Research on the Impact of Digital Economy on Industrial Innovation and Regional Economic Development

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Abstract: In view of the key problems such as low allocation efficiency of innovation factors, unbalanced development of digital economy and weak ability of scientific and technological transformation, this paper analyzes the reasons for insufficient impetus of industrial innovation based on transaction cost theory, scope economy theory and value chain theory, establishes a theoretical model of digital economy affecting innovation factors agglomeration, and proposes ways to accelerate the coupling and coordinated development of digital economy and innovation factors agglomeration. Promoting the upgrading of industrial structure and high-quality industrial development has important reference significance for promoting the upgrading of industrial structure.

1. Introduction

At present, there are problems such as the imbalance of industrial structure, the lack of key core technologies and the weak ability of independent innovation, which affect the development of industrial economy. In the era of digital economy, it is necessary to study the synergy between digital economy and technological innovation, optimize market mechanism, promote technological innovation and industrial upgrading, and improve the level of industrial structure.

Through the integration of data resources and information and communication technologies, the digital economy has promoted the transformation of scientific and technological achievements, promoted the evolution of economic forms, and promoted the birth and development of emerging industries. The digital economy breaks the constraints of geography and time and promotes synergies among all links of the industrial chain. The first session of the 14th National People's Congress of China has stressed that the country should further implement the strategy of innovation-driven development and promote the optimization and upgrading of industrial structure. Carlino etal[1-3]. found that digital technology is a potential productivity, and promoted the aggregation of innovation factors in R&D, manufacturing, marketing, circulation and other links of enterprises, thus improving innovation ability. Dominiak[4] et al. found that the digital economy can not only improve the utilization efficiency and allocative efficiency of innovative factors, but also that the digital economy region can attract high-tech and high-productivity enterprises to enter, so that enterprises with low productivity or low technical level can exit the market or locate in peripheral areas, making the output structure benefit change. Transaction relationship network can reduce comprehensive logistics costs, coordination costs and search costs, thereby reducing transaction costs (McCann P etal.,2019) [5] and realizing transaction cost savings. Zheng Guoqiang and Wan Mengze (2023) found that digital economy can promote total factor productivity growth mainly through innovation-driven effect, entrepreneurial incentive effect and industrial upgrading effect. The higher the development level of digital economy, the more obvious the productivity growth of cities, which leads to the productivity gap between regions [6] and others find that digital economy can not only improve the utilization efficiency of innovative factors. With the continuous development of the digital economy, the penetration of the real economy, the innovation of the industrial development model, the

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mechanism of the digital economy and the innovation function on the development of enterprises has also changed, and it is necessary to further study.

This study constructed an evaluation index for industrial structure upgrading, theoretically deduced the influence mechanism of innovation factor agglomeration on industrial structure upgrading, tested the influence of innovation factor agglomeration on industrial structure upgrading, and provided an important reference for improving the efficiency of innovation factor agglomeration and promoting innovation-driven development strategy and industrial structure upgrading strategy.

2. Theoretical basis and theoretical analysis frame

2.1 Digital economy

Digital economy refers to an economic form with digital technology as the core, data as the key element, and networking, intelligence and personalization as the main features. Through the Internet, big data, cloud computing, artificial intelligence, blockchain and other technologies, it accelerates innovation and integrates into the whole process of economic and social development.

The digital economy has three major characteristics, the first is the network characteristics, the use of the Internet platform to overcome the limitations of time and space, and quickly promote information transmission and economic activities. The second is intelligent characteristics, the use of artificial intelligence and other technologies to improve production efficiency and intelligence level. The third is personalized characteristics, according to user needs to provide personalized products and services.The digital economy can be divided into four parts:

Digital industrialization refers to the process by which digital technologies such as next-generation mobile communications and artificial intelligence are transformed into digital products and services, data into resources and factors of production, and new digital industries, new forms of business and new models are formed. Including electronic information manufacturing industry, telecommunications industry, software and information technology service industry, Internet industry, etc.

Industrial digitization, transforming the tools of production with digital technologies; Take data resources as key production factors; Reconstructing product structure with digital content; Take information network as the market allocation link; Take the service platform as the carrier of industrial ecology; Traditional industries use digital technologies to improve efficiency and output, such as industrial Internet, intelligent manufacturing, car networking, etc.

Digital governance means to realize modern and intelligent governance by integrating data resources, optimizing business processes, and making decisions more scientific. It involves multiple subjects such as government, enterprises and social organizations, as well as multiple fields such as economy, society and culture, including pluralistic governance and digital public services.

Data value, data value is to realize the commercialization of data elements through a series of technical and economic activities, so as to give full play to the economic value of data . It involves data collection, annotation, analysis, transaction and other links.

Related theories of digital economy driving theory: The first is endogenous growth theory, which mainly studies how to achieve economic growth, including Adam Smith's social division of labor theory, Malthus's growth determinism, Schumpeter's innovation theory, Harold Dormer's growth theory, and Romer's endogenous technological change new economic growth theory, establishing a long-term growth model with endogenous technological change as the core. Its core is "knowledge" as an important factor of production, emphasizing the role of knowledge and technology research in industrial growth, knowledge and human capital to promote industrial economic development. The second is the theory of technological innovation driving. The digital economy is an economic activity driven by digital technology, so the digital economy-driven innovation growth consists of two parts: the innovation of the digital economy industry itself, and the new output brought about by the spillover of digital technology. The third is the economic behavior theory of digital economy, which mainly discusses the central role of digital knowledge and information in modern economic activities, and how these roles affect economic behavior, economic structure and economic

development. Fourth, the integration of digital economy and innovation to promote economic development.

2.2 Innovation factor agglomeration

The concept of innovation elements was put forward by Lundvall, who believed that innovation elements are the essential resources used to complete the whole process of innovation activities and the basis of scientific and technological innovation, including talents, research and development funds and technology. For example, all the elements used by innovation entities such as industry, research and development institutions and universities to put inventions and discoveries into practical application in the innovation process. With the continuous progress of technology and the change of production factors, the definition criteria of innovation factors are also constantly developing.

Factor space flow theory: Factor flow theory belongs to the category of western classical economics, and was originally proposed as an untheorized idea by economist William Patti. William Pattie often included political factors into his calculations in his work. After continuous research, he found that economic development cannot be separated from the free flow of labor and capital. The increase of labor force in a certain region will increase the economic income of land, and vice versa. Production factors, as the basic factors to maintain economic operation, are also indispensable for the development of regional industries. Industrial clusters will allow the rapid accumulation of production factors in a certain region, and the resulting various resources will increase the competitiveness of regional industries. As a kind of industrial cluster, the integration of agricultural industry and service industry in rural areas also plays a role in promoting the accumulation of production factors in rural areas. When the factors of production have accumulated to a certain extent, the integration of rural resources and the development of characteristic industries can be rapidly improved. The theory of spatial flow of factors explains that differences in the types and abundance of production factors and scientific and technological resources between countries and regions lead to differences in regional comparative advantages, resulting in inter-regional flow of talents and product exchange. Technology, as an important factor of production that determines productivity, forms technological agglomeration and diffusion in spatial flow. It has become an important factor affecting the regional industrial innovation income.

According to the agglomeration life cycle theory put forward by Austrian economist Tichy, regional agglomeration experiences four stages: establishment, growth, maturity and decline. From the perspective of agglomeration evolution cycle, enterprises reduce transportation cost and increase revenue through geographical proximity. Due to the first-mover advantage, more and more enterprises begin to migrate and relocate to agglomeration areas.

Agglomeration and spatial disequilibrium related theories: The spatial concentration of economic activities brings about the disequilibrium of the distribution of spatial factors. The spatial disequilibrium under agglomeration economy mainly includes factor endowment gap theory, core and edge theory and growth pole theory. The factor endowment gap theory is developed on the basis of the factor endowment theory. It shows that due to the large differences in regional economic and social development status, natural environmental conditions and resource endowment status, the gap in the allocation of human resources, capital, technology and other resource elements in different regions has resulted, and this gap will trigger the flow of factors between different regions. The gradually accumulated human capital and knowledge and technology form regional competitive advantage.

Technology spillover theory: Technology spillover, as an externality of innovation factor agglomeration, plays a key role in shaping regional innovation conditions. Technology diffusion will affect the innovation in the surrounding region through the interregional correlation effect, transfer effect and growth effect. Technological innovation diffusion not only promotes economic development, but also enhances spatial economic welfare. The spatial effect of knowledge spillover has internal and interregional externalities.

2.3 Upgrading of industrial structure

The industrial structure is represented by the proportion of industries with different technical levels in the national economy and the proportion of different sectors within the industry. The upgrading of industrial structure is represented by the fact that the capital and technology endowment of the industry is superior to the endowment of labor, land and other resources, and the process of the industrial production mode becoming technology-intensive. In essence, the dynamic process of reconfiguration of production factors such as material resources, labor, knowledge and technology, and human capital to achieve industrial innovation and productivity improvement is a process or trend of transformation from low-level form to high-level form, and also a transformation of production direction from extensive growth mode to intensive and efficient. The theory of industrial structure upgrading can be summarized into two aspects: one is the theory of industrial structure evolution, and the other is the theory of industrial structure optimization. The optimization of industrial structure involves the balance of industrial structure and the benefits and quality of the structure, which reflects the proportional relationship between industries and the contact mode or correlation mode between industries.

The upgrading of industrial structure is an important trend in the current economic development, which involves many aspects, including high-end, intelligent and green transformation, and the cultivation and development of emerging industries .

High-end transformation is an important direction of industrial structure upgrading. Through technological innovation and industrial upgrading, we will promote the development of traditional industries towards high-end manufacturing and high value-added. For example, the reform of state-owned assets and state-owned enterprises has continued to deepen, effectively promoting a profound change in the development mode of state-owned enterprises, and taking solid steps in high-quality development. The total assets and total profits of enterprises supervised by the national state-owned assets system have achieved significant growth, and the scale and strength and quality and efficiency have been significantly improved.

Intelligent transformation is also the key to the upgrading of industrial structure. With the rapid development of artificial intelligence, big data, cloud computing and other technologies, intelligence has become an important force to promote industrial development. Various localities have implemented "AI+" special actions to accelerate the pace of industrial intelligent transformation. Through the introduction and cultivation of a number of intelligent enterprises with core competitiveness, to promote the optimization and upgrading of industrial structure.

In addition, green transformation is an inevitable choice for industrial structure upgrading. With the enhancement of global environmental protection awareness, green development has become the common pursuit of economic development in all countries. Promoting the transformation of industrial structure to green will not only help reduce environmental pollution, but also achieve sustainable economic development. For example, the central region, driven by the new energy automobile industry, has achieved a green transformation of the industrial structure, and the output of new energy vehicles has increased significantly.

The cultivation and development of emerging industries is also an important part of the upgrading of industrial structure. Through policy support and market guidance, we will cultivate a number of internationally competitive emerging industries, such as new energy, rail transit, and data industry. The development of these emerging industries will promote the industrial structure to a more high-end, intelligent, green direction. For example, the National Development and Reform Commission and other departments issued the Guiding Opinions on Promoting the High-quality Development of the Data Industry, proposing that by 2029, the compound annual growth rate of the scale of the data industry will exceed 15%, and the structure of the data industry will be significantly optimized.

2.4 Digital economy, innovation factor agglomeration and industrial structure upgrading

The development of the digital economy is an important force for upgrading the industrial structure. With data resources as the key element and modern information networks as the main carrier, the digital economy promotes the continuous evolution of economic forms through the

integrated application of information and communication technologies and the digital transformation of all factors. This new economic form has changed the traditional production mode and business model, promoted the birth and development of emerging industries, and provided a strong driving force for the upgrading of industrial structure.

Promoting digital innovation : The digital economy will improve the digital technological innovation system, strengthen the protection of digital intellectual property rights and related patents, encourage digital R & D and innovation, and thus promote the upgrading of industrial structure. The breakthrough and application of digital technology has provided a new growth point for traditional industries, and promoted the intelligent, automated and efficient development of industries.

Integrating traditional industries : The integrated development of digital economy and traditional industries is an important way to upgrade industrial structure. Through the penetration and application of digital technology, traditional industries can realize the optimization of production processes, the improvement of product quality and the broadening of market expansion, and thus improve the overall competitiveness and added value of the industry. For example, the rise of intelligent manufacturing, smart agriculture and other fields is the result of the deep integration of the digital economy and traditional industries.

Giving rise to emerging industries : The digital economy has also given birth to emerging industries such as cloud computing, big data and artificial intelligence, which have become new engines for upgrading industrial structure with their unique advantages and development potential. The development of these emerging industries has not only injected new vitality into the economy, but also driven the formation and development of related industrial chains, and further promoted the optimization and upgrading of the industrial structure.

In addition, the digital economy has also shown a strong integration and penetration force and innovation driving force in the process of helping to upgrade the industrial structure. It breaks the regional barriers, promotes the optimal allocation and efficient use of resources, and provides a broader space and opportunities for the transformation and upgrading of industrial structure. At the same time, the digital economy also promotes high-quality economic development by improving the efficiency of information collection, processing and application.

3. Digital economy development and industrial structure upgrading

3.1 Spatial pattern of innovation factors agglomeration

It can be seen from the development trend of specialized agglomeration of innovation factors that the level of innovation capital agglomeration in China as a whole shows an obvious upward trend, but the eastern, central and western regions show obvious heterogeneity of regional agglomeration development trend. The reason is that the high-quality resources of the innovation system are mainly concentrated in the eastern region. On the one hand, the eastern region has many first-class universities and institutions of higher learning and a sound cooperation mechanism between industry, university and research, which provides a better exchange platform for the creation, reserve, use and transfer of knowledge, skills and new products. On the other hand, the scientific and technological level of the eastern region is developed, and a large number of foreign-invested enterprises are concentrated in the eastern region, the proportion of high-tech industries is higher than the national level, and a large number of artificial intelligence industries and high-end manufacturing industries are concentrated in the eastern region.

The eastern region has attracted a large number of domestic and foreign advanced technology, management experience, high-tech talents, advanced production lines, machinery and equipment and other scientific and technological innovation resources, and has played a leading role in the process of scientific and technological innovation resources transfer, occupying a large number of scientific research centers and key universities, providing a good research platform for scientific and technological innovation resources agglomeration, and attracting scientific and technological innovation resources agglomeration; The R&D input and output capacity in the central region is relatively weak, and the capability of technological transformation and policy support is weak.

Although the government is aware of the imbalance between China's regional scientific and technological invention and output, and has begun to attach importance to the coordinated development of research and development level, the development of science and technology level in the central region is relatively slow; However, the level of innovation capital in western China lags behind in the whole country. Although the state focuses on promoting high-tech industries in the central and western regions and provides policy and financial support, the efficiency and capability of R&D funds in the western region are obviously weaker than that in the central and eastern regions. Meanwhile, most of the western regions are geographically remote, economically underdeveloped and have limited R&D capacity. National policy support and technology needs cannot be coordinated to promote technological innovation and transformation.

3.2 Space-time evolution of innovation resources and industrial structure upgrading

Innovative resources are a key factor in promoting the upgrading of industrial structure . Innovation resources, including scientific and technological personnel, research and development funds, advanced technologies, innovative ideas, etc., play a vital role in the optimization and upgrading of industrial structure.

First of all, scientific and technological innovation, as the core driving force for the development of new quality productivity, can profoundly change the industrial pattern and resource allocation. Through continuous technological innovation and breakthroughs, we can continuously optimize the industrial structure and promote the transformation and upgrading of traditional industries to high-end, intelligent and green directions. This transformation not only improves the added value and overall competitiveness of the industry, but also provides strong support for the diversified development of the economy.

Secondly, innovative resources promote the efficient allocation and utilization of resources. In the process of upgrading the industrial structure, innovation resources can guide the flow of capital, talents and other factors to more efficient and more potential industries, thus promoting the optimization of the entire industrial structure. This optimization is not only reflected in the upgrading of the industry, but also reflected in the collaboration and integration between industries.

In addition, innovative resources also give birth to new industrial forms and business models. With the continuous progress of science and technology and the accumulation of innovative resources, some emerging industries such as intelligent manufacturing, green energy, digital economy, etc., have gradually risen and become a new driving force for economic growth. The development of these emerging industries not only provides new growth points for traditional industries, but also drives the upgrading and transformation of the entire industrial structure.

Innovation resources play a vital role in the upgrading of industrial structure. By strengthening the investment and allocation of innovation resources, we can promote the optimization and upgrading of the industrial structure, and thus achieve high-quality economic development.

3.3 Analysis of spatial correlation mechanism of digital economy

The formation mechanism of spatial correlation network of digital economy mainly includes technology integration, virtual agglomeration and forced competition mechanism. Among them, technology integration and information sharing are the important "driving force" for the formation of spatial correlation network of digital economy. Digital economy takes information technology and big data analysis as the important core technologies. Driving factors such as capital, technology, talent and knowledge to gradually break through the physical space restrictions and realize trans-regional flow, resulting in a universal digital economy correlation effect among trans-regional cities; Under the continuous development of new digital economy infrastructure construction, information and communication industry layout, and digital trading system, the digital economy breaks through the restrictions of physical space and administrative region, realizes the exchange of energy, material and information elements, and the virtual agglomeration of new digital technologies and digital technologies has become an important force driving the formation of spatial correlation network of the digital economy. The high penetration of the digital economy has deepened the promotion of inter-regional exchanges and cooperation, accelerating the spillover of knowledge, within the

industry sector and between industries, which means that the spatial correlation of the digital economy is easier between regions with similar technologies, forcing the upstream and downstream industries in the region to improve the level of innovation.

3.4 Spatial correlation characteristics of digital technology and innovation elements

The spatial correlation of the comprehensive agglomeration of innovation factors under the inter-regional digital technology correlation is higher than the corresponding index of inter-regional economic correlation, and the comprehensive agglomeration of innovation factors shows strong spatial correlation characteristics in the correlation coefficient of digital technology, that is, the narrowing of the gap of technological innovation ability between regions will further promote the inter-regional technological exchange. It is conducive to the formation of positive spatial correlation of comprehensive agglomeration of innovation factors.

The comprehensive agglomeration level of innovation factors shows the following spatial agglomeration characteristics under the spatial correlation of regional digital technologies: The comprehensive concentration level of innovation factors is high. These regions mainly include Jiangsu, Zhejiang, Beijing and Shanghai. The main reason is that the concentration of more advanced talents, technology and capital in these regions has created huge advantages for the development of digital economy, forming a mutually beneficial development trend of the comprehensive concentration of digital economy and innovation factors. Heilongjiang, Liaoning, Jilin, Gansu and Yunnan regions are in a low-low agglomeration state, and the comprehensive agglomeration level of innovation factors is low. On the other hand, due to the technological correlation between regions, the spatial positive correlation of the comprehensive agglomeration of innovation factors becomes closer. Regions with similar technical levels can rely on technological cooperation to realize the exchange of R&D talents and R&D institutions, and form a comprehensive agglomeration of innovation factors with technological spatial correlation.

4. Urban innovation factors and industrial structure level

4.1 Mechanism analysis and empirical analysis

There is a close relationship between innovation factors and industrial structure. Innovation is a key factor to promote the optimization and upgrading of industrial structure .

Innovation elements, including technological innovation, talent innovation, financial innovation, institutional innovation and data innovation, are important driving forces for urban economic development. These factors affect the adjustment and optimization of industrial structure in different ways:

Technological innovation : technological innovation is the direct driving force of industrial structure optimization. The generation and application of new technologies will change the production mode of the industry, improve production efficiency, and then promote the upgrading of the industrial structure. For example, the introduction of new technologies can reduce costs and improve product quality in some industrial sectors, thus triggering the expansion mechanism of the industry and promoting the optimization of the industrial structure.

Talent innovation : A team of high-quality and highly skilled talents is an important part of the urban innovation system. By providing new ideas, methods and skills, they promote the innovation and development of the industry, and then affect the adjustment of industrial structure. Talent innovation provides intellectual support for the optimization of industrial structure.

Financial innovation : finance is the core of modern economy. By providing diversified financial products and services, financial innovation can meet the capital needs of industrial development and promote the virtuous cycle of industrial chain. Financial innovation can also reduce the financing cost of enterprises and improve the efficiency of the use of funds, thus promoting the optimization and upgrading of industrial structure.

Secondly, the optimization and upgrading of industrial structure will in turn affect the allocation and flow of innovation factors. With the adjustment of industrial structure, the demand for

innovation factors in different industries will also change, which will lead to the reconfiguration and flow of innovation factors among industries. This kind of flow not only helps to optimize the allocation of resources, but also promotes the continuous progress of innovation activities, forming a virtuous circle of industrial structure optimization and innovation factor flow.

There is an interdependent and mutually promoting relationship between urban innovation elements and industrial structure. Innovation factors are the key factors to promote the optimization and upgrading of industrial structure, which will in turn affect the allocation and flow of innovation factors. Therefore, in the process of urban economic development, we should pay attention to the cultivation and introduction of innovative elements, as well as the adjustment and optimization of industrial structure, in order to achieve sustainable and healthy economic development.

4.2 Knowledge and technology spillover of urban industrial structure upgrading

On the one hand, with the development of digital economy, the improvement of innovation intensity will further promote the comprehensive agglomeration of innovation factors among regions, and more R&D investment and human capital investment will form efficient knowledge sharing, frequent learning and close cooperation, and the development of core technologies. And occupy the high-end of the industrial chain within the cluster, improve the level of industrial structure of related areas; On the other hand, driven by the digital economy, by providing technical consultation, technical assessment, technical service loan, big data risk analysis and other services, the allocation efficiency of innovation factors can be improved, the knowledge spillover, application and integration of agglomeration areas can be greatly promoted, and the demonstration and imitation and knowledge and technology spillover can be formed under the "trickle-down effect" to promote the development of related regions. The innovation level of related regions has been improved. Therefore, the comprehensive agglomeration of innovative factors can not only alleviate the adverse impact of the asymmetry of capital supply and demand information in the region to a certain extent, but also improve the development speed of intelligent and digital transformation of related real estate industries.

As the flow of innovation factors is more frequent in regions with similar digital technologies, "digital technology distance" measures the ability of inter-regional industries to absorb knowledge spillover. The closer the level of digital technology between provinces, the more conducive to the spatial spillover of comprehensive agglomeration of innovation factors under the development of digital economy, and the promotion of industrial structure upgrading in regions related to digital technologies.

4.3 Spatial heterogeneity of industrial structure upgrading

The difference of digital economy and innovation factors in cities brings about the difference in the upgrading level of industrial structure. According to the location of cities, all the sample cities are divided into three types: eastern, central and western.

Cities in the eastern part of China have developed scientific and technological level, and the diversity of innovation factors is obvious, which increases the possibility of the generation of new technologies, thus improving factor productivity and promoting economic growth. Meanwhile, the development level of digital economy in the eastern part of China is high, which not only integrates new technologies and new knowledge of different types of innovation factors, but also produces many innovative cross-cutting technologies. In addition, the emergence of new technologies makes enterprises choose to use advanced energy-saving equipment to eliminate old equipment in order to win greater competitiveness, which in turn encourages the improvement of the allocation level of high-tech talents, and improves the level of industrial technology chain and innovation efficiency.

The interaction between the digital economy and the comprehensive agglomeration of innovation factors in the central region can promote the upgrading of industrial structure, but the promotion is less than that in the eastern region. The combination of digital economy and innovation factors in western China has the weakest role in promoting industrial structure upgrading.

The development of digital economy in western cities started relatively late, and the support of digital economy development policies is also relatively low, and the economic effect of digital

economy development on the comprehensive agglomeration of innovative factors has not yet fully emerged.

City size has a significant impact on the process of digital economy and comprehensive agglomeration of innovative factors. From megacities and megacities, big cities to small cities, the promotion effect of the comprehensive agglomeration of innovation factors driven by digital economy on the upgrading of industrial structure is gradually weakened, and from megacities and megacities to small cities, the promotion effect of the comprehensive agglomeration of innovation factors driven by digital economy on the upgrading of industrial structure is the strongest. On the one hand, the comprehensive agglomeration of innovation factors is mostly concentrated in large-scale cities. The innovation speed is much higher, which improves the level of industrial innovation on the whole; On the other hand, relatively large cities are rich in innovation resources, and the comprehensive agglomeration of innovation factors helps to promote the formation of the value chain of innovation industries. Due to the high-end development of the industrial chain, the innovation income of megacities and megacities is higher than the average level of other industrial sectors.

In contrast, due to the relatively low level of comprehensive allocation of urban innovation factors and the development level of digital economy, the advantages of comprehensive agglomeration of innovation factors have not been effectively released in small-scale cities, and the comprehensive agglomeration of innovation factors driven by digital economy has no significant effect on industrial structure upgrading.

4.4 Analysis of the spatial effect of "digital divide" on industrial structure upgrading

It is found that in cities with a high level of digital economy, the comprehensive concentration level of digital economy and innovation factors has a comprehensive promoting effect on the upgrading of industrial structure, while in a low level of digital economy development, the comprehensive concentration level of digital economy and innovation factors has a hindering effect on the upgrading of industrial structure. Another important reason for the lack of collaborative innovation efficiency among innovation subjects is that when the development level of regional digital economy is low, the continuous inflow of innovation elements intensifies the competition for innovation resources, which is reflected in the negative correlation between the concentration level of innovation elements and regional innovation ability. The reason is that in the initial stage of knowledge innovation, Although the inflow of innovation factors has improved the comprehensive concentration level of innovation factors, the structure of innovation factors does not fully match the production mode of the digital economy, and the innovation ability has declined.

Under the spatial matrix of economic distance, in regions with high level of digital economy, the comprehensive agglomeration level of digital economy and innovation factors has a positive spatial spillover effect on the upgrading of inter-regional industrial structure, while in regions with low level of digital economy development, the spatial spillover effect becomes negative. It shows that the comprehensive concentration level of digital economy and innovation factors will not show the promotion effect on the upgrading of industrial structure of cities with similar economic levels until the development of digital economy has reached a certain level. When the "siphon effect" of innovation factors agglomeration among industries is greater than the sum of technology diffusion effect and innovation-driven effect, innovation factors agglomeration will inhibit the upgrading of industrial structure in related regions. When the development level of digital economy is relatively low, the development of digital economy will lead capital, technology and talent resources to gather towards the growth pole. The insufficient accumulation of urban resources in low-level digital economy leads to the "siphon effect" of inter-regional innovation factors.

The "digital divide" between cities brings about the inconsistency of the upgrading level of industrial structure. In cities with high level of digital economy development, the direct effect of the cross-multiplication term of comprehensive agglomeration of digital economy and innovation factors on the upgrading of industrial structure under the economic distance weight and digital technology distance spatial matrix is higher than that of cities with low level of digital economy development. It

shows that the development level of digital economy among cities has different effects on the joint promotion of digital economy and the comprehensive agglomeration of innovation factors to the upgrading of industrial structure. The industrial structure of backward digital economy areas in China is dominated by traditional industries. In addition, the independent innovation ability of high-tech industries is weak, and the innovation is mainly imitated, so the comprehensive agglomeration efficiency of innovation factors is reduced, and the allocation of innovation resources is insufficient. The comprehensive degree between industries is weak; At the same time, in the process of promoting industrial digital transformation, it is easy to lead to excessive homogenization of low-end industries, which means that the low-level digital economy reduces the efficiency of the comprehensive agglomeration of innovative factors and is not conducive to the upgrading of industrial structure.

5. Synergistic effect of digital economy and innovation factor agglomeration

5.1 Agglomeration and synergy of digital economy and innovation elements

On the one hand, in the early stage of the development of the digital economy, the digital economy and innovation investment do not fully match, and the cost of industrial digital transformation is high, which is easy to induce the crowding out effect of the development of the digital economy on scientific and technological research and development activities. On the other hand, the environment conducive to innovation collaboration and agglomeration has not yet been formed, and the innovation network and platform have not yet been established, and the digital infrastructure is relatively backward. The mismatch between the accumulation of innovation factors and the mode of production leads to high input and low output of innovation activities, which cannot give full play to the effects of the concentration of digital economy and innovation factors, knowledge spillover and economies of scale, which is not conducive to the upgrading of industrial structure.

After the development level of digital economy crosses the threshold, the estimated coefficient of the amount of industrial structure upgrading changes from non-significant to significantly positive. After crossing the threshold, the coupling and coordination of digital economy and innovation factors show the promoting effect on the amount of industrial structure upgrading. On the one hand, further develop and deepen the open innovation environment, improve the ability to acquire knowledge from outside the region; On the other hand, the digital economy brings knowledge sharing, encourages the industries in the underdeveloped areas of the digital economy to participate in the industrial division of labor, promotes the rational structure of different innovation factors and the optimization of the allocation of innovation factors in the flow of innovation factors, and more easily promotes the improvement of the agglomeration efficiency of innovation factors, and exerts the innovation effect of agglomeration to promote the upgrading of industrial structure. The provinces that did not cross the threshold meant that they needed to further improve the level of digital economy development,

The low level of coupling and coordination of digital economy and innovation factors agglomeration restricts each other. The low level of digital economy reduces the ability of scientific and technological innovation, resulting in the difficulty of transforming scientific and technological achievements into productive forces. When the digital economy develops to a higher level, the high level of digital technology represents the improvement of the integration level of digital technology and production factors, and the improvement of the coordination level of the two. With the improvement of the concentration and coordination level of digital economy and innovation factors, the absorption effect of the industry on innovation knowledge spillover continues to increase. The coordinated development of digital economy and innovation factors agglomeration has played an increasing role in promoting the comprehensive level of industrial structure.

5.2 Retesting based on machine learning methods

At present, the application of machine learning method to analyze digital economy has

accumulated some academic achievements. The source of industrial structure upgrading and development is the utilization of innovative factors, and the other is the transformation of digital economy to innovative ways. Based on machine learning, this paper analyzes the contribution factors of the development level of digital economy and the concentration level of innovative factors: The contribution factors of the development level of the digital economy, first of all, the economic environment variables such as the level of economic growth, information and communication technology fixed asset investment and the level of opening up, are the basis of the development of the digital economy. Secondly, the development of the digital economy requires enterprises to have a certain capacity of technology absorption in order to improve innovation output, and technology absorption requires the support of highly skilled labor force and research and development funds. Third, basic economic factors such as the degree of government intervention, marketization level, financial development level and marketization level affect the development level of digital economy. Finally, the improvement of innovation quality reflects the ability of digital economy development; The process of innovation factor agglomeration is a long-term dynamic evolution law. In this long evolution process, some regions will maintain growth due to continuous inflow of innovation resources, while others may fall into recession due to insufficient allocation and low utilization efficiency of innovation resources.

5.3 Empirical result analysis

The digital economy and innovation achievements in the eastern region have the strongest contribution to the upgrading of industrial structure. This is due to the high utilization efficiency of innovation factors in the eastern region, which provides a driving force for industrial innovation and development. The coupled and coordinated development level of digital economy and innovation achievements agglomeration in central China has the strongest promotion force for the upgrading and upgrading of industrial structure, while the coupled and coordinated level of digital economy and innovation capital agglomeration has a weak promotion force for the upgrading and upgrading of industrial structure, mainly due to the low overall level of science and technology, low level of human capital, and insufficient utilization and absorption capacity of innovation funds in central China. In the process of digital transformation of traditional agriculture and manufacturing industry, due to the high investment cost of digital equipment and services in the early stage, as well as the mismatch between digital technology and production, the coordination level of digital economy and R&D capital concentration is low, which is not conducive to industrial innovation and development. The coupling level of digital economy and innovation capital agglomeration in western China contributes the most to the upgrading of industrial structure, while the coupling level of digital economy and innovation achievement agglomeration contributes the least to the upgrading of industrial structure, indicating that driven by digital economy in western China, the contribution to innovation achievements and innovation output is limited, and the transformation efficiency of innovation achievements in digital economy is relatively low. The promotion effect on the level of industrial structure is limited.

6. Conclusion

The digital economy has significantly boosted regional economic growth by increasing productivity, innovation capacity and market share. The development of digital economy is an inevitable choice for current economic and social development, and also an inevitable choice for high-quality economic development.

The measurement results of innovation factor agglomeration show that there is a significant spatial dependence relationship between innovation factor specialization agglomeration, and regional economy is positively correlated with the level of innovation factor agglomeration, and the degree of dependence has been increasing in recent years. The role of digital economy in regional economic development helps to narrow the economic gap between regions.

The rationalization of innovation factor agglomeration has a positive effect on the upgrading of regional industrial structure. Excessive innovation factor agglomeration will inhibit the quality of

industrial structure upgrading. With the continuous improvement of innovation factor agglomeration level, the promotion of innovation factor agglomeration's qualitative influence on industrial structure upgrading will become weak from strong to weak.

Driven by digital economy, China's innovation factor agglomeration has a significant role in promoting the upgrading of industrial structure. Digital economy not only improves the rationalization of innovation factor agglomeration, but also improves the innovation effect of innovation factor agglomeration.

The comprehensive agglomeration of innovation factors driven by digital economy has a significant contribution to the improvement of industrial structure level, and the comprehensive agglomeration of regional innovation factors driven by digital economy has a significant positive spatial spillover effect on the improvement of industrial structure level in regions with similar economic and technological levels.

Digital economy and innovation factor agglomeration form mutual influence, and the two subsystems of digital economy and innovation factor agglomeration interact, coordinate and promote each other, and produce the coupling and coordinated development effect.

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