

Research on the Coupling Development Mechanism of Industrial Chain and Innovation Chain in the Digital Economy Era

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Abstract

This paper takes the coupling development of industrial chain and innovation chain in the era of digital economy as the research goal, and comprehensively explores its internal mechanism, path and influencing factors. By combing the relevant literature at home and abroad, we can clarify the deficiencies and innovations of the current research, and explain the theoretical basis, formation mechanism and dilemma analysis in depth.

Keywords

Digital economy; coupling coordination degree; industrial chain; innovation chain.

1. Introduction

The advent of the digital economy era has brought unprecedented opportunities for the coupling development of industrial chain and innovation chain. With the rapid development of big data, artificial intelligence, blockchain and other technologies, digital technology has penetrated into all aspects of the industry, promoting the transformation of the traditional industrial chain to digital and intelligent. Full support at the policy level, from national strategic planning to specific local measures, has highlighted the great importance attached to the integration and development of digital economy and industrial chain, laying a solid foundation for the deep coupling of the two.

Under the background of digital economy, the reconstruction and optimization of industrial chain become feasible. Data-driven management model enables enterprises to efficiently allocate production factors and significantly improve operational efficiency. The rapid development of innovation chain has greatly shortened the technology research and development cycle and accelerated the market response speed. For example, with the help of cloud computing platform, enterprises can get real-time feedback from consumers and quickly adjust their R&D strategies, which not only improves the success rate of innovation, but also improves innovation. It also enhances the market competitiveness. Digital economy promotes the deep integration of industrial chain and innovation chain, which complement each other and jointly promote industrial upgrading.

This coupling development mechanism is very important to enhance industrial competitiveness and achieve high-quality economic development. Digital technology breaks the information barriers in all links of the industrial chain and makes the flow of innovative resources smoother, which not only reduces the cost of R&D, but also promotes the rapid transformation and application of new technologies. In this process, the overall efficiency of the industrial chain has been improved, and the value of the innovation chain has been maximized, which provides a continuous impetus for industrial upgrading.

2. Literature Review

(1) Research on Digital Economy

Don Tapscott(1996), an American scholar, first put forward the concept of "digital economy", which was initially based on the concept of the internet and the World Wide Web, and foresees

the impact of the internet on economic development. Since then, at the macro level, digital economy is an economic form driven by digital technology, covering digital industrialization and industrial digitalization, and its development is regarded as a long-term transformation process of technological and economic paradigm. Leading the transformation of economic structure. At the meso level, the digital economy mainly focuses on the optimization and upgrading of the industrial structure. Research shows that the development of digital economy can promote the upgrading of the overall structure or operation mode of enterprises. At the micro level, scholars focus on the specific behavior of enterprises and individual. For enterprises, the application of digital technology can improve operational efficiency, reduce costs and enhance market competitiveness. For individuals, the digital economy not only changes the way of life and consumption patterns, but also provides more employment opportunities and entrepreneurial platforms for individuals, and promotes inclusive growth of social economy.

(2) Research on the integration and development of industrial chain and innovation chain

The research on the integration development of industrial chain and innovation chain mainly focuses on its influencing factors, manifestations, path and measurement methods. 1) The dimension and manifestation of the integration of industrial chain and innovation chain. It mainly includes the integration of innovation subject and production subject, the integration of scientific and technological innovation and industrial development, and the integration of original innovation and industrial application. Later, scholars at the theoretical level (Visvanathans, 1977; Han Jiangbo, 2017; Hong Yinxing, 2019; Gao Hongwei, 2022; Zhu Sizhen and Wan Jinbo, 2022), empirical level (Wang Mingfeng et al., 2020; Chen Jun, 2022; Liu Jingyue and Wu Weixu, 2022; Wang Shuo, Zhu Chunyan, 2023), policy level (in April 2020, General Secretary emphasized during his visit to Shaanxi that “we should deploy innovation chains around the industrial chain, lay out the industrial chain around the innovation chain and make greater strides in promoting high-quality economy development”; In July of the same year, the State Council’s Opinions on Promoting the High-quality Development of National High-tech industrial Development Zones emphasized that “the innovation chain should be deployed around the industrial chain and the industrial chain should be laid out around the innovation chain.” Fostering new momentum for development and upgrading the modernization level of industrial development; In May 2021, the 20th Academician Congress of the Chinese Academy of Sciences, the 15th Academician Congress of the Chinese Academy of Engineering and the 10th National Congress of the Chinese Association of Science and Technology emphasized that “the key to the integration of the innovation chain and the industrial chain is to establish the dominant position of enterprise innovation”.) The research on the integration and development of the industrial chain and the innovation chain is also based on these three aspects. 2) The influencing factors of the integration of industrial chain and innovation chain. According to the interdependence and symbiotic development relationship between the industrial chain and the innovation chain, the main influencing factors include: technological innovation capability (Zhao Yulin and Pei Chengchen, 2019; Hong Yinxing, 2019; Chen Yuxin and Zhong Zheng, 2023), talent support (Gao Hongwei, 2022; Zhao Chen et al., 2023; Liu Yi et al., 2023; Gou Wenfeng, 2021), Policy Environment (Selected Research Reports, 2021), Degree of Globalization (Deloitte New World, 2020). 3) The measurement indicators of the integration of industrial chain and innovation chain mainly include economic benefit indicators, including sales revenue of new products, the proportion of high-tech enterprises, supply chain innovation indicators, market acceptance and conversion rate of innovation achievements. The improvement of the overall efficiency of the industrial chain and the ratio of innovation input to output (Hu Xuhua and Zhang Linyu, 2023; Wang Huiyan and Liu Jianxu, 2025). Technological innovation indicators, including: R & D investment intensity, number of innovators, technology conversion rate, innovation output indicators, technology synergies (Wang Yudong and Zhang Suodi et al.,

2024). 4) Research on the integration development path of industrial chain and innovation chain, mainly focusing on the direction of industrial chain deployment innovation chain, innovation chain layout industrial chain, and building integration platform (Visvanathan S, 1977; Kong Xiangnian, 2019; Liu Jingyue and Wu Weixu, 2022), design chain collaboration, and the use of the “meter” concept (Li Lihong, 2022) to provide a systematic collaborative innovation path.

(3) Coupling and its measurement

Coupling originates from physics, which refers to the mechanism of two or more systems or forms of motion influencing each other through various interactions, and the dynamic relationship of interdependence, mutual coordination and mutual promotion under the benign interaction among subsystems. The essence of coupling relationship reflects the interactive and symbiotic relationship between the objects of action. The degree of coupling and the coordinated development of coupling have become the science to measure the coupling relationship between the objects of action. Effective evaluation research tools (Wang Shujia et al., 2021). Among them, the degree of coupling coordination is a measure of the degree of harmony between systems or factors within the system in the process of development, indicating the trend of the system from disorder to order in the process of development, and can quantitatively describe the degree of coordination between systems in the process of development (Xiang Yong et al., 2018). However, the coupling coordination degree model only analyzes the static coupling relationship of the interaction and symbiosis of the objects. Therefore, more and more coupling relationship research institutes further study the dynamic interaction response between the objects on the basis of the coupling coordination degree model, so as to realize the dynamic prediction of the coupling relationship (Zhang Yuze et al., 2023). Lutkepohl (2004) it is pointed out that for the non-stationary time series, if the traditional OLS regression method is used, the phenomenon of “ spurious regression” may occur because of the non-stationary of the time series itself. VAR model can explain the dynamic relationship of multiple related variables, and is often used for dynamic impact analysis of time series variable system (Hou Yuqiao and Wang Fayuan, 2020). Based on this, Wang Chengfu (2023) , the coupling coordination degree model which can distinguish low level coordination is selected to study the static coupling relationship evolution of traffic energy level and economic energy level, and on this basis, the VAR model is further used to study the coupling relationship of dynamic interactive response between traffic energy level and economic energy level, aiming at studying the static evolution law of the coupling relationship between the two through the coupling coordination degree model. The dynamic prediction of the relationship between the two is realized through the VAR model.

The analysis of industry chain and innovation chain has formed some achievements, which laid a certain research foundation for this paper. However, there are few research results on the coupling development mechanism of digital economy enabling industry chain and innovation chain, and it is urgent to carry out corresponding theoretical research to guide practice. Firstly, there are still differences in the formation mechanism and internal logic of the coupling between industry chain and innovation chain in academia. It is necessary to systematically sort out the formation mechanism of the coupling between industry chain and innovation chain for further analysis of the internal dynamic correlation and synergy between them; Secondly, the literature on industry chain and innovation chain mostly focuses on practical experience summary and countermeasure research, some of which use empirical data to verify the necessity of synergy between industry chain and innovation chain, and the research on the coupling development of industry chain and innovation chain lacks systematic results. Thirdly, the existing research does not measure the coupling effect of industry chain and innovation chain through quantitative models. And verify the correlation of their interaction and symbiosis with each other. This is necessary for further analysis of the coupling path. Finally, there is also

a lack of targeted and operable research results to guide industrial practice on the coupling path of industrial chain and innovation chain in the digital economy era.

The sum up, at present, the research on the coupling development mechanism of industrial chain and innovation chain is still in the preliminary stage, especially the research on the coupling and path of industrial chain and innovation chain based on the construction of quantitative model in the era of digital economy. In view of the above shortcomings, this paper intends to start with the concept of coupling, analyze the formation mechanism of the coupling between the industrial chain and the innovation chain, and summarize the internal logic of the coupling between the two chains. This paper analyzes the coupling mechanism of the two chains, constructs the evaluation index system and quantitative model based on four dimensions of data-driven, technology-driven, mode change and linkage and synergy, and finally puts forward the path and countermeasures to promote the coupling of industrial chain and innovation chain.

3. The Theoretical Logic of Two Double Chains Coupling

(1) The concept and characteristics of the coupling of industrial chain and innovation chain

The coupling of industrial chain and innovation chain in the digital economy era shows a new connection and characteristics. This coupling is a systematic interactive relationship, aiming at achieving deep integration through technological innovation, resource integration and market application. Under the background of digital economy, data, as a new factor of production, has become the key link between the two, providing direction guidance for innovation, optimizing the allocation of industrial chain resources, and accelerating the transformation of technological achievements.

In the form of expression, the coupling of the digital economy era shows a high degree of integration. Digital technology is widely used to embed innovative activities in all aspects of the industrial chain, such as artificial intelligence to predict market demand, big data to monitor production processes, and so on. The platform economic model strengthens the coupling effect, builds an open and shared ecosystem, and effectively connects the decentralized innovation resources and industrial needs. Emerging technologies such as blockchain provide new ways for intellectual property protection and trading, and promote the efficient flow of value in the innovation chain.

In terms of characteristics, coupling shows the trend of intellectualization, networking and collaboration. Intelligent use of digital technology to transform traditional industries and promote the transformation of production mode; networking relies on the internet platform to achieve cross-regional and cross-industry resource integration and collaboration; collaboration emphasizes the participation of multiple subjects to form a cooperative mechanism of benefit-sharing and risk-sharing. These characteristics together shape an innovation-driven and digital-enabled modern industrial system, which injects lasting impetus into high-quality economic development.

4. Theoretical Connotation of Coupling Development

The coupling development of industrial chain and innovation chain is a systematic interactive process based on the optimal allocation of resources and synergy effect. Its core is to promote the efficient flow and integration of technology, capital, talent and other elements between the industrial chain and the innovation chain through deep integration. As the basis of economic activities, the operation efficiency and value creation ability of industrial chain depend on the technical support and innovation drive of innovation chain; Through basic research, application development and technology transformation, the innovation chain provides sustained

technological power for the industrial chain and promotes the development of the industry towards high added value.

In theory, this coupling development reflects the dynamic balance relationship, which requires the two to complement each other in function and coordinate in spatial layout and time series. In the regional economic development, the innovation chain can break through the weak links of the industrial chain and form a coordinated development model. In the era of digital economy, data, as a new factor of production, closely connects the industrial chain and innovation chain through the digital platform to reduce information asymmetry. Improve the efficiency of resource allocation. Coupling development also needs institutional support, such as government policy guidance, industry-university- research cooperation mechanism improvement and intellectual property protection system improvement.

The coupling of industrial chain and innovation chain is manifested by technological innovation driving industrial upgrading. Upgrading in the field of intelligent manufacturing can not be separated from the support of cutting-edge technologies such as artificial intelligence and big data, and the research and development of these technologies need to rely on universities, research institutes and enterprise R & D centers in the innovation chain. Therefore, it is very important to build a coupling development system with market demand as the guide, technological innovation as the core and cooperation as the link to enhance the modernization level of the industrial chain and enhance the competitiveness of the industry.

5. Dilemma of Coupling Development of Industrial Chain in the Era of Digital Economy

(1) Inefficient allocation of resources

The low efficiency of resource allocation is the key obstacle to the coupling development of industrial chain and innovation chain in the digital economy era. In the current economic environment, the allocation of resources is affected by multiple complex factors, and it is difficult to achieve optimal allocation. At the regional level, developed areas attract a large number of high-quality resources by virtue of policy, capital and technological advantages, while underdeveloped areas lack resources, which not only weakens the economic synergy effect, but also enlarges the regional development gap. At the industry level, high-tech industries and emerging industries get more resources because of policy support and market pursuit, while traditional industries may be in trouble because of the shortage of resources, which hinders the coordinated development of industrial chain and innovation chain.

Information asymmetry and market mechanism defects also seriously affect the efficiency of resource allocation. Although the development of information technology has promoted the dissemination of information, problems such as insufficient information sharing among enterprises, market monopoly and improper competition still exist, which lead to the failure of effective allocation of resources on demand and reduce the efficiency of economic operation. The role of the government is also crucial, and inaccurate policy guidance or poor implementation will aggravate the mismatch of resources and affect the integration of the industrial chain and the innovation chain.

The problem of matching technology and human resources is also prominent. In the era of digital economy, technological innovation and industrial upgrading have increased the demand for high-end talents, but there is a mismatch of skills in reality. Low-tech enterprises can not make full use of resources, high-quality brain drain, education and training system and market demand are out of touch, even if there are sufficient resources, these problems can not be transformed into productivity improvement, restricting the efficient coupling development of industrial chain and innovation chain. Therefore, optimizing the resource allocation

mechanism and improving the efficiency of resource use have become an important issue to be solved urgently.

(2) The Gap between Innovation Subjects

In the era of digital economy, the gap between innovators is particularly significant, which is mainly reflected in information circulation, cooperation mode and goal consistency. Although digital technology has promoted information sharing, the phenomenon of information islands is still prominent. The disunity of data formats and incompatibility of interfaces between departments within enterprises lead to low efficiency of cross-departmental collaboration, and the obstacles of information transmission between enterprises and scientific research institutions make it difficult for scientific research achievements to be rapidly transformed into industrial applications. This is due to the difference in understanding of technology maturity and market demand between the two sides. The increasing awareness of intellectual property protection has stimulated innovation, but it may also become an obstacle to information sharing.

In terms of cooperation mode, the conflict of interest demands among innovation subjects is obvious. Enterprises pursue short-term economic benefits, while universities and research institutions pay more attention to long-term academic value, which affects the depth of cooperation. In cross-regional or transnational cooperation, the differences in cultural background and policy environment further aggravate the difficulty of cooperation. For example, the conflict between data exit restrictions and open sharing policies challenges international cooperation. Lack of clear cooperation framework and incentive mechanism leads to insufficient willingness to cooperate. Even if the two sides intend to cooperate, they may be deadlocked because of the unclear distribution of responsibilities and unfair sharing of interests.

The issue of consistency of purpose is equally critical. The coupling of industrial chain and innovation chain needs multi-party coordination, but there are often deviations in the perception of innovation direction. Enterprises tend to follow the rapid iteration of market hotspots, while scientific research institutions focus on basic research and technological breakthroughs, which may lead to waste of resources. The mismatch between government policy orientation and the actual needs of enterprises also affects the efficiency of innovation. Therefore, the establishment of a unified strategic planning and coordination mechanism is the key to solving these problems.

(3) The connection between the main body of innovation and the main body of production is not close enough

In the era of digital economy, the problem of docking between the main body of innovation and the main body of production is particularly prominent. Universities, research institutes and other innovators tend to be theory-oriented R & D, while enterprises pay more attention to market-oriented practical technology. This dislocation between R & D and market demand leads to many scientific research achievements only staying in the laboratory, which is difficult to transform into actual productivity. Although frontier technology has high academic value, However, due to the lack of targeted transformation or high cost, it can not be adopted by enterprises. The long R& D cycle of innovators makes it difficult for enterprises to respond to customer needs in a rapidly changing market, which further aggraates the problem of docking. From the perspective of resource allocation, the resource sharing mechanism between innovation subject and production subject is not yet perfect. Innovation resources are mostly concentrated in universities and scientific research institutions, and small and medium-sized enterprises are often limited by capital and technology, which makes it difficult for them to bear high R & D costs. Even if they try to cooperate, they will stagnate because of the lack of clear agreement on the ownership of intellectual property rights and the distribution of benefits.

Information asymmetry also makes it difficult for enterprises to understand the progress of scientific research in universities, to accurately convey technological needs, and to form “information islands”, which not only wastes innovative resources, but also delays the industrialization of scientific and technological achievements.

In order to solve these problems, it is urgent to build a close cooperation mechanism. Through the platform of integration of production, teaching and research, we should strengthen the communication between the main body of innovation and the main body of production in terms of technology, talent and capital, and improve the efficiency of docking. Establish joint R&D centers or technology transfer agencies to make university R & D investment, and provide financial support and tax incentives. Only by realizing the deep integration of innovation chain and industrial chain can we release the innovation potential in the digital economy era and promote industrial upgrading and high-quality development.

(4) It is difficult to quickly transform scientific and technological innovation achievements into industrial applications

University researchers are facing multiple challenges in the process of transformation of scientific and technological achievements, the core of which lies in the disconnection between evaluation system and market orientation. The current academic evaluation mechanism focuses on the publication of papers and scientific research projects, which leads to insufficient attention paid by scientific researchers to the transformation of achievements. Legal risks such as ownership of intellectual property rights, income distribution, and lack of professional technology transfer teams and technology brokers make it difficult for scientific researchers to achieve even if they have the will to transform, which aggravates the problem of idle scientific and technological achievements.

The disconnection between scientific and technological achievements and market demand is also the key reason for the low efficiency of transformation. Universities and research institutes often pay attention to the frontier of technology and neglect the practical application value, which leads to the mismatch between R & D achievements and industrial demand. Enterprises tend to choose technologies with high maturity and low risk, while the achievements of universities are mostly in the laboratory stage, and there is a big gap in marketization. Poor information communication also limits the effective docking between supply and demand, and further hinders the transformation of achievements.

The shortage of funds also restricts the transformation of scientific and technological achievements. Although the government has increased its support, the coverage and efficiency of special funds are insufficient. Social capital has a low willingness to invest because of its long transformation cycle and high uncertainty, and lacks an effective risk-sharing mechanism. Universities and scientific research institutes mostly use their own funds for basic research, which is difficult to support the follow-up development and promotion. This problem is particularly prominent in small and medium-sized enterprises and local colleges and universities, which aggravates the uneven distribution of innovation resources.

The ecological environment supporting the transformation of achievements is not yet mature, and the implementation of policies, market system and service system need to be improved. There are some problems in the implementation of local government policies, such as cumbersome examination and approval, unclear incentive measures and so on, which affect the policy effect. The lack of authoritative evaluation institutions for scientific and technological achievements and unified market access standards has increased the cost of cooperative decision-making for enterprises. Therefore, it is very important to build a multi-party collaborative and efficient achievement transformation ecosystem to promote the deep integration of industrial chain and innovation chain.

(5) Insufficient information sharing

In the era of digital economy, the problem of inadequate information sharing is particularly prominent, which is mainly due to the interweaving of various factors. Technical barriers are an important reason, information systems between different enterprises or departments are heterogeneous, data formats, interface standards and transmission protocols are different, which makes it difficult to achieve seamless information docking. The lack of a unified data governance framework exacerbates this problem, which not only limits the speed and scope of information flow, but also may lead to data distortion or loss, weakening the synergy between the industrial chain and the innovation chain.

Obstacles at the institutional and cultural levels are equally significant. Considering the protection of core data, enterprises often hold a conservative attitude towards information sharing, coupled with the lack of internal data sharing culture, departments regard data as private resources, forming an “information island”. This behavior pattern not only hinders the integration of internal resources, but also affects the efficient operation of the entire industrial chain. In cross-enterprise cooperation, the lack of trust mechanism makes information sharing more difficult, and all parties tend to operate in a closed way rather than in an open way.

The lack of platform construction is also an important manifestation of inadequate information sharing. Despite the continuous emergence of data sharing platforms, their functions are single and difficult to meet complex needs. Although regional industrial alliances have established a preliminary information sharing mechanism, the platform coverage is limited and low, and the effect is limited. In addition, the high operating cost and the unclear income distribution mechanism further reduce the enthusiasm of the participants. These problems together restrict information sharing and need to be solved by technological innovation and institutional optimization.

6. The realistic path of coupling development of industrial chain and entrepreneurial chain in the era of digital economy

(1) Construction of main body coordination mechanism

1) Government guidance mechanism

In recent years, the Chinese government has attached great importance to the coupling development of the industrial chain and the innovation chain, with the core concept of “deploying the innovation chain around the industrial chain and laying out the industrial chain around the innovation chain”, and has promoted high-quality economic development through a series of policies and strategic deployments. These policies clarify the development goals and key tasks, and put forward specific safeguards, which provide systematic guidance for the deep integration of the two. In terms of policy implementation, the government has taken multi-dimensional measures. Strengthen top-level design, formulate planning documents, incorporate coupling development into the national strategic framework, and provide direction guidance for local and enterprises. Increase investment in scientific and technological innovation, increase scientific research funds, build a national platform for technological innovation, and accelerate the transformation of scientific and technological achievements into productive forces. The government has also optimized the innovation environment and improved the intellectual property protection system. Deepening industry-university-research cooperation, opening up scientific research infrastructure, stimulating the innovation vitality of market players, especially strengthening the role of private enterprises in technological innovation.

Regional coordinated development is also an important direction. Through the layout of major scientific and technological projects and the construction of regional innovation centers, the government promotes the rational allocation and sharing of innovation resources, promotes local economic development, and provides a broader space for the integration of industrial

chain and innovation chain. The government should establish a scientific evaluation system, regularly monitor and feedback the effect of policies, and timely adjust strategies to meet new challenges. Despite the uneven distribution of innovative resources and the imperfect transformation mechanism of achievements, the government is gradually solving these problems.

In order to further enhance the policy effect, it is suggested to strengthen policy publicity, improve supporting measures, deepen the synergy between industry, University and research, strengthen international cooperation, introduce global high-quality resources, and inject new momentum into the sustainable growth of China's economy.

2) Enterprise-led mechanism

China's current policy for the coupling development of industrial chain and innovation chain, starting from the enterprise level, focuses on strengthening the dominant position of enterprise innovation, building innovation platforms and deepening industry-university-research cooperation. The policy gives enterprises more autonomy and encourages them to establish R & D institutions. Through tax relief and other measures, enterprises are encouraged to increase investment in key technology areas. The construction of national technological innovation center provides a platform for enterprises to gather innovative resources and accelerates the transformation of scientific and technological achievements into industrial applications.

With the implementation of the policy, the dominant position of enterprises in innovation has been gradually established, and leading enterprises have built up a sound innovation system and launched competitive products and services. Significant progress has also been made in the construction of innovation platforms, which has promoted the industrialization of scientific and technological achievements. There are still problems in resource allocation optimization and collaborative cooperation, and some enterprises are facing the dilemma of poor cooperation. This shows that although the policy framework has been improved, it still needs to strengthen guidance and support in the specific implementation.

In order to ensure the effective implementation of the policy, it is suggested to strengthen policy publicity and training, improve supporting measures such as tax incentives and financial support, stimulate the innovation vitality of enterprises, strengthen the main responsibility of enterprises, and promote their cooperation with upstream enterprises. Deepening the integration of industry, University and research, promoting the efficient transformation of scientific and technological achievements through the co-construction of innovation alliances, and realizing the deep coupling development of industrial chain and innovation chain.

3) Supporting mechanism of scientific research institutions

Scientific research institutions are the key force for the coupling development of industrial chain and innovation chain, which has been fully reflected in the policy system. China's current policy mainly focuses on "double-chain" integration, emphasizing that scientific research institutions promote high-quality industrial development through frontier exploration and technological transformation. The goal of "deep integration of four chains" put forward in the report of the 20th National Congress of the Communist Party of China further clarifies the core position of scientific research institutions in technological innovation, achievement transformation and personnel training.

In the implementation of the policy, scientific research institutions mainly play three roles: First, they provide technical reserves for the industrial chain through basic and applied research, and state key laboratories and other institutions undertake key technical research tasks to directly serve industrial upgrading. The second is to promote industry-university-research cooperation, promote the docking of innovation chain and industrial chain, build joint laboratories or technology transfer centers with enterprises, and accelerate the industrialization of scientific and technological achievements. The third is to cultivate high-quality talents, through

interdisciplinary and practical teaching mode, to cultivate compound talents who understand both technology and industrial needs.

In recent years, the government has increased its support for scientific research institutions, set up special funds and optimized preferential tax policies, which have significantly enhanced their innovation capabilities and made breakthroughs. The transformation mechanism of achievements is still inadequate, and some scientific research achievements are difficult to industrialize due to lack of market orientation. Therefore, it is suggested to improve the construction of the platform for the transformation of scientific and technological achievements, strengthen the protection of intellectual property rights, strengthen policy publicity, and improve the understanding and execution of policies by scientific research institutions, so as to better play its supporting role in the coupling development of industrial chain and innovation chain.

4) Multi-agent collaborative promotion mechanism

The policy system of the coupling development of China's industrial chain and innovation chain emphasizes multi-subject coordination, and its core is to achieve the effective landing of the policy through the linkage of the government, enterprises, universities and scientific research institutions. From the perspective of top-level planning, the state has issued a series of guiding documents to clarify the strategic direction of the state's deployment of innovation chains around the industrial chain, such as the Guiding Opinions on Promoting the Integration and Development of Innovation Chains and Industrial Chains. These policies provide local governments with a framework for action, and local governments formulate implementation rules according to local conditions, such as the "Policy Opinions on High-quality Development of Industrial Economy" issued by a certain place, which focuses on the development needs of regional characteristic industries and promotes the deep integration of the two chains.

At the level of policy implementation, the government provides innovation guarantee for enterprises through financial support and platform building, and guides universities and scientific research institutions to participate in industry-university-research cooperation to promote the transformation of basic research to application. Financial institutions help the growth of technology-based enterprises through credit tilt and direct investment in the capital market. At present, there are still some problems in the implementation of policies, such as the low efficiency of the integration of innovation resources in some areas. Industry-university-research cooperation mechanism is not close enough. Therefore, it is necessary to further strengthen the interpretation of policy publicity and optimize the implementation mechanism. And build a more perfect innovation ecological environment to ensure the formation of an efficient and collaborative innovation network among the main bodies, and ultimately achieve high-quality integration and development of the industrial chain and innovation chain.

(2) Enabling path design of digital economy

1) Digital-driven innovation path

In the era of digital economy, digital drive has brought new opportunities for the coupling of industrial chain and innovation chain. Building a digital governance platform of regional industrial chain driven by big data can break the information barrier between industries and realize data integration and sharing. This platform integrates production, management, service and sales data, and assists scientific decision-making through accurate portraits, so that enterprises can accurately identify technical needs, adjust the direction of innovation, and ensure that the innovation chain is closely linked to the needs of the industrial chain based on market trends and consumer behavior data analysis.

Promoting the digital transformation and intelligent upgrading of enterprises is the key to improving the coupling level. Digital transformation improves the efficiency of enterprise operation, optimizes the allocation of resources, and enables enterprises to respond quickly to

market demand. Intelligent technology, especially the integration of artificial intelligence and the internet of things, promotes new business models in the field of intelligent manufacturing, enhances the added value of the industrial chain, provides rich application scenarios and technical support for the innovation chain, and promotes the deep interaction between the two. It is very important to strengthen the allocation of innovative resources driven by data. We will deploy innovation chains around the industrial chain, allocate scientific research resources according to actual needs, and overcome key technical bottlenecks; we will lay out industrial chains around the innovation chain, and guide the development of emerging industries. Big data market demand, designs industrial development path, and accelerates the transformation of scientific and technological achievements into productive forces.

It is also very important to build a scientific and technological platform to gather innovative elements. National laboratories and technological innovation centers attract high-end talents and capital to form innovative synergy. Define the function orientation of the platform, strengthen resource sharing and improve innovation efficiency. In the metropolitan area, we should strengthen the construction of innovation consortium, enlarge the synergistic effect, and promote the coupling development of industrial chain and innovation chain at a higher level.

2) Digital platform promotes double-chain coupling path

As the core infrastructure of the digital economy era, digital platform has opened up a new path for the coupling development of industrial chain and innovation chain. By building a comprehensive digital platform ecosystem, data resources can be efficiently integrated and shared. For example, the platform integrating big data, cloud computing and artificial intelligence technology can provide enterprises with data support for the whole process from production to sales, and promote collaboration among different subjects. Strengthen the interconnection between platforms, solve the problem of information islands, improve the efficiency of information flow through unified data standards and interface protocols, and promote in-depth collaboration between upstream and downstream enterprises in the industrial chain.

In practice, the digital platform promotes the double-chain coupling by promoting the digital transformation of the industrial chain. Intelligent supply chain uses internet of things and blockchain technology to track raw material procurement, manufacturing and logistics distribution in real time, improve operational efficiency, reduce management costs, inject vitality into the innovation chain, and accelerate the transformation of scientific research achievements into productivity. The digital platform also builds an innovative cooperation platform to strengthen the integration of production, education and research, such as universities, research institutes and enterprises jointly carry out technological research and development projects to accelerate the transformation of scientific and technological achievements.

In order to ensure the effective implementation of these paths, digital platforms need to pay attention to resource allocation and service guarantee. It is necessary to provide precise solutions according to the characteristics of the industry, solve practical problems, strengthen data security management, and establish a sound data security management system. The government should also introduce relevant policies, such as setting up special funds or tax incentives, to encourage enterprises to participate in the construction of digital platforms, and ultimately achieve the deep integrating and coordinated development of industrial chain and innovation chain.

3) Application and Promotion Path of Digital Technology

The wide application of digital technology provides a new opportunity for the coupling development of industrial chain and innovation chain. Enterprises can optimize the efficiency of resource allocation and strengthen the ability of information circulation by introducing

advanced technologies such as internet of things and blockchain. For example, the internet of things enables real-time data interaction between devices, making the production process more transparent and intelligent, thereby reducing operating costs and enhancing innovation capabilities. Blockchain technology has its decentralized characteristics. It can ensure the security and credibility of data, promote the establishment of trust among different subjects, and then promote the collaborative innovation between upstream and downstream of the industrial chain.

The application of artificial intelligence and big data analysis also creates conditions for the deep integration of industrial chain and innovation chain. Through in-depth learning algorithm, enterprises can accurately predict market trends and quickly respond to changes in consumer demand, thereby shortening the product development cycle and improving the success rate of innovation. Big data analysis can extract valuable knowledge points from massive information and provide scientific basis for enterprise decision-making. This data-driven innovation model not only enhances the competitiveness of enterprises, but also promotes the virtuous circle of the entire industrial chain ecosystem. Therefore, in the era of digital economy, making full use of the advantages of digital technology will help to build a more efficient and resilient coupling system of industrial chain and innovation chain.

(3) Construction of policy support system

1) Industrial policy optimization

The core of building industrial policy support system is to enhance the synergy and execution of policies. Establish innovative policy coordination agencies, integrate departmental resources, avoid policy fragmentation, and improve the “conventional science and technology plan + new national system” model, combined with short-term research and long-term layout, to ensure that policies are accurate and feasible. In key core technology areas, special funds and tax incentives should be used to guide enterprises to increase R & D investment and form a market-oriented technological innovation mechanism.

Strengthen the dominant position of enterprises in the innovation system, optimize the cooperation mechanism of industry, University and research, clarify the distribution of responsibilities and interests, and improve the efficiency of technology transformation. We should adjust the evaluation system of universities and scientific research institutions, increase the weight of achievement transformation indicators, and encourage the marketization of high-level scientific and technological achievements. We should build and open innovation ecosystem, encourage international R & D cooperation, set up joint laboratories or technology transfer centers, introduce external high-quality resources, and enhance the overall innovation capability.

Optimizing the allocation of resources and creating a fair competitive environment are the basis of policy implementation. We will deepen the reform of “releasing control clothing”, reduce market access, and expand space for small and medium-sized enterprises. We should strengthen anti-monopoly law enforcement, safeguard fair competition and prevent market failure. Improve the credit system, enhance trust among enterprises, promote industrial chain cooperation, and promote industrial upgrading.

The improvement of macro-control and policy transmission mechanism is very important to the policy effect. Fiscal policy supports basic research and generic technology research and development, and monetary policy guides the flow of financial capital to the real economy, such as the establishment of special loans and risk compensation funds to solve the financing problems of technology-based enterprises. Establish and improve the chain of policy transmission, use digital means to monitor the implementation, and ensure that policy intentions are accurately transmitted to the grass-roots level and the ultimate beneficiaries.

2) Improvement of innovation policy

The successful landing of innovation policy needs to build a systematic support system to ensure that policy objectives are translated into practical results, in which policy synergy is particularly critical. The establishment of a coordinated review body can avoid policy conflicts and duplication and improve the efficiency of implementation, while cross-sectoral collaboration, such as the linkage of science and technology, education and economic sectors, can promote the improvement of innovation ecology from multiple dimensions. Science and technology departments provide technical support, education departments train innovative talents, and economic departments provide financial support to form a policy synergy.

In order to improve the effect of policy implementation, it is necessary to clarify the allocation of responsibilities and optimize the process. Detailed implementation responsibilities are assigned to specific departments and individuals, and a supervision and assessment mechanism is established to ensure the implementation of policies. Simplify the approval process, improve transparency and reduce the resistance to implementation. As the core of innovation, enterprises should strengthen their position. Establish a national innovation system, guide enterprises to increase R & D investment, reduce innovation costs through special funds and tax incentives, stimulate enterprise innovation vitality, and provide sustainable development momentum.

Optimize the environment of industry-university –research cooperation, improve the cooperation mechanism, promote the deep interaction between universities, research institutes and enterprises, and accelerate the transformation of scientific and technological achievements into real productive forces. Adjust the evaluation and assessment system, increase incentives for cooperation results, and enhance the enthusiasm for participation. The role of market mechanism can not be ignored, play its decisive role in the allocation of resources, combined with market supervision, ensure fair competition order, and promote the efficient allocation of innovative resources. These measures together constitute a comprehensive and efficient policy support system to help the coupling development of industrial chain and innovation chain in the digital economy era.

3) Policy coordination of digital economy

The construction of digital economy policy support system needs to start from many aspects to ensure the effective implementation of the policy. It is necessary to clarify the policy objectives and positioning, incorporate the development of digital economy into the national strategy, formulate a clear blueprint for development, establish short-term, medim-term and long-term goals, and maintain the consistency and continuity of policies. In view of the key areas such as data factor market and digital infrastructure construction, we should formulate differentiated policies to avoid one-size-fits-all and concentrate resources to solve core problems.

Improving policy tools is the key to supporting the system. In terms of laws and regulations, we should speed up the formulation of relevant laws and regulations on the digital economy, clarify data property rights, trading rules and privacy protection, and provide legal protection. We will improve fiscal and tax policies, increase tax incentives, and set up special funds to support key technology research and demonstration projects. Financial support is also crucial to guide financial institutions to innobate service models, meet the financing needs of digital economy enterprises, and promote the deep integration of financial technology and digital economy.

Policy implementation and monitoring mechanisms are equally important. Establish a cross-sectoral and cross-regional policy coordination mechanism, clarify the main body of responsibility and time nodes, and strengthen execution. Establish a tracking and evaluation mechanism to dynamically adjust and optimize policies. Combining supervision, inspection and feedback mechanism, we can improve the implementation effect and ensure the orderly progress of policies.

It is also essential to create a good policy environment and cultural atmosphere. Strengthen the training and introduction of talents, and enhance to social awareness and identity of the digital economy. At the international level, we should actively participate in the formulation of global digital economic rules, strengthen international cooperation and jointly promote the healthy development of the digital economy. These measures complement each other and help the full implementation of the digital economy policy.

4) Regional differentiation policy design

The construction of regional differentiation policy needs to proceed from multiple dimensions to ensure a high degree of fit with local actual needs. The primary task is to scientifically evaluate the economic structure, resource endowment and innovation capability of each region, and to clarify its role in the coupling of industrial chain and innovation chain. Resource-based areas should focus on the digital transformation of traditional industries, while technology-based cities should focus on high-end technology research and development and transformation of achievements. By accurately identifying regional characteristics, we can formulate differentiated policy objectives and enhance policy pertinence and implementation effect. Establish quantitative indicators such as R & D investment intensity and technology transaction volume, and dynamically monitor the implementation of policies to provide a basis for subsequent adjustments.

Policy formulation needs to introduce a multi-party participation mechanism, and the government jointly with enterprises, universities, scientific research institutions and trade associations to discuss the policy direction and absorb the opinions of all parties. Establish a dynamic adjustment mechanism to adapt to the rapid development of the digital economy, and regularly evaluate and optimize the policy content. Improve feedback channels, encourage all sectors of society to put forward suggestions, form a benign interactive policy adjustment mechanism, and ensure the vitality of the policy.

Publicity, training supervision and evaluation should be strengthened in the process of policy implementation. Publicize policies through multiple channels and organize special training to help relevant subjects understand policy intentions. Establish and improve the supervision system, clarify the division of responsibilities, and hold accountable for ineffective implementation. The government should increase financial input, attract social capital participation through tax incentives, improve the financial service system, and provide diversified support for the coupling of industrial chain and innovation chain. Through inter-regional cooperation and coordination, we can break the geographical restrictions, realize resource sharing and complementary advantages, and enhance the overall effectiveness of policies.

References

- [1] Fan D , Li M .Digital Economy Development and Green Innovation Efficiency from a Two-Stage Innovation Value Chain Perspective[J].Sustainability,2024, 16(11): 1-20.
- [2] Yi L , Xuan Z , Wei Y .Impact of the Digital Economy on the Integration of Traditional Manufacturing Industry Chain and Innovation Chain: An Empirical Study Based on China's Provincial Experience[J]. Frontiers of Economics in China, 2024, 19(2):203-225.
- [3] Visvanathan S. From Laboratory to Industry: A Case Study of the Transfer of Technology[J]. Contributions to Indian Sociology,1977:117-136.
- [4] Han Jiangbo. Research on the integration of innovaton chain and industrial chain—Based on theoretical logic and its mechanism design[J]. Technical Economics and Management Research , 2017(12): 32-36.
- [5] Gao Hongwei. Promoting the integration and development of industrial chain and innovation chain: Theoretical connotation [J]. Practical Progress and countermeasures , 2022(5): 73-80.

- [6] Zhu Sizhen, Wan Jingbo. Research on the integration mechanism and path of innovation chain and industry chain [J]. *Innovation Technology*, 2022(10): 41-51.
- [7] Chen Jun. The economic development effect of innovation chain and industrial chain synergy— From the reform of urban administrative approval empirical evidence[J]. *Contemporary Economic Research*, 2022(9): 115-128.
- [8] Liu Jingyue, Wu weixu. Research on the development path and mechanism of innovation chain and industry chain integration from the perspective of industrial policy[J]. *Science and Technology Management Research*, 2022(15): 106-114.
- [9] Wang Shuo, Zhu Chunyan. Research on industrial chain in the construction of internal circulation— Taking Northeast China [J]. *Scientific Management Research*, 2023(2): 93-100.
- [10] Zhao Yulin, Pei Chengchen. Technological innovation, industrial integration and manufacturing transformation and upgrading[J]. *Scientific and Technological Progress and Countermeasures*, 2019, 36(11):70-76.
- [11] Hong Yingxin. Deploying the Innovation chain around the industrial chain: On the deep integration of scientific and technological [J]. *Economic Theory and Economic Management*, 2019(8): 4-10.
- [12] Zhao Chen, Lin Chen, Gao Zhonghua. Integration development path of innovation chain and industry chain supported by talent chain: Logic, comparison between China and the United States and Policy enlightenment[J]. *China Soft Science*, 2023(11):23-37.
- [13] Liu Yi, Zhao Xuan, Yang Wei. The impact of digital economy on the integration of traditional manufacturing industry chain and innovation chain: An empirical study based on China's Provincial experience[J]. *Zhejiang Social Sciences*, 2023, 19(03): 4-14+156.
- [14] Gou Wenfeng. Research on historical evolution, reconstruction and talent support of industrial chain modernization—Taking Chongqing as an example [J]. *Macroeconomic Research*, 2021(7): 79-88.
- [15] Wang Yudong, Zhang Bo, Wu Chuan. Research on the measurement of synergy degree between innovation chain and capital chain of high-tech industry—Based on the synergy degree model of composite system[J]. *Science and Technology Progress and Countermeasures*, 2019, 36(23):63-68.
- [16] Zhang Tingting, Zhang Suodi, Hu Linna. Research on multiple paths of integration of innovation chain and talent chain of urban artificial intelligence industry [J]. *Soft Science*, 2024(6) : 1-6+12.
- [17] Kong Xiangnian. Operation mechanism and construction path of industrial technology research institute based on the integration of innovation chain and industrial chain[J]. *China University Science and Technology*, 2019(10): 86-89.
- [18] Wang Shujia, Kong Wei, Ren Liang. Misunderstanding and correction of coupling coordination degree model in China [J]. *Journal of Natural Research*, 2021, 36(3): 793-810.
- [19] Zhang Yuze, Han Yinfeng, Zhang Shuo. Coordination measurement and interaction response of green finance and ecological civilization coupling in Shandong Province. [J]. *Ecological Economy*, 2023(4):221-229.
- [20] Lutkepohl H , Kratzig M . *Applied Time Series Econometrics: Univariate Time Series Analysis*[J]. 2004, 10 (2):8-85.
- [22] Hou Yuqiao, Wang Fayuan. Research on the dynamic relationship between green innovation and economic growth— Based on VAR model empirical analysis [J]. *Economical Economy*, 2020, 36(5):44-49.
- [23] Wang Chengfu. Research on measurement and coupling relationship between traffic energy level in Chengdu-Chongqing economic circle [D]. *Chongqing Jiaotong University*, 2023.