Analysis on Spatial Spillover Effect of High-Tech Industrial Agglomeration on Regional Innovation Capability

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Abstract: This article focuses on the influence of High-tech Industrial (HTI) agglomeration on regional innovation ability. The purpose of this article is to analyze the intrinsic principles and dynamic pathways of its influence on regional innovation ability through spatial spillover mechanism, and to explore the related influencing factors, thereby providing insights for promoting regional innovation development. By reviewing the relevant theories and research, this article elaborates the theoretical mechanism of HTI agglomeration in driving spatial spillover of regional innovation capability from the aspects of knowledge spillover, competition and cooperation, and factor allocation. Furthermore, it analyzes the factors that affect the spatial spillover effect, such as geographical distance, regional innovation environment and industrial correlation. The finding suggest that HTI agglomeration can generate spatial spillover effect on regional innovation capability through various mechanisms, with multiple factors moderating these effects. This implies that in order to enhance the regional innovation ability, policymakers should pay attention to the rational planning and development of HTI agglomeration while optimizing the relevant influencing factors in order to fully leverage its spatial spillover advantages.

1. Introduction

High-tech industry has become a key force in promoting economic growth and enhance national competitiveness [1]. Characterized by high value-added output, innovation intensity, and a strong driving force to other industries, HTI plays a core role in the process of economic restructuring and transformation and upgrading [2]. In this context, the phenomenon of HTI agglomeration is becoming increasingly evident, with many high-tech enterprises concentrating in specific areas to form an industrial clusters with considerable scale and distinct characteristics [3].

As an important indicator of the potential and sustainability of regional economic development, regional innovation ability is very significant for the transformation of regional economic growth patterns and enhancing competitiveness [4]. There is a close relationship between HTI agglomeration and regional innovation ability. The spatial spillover effects generated by industrial agglomeration are increasingly becoming a key factor in promoting regional innovation ability [5]. An in-depth analysis of the spatial spillover effect of HTI agglomeration on regional innovation ability will help deepen the understanding of the interactive relationship between industrial agglomeration and regional innovation at the theoretical level. It will also provide a strong theoretical basis for local governments to formulate scientific and reasonable industrial policies and optimize the regional innovation environment.

This article deeply explores how HTI agglomeration affects regional innovation ability through spatial spillover mechanism, analyzes its internal laws and action paths, and discusses related influencing factors, thereby providing valuable insights for promoting regional innovation development.

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2. Related theory and research summary

2.1. Related theories

The theory of industrial agglomeration is fundamental to understand the spatial distribution of HTI. Marshall's theory of external economies points out that enterprise agglomeration enables the sharing of labor market, access to intermediate product supply and knowledge spillover, which is especially critical for HTI, because it is highly dependent on the exchange of knowledge and technology [6]. Porter's diamond model emphasizes the influence of production factors, demand conditions, related and supporting industries, strategic structure of enterprises and horizontal competition on industrial competitiveness. This model provides a framework for analyzing the competitiveness of HTI. High-tech industries require advanced production factors, such as high-end talents and state-of-the-art scientific research facilities, the intense competition within the industry, and a pressing demand for innovation.

Regional innovation capability refers to the ability of the innovation subjects in the region to interact and realize the creation, dissemination and application of knowledge. It encompasses elements such as knowledge creation ability, knowledge flow ability, enterprise technological innovation ability, and the innovation environment, etc. [7] According to the theory of regional innovation system, enterprises, universities, scientific research institutions and governments in the region collectively drive innovation through complex network connections. The innovation activities of HTI are highly dependent on the robustness of the regional innovation system. Efficient knowledge flows and a favorable innovation environment can significantly enhance their innovation output.

The spatial spillover effect refers to the impact of economic activities in one region on other regions. The knowledge spillover theory indicates that knowledge is non-competitive and partially exclusive, making it prone to diffusion across regions [8]. The knowledge and technology of HTI are highly mobile, and the knowledge spillover caused by their agglomeration can enhance the innovation ability of surrounding areas through mechanisms such as personnel flow, technology transfer and enterprise derivative.

2.2. Research status

Many scholars have conducted extensive research on HTI agglomeration, regional innovation ability and spatial spillover effects. The international research started earlier and has largely empirically verified that industrial agglomeration promotes regional innovation and that the spatial spillover exist [9]. In recent years, the research on China has been increasing, with some studies focusing on specific regional case studies and some other scholars developing models to explore the influencing factors. However, the existing research remains insufficient in terms of in-depth exploration of the theoretical mechanism and investigation of the dynamic changes in spatial spillover effect. This article will focus on these discusses.

3. Theoretical mechanism of spatial spillover of regional innovation capability through the agglomeration of HTI

HTI agglomeration exerts a spatial spillover effect on regional innovation capacity through multiple channels, mainly encompassing mechanisms such as knowledge spillover, competition and cooperation, and factor allocation.

3.1. Knowledge spillover mechanism of agglomeration

The agglomeration of HTI brings enterprises, scientific research institutions and universities geographically into close geographical proximity, which significantly facilitates the dissemination and sharing of knowledge. Knowledge spillovers are primarily realized through the following mechanisms:

First, personnel flow. The frequent movement of talents within HTI promotes the transfer of knowledge between different enterprises and institutions. For example, researchers who move from

universities or large enterprises to start-ups and bring advanced technology and knowledge into new enterprises [10]. Second, cooperation and exchanges among enterprises. Firms within the agglomeration area share solutions to technical problems and innovative ideas through cooperative research and development, technology alliances and other forms of cooperation. Third, informal communication. The face-to-face communication opportunities created by industrial agglomeration, such as industry seminars and social activities, facilitate the spread of tacit knowledge.

In order to illustrate the influence of knowledge spillover on regional innovation ability more intuitively, take the agglomeration of HTI in a hypothetical region as an example, and create Table 1. As shown in the table, as knowledge spillovers become more diverse and frequent, the key innovation indicators in the region, such as the number of patent applications, sales revenue of new products and other innovative indicators, are on the rise. This demonstrates that knowledge spillover plays an significant role in enhancing regional innovation ability in HTI agglomeration.

Table 1: Impact of Knowledge Spillover Methods on Regional Innovation Indicators

Knowledge Spillover Method	Number of Patent Applications (Pieces)	New Product Sales Revenue (10,000 Yuan)
Personnel Mobility (Annual Mobility < 50 People)	100-150	1000-1500
Personnel Mobility (Annual Mobility 50-100 People)	150-200	1500-2000
Inter-firm Cooperation and Exchange (Annual Cooperation Projects < 5)	120-170	1200-1700
Inter-firm Cooperation and Exchange (Annual Cooperation Projects 5-10)	170-220	1700-2200
Informal Exchange (Monthly Exchange Activities < 2 Times)	110-160	1100-1600
Informal Exchange (Monthly Exchange Activities 2-4 Times)	160-210	1600-2100

3.2. Competition and cooperation mechanism of agglomeration

The intense competition within agglomerations compels enterprises to continually increase investment in innovation. In HTI clusters, enterprises must continuously introduce new technologies and products in order to gain competitive advantages. Furthermore, the cooperation networks among enterprises has also been expanding. Through cooperation, enterprises can integrate innovation resources, jointly overcome technical challenges and share innovation risks. For example, a number of enterprises have collaborated with universities and scientific research institutions to undertake Industry-University-Research cooperation projects. This coexistence of competition and cooperation not only enhances the innovation capabilities of enterprises within the agglomeration area, but also allows their innovation achievements and experiences to spill over to the surrounding areas through technology transfer and personnel mobility. This, in turn, enhances the overall innovation ability of the region.

3.3. Factor allocation mechanism of agglomeration

HTI agglomeration exerts a strong attraction to innovative elements such as talents and capital. High-quality talents tend to migrate to industrial agglomeration areas to acess better career development opportunities. Meanwhile, a large amount of capital will also provides financial support for innovation activities. The robust industrial supporting and innovative service system in these agglomeration areas further optimizes the efficiency of factor allocation. These abundant and efficient allocation of innovation elements not only meet the innovation needs of enterprises within the agglomeration area, but also spill over to the surrounding regions through technology diffusion and industrial transfer. This helps alleviate the shortage of innovation elements in the surrounding areas, thereby enhancing the overall innovation ability of the region.

4. Analysis of the factors affecting the spatial spillover effect of HTI agglomeration

The spatial spillover effect of HTI agglomeration is influenced by a multitude of factors, and an in-depth analysis of these factors will facilitate a more understanding and grasp of its underlying mechanisms.

4.1. Geographical distance factor between regions

Geographical distance has a significant impact on the spatial spillover effect of HTI agglomeration. On the one hand, close geographical proximity facilitates the rapid diffusion of knowledge and technology. Convenient transportation and frequent personnel exchanges between adjacent areas enable the innovation outcomes generated in the agglomeration area to spread rapidly. For example, within urban agglomeration, the short commuting time between cities and the low communication costs between enterprises make knowledge spillover more readily achievable. On the other hand, with the increase of geographical distance, the cost of information transmission will rise, as geographical distance increases, the cost of information transmission rises, and the spillover of knowledge and technology is impeded. For some tacit knowledge, which relies heavily on face-to-face communication for dissemination, long-distance communication will seriously limit its scope and effect.

In order to visually present the relationship between geographical distance and spatial spillover effect, this article takes a certain area as an example and constructs Table 2. As shown in the table, with the increase of the distance from the HTI cluster, the spillover indicators of innovation factors such as the number of technology transfers and the number of talent inflows have obviously decreased. This demonstrates that geographical distance plays an crucial role in the spatial spillover process of HTI agglomeration, and excessive distance can weaken the spatial spillover effect.

Table 2: Geographical Distance and Innovation Factor Spillover

Distance from Cluster (km)	Number of Technology Transfers (Annual)	Number of Talent Inflows (Annual)
0-50	50-80	100-150
50-100	30-50	60-100
100-200	15-30	30-60
200-300	5-15	10-30

4.2. Environmental factors of regional innovation

The regional innovation environment has a profound impact on the spatial spillover effect of industrial agglomeration. A favorable policy environment, such as tax incentives and innovation subsidies, can encourage enterprises to actively engage in innovation activities, attract the inflow of external innovation resources and enhance the spatial spillover effect. Well-developed infrastructure, including transportation, communication, helps to reduce the operating costs and information exchange costs of enterprises, thereby facilitating the spread of knowledge and technology. In addition, a vibrant innovation culture can stimulate innovation consciousness and improve the region's capacity to absorb innovation achievements.

4.3. Industrial correlation factor

The degree of correlation between HTI and other related industries directly affects the spatial spillover effect. When the high-tech industry is closely linked with the upstream and downstream industries, their innovation outcomes are easier to be transmitted and applied throughout the industrial chain. For example, the technological innovation of high-end equipment manufacturing industry can prompt parts suppliers to upgrade their technology, while the innovations of these suppliers are fed back to the equipment manufactures. This creates a virtuous circle that expands the scope and impact of spatial spillover. On the contrary, if the industrial correlation is weak, innovation is less likely to spread among industries, thereby limiting the spatial spillover effect. In addition, the degree of correlation between HTI and knowledge innovation entities such as scientific

research institutions and universities will also affect the efficiency and quality of knowledge spillover. Close cooperation through Industry-University-Research collaborations can accelerate the transformation of scientific research achievements into actual productive forces and enhance the spatial spillover effect.

5. Conclusions

There is a close relationship between HTI agglomeration and regional innovation capability, which has many effects on regional innovation ability through various spatial spillover mechanism. From the perspective of theoretical mechanism, the knowledge spillover mechanism facilitates the dissemination and sharing of knowledge, thereby enhancing regional innovation indicators through personnel flow, enterprise cooperation and informal communication. The competition and cooperation mechanism urges enterprises to increase innovation investment and integrate resources within the agglomeration area, with their innovation outcomes spilling over to surrounding areas. The factor allocation mechanism attracts talents and capital, optimizes allocation efficiency, and drives the improvement of innovative factors in adjacent areas. In terms of factors affecting the spatial spillover effect, the closer the geographical distance, the better the spillover of innovation elements. With the increase of the distance from the agglomeration area, the number of technology transfers and the talent inflows decreases. A favorable regional innovation environment and high industrial relevance can also enhance the spatial spillover effect.

Based on the above analysis, in order to promote regional innovation and development, the government should formulate policies to guide the rational agglomeration of HTI and shorten the geographical "distance" between regions. This can be achieved by strengthening the construction of transportation and communication infrastructure. Furthermore, the government should optimize the regional innovation environment, introduce incentive policies, and foster an innovative cultural atmosphere. Additionally, the government should promote the development of inter-industry linkages and strengthen Industry-University-Research cooperation. These measures will help fully leverage the spatial spillover effect of HTI agglomeration and enhance the overall regional innovation capability.

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