

A Comparative Study of Polarization Effects of Regional Innovation in China

—Calculation Based on TW Index

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Abstract—Innovative resources are concentrated from the surrounding backward areas to the economic center, thus forming an innovative polarization effect. As the growth poles appear to the surrounding areas, the polarization effect transitions to the diffusion effect. This paper uses the factor analysis method to obtain the comprehensive scores of innovation ability of the four economic regions from 1997 to 2016, and uses the TW index to measure the polarization of resources in the four economic regions of China. The results show that there are significant differences in the degree of polarization of innovation in the four economic regions, and there is a significant polarization phenomenon in the eastern and western regions, followed by the central region and the lowest in the northeast region. China should formulate regional development strategies in a targeted manner, promote cross-regional coordination and innovation, and build a multi-level growth pole system and promote the redistribution of innovative resources and promote the balanced and rational development of regional economies through the combined effects of polarization and diffusion effects.

Keywords—regional innovation; innovation polarization; TW index; resource allocation

I. INTRODUCTION

Innovative ability is an indispensable factor in evaluating the competitiveness of a country and region. With the development of the economy, innovation has become the main driving force for domestic regional economic development. However, at present, there are still many problems in China's regional economic development. At the same time as the inter-regional economic development is not balanced, the intra-regional differentiation is accelerating. Since the introduction of innovation-driven development strategy, the issue of innovation polarization has become a hot spot of concern in the academic community and the whole society. Myrdal (1957) proposed that there appeared some economic growth poles first in some developing countries and polarization effects formed. Only when the polarization effect is gradually reduced or disappears, there is a possibility of coordinated development between regions^[1]. Mohnen and DeBresson (2002) first proposed a series of concepts such as

“innovation pole” and “innovation hollowing out”, and believed that there are innovation poles in China's Guangdong, Shanghai, Jiangsu, Zhejiang and other places^[2]. Feng Zhiyong (2012) used the factor analysis method to evaluate the innovation power of the seven domestic metropolitan areas from three aspects: innovation external environment, self-ability and support conditions^[3]. Zhou Mi (2009) pointed out that there are three major polarization zones of Beijing-Tianjin-Hebei, (Pan) Pearl River Delta and Yangtze River Delta in China, and there exist phenomena of excessive polarization and serious shortage of proliferation, especially the Beijing-Tianjin-Hebei region, where exist obvious “polarization traps” characterized by “innovation hollowing out”^[4].

At present, the research objects of Chinese scholars on the issue of polarization of innovation mainly focus on the micro-views of provinces (municipalities, districts), or focus on the macro-wide national scale, with less research perspectives placed in the economic region, and the analysis at the meso level is relatively weak. Therefore, this paper comparatively analyzes the level and trend of innovation polarization in the four economic regions of China¹, and provides a scientific basis for promoting the coordinated development of regional innovation capability and rational allocation of innovative resources.

II. ANALYSIS ON THE FORMATION MECHANISM OF INNOVATION POLARIZATION IN CHINA

Karl Gunnar Myrdal first proposed the theory of polarization effect. He believes that with the development of the regional economy, the growth of the region will gradually form a strong attraction to the production factors of the surrounding areas by virtue of its advanced industries. Due to the existence of this attraction, the production factors in the surrounding areas are gathering in the growth pole, which further increases the growth rate of the growth pole, and the polarization effect further contributes to the unbalanced development between adjacent regions.

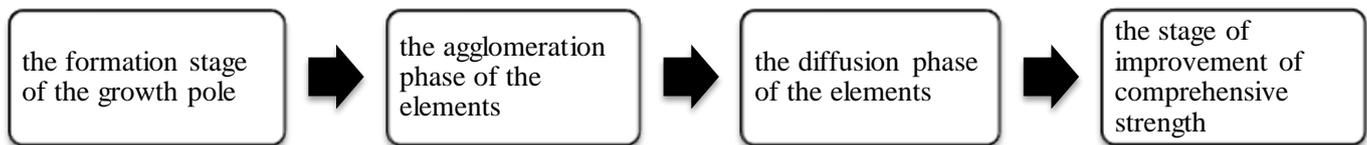
¹ Quoted from: Several Opinions of the Central Committee of the Communist Party of China and the State Council on Promoting the Rise of the Central Region and Implementation Opinions of the State Council on Several Policy Measures for the Development of the Western Region

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The polarization effect usually occurs in the early stage of the urbanization process of the city with high administrative level, and the resources seek rational accumulation. As the city develops, the aggregation effect gradually weakens. However, due to the inertia of resource accumulation, the polarization effect still exists. In the process of excessive development, resource accumulation gradually enters the stage of irrationality, and the city will have the phenomenon of "urban disease". Due to the demand for decentralized development, the diffusion effect is gradually increasing, the regional gap is reduced, and the region as a whole is moving towards a balanced one. In the development process of the region, the polarization effect gradually transitions to the diffusion effect. The development of a single city develops into an urban group with the central city as the core, and the urban diffusion effect is enhanced.

The dominant area (growth pole) and the affected area (radiated area) are the two main bodies of polarization effects. Growth poles have the corresponding capacity base, generating strong gravitational influence on the surrounding areas and forming polarization effects. The polarization effect will act on the growth pole in the opposite direction, strengthen its comprehensive strength, enhance the driving ability to the surrounding areas, form a diffusion effect, radiate the surrounding backward areas, and promote regional coordination and sustainable development.

There are four stages in the process of polarization effects. The first is the formation stage of the growth pole. Due to the



III. AN EMPIRICAL ANALYSIS OF THE POLARIZATION EFFECT OF REGIONAL INNOVATION IN CHINA

The TW economic index created by Hong Kong scholars Wang Youqiang and Cui Qiyuan² is widely used in the calculation of regional innovation polarization. Its specific calculation formula is as follows:

$$TW_{kt} = \frac{\theta}{\sum_{i=1}^{N_{kt}} P_{kti}} \sum_{i=1}^{N_{kt}} P_{kti} \left| \frac{y_{kti} - m_{kt}}{m_{kt}} \right|^r \quad (1)$$

Among them, TW_{kt} is the innovation polarization of the k-th area (1=northeastern region, 2=eastern region, 3=central region, 4=western region) in the t-th period (t is a sample period of twenty years from 1997 to 2016); y_{kti} is the innovation comprehensive score I_{kti} /patent authorization number P_{kti} of the i-th sample of the region k in the t-year; N_{kt} is the number of samples of region k in year t; m_{kt} is the median of all samples in region k during year t; P_{kti} is the number of patent grants for the region i in the i-th sample region during the t-th year; Both θ and r are constants greater

differences in natural conditions, resource abundance, production factors, and economic structure in various regions, there is a non-balanced development between regions. When a region has good natural resources, profound human resources and superior geographical location, the factors of production will gather to form growth poles.

The second stage is the agglomeration phase of the elements. As the growth poles generate strong attraction and centripetal force to the surrounding areas, the production factors such as capital, technology, labor, and information in the surrounding areas will gather in the core area, forming an industrial and geographical agglomeration phenomenon.

The third stage is the diffusion phase of the elements. After the polarization effect produced by factor agglomeration in the growth pole has a certain degree of gravity, the growth pole will in turn export factors and economic activities to the surrounding areas, and the economic factors of the growth pole will spread to the periphery to stimulate the economic demand of the periphery and promote the economic development of the surrounding areas.

The fourth stage is the stage of improvement of comprehensive strength. The "polarization-diffusion" effect of the factors enhances the comprehensive development strength of the growth poles, and the radiation capacity of the growth poles promotes the coordinated development of the surrounding areas, thus having a good impact on the long-term coordination and sustainable development of the entire region.

than 0. In this paper, we select $\theta=1$ and $r=0.5$ ³. At the same time, innovative resources cover many aspects, including capital investment and human resources. The difference between the regional economy and the innovation environment is also an important reason for the polarization of regional innovation. Therefore, this paper starts from the four aspects of innovation input index, innovation output index, regional economic environment and innovation environment index, selects 11 indicators with strong representativeness to establish an evaluation index system of innovation ability and calculate the comprehensive scores of innovation ability of the four economic regions in China by factor analysis method to obtain the I_{kti} values of the four economic regions of China from 1997 to 2016. The specific evaluation indicators are shown in the following table.

² Quoted from: WANG YOUQIANG, TSUI KAI-YUEN. Po: Orization Ordering and New Classes of Polarization Indices [J]. Journal of Public Economic Theory, 2000, 3 (2): 349-363

³ Quoted from: Ou Xiangjun, Gu Chaolin. Quantitative Analysis of Regional Economic Polarization and Its Dynamic Mechanism in Jiangsu Province[J]. Acta Geographica Sinica, 2004(05): 791-799.

TABLE I. EVALUATION SYSTEM OF REGIONAL TECHNOLOGICAL INNOVATION CAPABILITIES

Economic environment	GDP per capita (yuan/person)
	Household consumption level (yuan)
Innovative environment	The proportion of the population above junior college and above
	Total post and telecommunications business (100 million yuan)
	Education funding (100 million yuan)
Innovation resources investment	R&D personnel at the time of the full volume (person / year)
	R&D expenditure internal expenditure (100 million yuan)
	The proportion of government fiscal technology expenditure to local fiscal expenditure
Innovative resource output	High-tech market turnover (100 million yuan)
	Number of patent grants (items)
	High-tech industry main business income (100 million yuan)

The above data are from the *China Science and Technology Statistical Yearbook* from 1998 to 2017, the *Regional Statistical Yearbook* and the *China Urban Statistical Yearbook*.

In summary, according to the TW index calculation formula, the innovation polarization levels of China's four economic regions from 1997 to 2016 are as follows:

TABLE II. CHINA'S FOUR REGIONS OF ECONOMIC INNOVATION POLARIZATION INDEX FROM 1997 TO 2016

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Northeast	0.364	0.410	0.323	0.346	0.349	0.354	0.354	0.461	0.447	0.423
East	0.654	0.688	0.727	0.755	0.780	0.741	0.724	0.714	0.704	0.705
Central	0.521	0.531	0.523	0.561	0.523	0.508	0.520	0.481	0.510	0.622
West	0.649	0.731	0.718	0.741	0.748	0.777	0.807	0.788	0.750	0.692
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Northeast	0.477	0.446	0.502	0.557	0.294	0.355	0.335	0.357	0.344	0.255
East	0.700	0.638	0.646	0.536	0.530	0.599	0.528	0.594	0.613	0.597
Central	0.565	0.597	0.550	0.496	0.330	0.394	0.309	0.364	0.459	0.458
West	0.667	0.644	0.602	0.653	0.590	0.549	0.495	0.541	0.442	0.515

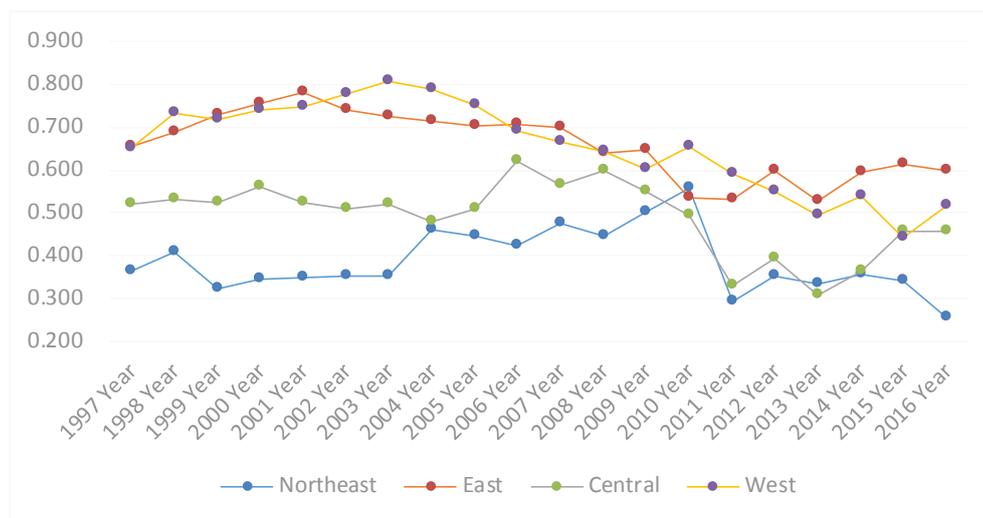


Fig. 1. China's Four Regions of Economic Innovation Polarization Trend from 1997 to 2016

It can be seen from the figure that the polarization trend of innovation in the four economic regions of China is similar,

both of which show an overall trend of rising first and then falling, and the polarization effect of innovation is gradually

increasing in the early years. With the development of economy and society and policy support, the polarization effect is gradually weakened, and the allocation of innovative resources was further optimized.

From the overall characteristics of the innovation polarization index, among the four economic regions, the degree of innovation polarization in the four economic regions of Northeast China, the eastern region, the central region and the western region shows a large difference. The polarization level in the eastern and western regions is greater than that in the central region, and the polarization level in the central region is greater than that in the northeast. The polarization index of the eastern region and the western region is relatively high, indicating that the innovative resources are more polarized in the eastern region and the western region. Innovative resources in the region flowed to economically developed regions, and innovation resources were highly concentrated, but the overall trend showed a downward trend, and the degree of polarization gradually decreased, indicating that the allocation of innovation resources was optimized, the polarization trend was weakened, and the diffusion effect appeared, and the gap in the region slowly narrowed. The polarization index of Northeast China is the lowest among the four regions, and the degree of polarization is relatively low, indicating that there is a small gap in the allocation of innovation resources in the Northeast, the concentration of innovation resources is relatively low, and the difference in innovation environment is relatively small; The central region's scientific and technological innovation polarization index is middle, indicating that the internal development level is equivalent, but the fluctuation range is large, and upward trend will continue in recent years. Moreover, it also shows that the flow of innovative resources is relatively fierce and has a tendency to gather in economically developed regions in recent years, also shows that the flow of innovative resources is relatively fierce and has a tendency to gather in economically developed regions in recent years.

IV. CONCLUSION AND COUNTERMEASURES

The results of the study show that although the polarization effect of the western and western regions of China's four economic regions has slowed down, it is still relatively serious; In recent years, the polarization effect of innovation in the central region has gradually increased, and the resources for innovation have a tendency to gather in individual regions; The polarization effect in the northeast region is the smallest, the resource allocation in the region is reasonable, and the polarization effect is not obvious.

Based on the above conclusions, several suggestions are made as follows:

First, a suitable regional development strategy should be targeted. According to the different development characteristics of the Northeast, East, Central and Western

regions, based on the new characteristics and new features of the current regional economic development, we should strengthen the existing innovative development strategy, adapt to local conditions, establish an effective regional development model suitable for the development of various economic regions, solve the problem of regional development imbalance, promote the role of growth and diffusion in urban areas, and achieve deep integration of resources within the region.

Second, we should promote coordination and cooperation between regions. It is unrealistic to improve the ability to innovate only by one city and the development of a region. Under the current economic development trend in China, we should make full use of the policy platform to carry out collaborative innovation, promote the flow of innovative resources among economic regions and transfer and diffusion of innovative technologies, strengthen inter-regional cooperation and exchanges, form a high-tech industrial cluster with overall competitive advantages, provide a good development environment for the improvement of regional innovation capabilities, enable better allocation of innovation resources, and further improve economic development.

Third, a multi-level growth pole system needs to be built. Economic development has a process of unbalanced development and balanced development, mainly relying on the growth pole to promote the development of surrounding areas through radiation, and the effect of diffusion effect is greater than the polarization effect. Therefore, building a multi-level, all-round growth pole system is conducive to the coordinated development of the economy between regions and regions. In an economic region, with one or several large developed cities as growth poles, the surrounding backward areas will be radiated and the redistribution of innovative resources will be promoted through the combination of its polarization effect and diffusion effect, thus contributing to the balanced and rational development of the regional economy.

REFERENCES

- [1] Myrdal G. *Economic Theory and Underdevelopment Regions* [M]. London: Duckworth, 1957.
- [2] Mohnen P, DeBresson C, et al. Explaining and Estimating Propensities to Innovate in China in 1993[C]. The 14th International Conference on Input-Output Techniques, Canada, 2002, part four: 1-37, part five: 1-32
- [3] J. Esteban, D. Ray. *A Comparison of Polarization Measures* [R]. New York: New York University, 2005.
- [4] Feng Zhiyong. A Comparative Study on Metropolitan Innovation in 7 Metropolitan Circles [J]. *Social Sciences in Nanjing*, 2012(05):9-14+29, In Chinese.
- [5] Zhou Mi. Regional Structure of Innovation Poles and Polarization Index Comparison in China [J]. *Modern Economic Science*, 2007(01):78-82+126-127, In Chinese.
- [6] Jiancheng Guan, Kaihua Chen. Measuring the innovation production process: A cross-region empirical study of China's high-tech innovations [J]. *Technovation*, 2010,30(5).