Theoretical Model of Industrial Innovation Ecosystem

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This entry takes the industrial innovation ecosystem as the research object and the realization of green development as the goal, discussing the temporal and spatial evolution of coupling coordination degree of industrial innovation ecosystem from the perspective of system view. Based on the data of 30 provinces in China from 2010 to 2021, the spatial and temporal pattern distribution and spatial connection evolution of synergy among the three subsystems of industrial innovation ecosystem are studied by using coupling coordination degree model, trend surface model and gravity model. It is found that during the study period, the coupling relationship between the three subsystems is in a dynamic upward state. The regions with high values and rapid growth are distributed in the key areas of the national economic development strategy. At the same time, they have the characteristics of "positive U-shaped first and then inverted U-shaped" in the east-west and north-south directions; the spatial connection strength of coupling coordination degree shows that the spatial connection strength of the eastern region is significantly greater than that of the western region. With the improvement of spatial connection strength, a radial coupling network centered on Beijing Tianjin Tangshan region and the Yangtze River Delta is formed, which is of core significance to promote the coordinated development of industrial innovation ecosystem.

industrial innovation ecosystem green transformation

coupled co scheduling

temporal and spatial distribution

1. Introduction

The 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Long-Term Goals for 2035 pointed out that it's important to promote the harmonious coexistence between people and nature and accelerate the green transformation, ensuring the coordinated promotion of highquality economic development and high-level protection of the ecological environment. Green transformation refers to taking the construction of ecological civilization as the leading, circular economy as the foundation and green management as the guarantee. Its core content is the transformation from traditional development mode to scientific development mode. Concurrently, high quality economic development must depend on scientific and technological innovation system, and the high level of ecological environment protection means that it is very important to implement the ecological environment strategy combined with innovative technology. As the concept of green transformation and innovation ecosystem has been paid more attention at the macro level [1][2][3], the innovation ecosystem combining green transformation and technological innovation will be more in line with the goal of "peak carbon dioxide emissions and carbon neutralization" and the driving force of growth changes from factor driven to innovation driven. Further, high-tech industry is at the core of national development because of its unique innovation ability and complete management system. Then, under the background of green transformation, the research on the innovation ecosystem of high-tech industry has become a meaningful proposition.

The circulation of capital, talents, and technology in the industrial innovation ecosystem provides necessary support for innovation activities and processes. There is a value relationship among innovation subjects, consumers, government, and society in the industrial innovation ecosystem. Innovation subjects are the producers of innovative knowledge and technology, the industry is the main body of this system, consumer behavior plays a guiding role, and the environmental factor composed of government and society has a supporting effect [4]. Each subject is interdependent with the innovation ecological environment, creating more value for industrial stakeholders. Therefore, just as the stability of the ecosystem in the ecosystem is inseparable from the normal interaction between species, the harmony and stability of the industrial innovation ecosystem are inseparable from the good development of the collaborative relationship between elements and subjects ^{[5][6]}. The relevant coupling and coordination relationship directly determines the overall performance of the industrial innovation ecosystem. However, there are still problems of uneven levels of scientific and technological innovation, patchwork of innovation elements and low utilization of innovation resources \square . In some regions, due to the one-sided emphasis on the input of single elements, the "fragmentation" and "isolation" of innovation and the imperfect innovation system, the original innovation ability is insufficient, the transformation ability of scientific and technological achievements is limited. The phenomenon that innovation vitality does not increase but decreases seriously restricts the healthy and sustainable development of innovation ecosystem. Therefore, it's important to research on the coupling and synergy existing in the industrial innovation ecosystem for finding the gap between regions, so as to narrow the regional differences and promote the coordinated development of economy.

2.Theoretical Model of Industrial Innovation Ecosystem

2.1 Knowledge Subsystem

Knowledge is the foundation of all innovation activities, and knowledge subsystem is the basis of industrial innovation ecosystem. In the process of industrial innovation, here obtain knowledge reserves from universities and R&D institutions and absorb excellent innovative talents from knowledge subjects.

The most important constituent element of the knowledge subsystem is knowledge. Innovative talents take the innovation subject as the knowledge carrier and the internal and external innovation funds as the R&D investment ^[8] and complete the knowledge output in four stages: Firstly, using the existing knowledge reserve to extract valuable information through various channels and complete the knowledge absorption ^[9]; secondly, recombining relevant knowledge factors and knowledge associations in structure to realize knowledge integration; and thirdly, based on the carrier of knowledge innovation, sharing their own cutting-edge theories to realize the cross organizational flow of knowledge. Finally, through knowledge sharing, integrating advantageous resources and complete knowledge innovation, and in the future, it will be combined repeatedly according to practical requirements to realize the renewal and evolution of knowledge ^[10]. At the same time, in the process of knowledge

output, the government provides R&D funding support for colleges and universities and R&D institutions, solving the financial difficulties through effective cooperation between industry, University, and research, and producing economic and social benefits.

2.2 Innovation Subsystem

Under the background of green transformation, the key of innovation subsystem in industrial ecosystem lies in technology. In order to achieve high-quality development, innovative technology should be endowed with green attribute. The technology should be put into production according to the minimum ecological negative effect ^{[11][12]} to produce green products with pollution-free green process, green recycling equipment, and green product design ^[13].

Knowledge innovation ultimately serves to solve practical problems, and technological innovation is an important part in the application of knowledge. Technological innovation cannot be completed only by the innovation subject itself, but by the joint efforts of Technology exchange, market orientation, government support, and environmental impact. First, the basic technology, cutting-edge technology and common technology required by the innovation subject to carry out innovation activities are the basis of technological innovation. It is important for promoting the project and upgrades the products to widely absorb internal and external excellent scientific and technological achievements and patented inventions, and fully communicate with the external technology market [14]. Next, the purchasing power of consumers in the innovative market and the trading results of technology transformation products market have market guidance for the transformation of green technology, and the main body of technology transformation optimizes the technology through the test and feedback of the market. Besides, the government's financial support to the innovation subject will reduce the cost of technological innovation and R&D risk, creating innovation motivation and improving innovation efficiency ^[15]. Also, social, and economic resources are naturally accumulated and full of productivity, which can help enterprises to realize their objectives.

2.3 Industrial Subsystem

Innovation ultimately serves to solve practical problems and turns into practical value, which is to transfer innovation output from one organization to another and create economic benefits through commercialization ^[16]. In the process of technology transformation, high-tech enterprises with commercial value will become the main subject of technology transformation. At the same time, with the continuous emergence of start-ups and small and medium-sized science and technology enterprises, government and society gradually pay more attention to the construction of service organization platforms such as science and technology incubators, provide information resources and professional services, and provide strong support for the cultivation and construction of industrial innovation ecosystem.

The industrial development under green transformation should be guided by the concept of green development, based on the current economic and social development and the bearing capacity of resources and environment, and realize enterprise green operation, efficient utilization of resources and government green supervision by changing the operation mode, resource consumption structure and government supervision means of high-tech

enterprises. And in the current environment of green transformation, a good natural ecological environment is the basis for the normal operation of the industrial ecological innovation system ^[17]. For example, water resources are essential resources in the development of green ecology. Simultaneously, as the largest carbon pool in the terrestrial ecosystem, forest carbon is gradually becoming an important tool for many countries to solve the problem of climate change and is committed to reducing the concentration of greenhouse gases and slowing down the process of climate warming. Furthermore, low carbon economy aims at sustainable development and reducing carbon emissions, relying on technological innovation and clean energy development such as electric energy. For example, through the development and application of environmental protection technology, carbon (c) and sulfur (s) emissions in industrial production can be reduced and the "three wastes" of traditional industry comprehensive utilization rate can be increased, which can lead to realize the treatment and recycling of pollutants discharged from non-clean energy such as coal, oil and natural gas, achieve the low-carbon development of energy flow and the recycling of resource flow, reduce the consumption of high-carbon energy and carbon dioxide emission as much as possible, so as to solve the problem of climate warming and realize the synchronous development of economic development and ecological protection [18][19].

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