

Economic Network Analysis: Theoretical Evolution, Empirical Progress, and Implications for Regional Development

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ABSTRACT

With the deepening of globalization and informatization, economic activities are increasingly breaking through traditional geographical and administrative boundaries. The relational patterns between cities and regions are undergoing a profound transformation from a "hierarchical system" to a "network structure." Economic network analysis, as a cutting-edge perspective integrating geography, economics, and sociology, provides a new analytical framework for understanding the dynamic mechanisms of regional economic growth. This paper aims to systematically review the theoretical foundations, empirical methods, and key research findings in the field of economic network analysis. The literature indicates a general trend in urban networks evolving from monocentric to polycentric, from administration-dominated to market-driven, and from loose to tight. Furthermore, network connectivity has a significant positive effect on economic growth, with spatial heterogeneity in its impact. Finally, this paper points out the current research challenges in theoretical integration, methodological innovation, data acquisition, and scale linkage. It also provides an outlook on future research directions, aiming to offer more solid theoretical support for China's regional coordinated development strategy.

KEYWORDS

Economic network analysis; Network architecture; Economic growth; Social network analysis

1. INTRODUCTION

In the research paradigms of traditional regional economics and urban geography, urban systems are typically understood as vertical hierarchical structures based on scale, administrative rank, or functional division of labor, as described by Christaller's Central Place Theory. However, since the latter half of the 20th century, revolutionary breakthroughs in information and communication technology, the deep integration of global production networks, and the rapid flow of production factors (capital, information, talent) have profoundly reshaped the interactive relationships between cities and regions. Inter-city relationships increasingly exhibit the "networked" characteristics of being flattened, multi-directional, and complex [1]. This "space of flows" gradually replaces or complements the "space of places" based on physical proximity, becoming the primary form organizing socio-economic activities.

Against this backdrop, "economic network analysis"—which treats cities or regions as nodes in a network and their economic, social, and informational connections as edges—has emerged and rapidly become a hotspot in economic geography, regional science, and urban studies. The core of this paradigm shift lies in recognizing that a region's economic growth depends not only on its internal inputs of production factors (e.g., capital, labor, technology) but also significantly on externalities

stemming from its position, connection strength, and network structure within broader regional or even global networks [5].

This paper aims to provide a systematic review of the literature related to economic network analysis. First, it outlines the core theories underpinning this field. Second, it reviews major methods for network construction and analysis. Then, it focuses on two key empirical research areas: characterizing urban network structures and their mechanisms influencing economic growth. Finally, it summarizes current research shortcomings and proposes future directions.

2. THEORETICAL FOUNDATIONS: THE LOGIC OF ECONOMIC NETWORK FORMATION AND EVOLUTION

Research on economic networks is built upon the integration of multi-disciplinary theories. Its main theoretical foundations include:

2.1. The Space of Flows and Global City Network Theory

Sociologist Manuel Castells' proposed "space of flows" theory provides a philosophical basis for understanding the network society. He argues that in the information age, the organization of power and function is no longer primarily attached to specific geographical places but is realized through global networks of capital, information, technology, images, and population flows [1]. Building on this, Friedmann's "World City Hypothesis" and Sassen's "Global City" theory emphasize the function of cities as nodes for global capital control. Taylor and the GaWC research group further pioneered the empirical research paradigm of the "world city network," arguing that city networks are "interlocked" through the global office networks of advanced producer service firms [2]. These theories collectively point out that a city's value is closely related to its connectivity, not merely its own size.

2.2. Network Externality and Synergy Theory

Network externality theory from economics has been introduced into regional studies to explain the growth impetus generated by urban networks. Camagni and Salone were among the first to explicitly propose that urban networks generate two positive externalities: complementarity effects (acquiring resources and services lacking locally through the network) and synergy effects (achieving overall benefits where "1+1>2" through cooperation) [3]. Capello further conceptualized network externalities, noting that cities participating in a network can share a kind of "club good," jointly benefiting from economies of scale, risk reduction, and knowledge spillovers. Boix and Trullén's model decomposes urban economic growth into internal economies, external agglomeration economies, and external network economies, formally incorporating network effects into the framework of economic growth analysis [4].

2.3. The Evolution of Spatial Development Structure Theory

From Growth Pole Theory and Point-Axis Theory to Network Structure Theory, this progression reflects the deepening understanding of the organizational laws of regional space. Lu Dadao's "Point-Axis System" theory has had a profound influence on regional planning in China [11]. With the multi-dimensionalization and networking of connections, scholars like Wei Houkai pointed out that regional spatial structures will ultimately evolve towards a balanced, open network structure [12]. Network structure theory emphasizes horizontal connections and multi-dimensional interactions between nodes, representing an advanced development of the "point-axis" structure in the information age.

3. RESEARCH METHODS: MEASURING ECONOMIC NETWORKS AND ANALYZING STRUCTURE

Quantifying "invisible" economic connections is key to empirical research. Existing literature primarily employs the following three categories of methods:

3.1. Gravity Model based on Attribute Data and Its Modifications

This is a classic method for measuring the theoretical strength of connections between cities. The traditional gravity model uses urban GDP and population size as "mass" and geographical distance as a friction factor. For more accurate reflection of actual economic flows, scholars have made various modifications: First, introducing urban flow intensity, calculated via location quotient to measure a city's outward service function across sectors, thus gauging its actual capacity for external radiation and attraction [7]. Second, using comprehensive multi-indicator mass, such as combining market size, innovation capability, infrastructure, etc. Third, employing actual travel time or cost instead of geometric distance to better reflect accessibility.

3.2. Interlocking Network Model and Enterprise Network Model Based on Relational Data

This method uses micro-level firm entities as proxies to directly depict actual inter-city connections. It mainly includes two approaches:

Interlocking Network Model: Established by the GaWC group, it posits that a connection exists between two offices of the same multinational firm located in different cities. By aggregating the global distribution of advanced producer service firms across cities, a city-firm value chain is constructed and then converted into a city-city connection matrix [2]. This method is widely used in global and national-level urban network research [8].

Headquarters-Branch Model: Addressing potential overestimation in the interlocking model, Alderson et al. and Neal suggested that economic connections are more evident in the control and resource flows between a firm's headquarters and its branches. Constructing spatial correspondences between headquarters and branches can form a directed city network [6]. This method is particularly suitable for analyzing regional urban networks within a single country.

3.3. Social Network Analysis Methods

After constructing a city relational matrix, Social Network Analysis (SNA) provides a mature set of indicators and tools to analyze network structure:

Node Centrality Analysis: Includes degree centrality (number of direct connections), closeness centrality (ability to avoid control by others), betweenness centrality (ability to control resource flows), etc., used to measure an individual city's position and power within the network.

Overall Network Structure Analysis: Indicators such as network density, core-periphery structure, cohesive subgroups (community detection) are used to characterize the overall tightness, hierarchy, and clustering features of the network [7].

Spatial Econometric Models: To test the impact of networks on economic growth, scholars incorporate network centrality indicators as explanatory variables into Cobb-Douglas production functions or spatial panel models, controlling for other traditional variables, for regression analysis [5-6].

4. KEY RESEARCH FINDINGS: STRUCTURAL CHARACTERISTICS AND EVOLUTIONARY PATTERNS OF URBAN NETWORKS

Extensive empirical research reveals the structural characteristics and dynamic evolution of urban networks at different scales:

4.1. Spatial Pattern: from Monocentric Polarization to Polycentric Networking

Whether at the global, national, or regional scale, urban networks generally show a trend evolving from a "core-periphery" structure dominated by a few core cities towards a polycentric, flattened network structure. For example, in the Yangtze River Delta region, Shanghai was initially the absolute network core. However, with the rise of cities like Hangzhou, Nanjing, Suzhou, and Ningbo, the network structure has clearly evolved towards polycentricity, with more balanced connections between nodes [6]. Yet, in the Guanzhong Plain urban agglomeration in western China, Xi'an's dominance remains pronounced, with significant network polarization and underdeveloped sub-centers, indicating regional development imbalances [7].

4.2. Connection Boundaries: Coexistence of Weakening and Strengthening Administrative Barriers

In theory, network connections should transcend administrative boundaries. Empirical evidence in China shows that economic connections between cities within a province are typically stronger than inter-provincial connections, indicating that administrative divisions still strongly shape the formation of economic networks [6]. However, in eastern developed regions or under national strategic promotion (e.g., Yangtze River Delta integration), cross-provincial connections are rapidly strengthening. Research on the Guanzhong Plain urban agglomeration found that its internal subgroup divisions gradually evolved from cross-provincial combinations to align completely with provincial boundaries, reflecting the complexity of interaction between market forces and administrative power [7].

4.3. Evolutionary Drivers: The Dual Engines of Firm Organization and Transportation Infrastructure

The spatial location and expansion strategies of firms (especially producer service firms and large manufacturing firms) are the most active micro-level drivers shaping urban networks [9]. Simultaneously, the construction of transportation infrastructure such as high-speed rail, expressways, and aviation, by drastically compressing time-space distance, reshapes the accessibility landscape of cities, becoming a key material foundation for strengthening or altering the strength of inter-city connections [10].

4.4. The Dual Impact of Network Structure: Efficiency and Lock-in

On one hand, an efficient and open network structure (e.g., high network efficiency, low structural hole constraints) facilitates resource flow and innovation, promoting economic growth. On the other hand, a "core-periphery" structure overly reliant on a single core may inhibit development in peripheral areas, leading to a "black hole effect" or "siphon effect." Excessive agglomeration in core cities can also bring congestion costs. Therefore, there exists an "optimal" range for network structure; both excessively loose and excessively tight networks may be detrimental to the sustainable development of the overall regional economy.

5. RESEARCH COMMENTARY AND FUTURE OUTLOOK

Although economic network analysis has yielded fruitful results, the following aspects still require further exploration:

5.1. Methodological Innovation and Data Expansion

First, dynamic network models should be explored to better capture the evolutionary process of networks rather than static snapshots. Second, big data provides new opportunities for network research. Utilizing massive real-time data such as enterprise equity relationships, patent cooperation, talent flow, internet search trends, and social media to construct multi-dimensional networks can more comprehensively and finely depict the complex connections between cities. Finally, more robust models need to be developed to distinguish the causal direction of network effects (Does the network promote growth, or does growth attract network connections?).

5.2. Scale Linkage and Policy Implications

Existing research mostly focuses on a single scale (global, national, urban agglomeration). Future work needs to strengthen research on the nesting and interaction of multi-scale networks (e.g., global-national-regional-local). At the policy level, research should more explicitly answer: How can local governments improve their position within regional networks by enhancing the business environment, nurturing local enterprises, and investing in specific infrastructure (e.g., digital infrastructure)? How should regional planning guide the formation of a "polycentric, nested, open" healthy network structure to balance efficiency and equity?

6. CONCLUSION

Economic network analysis provides a powerful perspective for understanding regional development in the era of globalization and informatization. It reveals that regional competitiveness increasingly depends on its "capacity to connect" rather than isolated "possessed resources." China is at a critical juncture of deeply implementing regional coordinated development and new urbanization strategies. A deep understanding of the structural characteristics, evolutionary patterns, and economic effects of urban networks in different regions holds significant practical importance for scientifically formulating regional policies, optimizing territorial spatial layout, and promoting common prosperity. Future research needs continuous innovation at the theoretical, methodological, and application levels to better uncover the mysteries of complex economic network operations and serve high-quality development.

REFERENCES

- [1] M C. The Rise of the Network Society [J]. Вопросы экономики, 2001, 0(3):154-158.
- [2] Taylor J P. Specification of the World City Network [J]. Geographical Analysis, 2001, 33(2): 181-194. DOI:10.1111/j.1538-4632.2001.tb00443.x.
- [3] Camagni R P, Salone C. Network urban structures in northern Italy: elements for a theoretical framework [J]. Urban studies, 1993, 30(6): 1053-1064.
- [4] Boix R, Trullén J. Knowledge, networks of cities and growth in regional urban systems [J]. Papers in Regional Science, 2007, 86(4): 551-574.
- [5] Qin Chenglin, & Sang Mancheng. Urban Network and Urban Economic Growth. Study and Practice, (4), 5-11+2. DOI: 10.19624/j.cnki.cn42-1005/c.2015.04.001.
- [6] Wang Yanru. Research on Urban Network Linkages in the Yangtze River Delta Region and Their Economic Growth Effects. Master's Thesis, East China Normal University (2020).

- [7] Ye Shanshan, Cao Mingming, & Hu Sheng. Evolution of economic linkage network structure in Guanzhong Plain Urban Agglomeration and its impact on economic growth [J]. *Arid Land Geography*, 2022, 45(1): 277-286.
- [8] Ni Pengfei, Liu Kai, & Taylor, P. J. (2011). Measuring Chinese City Connectivity: Based on the Interlocking Network Model. *Comparative Economic & Social Systems*, (6), 95-103.
- [9] Wu Qianbo, & Ning Yuemin. Analysis of Urban Spatial Network in China: From the Perspective of Electronic Information Enterprise Production Network [J]. *Geographical Research*, 2012, 31(02): 207-219.
- [10] Wang Jiao'e, & Jing Yue. Characteristics and Organization Pattern of the Hierarchical Structure of Chinese Urban Network: A Comparison Based on Railway and Air Traffic Flows [J]. *Acta Geographica Sinica*, 2017, 72(08): 1508-1519.
- [11] Lu Dadao. *Spatial Structure Theory and Regional Development* [J]. *Science*, 1989, (02): 108-111+159.
- [12] Wei Houkai. *Towards Sustainable and Coordinated Development*. Guangdong Economic Publishing House (2001).