research gaps and research motivation

Overall, existing studies have laid a solid theoretical and empirical foundation for exploring industrial and innovation chain integration. Previous industrial chain research primarily focuses on industrial upgrading, structural restructuring, and chain expansion, while innovation chain studies concentrate on the seamless transformation of R&D achievements from laboratory research to industrial production and market application. Nevertheless, most existing studies conduct separate discussions on the two chains, with insufficient in-depth quantitative analysis of their coupling coordination and integrated development, especially empirical evidence targeting high-tech manufacturing at the provincial level. Accordingly, this study focuses on Jiangsu Province and systematically investigates the coupling coordination level and evolutionary characteristics of industrial and innovation chains in its high-tech manufacturing industry, so as to fill the above research gap.

3. Integration and Development of Industrial and Innovation Chains in Jiangsu's High-Tech Manufacturing Industry

3.1 Mechanism of Industrial and Innovation Chain Integration

Industrial chains and innovation chains interact, mutually promote development, and achieve synergistic upgrading. The modernization and optimization of industrial chains rely heavily on the continuous advancement of innovation chains. Specifically, innovation chains drive industrial upgrading by facilitating breakthroughs in basic and applied research and strengthening the cumulative effects of technological innovation. This process enables industrial chains to evolve continuously toward high-technology and high-value-added links. Essentially, the interactive coupling between industrial and innovation chains aims to create favorable conditions for technological innovation centered on industrial development. Industrial chains can consolidate their development foundation and realize large-scale industrialization by absorbing innovative technologies from innovation chains. In return, industrial application scenarios further promote the transformation, scale expansion, and industrialization of scientific and technological achievements, thereby driving the overall industry toward high-level and high-quality development.

3.2 Synergistic Coupling Development of High-Tech Manufacturing Industry Chain and Innovation Chain

High-tech manufacturing industries cover six major sectors: pharmaceutical manufacturing; aviation, aerospace and equipment manufacturing; electronic and communication equipment manufacturing; computer and office equipment manufacturing; medical instrument and equipment manufacturing; and information chemical product manufacturing.

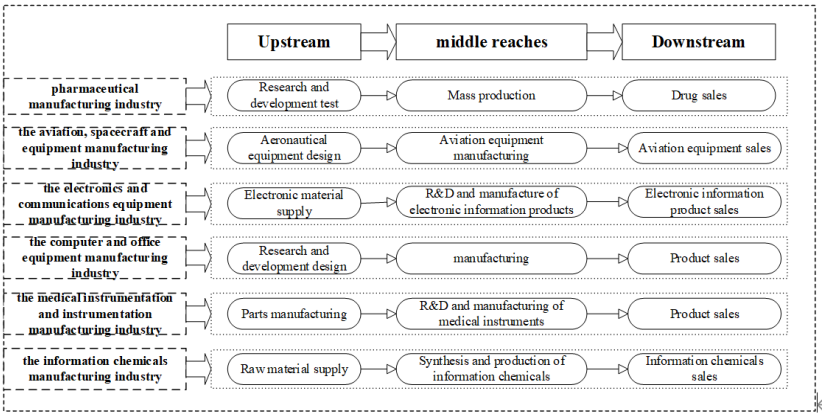

Fig 1: High-tech manufacturing industry chain

As illustrated in Figure 1, this article decomposes the industrial chain of the high-tech manufacturing sector into multiple sub-sectors for systematic analysis.

In addition to enterprises, governments, research institutions, financial institutions and other innovative participants are involved in the development of the industry. These stakeholders play an essential role in improving industrial innovation and productivity. Through extensive cooperation and resource sharing, they jointly form a complete innovation chain covering innovative ideas, technological development, achievement transformation, production layout and industrial application. Specifically, the upstream links of the innovation chain mainly include three core processes: innovative concept cultivation, technological breakthrough, and achievement transformation, as demonstrated in Figure 2.

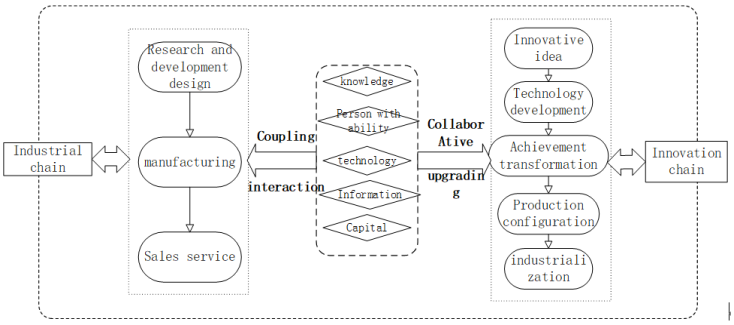

Fig2: Schematic Diagram of Coupling and Coordination of High-Tech Manufacturing Industry Chain and Innovation Chain

4. Measurement of Industrial and Innovation Chain Integration in Jiangsu's High-Tech Manufacturing Industry

4.1 Establishment of Integration Level Evaluation Indicator System

This paper draws on domestic and international research findings to systematically evaluate the coupling and coordination development degree of the high-tech manufacturing industry in Jiangsu Province. Specifically, this paper constructs an evaluation indicator system for industrial–innovation chain integration level in Jiangsu's high-tech manufacturing industry. The industrial chain evaluation covers two dimensions, namely industrial scale and industrial correlation, while the innovation chain evaluation includes three dimensions: innovation input, innovation output, and innovation environment (see Table 1).

Table 1： Evaluation Index System of Double Chain Integration of High-Tech Manufacturing Industry in JiangSu Province

Chain	Primary index	Secondary index
Innovation chain	Innovation input	R&D Full-time equivalent of active personnel (person/year)
		R&D Internal expenditure (100 million yuan)
		R&D Institute personnel (person)
		Expenditure of research and development institutions (100 million yuan)
		Number of new product development projects(item)
		New product development expenditure (100 million yuan)
	Innovation outputs	New product sales revenue (100 million yuan)
		Export sales revenue of new products (100 million yuan)
		Number of patent applications (pieces)
		Number of invention patent applications (pieces)
	Innovation environment	Number of invention patents (pieces)
		Number of enterprises with R&D institutions (units)
		Number of R&D institutions (units)
		Number of enterprises with R&D activities (units)
Industry chain	industrial scale	Number of Enterprises (units)
		R&D staff wages (billion yuan)
		Technology market turnover（billion yuan）
	industrial link	Expenditure on technology introduction（billion yuan）
		Expenditure on digestion and absorption（billion yuan）
		Expenditure on the purchase of domestic technology（billion yuan）
		Expenditure on technological transformation（billion yuan）

This paper selects statistical data on the industrial and innovation chains of the high-tech manufacturing industry in Jiangsu Province from 2013 to 2022 for empirical analysis. The original data are mainly sourced from the *China Statistical Yearbook* and *Jiangsu Statistical Yearbook*.

4.2Coupling Coordination Measurement Models

According to the dual-chain integration mechanism, this study regards the integrated development of industrial and innovation chains in Jiangsu's high-tech manufacturing industry as a composite system and adopts the coupling coordination degree model to measure its integration level. To scientifically and objectively reflect the comprehensive development status of industrial and innovation chains, this paper applies the entropy method to determine the indicator weights of the two systems. The measurement of coupling coordination degree is implemented in five steps.

1）Standardize all indicators using the extreme difference method to eliminate bias from inconsistent statistical units across indicators:

$$Positive\ indicators: x'_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{1}$$

$$Negative\ indicators: x'_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \tag{2}$$

Where, $x_{ij'}$ denotes the value of the j th indicator in the i th year after standardization, and the size of the standardized value is between 0-1. x_{ij} is the value of the j th indicator in the i th year,

$\max(x_{ij})$ and $\min(x_{ij})$ denote the maximum and minimum values of the j th indicator in the study time period, respectively.

2）Calculate the weight of the indicator value Pij of the j th indicator in the i th year:

$$P_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}} \tag{3}$$

3）Calculate the information entropy value ej of the j th indicator:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} P_{ij} \times \ln P_{ij} \tag{4}$$

4）Calculation of the weight of indicator j:

$$\lambda_j = \frac{1 - e_j}{\sum_{1}^{n} (1 - e_j)} \tag{5}$$

Let λ_{aj} , λ_{bj} be the weights of the j th indicator of the industrial chain system and the innovation chain system, respectively, and after determining the weights by using the entropy value method, the comprehensive development levels of the industrial chain and the innovation chain system, Za and Zb, can be obtained [23]:

$$Z = \sum_{j=1}^{n} \lambda_{ij} \times x'_{ij}, \sum_{j=1}^{n} \lambda_{ij} = 1 \tag{6}$$

Where Z denotes the comprehensive evaluation score value, Z_a denotes the comprehensive score of the industrial chain system, and Z_b denotes the comprehensive score of the innovation chain system.

Therefore, the coupling degree Cab between the two systems is:

$$C_{ab} = 2 \times \sqrt{\frac{Z_a Z_b}{(Z_a + Z_b)^2}} \tag{7}$$

The degree of coordination is:

$$T_{ab} = \alpha \times Z_a + \beta \times Z_b \tag{8}$$

α, β are coefficients to be determined, respectively, and according to the existing literature, it is not possible to determine the important bias between the industrial chain and the innovation chain, so the values of α, β are both 0.5.

The coupling coordination degree E_{ab} of the industrial chain system and innovation chain system is:

$$E_{ab} = \sqrt{(C_{ab} \times T_{ab})} \tag{9}$$

As indicated in Table 2, the weights of the indicators were determined by applying the entropy technique in accordance with Eq. (1), (2), (3), (4), and (5).

Table 2： Evaluation index system of double chain integration of high-tech manufacturing industry in Jiang Su province

Chain	Primary index	Secondary index	Indicator properties	weights
Innovation chain	**Innovation input**	R&D Full-time equivalent of active personnel (person/year)	positive	0.040
		R&D Internal expenditure (100 million yuan)	positive	0.037
		R&D Institute personnel (person)	positive	0.049
		Expenditure of research and development institutions (100 million yuan)	positive	0.039
		Number of new product development projects(item)	positive	0.058
		New product development expenditure (100 million yuan)	positive	0.055
	Innovation outputs	New product sales revenue (100 million yuan)	positive	0.038
		Export sales revenue of new products (100 million yuan)	positive	0.032
		Number of patent applications (pieces)	positive	0.038
		Number of invention patent applications	positive	0.032
	Innovation environment	Number of invention patents (pieces)	positive	0.036
		Number of enterprises with R&D institutions (units)	positive	0.035
		Number of R&D institutions (units)	positive	0.034
		Number of enterprises with R&D activities (units)	positive	0.030
industry chain	**industrial scale**	Number of Enterprises (units)	positive	0.05
		R&D staff wages (billion yuan)	positive	0.042
		Technology market turnover（ billion yuan）	positive	0.077
	industrial link	Expenditure on technology introduction（billion yuan）	positive	0.040
		Expenditure on digestion and absorption（billion yuan）	positive	0.052
		Expenditure on the purchase of domestic technology（billion yuan）	positive	0.125
		Expenditure on technological transformation（billion yuan）	positive	0.041

In order to make the coupling coordination degree practical and observable, this paper divides the coupling coordination degree of the industrial chain and the innovation chain , and initially divides the coupling coordination degree into 4 stages specifically, as shown in Table 3.

Table 3： Evaluation Of the Coupling Coherence Stage

Stage	(0,0.1]	(0.1,0.25]	(0.25,0.55]	(0.55,1)
Description	dissonance	Low coupling coordination	Moderately coupled coordination	Highly coupled coordination

According to Equ.(6), (7), (8) and (9), the system coordination degree of the industrial chain and innovation chain of high-tech manufacturing industry in JiangSu Province is derived and its dual-chain coupling and synergy level is determined, as shown in Table 4.

Table 4： Dual-Chain Coupling Coordination Degree and Its Rank of High-Tech Manufacturing Industry in JiangSu Province

Year	Degree of coupling	Degree of coordination	Degree of coupling coordination	Level
2013	0.290	0.080	0.152	Low
2014	0.945	0.114	0.329	Moderately
2015	0.998	0.095	0.308	Moderately
2016	0.933	0.130	0.348	Moderately
2017	0.854	0.123	0.324	Moderately
2018	0.804	0.157	0.355	Moderately
2019	0.679	0.191	0.360	Moderately
2020	0.879	0.226	0.446	Moderately
2021	0.938	0.298	0.528	Moderately
2022	0.983	0.440	0.658	Highly

The coupling degree is a metric that quantifies the interactive relationship between the high-tech manufacturing industrial chain and innovation chain in Jiangsu Province. However, it only reflects the strength of interaction between the two systems but cannot reveal the independent development status of a single chain. In contrast, the coordination degree reflects the harmonious interactive state of the two chains; a high coordination degree indicates mutually reinforced and high-level coordinated development. By contrast, although the two chains may achieve coupling, low coordination implies mutual constraints that hinder high-quality development. As a comprehensive indicator integrating coupling and coordination characteristics, the coupling coordination degree can effectively reflect the interactive relationship between industrial and innovation chains and identify their respective development stages. According to the results in Table 4, the high-tech manufacturing industry in Jiangsu Province presents a high coupling level but a relatively low coordination level between industrial and innovation chains, which ultimately restricts the overall performance of dual-chain coupling coordination.

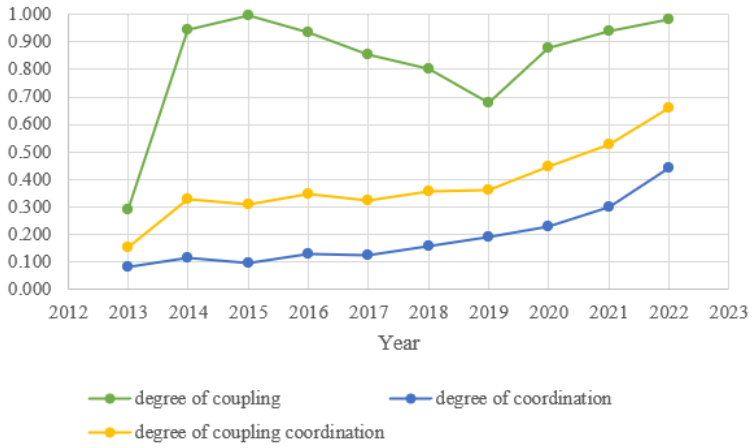

Fig3: Changes in the coupling coordination degree of high-tech manufacturing industry in JiangSu Province, 2013-2022

As shown in Figure 3, the coupling coordination value of the high-tech manufacturing industry in Jiangsu Province ranged from 0.152 to 0.528 during 2013–2021, corresponding to a medium-low coupling coordination level. In contrast, the value reached 0.658 in 2022, representing high coupling coordination. It can be clearly seen that the integration level of industrial and innovation chains in Jiangsu's high-tech manufacturing industry presents a continuous upward trend. Both the coordination degree and the overall coupling coordination degree show growth over the study period.

5. Suggestions on the Integrated Development of Industrial and Innovation Chains in Jiangsu's High-Tech Manufacturing Industry

Drawing on the above research findings, this article puts forward the following suggestions to promote coordinated innovation and high-quality development of the industrial and innovation chains in Jiangsu's high-tech manufacturing industry:

Establish industry–university–research cooperation platforms and improve the joint research and collaborative innovation mechanism.

Build a factor resource sharing platform and optimize the industrial resource allocation structure.

Set up a talent introduction and service center to build a high-level talent gathering base.

Acknowledgements

The research in this paper is supported by the Fundamental Research Funds for the Central Universities (No. ND2024002) and the Humanities and Social Sciences Research Program of the Ministry of Education of China (No. 23YJA630016).

References

Jiang X M.（2014）. "Study on the Connotation Path of Industrial Transformation and Upgrading", *Exploration of Economic Issues*, (12): 43-49.

Liang, B., Xie, K. F., Chen, H. M.（2023）. "A study on two-way embeddedness of innovation chain and industrial chain - based on the sample data of Chinese provincial area", *Technology Economics* ,42 (10): 26-37.

Lin, Liu-Lin.（2023）. "Research on the integration path of industrial chain and innovation chain based on synergy drive", *Academic Search for Truth and Reality*, (05): 100-107.

Li X S., Gong X Q.（2021）. " Synergistic development of regional industrial chain, innovation chain and total factor productivity", *Exploration of Economic Issues*, (11):30-44.

Roper S，Du J.（2008）. " Modelling the innovation value chain", *Research Policy*, 37（6-7）：961-977. https://doi.org/10.1016/j.respol.2008.04.005

Xing Chao.（2012）. " Effective Organization of Innovation Chain and Industry Chain Integration - An Example of Big Science Project", *Science of Science and Management of S.&.T*, 33 (10): 116-120.

Zhang X L., Huang W R.（2023）. " Trend characteristics, experience and strategic points of the integration and development of China's industrial chain and innovation chain", *Economic Review Journal*, (01): 93-101.

Zhao C.,Wang G F.（2023）. "Study on the dynamic synergy model of talent chain supporting the integration of innovation chain under the perspective of value chain--Taking new research and development institutions as an example", *Technology Economics*, 42 (09): 1-11.

Xie Z., Bu W., Feng H.（2024）. "Integrated development of the industrial chain and innovation chain of high-tech manufacturing industry based on the Internet of Things", *Alexandria Engineering Journal*,108828-838. https://doi.org/10.1016/j.aej.2024.09.052

Li Z. （2023） "Research on Quality Evaluation of Innovation Chain and Industrial Chain Ecological Integration in Jilin Province —A Case Study of High-Tech Industry" , *Information Systems and Economics*,4(10).