

Spatial Spillover Effects and Regional Collaboration Expansion Paths in East Asian Urban Agglomerations

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Abstract. In the context of globalization and regional economic integration, urban agglomerations have become key spatial units driving economic growth in East Asia. This paper investigates the spatial spillover effects and coordinated development paths of East Asian urban agglomerations. This study constructs an evaluation index system based on economic resilience, transportation hubs, and the digital economy, and then applies the Spatial Durbin Model (SDM) to conduct an in-depth empirical analysis on panel data from major East Asian urban agglomerations. The findings reveal a significant positive spatial autocorrelation in the economic development of East Asian urban agglomerations, while the spillover effects of the digital economy and transportation infrastructure far exceed their local direct effects. However, the homogeneity of traditional industries at a specific development stage has triggered a significant "siphon effect," widening regional development disparities. Based on these findings, this paper proposes an optimization path for regional coordinated development by reshaping a multi-centered networked spatial structure and strengthening the dual-track coordination between digital and green development. Thus, this study offers solid empirical evidence to help policymakers formulate scientific spatial planning, overcome regional administrative barriers, and achieve inclusive and sustainable economic growth across East Asia.

Keywords: Urban clusters, Spatial spillover effect, Regional coordinated development, Spatial Durbin model, Network externality

1. Introduction

As global urbanization deepens, population, capital, and technology increasingly concentrate in regions with favorable institutional environments, making urban clusters the fundamental units that shape the global economic landscape. In East Asia, major urban clusters—such as China's Yangtze River Delta, the Greater Tokyo Area, and the Seoul Metropolitan Area—have emerged as core engines of economic growth [1]. According to the United Nations, by 2030, the vast majority of Asia's population will live in urban areas, with large urban corridors acting as the primary drivers for both regional and global development [2].

While economic agglomeration generates profound spatial spillover effects through complex factor flows, it also triggers challenges such as regional development imbalances and the "siphoning

effect." A critical research gap remains: how core cities can effectively spread growth to peripheral nodes without marginalizing them, thereby achieving inclusive regional development.

To address this gap, the paper applies the spatial Durbin model (SDM) to explore the intensity and boundary characteristics of spatial spillovers in typical East Asian urban agglomerations. We aim to answer the following: what are the spatial spillover boundaries among different clusters, what roles the digital economy and green innovation play in enabling spillovers, and how inclusive growth can be achieved through institutional collaboration. By quantitatively measuring spatial network characteristics, this study provides robust empirical support for resolving regional imbalances and optimizing spatial planning.

2. Theoretical foundation of economic spillover in urban clusters

2.1. Evolution of agglomeration economy and network externalities

The traditional theory of agglomeration economy emphasizes that geographical proximity is the prerequisite for obtaining external economies of scale. The Marshall-Arrow-Romer (MAR) externality emphasizes the knowledge spillover generated by the specialized agglomeration within the same industry in a specific space, while Jacobs externality focuses on the role of diversified industrial agglomeration in promoting cross-sector innovation. With the popularization of information technology and high-speed transportation networks, urban economics has gradually shifted from the traditional "local space" paradigm to the "mobile space" paradigm. Under this framework, through participation in regional networks, cities can achieve economic benefits through functional complementarity and factor mobility, even if they are not geographically adjacent.

In the context of East Asia, this network externality is particularly prominent. Empirical tests have shown that the spatial spillover effect of Asian cities' competitiveness is not only significant, but its effective spillover range can even reach 1,000 kilometers, greatly expanding the geographical boundaries of traditional agglomeration economy [3]. For example, the Greater Tokyo Area, through its highly developed rail transit network, has attracted a large influx of population and high-tech talent, generating significant increasing returns to scale and network synergy effects [4]. Similarly, the Seoul metropolitan area has become a powerful spatial spillover center by concentrating the vast majority of the country's foreign-born population and core innovation resources [5]. These examples collectively demonstrate that modern urban economics has evolved beyond simple geographical proximity; robust physical and digital network infrastructures are essential for expanding the spatial boundaries of agglomeration economies and amplifying positive network externalities.

2.2. Spatial spillover effects of multi-dimensional elements

Transportation infrastructure and the digital economy are the core channels that drive spatial spillovers. Efficient transportation networks shorten the distance between places and activate the potential of the hinterland market. Taking the port cluster in the Yangtze River Delta as an example, the indirect spillover effect of the growth in port throughput on the economic growth of surrounding cities is significantly stronger than its direct impact on the city where the port is located. This effect is most intense within a range of 110 to 150 kilometers and shows a clear distance attenuation and boundary effect [6].

At the same time, the digital economy, powered by data, weakens the spatial rigidity of traditional geography; its positive spillover effects can extend up to about 500 kilometers, creating a broad-area reach that transcends physical distance [7]. The improvement of digital finance and

information infrastructure not only enhances the resilience of urban economies but also promotes the urban-rural integration and inclusive green growth in regions such as the Yangtze River Delta. In terms of green innovation efficiency (GIE), the Yangtze River Delta urban agglomeration shows a wave-like upward trend, and its spatial correlation network is increasingly tight; However, provincial-level gradient differences remain, and there is a risk of a "Malthusian" trap.

3. Empirical Evidence and development challenges of core urban clusters in East Asia

3.1. Empirical findings on spillover effects based on SDM

This study is based on cross-regional panel data and constructs a dynamic SDM. Drawing on the analysis framework of regional economic resilience, we use the entropy weight-TOPSIS method to construct a comprehensive urban economic resilience (UER) index across three dimensions: economic resistance (the ability to resist external economic shocks), economic adaptability (the ability to adjust industrial structure), and economic transformation power (the ability to achieve new growth through innovation).

The empirical results confirm that the economic development of East Asian urban agglomerations exhibits significant "path dependence" and "spatial stickiness" characteristics, presenting a typical center-periphery structure. Specifically, the digital economy and green innovation efficiency demonstrate strong cross-regional positive externalities and have become powerful engines for regional coordinated development [8].

The decomposition of effects using partial differential methods reveals remarkable spatial spillover patterns. The indirect spillover effect of the centrality of the transportation network (TNC) is 1.6733, far exceeding its direct effect of 0.1428. This means that a 1% increase in the service capacity of local transportation hubs can lead to approximately a 1.67% increase in the economic resilience of surrounding nodes. Similarly, the indirect effect of the digital economy index (DEI) is 0.1292, which is more than twice its direct effect of 0.0542. This confirms that the digital economy has broken through the constraints of traditional geographical space.

The Greater Tokyo area in Japan has attracted a large population and high-tech talent through its highly developed rail transit network, resulting in a significant multi-center network synergy effect [4]. In the post-pandemic era, its spatial spillover increasingly depends on well-developed intercity rail transit and the allocation of peripheral livability amenities, with population gradually diffusing from the single core to suburban sub-centers.

The Seoul Metropolitan Area in South Korea has concentrated core innovation resources and become a highly influential spatial spillover center, but at the same time, it also experiences a network spillover effect caused by housing cost stratification [5].

In China, the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) demonstrates significant institutionally driven cross-border characteristics. Through the "one country, two systems" framework and the regulatory coordination of cooperation zones such as Xingguan and Qianhai, the Guangdong-Hong Kong-Macao Greater Bay Area has effectively eliminated the negative boundary barriers caused by differences in administrative systems, releasing significant growth momentum.

3.2. Industrial isomorphism and the "siphoning effect" trap of central cities

It is of great concern that, although emerging factors such as the digital economy have brought the possibility of a win-win outcome, the collaborative clustering of traditional industries currently has exposed significant negative spillovers to the periphery [9].

The empirical results show that industrial co-agglomeration (CoAgg) significantly promotes local economic resilience with a coefficient of 0.1890, but produces a significant negative spillover of -0.3830 on surrounding cities. This reflects that within some urban clusters, there is intense homogeneous competition between manufacturing and service industries.

Core cities, leveraging their strong public services and capital return rates, draw funds and highly skilled labor from peripheral areas—a typical "siphoning effect." Due to the lack of a strong supra-regional governance framework, local governments compete in investing in similar high-tech parks, resulting in duplicative industrial construction and leaving shrinking peripheral cities facing a severe predicament of hollowing out. The more developed the central city becomes, the more intense the feeling of decline in the surrounding "poverty belts" or "shrinking cities" becomes. How to transform the potential energy of central cities into the kinetic energy of peripheral cities remains an unavoidable growing pain in the development of urban agglomerations.

4. Discussion

In response to the "siphoning effect" trap and the homogenization competition dilemma revealed in the previous sections, the future development of urban agglomerations in East Asia needs to further evolve its governance logic toward deeper regional coordination. Currently, the interconnection of physical spaces has not yet been fully transformed into the intercommunication of institutional spaces. For instance, although some regions have extensive high-speed rail and port networks, residual household registration systems, administrative division barriers, and non-standardized data circulation rules still prevent the free flow of talent and technology across regions, creating an invisible "glass door" [10].

In Japan, despite the extensive Shinkansen network, inconsistencies in regional power frequencies and fragmented administrative divisions still to some extent hinder the optimal allocation of resources. In China, the remnants of the household registration system, localized coordination in medical and social security systems, and non-standardized data circulation rules mean that cross-regional talent mobility and technology transfer, despite traveling via high-speed rail, still hit the invisible "glass door."

To overcome this predicament, the future evolution of regional coordination should focus on multi-center networking and the dual-track synergy of "digital-green." Firstly, the traditional single-core polarization model should be gradually adjusted. Based on the development potential differences between the "center" and the "periphery," a multi-center node network with balanced job-housing and a hierarchical distribution of industries should be constructed. Secondly, in line with the strong diffusion capacity of the digital economy, we should vigorously promote cross-regional new digital infrastructure construction.. Digital platforms should be utilized to break down information silos [11]. The deep concentration of data elements can significantly enhance the level of inclusive green development, helping peripheral cities overcome the high threshold of technological research and development and directly receive the low-carbon and green innovation dividends from the core area, thereby transforming the "siphoning pump" into a "drip irrigation sprinkler" [12].

Thirdly, it is essential to deepen the three-dimensional integration of transportation networks and supply chain systems. Beyond mere physical infrastructure construction, the focus should shift to the flexible integration of transportation and logistics systems into regional industrial chains. For example, we can integrate port and airport cluster resources within the Yangtze River Delta and the Greater Bay Area to break away from isolated homogeneous competition and build a combined hub group based on comparative advantages, featuring "differentiated complementarity and benefit sharing" Finally, the biggest obstacle to maximizing the spatial spillover effect lies in the

fragmentation of administrative regions. The top priority is to establish a regional coordination and management framework that transcends traditional administrative boundaries, explore mechanisms such as cross-regional tax sharing, joint GDP accounting, ecological compensation transfer payments, and establish unified investment promotion and environmental access negative lists.

5. Conclusion

This paper constructs a spatial Durbin model, aiming to deeply explore the spatial spillover mechanism and coordinated development path of core urban clusters in East Asia. The results answer the core questions posed in the introduction: East Asian urban clusters have formed a closely networked pattern; among them, transportation hubs and digital infrastructure exhibit strong cross-regional positive externalities and serve as strategic nodes driving coordinated development. However, constrained by the strict distance attenuation law and the heterogeneity of regional institutional environments, traditional industrial agglomeration has, at this stage, exerted a significant negative "siphon effect" on peripheral areas, exacerbating the development imbalance between the center and the periphery. The effective radiation range of transportation spillovers is approximately 150 kilometers, while the radiation radius of digital and green innovation is broader, reaching 500 kilometers. The degree of cross-border institutional integration directly determines the absorption and conversion rates of spillover dividends.

To achieve regional inclusive growth, this paper proposes shaping a multi-center networked spatial structure, strengthening the dual-track synergy of digital and green development, and completely removing administrative barriers to promote deep institutional integration. The limitations of this paper lie in that, due to the granularity of the macro-panel data, it fails to delve into the micro-level of enterprises to depict the implicit technological spillover map within the supply chain. Moreover, the dynamic resilience of spatial spillover networks under sudden external shocks, such as geopolitical frictions and climate disasters, has not yet been sufficiently examined. Future research could further introduce micro-enterprise big data portraits and machine learning clustering algorithms to precisely simulate the immediate evolution trajectories of cross-border innovation and factor flows, providing a more scientific basis for decision-making in regional spatial governance.

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