A Study on the Spatial Synergistic Allocation of China' s Innovation and Industrial Chains and Regional Economic Layout (Postprint)

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Abstract

The development drivers of China' s economy in the new era are gradually shifting from traditional factor inputs and export-driven growth to technological innovation-driven growth, with scientific and technological innovation increasingly becoming the primary engine of China' s economic development. China needs to urgently address challenging issues such as the disconnect between science and technology and the economy, as well as prominent problems including duplicative resource allocation and dispersed research forces. Under a complex and changing development environment, it is essential to further optimize the spatial collaborative allocation of innovation chains and industrial chains, and to promote rational and scientific spatial layout of regional economies. This article analyzes, from the perspective of spatial layout, the spatial patterns and development trends of the widening regional disparities in China' s innovation chains and industrial chains. It finds that there exists a spatial misalignment between scientific and technological support capacity and innovative industry layout across the national territory, that internal linkages within innovation chains are not sufficiently close, that some industrial chains suffer from long resource allocation distances and short chains, and that western regions find it difficult to fully integrate into eastern industrial chains. In response to these characteristics and problems, the article proposes an overall layout strategy of "grasping the two ends, releasing the middle," seeking to guide the overall optimization of national economic spatial development by promoting the spatial collaborative allocation of innovation chains and industrial chains.

Full Text

Preamble

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Research on Spatial Collaborative Allocation of Innovation Chain and Industrial Chain and Regional Economic Layout in China

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Abstract

The driving force of China' s economic development in the new era is gradually shifting from traditional production factor inputs and export-led growth to scientific and technological innovation-driven development, with technological innovation increasingly becoming the main engine of China' s economic growth. China urgently needs to address difficult issues such as the disconnect between science and economy, as well as prominent problems like redundant resource allocation and scattered research forces. Under a complex and volatile development environment, it is essential to further optimize the spatial collaborative allocation of innovation and industrial chains to promote rational and scientific regional economic layout. This article analyzes the spatial pattern and development trends of widening regional disparities in China' s innovation and industrial chains from a spatial layout perspective. The findings reveal a spatial mismatch between China' s technological support capabilities and the layout of innovative industries, weak internal linkages within innovation chains, long resource allocation distances and short chains in some industrial chains, and difficulties for western regions to fully integrate into eastern industrial chains. In response to these characteristics and challenges, the article proposes an overall layout strategy of "grasping both ends and releasing the middle," aiming to guide the overall optimization of national economic spatial development through promoting spatial collaborative allocation of innovation and industrial chains.

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The current international political and economic environment is complex and volatile, with rising trade protectionism and the emergence of restructuring phenomena in global industrial and supply chains across different spatial scales. Meanwhile, a new round of scientific and technological revolution and industrial transformation is advancing rapidly, with emerging technologies continuously appearing and industrial transformation and diffusion accelerating, becoming a new driving force for economic and social development. The driving force of China' s economic development in the new era is gradually shifting from traditional production factor inputs, resource investment, and export-led growth to innovation-driven development, with technological innovation increasingly becoming the main engine of China' s economic growth. General Secretary Xi Jinping has repeatedly emphasized that "innovation is the primary driving force for development"and pointed out that "we must deploy innovation chains around industrial chains and layout industrial chains around innovation chains to take greater steps in promoting high-quality economic development," profoundly revealing the inherent requirement that scientific and technological innovation must be closely integrated with industrial and economic development, moving in the same direction and promoting each other. Giving full play to the driving role of scientific and technological innovation, accelerating the precise connection between industrial and innovation chains, and promoting deep integration of the "dual chains" have become important measures to cope with the evolution of the global industrial pattern and key to ensuring China's industrial upgrading in the global value chain and achieving high-quality economic development.

Since the 18th National Congress of the Communist Party of China, China' s scientific and technological strength has moved from quantitative accumulation to qualitative leap, with the contribution rate of scientific and technological progress to economic growth increasing significantly from 52.2% in 2012 to over 60% in 2021, and its contribution to world scientific and technological innovation has also increased substantially. While fully affirming China' s scientific and technological development achievements, General Secretary Xi Jinping has repeatedly emphasized the need to make great efforts to solve difficult problems such as the disconnect between science and economy, as well as prominent issues like redundant resource allocation and scattered research forces. From a spatial layout perspective, analyzing how to achieve spatial collaborative allocation of innovation and industrial chains to further promote rational regional economic layout is of great significance for realizing China' s high-quality economic development and consolidating strategic support for Chinese-style modernization.

1. Spatial Layout Characteristics of China' s Innovation and Industrial Chains

1.1 Regional Innovation Capacity Differences Gradually Expanding with Strong Agglomeration in Leading Regions

With the continuous improvement of the new innovation system, China has accelerated its pace toward self-reliance and self-improvement in science and technology, with noticeable enhancement in innovation capacity. Since 2005, China' s R&D personnel and expenditure, scientific and technological achievements such as papers and patents, as well as the scale of high-tech product imports and exports and technology market transactions have all shown rapid growth (Table 1), with comprehensive R&D capabilities entering the global forefront. Spatially, regional innovation capacity shows significant differences, with all indicators displaying a "T-shaped" layout characterized by large heads and long tails (Figure 1 [Figure 1: see original paper]). In 2022, the combined values of the top six provinces accounted for 50.2%, 61.2%, 59.0%, and 54.8% of the national total in terms of urban employment in scientific research and technical services, patent applications and authorizations, R&D expenditure of industrial enterprises above designated size, and technology market transaction volume, respectively, indicating high spatial concentration.

From a regional perspective, the innovation capacity of eastern and central China and southern China continues to strengthen. Analysis of the evaluation results from the *China Regional Innovation Capacity Evaluation Report* [1] shows that since 2001, the comprehensive innovation capacity of eastern, central, and western regions has continuously diverged, with the gap in innovation capacity between regions (represented by the variance in evaluation rankings) generally showing an expanding trend. Particularly in the past decade since 2012, the variance in regional innovation capacity evaluation rankings has grown from 30.5 to 41.0, indicating a significant widening of regional disparities. By region, Northeast China' s comprehensive innovation capacity has declined year by year, central China has gradually improved, eastern China has maintained its leading advantage, and western China has remained in a lagging position (Figure 2 [Figure 2: see original paper]). Meanwhile, the innovation capacity gap between southern and northern China has also continued to expand, with the ranking gap increasing from 2.5 places in 2001 to 9.1 places (Figure 3 [Figure 3: see original paper]). From an enterprise perspective, from 1990 to 2019, the headquarters of listed companies, as the most innovative enterprises, have gradually evolved from an early point distribution pattern to a pattern centered on three major dense distribution areas: Beijing-Tianjin-Hebei, the Yangtze River Delta, and the Pearl River Delta [2].

1.2 Strengthening Industrial Agglomeration with Regional Characteristic Development Trends

Currently, strategic emerging industries, high-end manufacturing, and resource-energy industries that are crucial for China' s industrial competitiveness and supply chain security show continuously strengthening spatial agglomeration trends, with increasingly distinct industrial characteristics in eastern, central, and western regions.

(1) Strategic emerging industries are generally concentrated within a diamond-shaped area with Beijing-Tianjin-Hebei, the Yangtze River Delta, the Pearl River Delta, and the Chengdu-Chongqing region as vertices (Table 2). Based on the distribution of 1,109 sample enterprises included in the China Strategic Emerging Industries Composite Index released by the China Securities Index Co., Ltd. and Shanghai Stock Exchange, and their associated 19,540 enterprises, over 50% of core enterprises are concentrated in eight cities including Beijing and Shenzhen, roughly forming five regional strategic emerging industry cluster development zones: the Bohai Rim region, the Guangdong-Hong Kong-Macao Greater Bay Area, the Yangtze River Delta and middle-lower Yangtze River region, the Chengdu-Chongqing region, and the West Coast of the Taiwan Strait region.

(2) The agglomeration trend of high-end manufacturing industries such as aerospace and shipbuilding toward coastal areas is not obvious. Spatially, they are concentrated along the "Third Front" construction development axis from Northeast to Southwest and along the Yangtze River development axis. China' s aerospace and shipbuilding high-end equipment is mainly dominated by five central enterprises: the Aero Engine Corporation of China, the Aviation Industry Corporation of China, the China Aerospace Science and Industry Corporation, the China Aerospace Science and Technology Corporation, and the China State Shipbuilding Corporation. Therefore, the distribution of these five central enterprises and their subsidiaries can basically reflect the layout characteristics of China' s aerospace and shipbuilding industries. Among the more than 10,000 associated enterprises, only Beijing and Shanghai have over 200 core enterprises at the second level or above of the group, while Sichuan, Shaanxi, Guizhou, Guangdong, Jiangsu, Chongqing, Hubei, Hunan, and Liaoning have 100-200 such enterprises.

(3) Resource and energy industry bases are mainly concentrated in central and western regions, showing obvious resource-oriented characteristics. In particular, the large-scale development of clean energy such as hydropower, wind power, and photovoltaics is mainly concentrated in southwestern China and the "Three North" regions where water, wind, and solar energy resources are abundant. Since coal transportation is relatively convenient, the layout of traditional coal-fired power industry presents characteristics of both market orientation and resource orientation. In recent years,

driven by the need to ensure its own energy supply security and stability, the market orientation of coal-fired power layout has become increasingly evident. For example, Binzhou, Shanghai, and Suzhou rank among the top in China in terms of both installed coal-fired power capacity and power generation.

2. Main Problems in Spatial Collaborative Allocation of China' s Innovation and Industrial Chains

2.1 Global Perspective: Spatial Mismatch Between Technological Support Capacity and Innovative Industry Layout

Currently, China' s economic development differentiation is becoming increasingly apparent [3], and the new characteristic of "fast in the South, slow in the North" in the layout of innovation chains and industrial chains is gradually consolidating [4]. While Shenzhen, Hangzhou and other cities have developed rapidly in innovative industries, the North holds certain advantages in innovation infrastructure. Apart from Beijing, Shandong, Henan, Shaanxi, and even the three northeastern provinces have accumulated strong basic scientific research capabilities through long-term substantial national R&D investment. According to publicly available statistics, Zhejiang Province, an economically developed province, has only 14 national key laboratories, fewer than Liaoning' s 20 and Shaanxi' s 25. Fujian Province has 10 national key laboratories, equivalent to Gansu Province. Taking institutes of the Chinese Academy of Sciences as an example, Liaoning, Shaanxi, and Gansu have 6, 3, and 8 CAS institutes respectively, while economically developed Zhejiang and Fujian have only 1 each. Since the founding of the People' s Republic of China, a large number of national defense science and technology industries and related R&D institutions have been laid out in inland cities in central and western China such as Chengdu, Xi' an, Taiyuan, Guiyang, and Kunming. These R&D institutions have accumulated and mastered a large amount of advanced technology that can be used for strategic emerging industry development while supporting the research and development of advanced equipment such as aerospace. For example, purification technology mastered by aerospace R&D institutions is one of the most important technologies in semiconductor material development. However, spatial misalignment hinders the smooth flow of relevant information and technology between R&D institutions and enterprises, exacerbating information asymmetry between technology supply and demand. Scientific and technological innovation in universities has good spatial spillover effects on enterprise development and even regional economic development [5], and the spatial mismatch between innovation infrastructure and related industrial layout constrains the effective coordination of China' s innovation and industrial chains and rapid regional economic development.

2.2 Innovation Chain Perspective: Weak Linkage Between Basic Research, Application Expansion, and Industrial Transformation

(1) The problem of "emphasizing application while neglecting basic research" in China' s current scientific and technological innovation investment remains prominent. In 2020, national basic research expenditure accounted for only 6.01% of total R&D expenditure, far below the 15% overall level in developed countries, and representing only a slight increase of 0.8 percentage points compared with 1998. The original innovation capacity for high-quality industrial chain development needs improvement [6].

(2) The transformation capacity from basic research to practical application in universities and research institutions is relatively low. According to the *2021 China Patent Survey Report* released by the China National Intellectual Property Administration, the industrialization rate of invention patents in Chinese enterprises was 46.8% in 2021, while that in research institutions and universities was only 15.6% and 3.0%, respectively, indicating substantial room for improvement in research achievement transformation.

(3) The layout of facilities to promote industrial transformation of scientific research achievements is not rational enough, reducing transformation efficiency. Currently, China' s innovation achievement transformation platforms tend to be located in capital agglomeration areas rather than being deeply rooted in innovation research origins. Additionally, under institutional constraints, the mobility of scientific research personnel is not convenient, resulting in many research achievements not being effectively exploited. This explains why China has rarely seen famous innovation incubation bases like North Carolina's Research Triangle Park in the United States, which developed by relying on numerous universities. Taking the layout of national-level technology business incubators and nationally registered maker spaces as examples, current national-level innovation and entrepreneurship incubation platforms are concentrated in economically developed, culturally prosperous, and highly open regions. Guangdong, Jiangsu, Shandong, and Zhejiang provinces account for 41.0% of national-level innovation and entrepreneurship incubation platforms, while hosting only 15.3% of basic R&D institutions such as 985/211 universities and CAS institutes (Table 3).

2.3 Some Industries Face Long Resource Allocation Distances, Short Chains, and Spatial Mismatch Between Resource Development and Processing

(1) The implementation of the "dual carbon"strategy has further promoted the large-scale development and construction of wind and solar energy bases in Northwest China and hydropower bases in Southwest China, while continuously reducing coal-fired power layout, which will strengthen the sep-

aration characteristics between energy supply areas and market demand areas. Western regions have insufficient energy demand, while ultra-high voltage long-distance transmission lines require large investments and lack flexibility, which conflicts with the power supply tendency and trend of central and eastern provinces to reduce cross-regional power dependence and improve their own energy supply stability and controllability.

(2) Mineral resource bases in western regions have low resource conversion rates, short industrial chains, and spatial mismatch between resource development and processing. For example, China' s lithium resources are mainly located in Qinghai, but processing capacity is concentrated in coastal areas. Once overseas lithium resource imports are blocked, domestic mineral resources require unreasonable long-distance transportation to achieve matching. Therefore, fully utilizing the resource endowment advantages of western regions to improve resource utilization levels locally and build regional characteristic industrial chains and clusters is a path to solve the industrial 困境 of western regions [7].

2.4 Western Regions Have Difficulty Fully Integrating into Eastern Industrial Chains and Need New Breakthroughs

Although gradient transfer theory suggests that industries will gradually transfer from high-gradient eastern regions to medium- and low-gradient central and western regions, thereby driving the development of central and western regions, existing research [8] indicates that with the continuous advancement and expansion of industrial transfer, some central, western, and northeastern regions have begun to face significant constraints in labor, land, and environmental capacity. Under current circumstances, the trend of industrial transfer from eastern to central and western regions is not obvious [9], and the willingness to transfer to central and western regions is low [10]. Moreover, in recent years, due to the sudden increase in international "decoupling and chain-breaking" risks, eastern export-oriented processing industries have instead transferred abroad, primarily to Southeast Asian countries, which have become important alternatives to transfer to central and western China. Meanwhile, labor and material costs in central and western China have risen rapidly, offering no obvious advantage compared with Southeast Asian countries (Table 4) [6], making it difficult to replicate the development path of eastern regions. Central and western regions need to find alternative paths, leverage resource endowment advantages to innovate and shape industrial advantages, and embark on a distinctive path different from eastern development.

3. Countermeasures and Suggestions for Promoting Spatial Collaborative Allocation of Innovation and Industrial Chains and Optimizing Regional Economic Layout

To adapt to the potential impacts and new requirements of domestic and international development environment changes and national strategic adjustments on China' s economic layout, future innovation and industrial chain layout in China should adopt the overall strategy of "grasping both ends and releasing the middle." This strategy focuses on fundamentally ensuring national production and living safety in basic industries such as energy and raw materials, and enhancing international competitiveness in cutting-edge innovation fields from a sectoral perspective. Spatially, it emphasizes enhancing innovation capacity in central cities of eastern coastal areas and promoting the westward opening-up development and industrial incubation resource docking in central cities of western regions. The approach aims to improve the transfer and transformation level of achievements, using national laboratories and other R&D institutions as well as innovation incubation platforms and maker spaces as levers, and innovative regional economic complexes and regional-level science and technology innovation-industry sub-centers as the framework. This will build a collaborative system integrating basic research, applied innovation, manufacturing, and marketing to form an innovation chain, value chain, industrial chain, and supply chain, ultimately creating an independent, secure, and competitive national industrial system.

3.1 Accelerate the Coupled Allocation of Innovation and Industrial Chains to Form Innovative Regional Economic Complexes with Specialized Advantages

From the perspectives of global scientific and technological development trends, medium- and long-term national economic and social development strategic needs, national security and scientific and technological development patterns, and local economic development drivers, China urgently needs to couple innovation chains, value chains, supply chains, and industrial chains in space to form innovative regional economic complexes with specialized advantages [11], better responding to international competition.

Concentrate eastern advantages in innovation and industrial resources to build three national-level innovative regional economic complexes in Beijing, Shanghai, and Hong Kong-Shenzhen [12]. Specifically, the Beijing complex takes Beijing as the core to drive the Beijing-Tianjin-Hebei region; the Shanghai complex takes Shanghai as the core to drive the Yangtze River Delta region; and the Hong Kong-Shenzhen complex takes Shenzhen and Hong Kong as the core to drive the Guangdong-Hong Kong-Macao Greater Bay Area. Leverage scientific and technological resources, talent, and industrial development foundations to promote the combination of scientific and technological innovation with regional development and national security. At the national level, layout and construct five

regional-level science and technology innovation-industry sub-centers in Wuhan, Shenyang-Dalian, Jinan-Qingdao, Chengdu-Chongqing, and Xi' an to build a multi-polar, relatively balanced science and technology innovation-industry coupling development pattern. From a spatial coordination perspective, nationally coordinate the layout of a batch of national key laboratories, national engineering laboratories, and other research institutions, appropriately tilting the layout toward southeastern regions with developed industries but relatively weak scientific and technological forces. Further improve the functions of high-tech industry incubation and transformation platforms such as science and technology innovation incubation platforms and maker spaces around universities and research institutes with strong basic research capabilities, strengthen the connection between scientific and technological achievements and industrial incubation resources, and improve the level of achievement transfer and transformation.

3.2 Concentrate Innovation Resources to Promote the Agglomeration of New Quality Productive Forces in Eastern Urban Agglomerations

Take urban agglomerations as important spatial carriers, strengthen the high integration of innovation and industrial space, significantly improve the quality and efficiency of territorial space development and utilization, and optimize the layout of major productive forces [13]. In the eastern urban agglomerations such as Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta, as well as Chengdu-Chongqing and middle Yangtze River urban agglomerations, significantly enhance the spatial cohesion to attract global innovation elements, cultivate strategic spaces that carry China' s scientific and technological innovation frontier and future industries, and focus on building core areas for China' s participation in global competition and new quality productive forces layout. In Shandong Peninsula, Central Plains, Guangdong-Fujian-Zhejiang coastal area, Guanzhong Plain, and Beibu Gulf metropolitan areas, accelerate the technological transformation of traditional processing and manufacturing industries to create key areas for promoting new industrialization nationwide. Stimulate the scientific and technological resource vitality accumulated in Chengdu-Chongqing, Guanzhong, central and southern Liaoning, and central Shanxi urbanization areas, and prioritize the creation of pilot demonstration zones led by scientific and technological innovation.

3.3 Tap Characteristic Endowments and Guide the Layout of Resource Development and Processing Industries to Shift Westward

Relying on natural resource endowments such as minerals, ecology, and biology, as well as geographical location conditions, accelerate the local green transformation of resource advantages into economic advantages in western-dominated regions to cultivate new regional economic growth clusters [14]. In the Gobi and desert areas of western Inner Mongolia, northwestern Gansu, northwestern Qinghai, and eastern and southern Xinjiang, focus on laying out a batch of green energy production bases and large-scale scarce strategic mineral resource devel-

opment and processing utilization bases to significantly enhance the security and green low-carbon transformation of China' s industrial and supply chains. In China' s central and western national parks, natural parks, and areas rich in historical and cultural resources, create experiential and learning-oriented tourism regional brands, build a national backyard garden system, deeply practice the "Two Mountains Theory," drive local characteristic economic development, and meet the needs of comprehensive consumption upgrading. Combine the unique animal and plant resources in western regions with modern biotechnology R&D in eastern regions, cultivate modern biological industry chains of "company + R&D + farmers + logistics," build western modern biological industry clusters, and cultivate western future industry incubation and growth bases. Cultivate natural resource processing industry chains centered on Lanzhou, Xining, Urumqi, Kashgar, Lhasa, Kunming, and other central cities to form new regional economic growth clusters in China.

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