Research on the Two-Way Embedding of Industrial Chain and Innovation Chain in Guangxi Based on the TOPSIS Model

Yongyi Shen[1], Xin Su[1,*], Yue Zhao[1], Siyu Wu[2]
[1]*School of Business, Guilin University of Electronic Technology, Guilin, Guangxi, China*
[2]*Guangzhou Petroleum Training Center Co., Ltd, Guangzhou, Guangdong, China*
**Corresponding Author.*

Abstract: Based on the theories of industrial value chain and network embeddedness, this paper takes Guangxi as an example and uses the entropy-weighted TOPSIS model to measure the two-way embedding level of the industrial chain and innovation chain in 14 prefecture-level cities from 2017 to 2023.Combined with the geographical detector, the spatial-temporal differentiation mechanisms are analyzed. The results show that the dual-chain embedding presents a three-tier gradient pattern led by Nanning and Liuzhou, with regional synergy constrained by the imbalance of innovation resource allocation and barriers to factor flow. The time-series dimension exhibits a fluctuating curve of "rise-sharp decline-recovery," where demand-embedded elements have the strongest explanatory power for spatial heterogeneity and exhibit a nonlinear enhancement effect. The study reveals the unique patterns of dual-chain synergy in Guangxi and proposes pathways for upgrading strategic awareness, optimizing market mechanisms, and cultivating technological potential, providing theoretical support for breaking the inefficient lock-in of regional innovation and fostering new quality productivity.

Keywords: Industrial Chain; Innovation Chain; Two-Way Embedding; TOPSIS Model; Geographical Detector

1. Literature Review

The industrial chain and innovation chain are two critical frameworks in understanding economic development and technological progress. While the industrial chain focuses on the sequential stages of production and distribution, the innovation chain emphasizes the processes of knowledge creation, technological advancement, and commercialization. Both concepts are deeply interconnected, and their integration plays a pivotal role in driving regional and national economic growth. This section reviews the theoretical foundations of these concepts, explores the notion of embeddedness, and examines the relationship between the industrial chain and innovation chain.

1.1 Theoretical Connotations of Industrial Chain and Innovation Chain

The concept of the "industrial chain" originates from Adam Smith's theory of social division of labor [1] and was first explicitly defined in academia by Hirschman [2]. Subsequently, this theory sparked extensive research interest [3]. Domestic scholars, such as Lin et al. [4], Yu [5], Wang and Zhu [6], have conducted in-depth discussions on the industrial chain, generally agreeing that it refers to the entire production process from raw material supply to the final product delivery to consumers, involving various stages and the collaborative network of participants.

Compared to the industrial chain, the innovation chain emphasizes innovation entities and the connections among them [7]. According to research by Wu and Wu. [8], Li [9], Cai [10], and Li et al. [11], the innovation chain is a comprehensive process from basic research, technological development, to commercialization and industrial application, aiming to promote industrial upgrading and economic development through knowledge creation, technological breakthroughs, and commercialization.

1.2 The Connotation of Embeddedness

The concept of "embeddedness" is widely used in economics, sociology, and political science. It was first proposed by the Hungarian

 Copyright @ STEMM Institute Press

philosopher Karl Polanyi and later systematically explained by Granovetter, who introduced it into the field of economic sociology. It has since become an important theoretical tool in public policy and public management research [12]. Embeddedness refers to the process by which external elements (A) integrate into the embedded object (B), adapting to the operational mechanisms of the embedded object to achieve deep integration and synergistic development [13].In real-world scenarios, embedded entities often exhibit a two-way embedded relationship, where A embeds into B while B also embeds into A. This process involves multiple dimensions such as institutional systems, policy elements, and social entities, fully reflecting the complexity and interactivity of embedded relationships.

1.3 The Relationship between Industrial Chain and Innovation Chain

Existing research has preliminarily explored the theoretical framework of the relationship between the industrial chain and innovation chain. Some scholars, such as Zeng and Liu, argue from the perspective of value chain theory that the innovation chain is an extension and upgrade of the industrial chain, with the two achieving synergy through knowledge flow and technological transformation [14]. Tan et al. believe that core technologies and innovation ecosystems dominate the value chain, and fluctuations in the value chain may reverse the dual-chain relationship [15]. Other studies propose the concept of "dual-chain integration" emphasizing that the integration of industrial and innovation chains is a complex dynamic process involving multi-entity and multi-stage interactions [16-18]. In practice, the dual-chain relationship is viewed from two main perspectives: "deploying the innovation chain around the industrial chain" focuses on tackling technical challenges to enhance core competitiveness [19], while "arranging the industrial chain around the innovation chain" leverages enterprises as innovation entities to emphasize the commercialization of scientific achievements [20-21].

Based on the above literature review, it is evident that significant progress has been made in the research on industrial and innovation chains. However, existing studies rarely delve into the perspective of two-way embedding between the dual chains, and there is no unified consensus on the connotation of two-way embedding. Discussions on related principles and mechanisms also suffer from conceptual ambiguity and logical inconsistencies. Moreover, limited attention has been paid to underdeveloped regions like Guangxi, leaving a research gap. Therefore, this paper builds on existing research to construct an evaluation index system for the two-way embedding of industrial and innovation chains. Using the entropy-weighted TOPSIS model, it quantifies the embedding level of the dual chains in various cities in Guangxi, conducts in-depth analysis from temporal and spatial dimensions, and explores key influencing factors for the synergistic development of the dual chains in Guangxi. Combining Guangxi's regional characteristics, the paper proposes targeted countermeasures to promote high-quality economic development in Guangxi.

2. Theoretical Basis

The integration of the industrial chain and innovation chain is based on their mutual embedding and synergy. The industrial chain embeds into the innovation chain through demand-driven mechanisms, resource integration, and feedback loops, while the innovation chain embeds into the industrial chain via technology-driven advancements, process optimization, and market expansion. Guided by principles of synergy, dynamic adaptability, and systemic integration, this two-way embedding ensures alignment and efficient collaboration.

2.1 Embedding of Industrial Chain into Innovation Chain

The embedding of the industrial chain into the innovation chain is mainly reflected in demand-driven, resource integration, and feedback mechanisms. First, market demand in the industrial chain is a significant driver of the innovation chain's R&D direction. Enterprises adjust innovation strategies based on market demand to ensure alignment with actual needs, thereby enhancing the effectiveness and practicality of innovation. Second, resources in the industrial chain, such as funding, equipment, and talent, provide essential support for the innovation chain, facilitating smooth technological R&D. Finally, the industrial chain offers improvement suggestions to the innovation chain through market feedback mechanisms, optimizing the R&D process and improving innovation efficiency, forming a virtuous cycle of "demand-R&D-feedback."

2.2 Embedding of Innovation Chain into Industrial Chain

The embedding of the innovation chain into the industrial chain is primarily manifested in technology-driven, process optimization, and market expansion. First, technological breakthroughs in the innovation chain are the core driver of industrial chain upgrading. By introducing new technologies, the industrial chain can enhance product performance and quality, strengthening market competitiveness. Second, technological improvements in the innovation chain optimize production processes in the industrial chain, increasing efficiency and reducing costs, thereby improving overall operational efficiency. Finally, new products and technologies developed by the innovation chain open up new market opportunities for the industrial chain, helping enterprises expand market share and increase revenue, achieving sustainable development.

2.3 Principles of Two-Way Embedding

2.3.1 Synergy principle

The core of two-way embedding lies in the deep synergy between the industrial chain and innovation chain, which requires multi-dimensional mechanisms such as institutional design, platform building, and interest coordination to ensure alignment in goal setting, resource allocation, and action paths. The industrial chain should guide the innovation chain's R&D direction based on market demand, while the innovation chain drives industrial chain upgrading through technological breakthroughs, forming a virtuous cycle of "demand-driven R&D—technology-empowered production." To achieve this, traditional departmental barriers must be broken down to promote information sharing and resource flow, avoiding one-way dependency or fragmented development. The synergy principle emphasizes not only the interaction between the industrial chain and innovation chain but also the establishment of cross-departmental and cross-domain collaboration mechanisms to enhance overall innovation efficiency [22].

2.3.2 Dynamic adaptability principle

In the context of rapid technological iteration and volatile market environments, two-way embedding requires dynamic adjustment capabilities to adapt to external changes. The industrial chain must capture market demand changes in real-time and feed this information back to the innovation chain to adjust R&D directions promptly. Simultaneously, the innovation chain must stay at the forefront of technology, quickly transforming the latest research achievements into competitive advantages for the industrial chain. The dynamic adaptability principle emphasizes the establishment of agile response mechanisms, such as using digital tools for precise demand forecasting and R&D alignment. This principle requires the industrial chain and innovation chain to have rapid response capabilities and flexible organizational structures and decision-making mechanisms to address uncertainty and complexity [23].

2.3.3 Systemic principle

The two-way embedding of the industrial chain and innovation chain requires a systemic approach, treating the two as an organic whole. The systemic principle focuses on the interaction between the industrial chain and innovation chain and their interaction with the external environment. It is reflected in three aspects: first, vertical integration, covering the complete chain from basic research, technological development to industrial application, ensuring seamless connections at all stages; second, horizontal synergy, emphasizing resource complementarity and collaborative innovation across industries and fields, breaking industry boundaries to achieve knowledge, technology, and resource sharing; third, ecosystem building, fostering an innovation ecosystem that includes enterprises, universities, research institutions, and governments, creating an open, inclusive, and sustainable innovation ecosystem. The systemic principle emphasizes integrity and coordination, achieving maximum benefits of two-way embedding through multi-dimensional integration and synergy.

2.4 Two-Way Embedding Theory

Based on the industrial value chain perspective

 Copyright @ STEMM Institute Press

and network embeddedness theory, and drawing on the research of Liang et al. [24], this paper posits that the two-way embedding mechanism of the dual chains is a composite theoretical system consisting of consciousness embedding, demand embedding, and technology embedding.

Consciousness embedding, as the strategic guidance layer of two-way embedding, systematically integrates innovation consciousness into the entire process and cycle of the industrial chain and innovation chain, forming a top-down design mechanism that drives value creation activities. Its theoretical characteristics are: innovation consciousness follows a spiral evolution path, forming a positive feedback loop from strategic planning to practical application, achieving strategic upgrading through continuous iteration; it also has dual functions, serving as both the adhesive for dual-chain synergy, bridging organizational gaps through unified strategic goals, and the selector of innovation directions, guiding resource focus in strategic and forward-looking industries. This embedding method constructs a "strategic consciousness-innovation outcomes-industrial practice" transmission chain, providing the ideological foundation and strategic framework for subsequent innovation activities [25].

Demand embedding focuses on the dynamic adaptation mechanism between market demand and the dual chains, with its core being the precise mapping of value demands emerging in the product lifecycle to the corresponding stages of the innovation chain and industrial chain. In highly marketized competitive fields, this embedding method drives the reorganization of innovation elements through a three-stage transmission model of demand identification, value decoding, and element allocation. Its theoretical core lies in constructing a "market signal-innovation response-value realization" closed-loop system: capturing consumer demand trends through extensive market research, transforming abstract demands into actionable innovation parameters, and ultimately realizing value through element allocation in the industrial chain. This dynamic interaction mechanism requires the dual chains to remain sensitive to market changes, ensuring continuous alignment between innovation directions and commercial value [26].

Technology embedding, as the mediation layer of dual-chain synergy, constructs a symbiotic interface between the innovation chain and industrial chain with core technology as the hub. Its theoretical logic revolves around technological potential difference, forming a "R&D breakthrough-industrial application-technological iteration" value loop through the penetration, transformation, and diffusion of technological elements. In bottleneck areas of foundational industries, technology embedding manifests as the directional aggregation of dual-chain elements toward core technology R&D, aiming to break the dual constraints of technological lifecycle and industrial adaptability [27]. This process faces challenges such as technological scarcity, intellectual property barriers, and high risks, requiring continuous R&D investment to build technological barriers while relying on technology diffusion mechanisms to achieve industrial penetration of innovation outcomes. The essence of technology embedding is to establish a dynamic balance between technological capability and industrial demand, driving the efficient transformation of innovation strategies into tangible productivity [28].

In summary, consciousness embedding, demand embedding, and technology embedding interact in the two-way embedding process of the industrial chain and innovation chain, forming a complex system. Consciousness embedding provides strategic guidance, demand embedding ensures the alignment of market with the innovation chain and industrial chain, and technology embedding offers technical support for the efficient operation of the dual chains. Through reasonable configuration and synergistic effects, these three embedding types can effectively promote the deep integration of the industrial chain and innovation chain, driving enterprise innovation and development, and achieving high-quality economic growth.

3. Research Methods and Models

To comprehensively evaluate the two-way embedding of the industrial chain and innovation chain, this study employs a combination of quantitative and qualitative methods. The TOPSIS (Technique for Order

Preference by Similarity to Ideal Solution) method is utilized to assess the degree of embedding, leveraging its advantages in multi-criteria decision-making. Additionally, the geographical detector method is applied to analyze the driving factors behind the observed spatial heterogeneity. These methods provide a robust framework for understanding the mechanisms and dynamics of the dual-chain integration, offering insights for policy-making and strategic planning.

3.1 Principles of TOPSIS

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is a multi-criteria evaluation method based on the ideal solution. Its core principle is to rank evaluation objects by calculating their proximity to the ideal solution and the negative ideal solution [29]. Compared to traditional evaluation methods, TOPSIS has the advantages of intuitive principles, simple calculations, and low sample size requirements, and has been widely used in multi-objective decision-making analysis.

3.2 Establishment of the Evaluation Model

This paper employs the entropy-weighted TOPSIS method. The specific steps to establish the evaluation model are as follows:

Assuming the evaluation of m indicators for n evaluation objects, the initial matrix is established:

$$A=\begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mn} \end{bmatrix} \tag{1}$$

Step 1: Normalize the initial matrix to obtain the standardized matrix:

$$R=\left(r_{ij}\right)_{mn} \tag{2}$$

This means that r_{ij} represents the normalized score of the i-th object for the j-th indicator, and its value ranges between 0 and 1.

For positive indicators (the larger the value, the better):

$$r_{ij}=\frac{X_{ij}-minX_j}{maxX_j-minX_j} \tag{3}$$

For negative indicators (the smaller the value, the better):

$$r_{ij}=\frac{maxX_j-X_{ij}}{maxX_j-minX_j} \tag{4}$$

Step 2:Calculate the proportion of the i-th evaluation object in the j-th indicator:

$$p_{ij}=\frac{X_{ij}}{\sum_{i=1}^{n}X_{ij}} \tag{5}$$

Step 3:Calculate the entropy value of the j-th indicator:

$$e_j=-k\sum_{i=1}^{n}p_{ij}\ln p_{ij} \tag{6}$$

Where $k=\frac{1}{\ln n}$,$0<e_j<1$

Step 4:Calculate the weight of each indicator:

$$\omega_j=\frac{1-e_j}{m-\sum_{j=1}^{m}e_j} \tag{7}$$

Where $0<\omega_j<1$,$\sum_j^m\omega_j=1$

Step 5:Construct the weighted standardized matrix:

$$p=\begin{bmatrix} \omega_1 r_{11} & \cdots & \omega_1 r_{1n} \\ \vdots & \ddots & \vdots \\ \omega_m r_{21} & \cdots & \omega_m r_{mn} \end{bmatrix}=\begin{bmatrix} p_{11} & \cdots & p_{1n} \\ \vdots & \ddots & \vdots \\ p_{m1} & \cdots & p_{mn} \end{bmatrix} \tag{8}$$

Step 6:Determine the positive ideal solution and the negative ideal solution:

$$p^{+}=[\max p_1^{+},\max p_2^{+},\cdots,\max p_m^{+}] \tag{9}$$

$$p^{-}=[\min p_1^{-},\min p_2^{-},\cdots,\min p_2^{-}] \tag{10}$$

Step 7:Calculate the distances between the evaluation objects and the optimal solution and the worst solution:

$$D_i^{+}=\sqrt{\sum_{j=1}^{m}(p_{ij}-p_j{}^{+})^2} \tag{11}$$

$$D_i^{-}=\sqrt{\sum_{j=1}^{m}(p_{ij}-p_j{}^{-})^2} \tag{12}$$

Finally, calculate the proximity of the evaluation objects to the most ideal solution:

$$D_i=\frac{D_i^{-}}{D_i^{+}+D_i^{-}} \tag{13}$$

According to the TOPSIS model evaluation principle, the larger the proximity value[30],the closer the sample is to the ideal solution and the farther it is from the negative ideal solution, indicating a higher degree of two-way embedding between the industrial chain and innovation chain. Conversely, the smaller the proximity value, the farther the sample is from the ideal solution and the closer it is to the negative ideal solution, indicating a lower degree of two-way embedding between the industrial chain and innovation chain [31-32].

3.3 Geographical Detector Method

The geographical detector, as a statistical analysis method based on spatial stratification heterogeneity, reveals the internal driving mechanisms of geographical phenomena by detecting the spatial differentiation characteristics of geographical elements. It can effectively analyze the spatial heterogeneity of geographical phenomena and the interaction effects among influencing factors [33].Based on this, this study adopts the geographical

 Copyright @ STEMM Institute Press

detector method to explore the driving forces of factors influencing the two-way embedding of the industrial chain and innovation chain. Its core expression can be described as:

Where represents the explanatory power of influencing factors on the degree of two-way embedding. The larger the value, the more significant the spatial heterogeneity. N is the total number of samples in the study area, is the variance of the indicator, and are the sample size and variance of the j-th layer of the indicator, and p is the total number of indicators [34].

4. Empirical Analysis

The empirical analysis of this study aims to quantitatively assess the two-way embedding degree of the industrial chain and innovation chain in Guangxi. By leveraging data from statistical yearbooks and national databases, the analysis focuses on the period from 2017 to 2023, capturing the evolution of dual-chain integration under the guidance of high-quality development policies. This section details the data sources, indicator construction, and methodological approach used to analyze the spatial and temporal dynamics of dual-chain integration in Guangxi.

4.1 Data Sources

Based on the evaluation indicators of the two-way embeddedness of dual chains, the data were collected from the statistical yearbooks of 14 prefecture-level cities in the Guangxi Zhuang Autonomous Region and national databases, covering the period from 2017 to 2023. The study focuses on the distribution characteristics of the two-way embeddedness of dual chains in Guangxi under the guidance of high-quality development.

4.2 Construction of the Indicator System

Drawing on the research of Liang et al. [24], the evaluation system adopts three order parameters: consciousness embedding, demand embedding, and technology embedding. The selection of indicators follows the principles of systematicness, scientificity, and applicability. The specific indicators are shown in Table 1.The explanations of the indicators are as follows:

Indicators reflecting consciousness embedding aim to capture strategic thinking and innovation capabilities in regional development. The total fixed asset investment, as an important indicator of regional economic development, reflects the strategic awareness of local governments in infrastructure construction and industrial upgrading, demonstrating their capabilities in long-term planning and resource allocation. R&D internal expenditure, as a core indicator of regional innovation awareness, not only represents the systematic investment intensity of enterprises, research institutions, and universities in technological R&D but also reveals the strategic layout of regions in basic research, applied research, and technology transformation. These two indicators jointly constitute the dual-drive of regional development top-level design: the former consolidates the development foundation through material capital accumulation, while the latter activates innovation momentum through knowledge capital investment. Their synergy profoundly reflects the differences in consciousness orientation in physical investment and intellectual investment [35-36].

Indicators reflecting demand embedding are mainly used to characterize economic demand and market vitality in regional development. The regional GDP, as a core indicator of regional economic scale and development level, reflects the matching degree between regional economic demand and overall development level, serving as an important basis for evaluating regional economic vitality. The total retail sales of consumer goods represent the embedding degree of regional consumption demand and market vitality, revealing the synergy between residents' consumption capacity and market supply. The total import and export volume of foreign-invested enterprises further reflects the embedding degree of regional openness demand in the global economy, demonstrating regional participation and competitiveness in the international market. These three indicators jointly reveal the demand characteristics of regions in economy, consumption, and openness, providing scientific support for the market adaptability of regional development [37-38].

Indicators reflecting technology embedding mainly measure technological innovation and application capabilities in regional development. The number of patents granted, as an important indicator of regional technological innovation capability, reflects the output efficiency and innovation capability of technological achievements, serving as a key basis for evaluating regional technological development level. The transaction volume of the technology market represents the activity of the technology market and the matching degree of technology supply and demand, revealing the driving effect of technology embedding on regional economic development. These two indicators jointly reveal the embedding characteristics of regions in technology R&D and the technology market, providing quantitative evidence for the technological driving force of regional development [39-40].

Table 1. Evaluation System of Two-Way Embedding of Industrial Chain and Innovation Chain

Subsystem	Order Parameter	Primary Indicator	Secondary Indicator
Regional Two-Way Embedding Degree	Consciousness Embedding	Regional Strategic Awareness	Total Fixed Asset Investment (x_1)
		Regional Innovation Awareness	Internal R&D Expenditure (x_2)
	Demand Embedding	Regional Economic Demand	Regional GDP (x_3)
		Regional Consumption Demand	Total Retail Sales of Consumer Goods (x_4)
		Openness Demand	Total Import and Export Volume of Foreign-Invested Enterprises (x_5)
	Technology Embedding	Technology Output Level	Number of Patents Granted (x_6)
		Technology Market Activity	Technology Market Transaction Volume (x_7)

4.3 Calculation Results

Based on formulas (1) to (7), the weights of each indicator are calculated as shown in Table 2.

Based on formulas (8) to (13), the proximity to the most ideal solution for each prefecture-level city in each year is calculated, i.e., the two-way embedding degree of the industrial chain and innovation chain, as shown in Table 3.

Table 2. Calculation Results of Indicator Weights

Indicator	Entropy Value	Difference Coefficient	Weight
Total Import and Export Volume of Foreign-Invested Enterprises	0.846515	0.153485	0.202133
Technology Market Transaction Volume	0.919155	0.080845	0.106469
Regional GDP	0.930911	0.069089	0.090988
Total Retail Sales of Consumer Goods	0.874615	0.125385	0.165126
Total Import and Export Volume of Foreign-Invested Enterprises	0.900066	0.099934	0.131609
Number of Patents Granted	0.842558	0.157442	0.207344
Technology Market Transaction Volume	0.926853	0.073147	0.096331

Table 3. Two-Way Embedding Degree of Prefecture-Level Cities in Guangxi(2017-2023)

City	2017	2018	2019	2020	2021	2022	2023	Average	Rank
Nanning	0.52628	0.62464	0.55773	0.61342	0.60197	0.60448	0.60634	0.59069	2
Liuzhou	0.82138	0.75790	0.84148	0.74256	0.73300	0.72987	0.73443	0.76580	1
Guilin	0.40986	0.34755	0.34929	0.29024	0.28799	0.29605	0.29315	0.32487	3
Wuzhou	0.13428	0.12452	0.14975	0.15466	0.19063	0.23577	0.21613	0.17225	5
Beihai	0.10060	0.11302	0.09122	0.08692	0.08769	0.09043	0.08867	0.09408	10
Fangchenggang	0.20647	0.20008	0.17921	0.16674	0.15153	0.14205	0.14735	0.17049	6
Qinzhou	0.09518	0.12708	0.10480	0.09892	0.10171	0.10812	0.10497	0.10583	8
Guigang	0.12334	0.09365	0.12899	0.09123	0.08749	0.09182	0.08932	0.10084	9
Yulin	0.17217	0.23194	0.25087	0.20291	0.20848	0.21043	0.20957	0.21234	4
Baise	0.07626	0.09092	0.10466	0.11254	0.12833	0.14116	0.13563	0.11279	7
Hezhou	0.05886	0.03494	0.04085	0.03123	0.03045	0.03591	0.03295	0.03788	13

 Copyright @ STEMM Institute Press

Hechi	0.06488	0.05599	0.05343	0.04384	0.04386	0.04806	0.04613	0.05088	12
Laibin	0.04236	0.01812	0.02448	0.01237	0.01584	0.01788	0.01680	0.02112	14
Chongzuo	0.08890	0.09173	0.09579	0.08918	0.08598	0.08472	0.08531	0.08880	11

4.4 Spatial Difference Analysis

The average two-way embedding degree of prefecture-level cities in Guangxi from 2017 to 2023 is divided into three levels, as shown in Table 4:

Among them, Nanning and Liuzhou in the first level perform prominently in the two-way embedding of the industrial chain and innovation chain. As the capital of the autonomous region, Nanning has gathered most of the headquarters of financial institutions and central enterprises in the region, building an innovation chain centered on financial services. Through the efficient allocation of financial resources, it deeply embeds into the industrial chain of Liuzhou and other cities. Liuzhou, as an industrial hub, has its automobile industry output value occupying an important position in the region's equipment manufacturing industry, forming an industrial chain centered on manufacturing. Through technological innovation and industrial upgrading, it feeds back the financial service demand of Nanning. The two cities are closely connected by transportation, with frequent commuting, forming an efficient industrial collaboration circle, further strengthening the synergy between the industrial chain and innovation chain. In addition, a high proportion of Liuzhou's industrial products are exported through the Nanning hub port, and Nanning's financial services widely cover Liuzhou enterprises, reflecting the deep integration and two-way driving of the industrial chain and innovation chain in the regional economy, providing important support for the high-quality development of the regional economy.

Cities in the second level show locality and imbalance in the two-way embedding of the industrial chain and innovation chain, indicating that there is still significant room for improvement in their synergy. Among them, Guilin, relying on the construction of an international tourist destination, has a relatively high proportion of tourism revenue in its economic output, but its industrial relevance is relatively low, reflecting the weak synergy between the tourism industrial chain and the regional innovation chain, as innovation resources are not fully embedded in the value chain of the tourism industry. Wuzhou and Yulin have undertaken many industrial transfer projects from Guangdong and other eastern regions, but the local supporting rate is insufficient, indicating a low degree of localization of the industrial chain, and the supporting role of the innovation chain to the industrial chain is limited. Fangchenggang, as an important port city, has a large share of cargo throughput in the region, but the added value of port-related industries accounts for a low proportion of the economic output, indicating insufficient linkage between port economy and industrial development, and the embedding depth of the innovation chain in the port-related industrial chain needs to be improved. In addition, spatial connection bottlenecks further restrict the two-way embedding of the industrial chain and innovation chain. For example, the transportation frequency between some cities is low, the matching degree between industrial parks and regional supply chains is insufficient, and the proportion of sea-rail intermodal transport is insufficient, which limits the efficient collaborative development of the regional economy.

Cities in the third level are still in the preliminary stage of the two-way embedding of the industrial chain and innovation chain, facing multiple constraints. For example, in terms of transportation accessibility, the road network density of Hechi and Baise is significantly lower than the regional average, limiting the linkage development of the industrial chain and innovation chain between regions. The problem of industrial homogenization is also prominent. The high repetition rate of the calcium carbonate industry in Hezhou and Laibin leads to the dispersion of innovation resources, making it difficult to form effective synergy between the industrial chain and innovation chain. In addition, the serious loss of elements, with high labor outflow rates in Guigang and Chongzuo, weakens the sustainable development capacity of the regional innovation chain. Nevertheless, these cities still have certain potential in characteristic fields. For example, Baise's aluminum industry has significant potential for deep processing, promoting the extension of the industrial chain to the high-end through technological innovation; Qinzhou's petrochemical industry has great potential for chain extension, enhancing the added value of the industrial chain through the embedding of the innovation chain; Beihai's electronic information industry can further improve local supporting rates, enhancing the competitiveness of the regional economy through the collaborative development of the industrial chain and innovation chain. By tapping into these potential fields, these cities are expected to achieve deep two-way embedding of the industrial chain and innovation chain, promoting high-quality regional economic development.

Table 4. Level Division of Two-Way Embedding Degree in Guangxi

Level	Two-Way Embedding Degree	Cities
First Level	0.5-1.0	Nanning, Liuzhou
Second Level	0.15-0.5	Guilin, Yulin, Wuzhou, Fangchenggang
Third Level	0-0.15	Baise, Qinzhou, Guigang, Beihai, Chongzuo, Hechi, Hezhou, Laibin

4.5 Temporal Trend Analysis

4.5.1 Overall trend analysis

To measure the overall two-way embedding degree of the industrial chain and innovation chain in Guangxi, this study calculates the mean two-way embedding degree of prefecture-level cities in Guangxi from 2017 to 2023,as shown in figure 1:

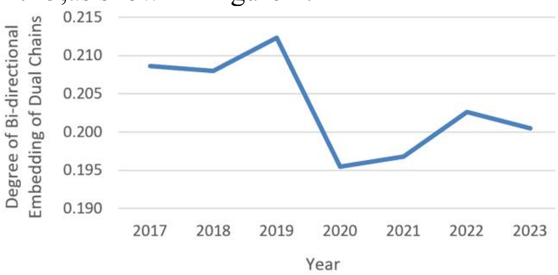

Figure 1. Overall Two-Way Embedding Degree of Industrial Chain and Innovation Chain in Guangxi

The overall two-way embedding degree of the industrial chain and innovation chain in Guangxi shows a fluctuating trend, but the variation range is relatively small, indicating that although Guangxi has made some progress in the two-way embedding of the industrial chain and innovation chain, there is still significant room for improvement. From 2017 to 2019, the two-way embedding degree showed an upward trend, reaching the highest value in 2019,reflecting the promoting effect of technological innovation and industrial upgrading. However, in 2020, due to the impact of the COVID-19 pandemic, the two-way embedding degree significantly decreased, reaching the lowest value in seven years, indicating that external shocks have a significant impact on the synergy between the industrial chain and innovation chain. From 2021 to 2023, the two-way embedding degree slowly recovered, showing that the regional economic recovery still faces certain challenges.

4.5.2 Growth rate analysis

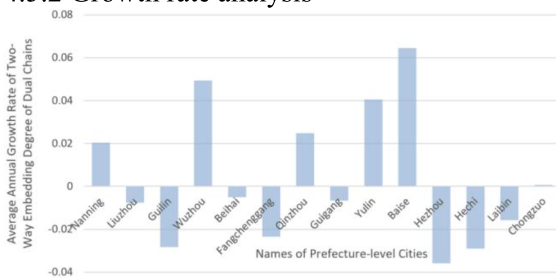

Figure 2. Average Annual Growth Rate of Two-Way Embedding Degree in Prefecture-Level Cities in Guangxi (2017-2023)

To reveal the dynamic characteristics and regional differences in the collaborative development of the industrial chain and innovation chain in Guangxi, this study calculates the average annual growth rate of the two-way embedding degree of the industrial chain and innovation chain in prefecture-level cities in Guangxi from 2017 to 2023,as shown in figure 2

Among them, Wuzhou, Yulin, Baise, and Qinzhou show a relatively significant upward trend in the two-way embedding degree of the industrial chain and innovation chain. Baise has the highest growth rate, indicating that its characteristic fields such as the aluminum industry have achieved significant results in the collaborative development of the industrial chain and innovation chain. The deep integration of technological innovation and industrial upgrading has promoted the high-quality development of the regional economy. Wuzhou and Yulin may benefit from the driving effect of industrial transfer from the eastern region. By undertaking industrial transfer projects, they have gradually deepened the embedding degree of the industrial chain and innovation chain, forming new momentum for regional economic development. Qinzhou, as a port city, has also made certain progress in the extension of the petrochemical industrial chain and the embedding of the innovation chain. The linkage effect between port economy and industrial development has gradually strengthened, providing important support for the sustainable development of the regional economy.

Guilin, Fangchenggang, Hechi, Hezhou, Laibin, and Chongzuo have negative average annual growth rates in the two-way embedding degree of the dual chains. Among them, Hezhou has the highest negative growth rate, reflecting the serious homogenization problem of its calcium carbonate industry, the insufficient supporting role of the innovation chain to the industrial chain, and the low efficiency of resource allocation. Guilin as a tourist city, has a weak synergy between the industrial chain and innovation chain, and the linkage between the tourism industry and other industries is insufficient. Innovation resources are not fully embedded in the value chain of the tourism industry. Fangchenggang and Hechi may be constrained by transportation conditions and industrial structure, and the two-way embedding degree has not been effectively improved. The linkage between port economy and port-related industries is insufficient, and the endogenous driving force of regional economic development needs to be enhanced.

Nanning, Liuzhou, and Guigang have relatively small changes in the average annual growth rate of the two-way embedding degree of the dual chains. As the capital city, Nanning has a relatively stable synergy between financial services and the industrial chain. The efficient allocation of financial resources provides important support for regional economic development. Liuzhou, as an industrial hub, has a slightly decreased embedding degree of the automobile industrial chain and innovation chain, but it still maintains a high level overall. The synergy between technological innovation and industrial upgrading is significant. Guigang may be affected by factors such as labor outflow, and the improvement of the two-way embedding degree is relatively slow. The endogenous driving force of regional economic development needs to be further stimulated.

4.6 Influencing Factor Analysis

4.6.1 Interaction detection analysis

The interaction effect refers to the phenomenon where a variable plays a role while also synergizing with other variables or depending on another variable. This study uses the geographical detector to analyze the interaction effects of influencing factors, focusing on the seven influencing factors in 2019, the year with the highest overall two-way embedding degree of the dual chains. The analysis results are shown in table 5:

Table 5. Interaction Detection Results of Factors

Factor	x_1	x_2	x_3	x_4	x_5	x_6	x_7
x_1	0.76734						
x_2	0.783959	0.76734					
x_3	0.975669	0.975669	0.962433				
x_4	0.975669	0.975669	0.965117	0.962433			
x_5	0.945362	0.945362	0.966034	0.966034	0.891556		
x_6	0.945362	0.945362	0.966034	0.966034	0.899302	0.891556	
x_7	0.982312	0.982312	0.969235	0.969235	0.971697	0.971697	0.944992

The interaction effect analysis results show that among the seven factors affecting the two-way embedding degree of the dual chains in 2019, most exhibit a phenomenon of dual-factor enhancement. This result reveals the importance of synergistic effects among factors in the economic system, indicating that when two factors act together, their explanatory power for the two-way embedding degree of the dual chains is significantly enhanced. This emphasizes that in the actual economic system, the role of a single factor is often influenced by the synergy of other factors. Analyzing a single factor in isolation may not fully understand its impact on the results, reflecting the dynamic nature of the interaction of multiple factors in a complex economic system. It demonstrates that economic phenomena often arise from the combined effects of multiple factors rather than the isolated action of a single factor.

4.6.2 Factor detection analysis

This study uses SPSS software and the k-clustering method to discretize and grade the raw data of the seven influencing factors, transforming them into categorical variables. Subsequently, the geographical detector method is employed to calculate the explanatory power(q-value) of each influencing factor on the spatial heterogeneity of the two-way embedding of the dual chains. By ranking the q-values of influencing factors over the years, the top five factors with the strongest explanatory power for each year are selected, and the frequency of their occurrence is counted. The study finds that the regional GDP(x_3),total retail sales of consumer goods(x_4),total import and export volume of foreign-invested enterprises(x_5),and the number of patents granted(x_6)appear most frequently.This result indicates that demand embedding plays a significant role in the two-way embedding process of the industrial chain and innovation chain in Guangxi.

5. Policy Recommendations

Based on the empirical analysis results, this paper proposes the following policy recommendations to promote the two-way embedding of the industrial chain and innovation chain in Guangxi and drive high-quality regional economic development.

5.1 Expand Domestic Demand and Openness to Enhance Market Vitality

5.1.1 Increase total retail sales of consumer goods to expand the domestic market

The total retail sales of consumer goods, as a key indicator of domestic market vitality, significantly promote demand embedding. To fully leverage the role of consumption in driving the economy, it is recommended to enhance residents' consumption capacity through policy guidance, further unleashing the potential of domestic demand. Regional consumption promotion activities can be organized to stimulate market vitality, while optimizing the consumption environment and strengthening market supervision to protect consumer rights and improve the safety and convenience of shopping environments. Additionally, promoting the standardization of the service industry and improving service quality can enhance consumer satisfaction, which is a key measure to stimulate consumption upgrading. These measures will help expand the domestic market, increase total retail sales of consumer goods, enhance demand embedding effects, and promote the deep integration of the industrial chain and innovation chain, forming a virtuous interaction mechanism between consumption and the economy, providing sustained momentum for high-quality economic development.

5.1.2 Deepen openness to enhance the total import and export volume of foreign-invested enterprises

The total import and export volume of foreign-invested enterprises is a key indicator of regional openness and integration with the global economy. To improve this indicator, it is recommended to optimize the foreign investment environment to attract more foreign enterprises, thereby enhancing regional competitiveness in the international market.

To attract foreign investment, streamlining the approval process for foreign investment, reducing approval steps, and improving efficiency are necessary. Additionally, formulating tax incentives for foreign-invested enterprises, such as reducing corporate income tax rates and providing investment rebates, can effectively attract foreign enterprises. Establishing dedicated service windows for foreign investment to provide one-stop services and help enterprises address issues during the investment process is also an important support measure. These measures can attract more foreign investment, increase the total import and export volume of foreign-invested enterprises, enhance regional openness, improve regional competitiveness in the international market, and promote the two-way embedding of the industrial chain and innovation chain.

5.2 Strengthen Regional Collaborative Development to Enhance Overall Competitiveness

5.2.1 Promote industrial collaboration between cities

 Copyright @ STEMM Institute Press

As the capital of the autonomous region, Nanning has significant advantages in financial services and resource allocation. To further enhance regional competitiveness, it is recommended to strengthen industrial collaboration between Nanning and industrial hubs like Liuzhou, building an efficient industrial collaboration circle. Specific measures include establishing industrial alliances, promoting resource sharing, and enhancing technical exchanges to drive the deep integration of the industrial chain and innovation chain. For example, encouraging enterprises, research institutions, and universities in Nanning and Liuzhou to form industrial alliances can achieve resource sharing and technical synergy, integrating Nanning's financial services with Liuzhou's industrial development, optimizing resource allocation, and enhancing the synergy between the industrial chain and innovation chain. Regularly organizing technical exchange meetings and innovation forums can promote technical sharing and cooperation, accelerating the transformation of innovation achievements. These measures can effectively strengthen industrial collaboration between cities like Nanning and Liuzhou, forming a regional economic pattern of complementary advantages and collaborative development, promoting the deep integration of the industrial chain and innovation chain, and comprehensively enhancing regional competitiveness.

5.2.2 Tap into the Potential of Cities' Characteristic Industries

For cities in the third tier, such as Baise, Qinzhou, and Beihai, it is recommended to leverage their characteristic industrial advantages to promote the two-way embedding of the industrial chain and innovation chain, thereby enhancing regional economic competitiveness. Specifically, Baise can build on its aluminum industry foundation, enhance deep processing capabilities through technological innovation, and extend the aluminum industrial chain toward high-end and high-value-added directions. Qinzhou can fully utilize its petrochemical industry advantages, extend the industrial chain, and develop high-value-added petrochemical products to enhance industrial competitiveness. Beihai can focus on the electronic information industry, improve local supporting rates, and complete the industrial chain to enhance industrial agglomeration effects. By supporting enterprise technological transformation, promoting industrial chain extension, and strengthening local supporting measures, these cities can effectively tap into their characteristic potential, promote the deep integration of the industrial chain and innovation chain, enhance the added value of characteristic industries, and thereby improve the overall competitiveness of the regional economy, achieving high-quality development.

5.2.3 Address the issue of factor outflow to enhance endogenous development momentum

To address the issue of labor outflow, it is recommended to implement measures to attract and retain talent. Providing employment incentives, improving living environments, and enhancing education and healthcare levels can attract labor back, strengthening the sustainable development capacity of the regional innovation chain. Formulating employment policies to attract talent, such as providing employment subsidies and entrepreneurial support, can effectively attract talent back. Strengthening urban infrastructure construction and improving the quality of living environments can attract more talent to settle. Additionally, increasing investment in education and healthcare and improving public service quality can enhance talent attraction. These measures can address the issue of labor outflow, enhance endogenous development momentum, improve the sustainable development capacity of the regional innovation chain, and promote the two-way embedding of the industrial chain and innovation chain.

5.3 Strengthen Policy Guidance and Support to Drive High-Quality Economic Development

5.3.1 Formulate differentiated policies to support the development of cities at different levels

For cities at different levels, differentiated policy support should be formulated. For first-tier cities like Nanning and Liuzhou, further support can be provided to enhance the synergy between financial services and industrial development. For second-tier cities, measures such as undertaking industrial transfer and improving local supporting rates can promote the synergistic development of the industrial chain and innovation chain. For third-tier cities, tapping into characteristic potential and strengthening infrastructure construction can enhance their two-way embedding degree. Specifically, increasing policy support for Nanning's financial services and Liuzhou's industrial development can effectively support the development of first-tier cities. Encouraging Guilin and Wuzhou to undertake industrial transfer and improve local supporting rates can promote the synergistic development of the industrial chain and innovation chain. Supporting Baise, Qinzhou, and other cities to tap into their characteristic potential and strengthen infrastructure construction can enhance their two-way embedding degree. These measures can formulate differentiated policy support, promote the development of cities at different levels, drive the two-way embedding of the industrial chain and innovation chain, and promote high-quality regional economic development.

5.3.2 Strengthen monitoring and evaluation of policy implementation

It is recommended to establish a monitoring and evaluation mechanism for policy implementation, regularly assessing the effectiveness of policies and making timely adjustments and optimizations. For example, by regularly collecting and analyzing relevant data, the impact of policies on the two-way embedding degree can be assessed, issues can be identified, and improvement suggestions can be proposed to ensure the effectiveness and sustainability of policies. Specific measures include setting up dedicated monitoring agencies to regularly collect and analyze policy implementation data and evaluate policy effectiveness. Conducting annual policy assessments, identifying issues, and making timely adjustments to ensure the effectiveness and sustainability of policies are also necessary. Encouraging public participation in policy evaluation and collecting feedback from various sectors of society to optimize policy implementation effects are also important. These measures can strengthen the monitoring and evaluation of policy implementation, ensure the effectiveness and sustainability of policies, and dynamically adjust policies to meet the new demands of regional economic development, driving high-quality economic development.

Acknowledgments

This paper is supported by the National College Students' Innovation and Entrepreneurship Training Program of Guilin University of Electronic Technology (No.202410595067), and the National Natural Science Foundation of China under contract no. 72464008, 72364008, Guangxi Project of Philosophy and Social Science for Planning no., 22BJY002, 24JYF027.

References

[1] Smith, A. An Inquiry into the Nature and Causes of the Wealth of Nations. Beijing: The Commercial Press,1972:7-22.
[2] Hirschman, A.O. The Strategy of Economic Development. London: Yale University Press,1958:1331-1424.
[3] You Zhenhua, Li Yanjun. A Brief Analysis of the Concept of Industrial Chain and Its Formation Driving Factors. East China Economic Management,2011,25(1):100-103.
[4] Lin Miao, Su Jun, Zhang Yaxian, et al. Technology Chain, Industrial Chain, and Technological Innovation Chain: Theoretical Analysis and Policy Implications. Studies in Science of Science, 2001, (4):28-31+36.
[5] Yu Yihong. Types of Industrial Chains and Efficiency Benchmarks. China Industrial Economics, 2005, (11):35-42.
[6] Wang Shuo, Zhu Chunyan. Building China-led International Industrial Chains: Models and Mechanisms. Scientific Management Research, 2021, 39(6):156-161.
[7] Chesbrough, H.W. Open Innovation: The New Imperative for Creating and Profiting from Technology.Boston: Harvard Business School Press,2006.
[8] Wu Xiaobo, Wu Dong. On the System Evolution of Innovation Chains and Its Policy Implications. Studies in Dialectics of Nature,2008,24(12):58-62.
[9] Li Xiaofeng. Theoretical Research on the Integration of "Four Chains" to Enhance the Energy Level of Innovation Ecosystems. Science Research Management, 2018, 39(9):113-120.
[10] Cai Xiang. Innovation, Innovation Clusters, and Innovation Chains: Implications. R&D Management, 2002,

 Copyright @ STEMM Institute Press

(6):35-39.

[11] Li Ting, Deng Xuelai, Xu Zhiyun. Research on Policies for Innovation-oriented Enterprises Based on Innovation Chains.Forum on Science and Technology in China, 2015, (10):63-68.

[12] Yin Ali, Zhao Huan, Xu Xuanguo. Two-way Embedding: A New Perspective on Understanding the Development Path of Social Work in China. Social Work,2016,(3):47-55.

[13] Wang Chao, Wang Peigang, Lu Zuxun. Healthy China and Common Prosperity: Two-way Embedding and Two-way Empowerment. Chinese Journal of Health Policy,2023,16(8):1-7.

[14] Zeng Xiangyan, Liu Youjin. Collaborative Innovation Based on Value Innovation Chains: Three-stage Evolution and Its Role. Science & Technology Progress and Policy, 2013, 30(20):20-24.

[15] Tan Jinsong, Song Juan, Chen Xiaohong. The Formation and Evolution of Industrial Innovation Ecosystems: The Change of "Architects" and Their Strategic Behaviors. Management World,2021,37(9):167-191.

[16] Han Jiangbo. Research on the Integration of Innovation Chains and Industrial Chains: Theoretical Logic and Mechanism Design. Technoeconomics & Management Research, 2017, (12):32-36.

[17] Nie Libing, Lai Xiuping, Zhou Qing, et al. Theoretical Logic and Implementation Path of Technology Standards Driving the Integration of Dual Chains. Studies in Science of Science,1-15[2025-01-30].

[18] Zhang Jin, Wan Jinbo. Theoretical Analysis and Practical Requirements for Promoting the Deep Integration of Innovation Chains, Industrial Chains, Capital Chains, and Talent Chains. People's Tribune Academic Frontiers, 2024, (20):50-58.

[19] Zhang Qizi. Research on the Path to Enhance the Modernization Level of Industrial and Supply Chains. China Industrial Economics, 2021, (2):80-97.

[20] Dai Jianping, Luo Wenping. Development Strategies for China's Advanced Manufacturing Clusters from the Perspective of Collaborative Innovation:An Empirical Study Based on Changzhou's Advanced Manufacturing Clusters. China Business and Market,2021,35(1):79-88.

[21] Sun Tao. Research on the Efficiency Evaluation of Scientific and Technological Achievements Transformation in China's Old Industrial Bases: A Case Study of Northeast China. China Soft Science, 2020,(1):164-170.

[22] Liu Xiaohua, Gao Shanxing. The Impact Mechanism of Institutional Elements on Breakthrough Innovation in Complex Institutional Environments. Science of Science and Management of S.&T.,2020,41(11):117-131.

[23] Li Wuyan, Zhou Yidian. Industrial Agglomeration, Spatial Spillover, and Regional Innovation Efficiency: A Case Study of the Yangtze River Economic Belt. Technology Economics,2022,41(8):11-22.

[24] Liang Benbu, Xie Kefan, Chen Hanmei, et al. Research on Two-way Embedding of Innovation Chains and Industrial Chains: Based on Provincial Sample Data in China. Technology Economics, 2023,42(10):26-37.

[25] Wang Guomeng, Zhang Mengsi, Zhao Shuming, et al. Personalized Contracts and Core Employees' Pro-organizational Unethical Behavior: A Social Cognitive Theory Perspective. Journal of Industrial Engineering and Engineering Management, 2020, 34(4):44-51.

[26] Song Y., Su Q., Liu Q., et al. Impact of Business Relationship Functions on Relationship Quality and Buyer’s Performance. Journal of Business & Industrial Marketing, 2012,27(4):286-298.

[27] Yang B.X., Li X.G., Kou K., 2022.Research on the Influence of Network Embeddedness on Innovation Performance: Evidence from China’s Listed Firms. Journal of Innovation & Knowledge,7(3):100210.

[28] Zhang Yufei, Yuan Changhong. Research on the Evolution of Deep Integration of Industry-University-Research to Breakthrough Key Core Technologies. Studies in Science of Science,2022,40(5):852-862.

[29] Zheng Jing, Yu Hao, Huang Senwei. Evaluation of Ecological Environment Carrying Capacity and Obstacle Factors in Fujian Province Based on DPSIR-TOPSIS Model. Acta Scientiae Circumstantiae,

2017, 37(11):4391-4398.
[30] Lei Xunping, Robin Qiu, Liu Yong. Performance Evaluation of Regional Land Use and Diagnosis of Obstacle Factors Based on Entropy-weighted TOPSIS Model. Transactions of the Chinese Society of Agricultural Engineering, 2016,32(13):243-253.
[31] Gao Lei, Xi Yongqin. Evaluation of Industrial Technology Innovation Capability in Fujian Province Based on Entropy-weighted TOPSIS Method. Science Technology and Industry,2012,12(12):92-96.
[32] Yang Xiumin, Geng Jing, Xu You, et al. Spatiotemporal Changes and Obstacle Degree Diagnosis of Land Comprehensive Carrying Capacity in Hainan Island Based on TOPSIS Model. Acta Ecologica Sinica, 2022, 42(22):9324-9334.
[33] Wang Jinfeng, Xu Chengdong. Geographical Detector: Principles and Prospects. Acta Geographica Sinica,2017,72(1):116-134.
[34] Wang Qi, Huang Guomin, Lu Enqi, et al. Research on Spatiotemporal Characteristics and Influencing Factors of Tourism Ecological Security Based on Geographical Detector. Journal of Northeast Normal University(Natural Science Edition), 2024, 56(4):133-143.
[35] Wang Yudong, Zhang Bo,Wu Chuan, et al. Research on the Measurement of Synergy between Innovation Chains and Capital Chains in High-tech Industries: Based on Composite System Synergy Model. Science & Technology Progress and Policy, 2019, 36(23):63-68.
[36] Liu Xielin, Zhu Langmei. The Evolution Dynamics of Total Factor Productivity in Regional Innovation in China: Catching Up or Falling Behind? Science of Science and Management of S.&T.,2021,42(12):99-112.
[37] Ma Xiao. Evaluation of Regional Economic Synergy in Beijing-Tianjin-Hebei Based on Composite System Synergy Model. Industrial Technology Economics, 2019, 38(5):121-126.
[38] Li Genqiang, Pan Wenqing. How Domestic Value Chains Embed in Global Value Chains: A Value-added Perspective. Management World,2016,(7):10-22+187.
[39] Liu Jiashu, Shi Hongbo, Qi Xin. Research on the Path of Integration of Innovation Chains and Capital Chains: Configuration Analysis Based on the Symbiosis Theory Framework of Regional Innovation Ecosystems. Scientific Management Research,2022,40(1):153-161.
[40] Li Feng, Li Mingxiang, Zhang Yujing. Empirical Analysis of Technological Innovation, Industrial Structure Upgrading, and Economic Development. Technology Economics, 2021, 40(7):1-10.

 Copyright @ STEMM Institute Press