Local Political Connections, Transaction Costs, and Input-Output Linkages *

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Abstract

Local governments play a pivotal role in shaping the structure of national economic circulation and fostering coordinated regional development. This paper integrates insights from transaction cost economics, social network theory, and embeddedness analysis to investigate how political connections formed through interregional official rotations affect urban input–output linkages, which reflect the broader national economic circulation structure. Using a simplified linked game model, I show that such connections reduce transaction costs in intercity trade, with official rotations acting as credible commitments to lower institutional barriers. I develop a multi-region, multi-sector general equilibrium trade model that incorporates an official rotation network to quantify these effects. Empirically, I employ comprehensive data on official transfers and intercity input–output flows, and apply gravity models, spatial econometrics, and network analysis to identify causal relationships. Counterfactual simulations reveal significant direct and spillover effects of political networks on urban production linkages in both the short and long term. The findings underscore the importance of political networks in facilitating economic integration and efficiency.

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1 Introduction

Building upon the New Institutional Economics, which identifies institutions and their structural evolution as the deep determinants of economic growth (Acemoglu et al., 2001; North and Thomas, 1973), this paper draws specifically on transaction cost economics (Coase, 1937; Williamson, 1975, 1981, 1985, 1996) to argue that growth-enhancing institutions function primarily by lowering transaction costs (North, 1981; Williamson, 2000). Since political-economic institutions are endogenously shaped by governments wielding legitimate coercive power (Acemoglu et al., 2005), a key question follows: in a large territorial country, how do local governments, through formal and informal institutional arrangements, lower transaction costs while guiding and shaping the complex process of national economic circulation? Traditional transaction cost economics, however, is constrained by its reliance on atomistic individualism and the market-hierarchy dichotomy, leaving it underequipped to account for the role of social embeddedness. Social network theory and embeddedness theory (Granovetter, 1985, 1992, 2002, 2005) offer a complementary perspective by highlighting how economic behavior is structured within informal constraints such as customs and relational networks. Integrating these perspectives, this paper examines how Chinese local officials, embedded in informal institutions formed through interregional official rotations, lower transaction costs and thereby reshape the structure of national economic circulation.

Drawing on social network theory and embeddedness theory, this paper conceptualizes interregional rotations of officials, a distinctive feature of China's governance system, as a mechanism for forming informal political connections, and investigates how such connections shape the development of the national economic circulation structure. Throughout China's history, officials have frequently been rotated across regions within its vast governance system. This practice carries several positive implications: it strengthens interregional economic collaboration (Jiang and Mei, 2020; Persson and Zhuravskaya, 2016), reduces local corruption, and mitigates collusion between officials and firms. Zhou (2002) identifies three key effects of rotation: a knowledge-learning effect that broadens governance experience and narrows regional disparities; a rent-seeking prevention effect that curbs factionalism and patronage; and an incentive effect that alleviates vicious competition while intensifying promotion tournaments. However, official rotations also introduce negative consequences (Nian and Wang, 2023; Shi et al., 2021). Existing literature has primarily focused on regional economic interactions resulting from official rotations and their micro-level impact on corporate behavior, yet overlooked their role in shaping the national economic circulation structure.

Moreover, little attention has been paid to how local political connections lower transaction costs, a gap this paper aims to address.

Furthermore, while existing literature has established that the interregional rotations of officials influence the direction of regional industrial restructuring, most studies measure such restructuring at the micro level, focusing on product switching by individual firms, rather than adopting a macro perspective. This micro-level approach inevitably results in a loss of systemic information and fails to capture the full picture of how China's national economic circulation structure is being reconfigured. To bridge this gap, this paper adopts the input-output framework pioneered by Leontief (1936, 1951, 1986, 1991) as an empirical tool for characterizing real economic structures. By capturing the full spectrum of economic activities, including production, distribution, circulation, and consumption, within a unified accounting system, this approach allows us to thoroughly map and analyze input-output linkages between Chinese cities, thereby offering a comprehensive macro-level assessment of structural change.

Prevailing forms of transaction costs include information acquisition costs and institutional friction costs. Empirical literature has demonstrated that interregional rotation of officials and the resulting formation of local political connections can lower these costs in regional market activities (Jiang and Mei, 2020). However, the theoretical mechanisms underlying this effect remain inadequately articulated. To bridge this gap, this paper employs a simplified linked game model to illustrate how informal local political connections lower transaction costs in inter-city input-output trade. Specifically, the reduction of transaction costs through such political connections operates primarily by mitigating three core features of economic exchange: bounded rationality, opportunism, and asset specificity inherent in cross-city economic transactions. The rotation of officials across regions establishes robust information channels and political influence channels between their origin and destination areas. By embedding these informal mechanisms within formal institutional frameworks, rotations help relax incentive constraints in the linked game and provide credible commitments for interregional input-output trade.

Closely related to this paper, Jiang and Mei (2020) conducted an in-depth investigation into how cross-regional rotations of Chinese provincial officials affect interprovincial trade flows. Using a multi-sector, multi-region quantitative trade model with input-output linkages, their counterfactual analysis quantified the welfare effects generated by connections formed through official rotations. Building upon this general equilibrium framework, our paper introduces an innovative extension by incorporating the official rotation network and its structural features. While Jiang and Mei (2020) focused primarily on regional trade, proxied by interprovincial railway freight volumes, this paper shifts the focus to the structural configuration of national economic circulation, utilizing city-level input-output data within China. This paper advances the existing literature in three major aspects:

First, although Jiang and Mei (2020) identified official rotations as a channel for reducing trade frictions, their paper remained largely empirical and did not provide a theoretical microfoundation for the mechanism. This paper fills that gap by integrating transaction cost economics, social network theory, and embeddedness theory into a streamlined linked game model to formally theorize how cross-regional official rotations lower transaction costs. Moreover, our quantitative model explicitly incorporates the structural effects of the official rotation network, a dimension absent in their work.

Second, whereas their analysis was confined to interprovincial trade flows, this paper leverages disaggregated input-output data to examine how official rotations influence urban production networks. My empirical analysis achieves considerably finer resolution by examining official rotations and input-output linkages among nearly 200 Chinese cities, a significant improvement over province-level aggregation.

Third, methodologically, this paper advances beyond conventional gravity models by employing spatial econometric and network econometric techniques to capture spatial spillover effects within the official rotation network and direct effects of the official rotation network on the inter-city production network, thus better reflecting the interconnected nature of political and economic systems. Within the network econometric framework, I conduct counterfactual simulations assuming the absence of official rotations, which disentangle both the direct and spillover effects of political connections on input-output linkages in the short and long term.

The remainder of this paper will proceed as follows. Section 2 reviews the relevant literature. Section 3 describes stylized facts derived from empirical data. Section 4 presents the theoretical model, including a simplified linked game model and a general equilibrium trade model that incorporates the official rotation network. I also present the network econometric framework based on a network game in the section 4. Section 5 first details the empirical methodology, employing gravity models, spatial econometric models, and network econometric techniques, with its core concern being the issue of endogeneity. Section 6 presents a counterfactual analysis simulating the absence of official rotations. Section 7 concludes with a discussion of findings and policy implications.

2 Literature Review

As previously discussed, Chinese local officials play a crucial role in driving economic growth and structural transformation, with the interregional rotation system exhibiting a distinct "double-edged sword" effect. These substantive empirical findings are underpinned by the distinctly Chinese theoretical paradigm of promotion tournament theory (Li and Zhou, 2005; Zhou, 2002). From a micro-level perspective of official incentives, this theory contends that since the reform and opening-up, economic performance metrics, particularly GDP growth, have become the dominant criteria for political advancement. The intense competition for promotion among local officials has provided fundamental motivation for economic development, serving as a key engine behind regional growth. The promotion tournament mechanism, an internal governmental incentive structure, operates in conjunction with China's unique systems of administrative subcontracting, territorial management, and fiscal revenue sharing, collectively forming an institutional foundation for the country's economic expansion (Zhou, 2002). Moreover, local officials often dualistically function as both a "grabbing hand" and a "helping hand" (Frye and Shleifer, 1997), wielding substantial administrative power that can be channeled toward either destructive or developmental ends. Government failure in this context stems largely from principal-agent problems within the political system, manifested in goal divergence and information asymmetry. Effectively mitigating such failures and their accompanying social costs requires the establishment of incentive and governance structures that lower transaction costs (Zhou, 2002). Zhou (2002) argues that promotion tournaments constitute a powerful incentive mechanism that significantly curtails transaction costs, particularly information and monitoring expenditures, while maintaining credible commitments through transparent, rules-based performance criteria. This mechanism serves as an important alternative to formal judicial and property rights institutions and helps prevent the capture of officials by narrow interest groups. Empirical support for this theory has been provided by seminal studies such as Chen and Kung (2019), Landry et al. (2018), Li et al. (2019), and Yao and Zhang (2015), though it has also attracted considerable scholarly skepticism. Notably, the theoretical pillars of promotion tournament theory, namely, transaction cost reduction and credible commitment, are inherently aligned with the analytical framework of this paper. The crucial distinction lies in the domain of transaction costs: whereas promotion tournaments primarily reduce costs between the principal (central government) and agents (local officials), this paper elucidates how local political connections lower transaction costs within and across urban jurisdictions through input-output linkages.

Coase (1937) introduced the foundational concept of transaction costs to explain the boundaries of the firm, arguing that firms expand until the cost of organizing an additional transaction internally equals the cost of conducting it in the market. Williamson (1975, 1985) further developed transaction cost economics into a comprehensive framework, identifying three core determinants of transaction costs: bounded rationality, opportunism, and asset specificity. In contexts of high asset specificity, market transactions become costly, necessitating tailored governance structures to mitigate these costs. Thus, a central aim of institutional design is to devise governance mechanisms that minimize transaction costs, with a particular emphasis on providing credible commitments for ex ante specific investments and ensuring ex post safeguards (Williamson, 1975, 1985, 1996). Credible commitment, a concept rooted in game theory referring to promises that are incentive-compatible over time, is essential to effective institutions (Acemoglu et al., 2005) and functional incentive systems (Zhou, 2002). Qian and Weingast (1997), for instance, applied this idea to fiscal federalism, arguing that decentralization can serve as a credible commitment mechanism that motivates local economic development and hardens budget constraints. Meanwhile, new economic sociology, particularly through the work of Granovetter (1985), critiqued transaction cost economics for underemphasizing the role of social embeddedness. Granovetter demonstrated that economic actions are deeply embedded in social networks and shaped by informal constraints, which led him to advance social network theory and embeddedness theory. Notably, Williamson's (1975; 2000) framework does acknowledge the role of social relations, though less centrally. A significant refinement in social network theory and embeddedness theory is their integration with institutional analysis (Granovetter, 1992), conceptualizing institutions as "congealed networks" and highlighting how economic decisions are interwoven with networks, institutions, and cultural-historical contexts (Granovetter, 2002, 2005). Guided by transaction cost economics and enriched by insights from social network and embeddedness theories, this paper employs a simplified linked-game model to systematically analyze how informal political connections, forged through interregional rotation of officials, lower transaction costs, thereby guiding, adjusting, and shaping the structure of national economic circulation.

This paper also complements and extends the theoretical framework advanced by Acemoglu et al. (2023). It conceptualizes the informal political connections formed through interregional official rotations as weak ties, a form of low-intensity relational link proposed by Granovetter (1977, 1983). The functional importance of such weak ties inherently reflects the adaptive efficiency afforded by institutional diversity (Acemoglu et al., 2023). Whereas Acemoglu et al. (2023)

theoretically establishes the advantages of institutional diversity emerging from weak ties using Bayesian learning models in social networks, this paper empirically analyzes the magnitude and mechanisms through which these weak ties operate in practice.

This paper is closely aligned with a growing body of work emphasizing the role of knowledge spillovers resulting from cross-regional official rotations in facilitating industrial restructuring. The rotation of local officials across regions constitutes a deliberate intervention by the Chinese government in the flow of leadership human capital, effectively enabling these officials to serve as conduits for cross-regional knowledge diffusion. Rooted in the psychological mechanism whereby individuals' past knowledge and experiences exert long-term influences on their behaviors and preferences (Bordalo et al., 2012; Gopalan et al., 2021; Malmendier and Nagel, 2011; Schoar and Zuo, 2017), the early career experiences of officials also shape their subsequent policy preferences (Guo et al., 2024). The rotation system inherently generates knowledge spillover effects (Zhou, 2002), endowing local governments with "soft comparative advantages", such as prior industrial development experience, that inform and guide regional industrial restructuring. From a transaction cost perspective, these soft comparative advantages lower information acquisition barriers and improve the accuracy of information in regional industrial development, thereby lowering information costs. Fundamentally, the knowledge spillover effects resulting from official rotations reflect a measurable reduction in information costs, a phenomenon consistent with the New Structural Economics view regarding the informational advantages that governments in developing countries can possess. Therefore, when evaluating the impact of informal political connections forged through official rotations on the structure of national economic circulation, this paper explicitly accounts for the transmission channels and mechanisms through which information costs are lowered.

Another closely related strand of literature investigates how interregional rotations of officials influence local protectionism, market segmentation, and regional specialization. China's distinctive governance system, often characterized as "vertical contracting and horizontal competition", exhibits pronounced tendencies toward local protectionism (Young, 2000), resulting in issues such as redundant construction, excessive competition, and market fragmentation. Considerable scholarly effort has been devoted to identifying and addressing the institutional frictions stemming from such protectionist behaviors (Han and Wu, 2024; Tombe and Zhu, 2019). Interregional rotations of officials have been shown to mitigate vicious competition and alleviate institutional friction (Zhou, 2002). Seminal work by Bai et al. (2008) revealed that such rotations help curb local protectionism, reduce market segmentation, and enhance regional specialization. Using a gravity model of trade, Jiang and Mei (2020) further demonstrated that rotations facilitate interprovincial input-output trade by lowering trade friction and promoting market integration. Collectively, this strand of literature indicates that interregional official rotations can mitigate barriers caused by market segmentation, can strengthen production and distribution linkages between origin and destination regions, and can promote smoother economic circulation and the emergence of a unified national market. From a transaction cost perspective, these effects reflect a reduction in institutional friction costs across regions. The political connections formed through official rotations thus exhibit clear institutional friction-reduction effects, providing empirical insight into how local political connections shape the structural dynamics of national economic circulation.

3 Stylized Facts

Drawing on data from Zecheng Website, local party and government leadership databases, and municipal government résumé archives, this paper manually constructs a novel dataset on inter-city mobility of municipal party secretaries and mayors across 309 Chinese cities since the year 2000. Compared to existing databases on Chinese leadership mobility—such as those documenting interprovincial rotations of provincial leaders or the Chinese Political Elite Database (CPED) by Jiang (2018)—the self-compiled dataset offers distinct advantages in terms of temporal coverage, spatial scope, and granularity of detail.

This paper constructs an official rotation network by tracing the relocation paths of mayors across 188 Chinese cities between 2000 and 2023. This network serves as a measure of informal political connections among cities. Separately, sectoral data from interregional input–output tables for the same 188 cities in 2012, 2015, and 2017 are aggregated from CEADs to derive intermediate input and demand matrices. Based on these data, an inter-city production network is constructed to systematically represent supply–demand relationships of intermediate goods, thereby quantifying inter-city input–output linkages.

We begin by comparing the average input–output linkages between city pairs with varying degrees of political connections across the three sample years. City pairs with stronger political connections generally exhibit higher levels of input–output linkages. As shown in Figure 1, a positive correlation is observed between political connection strength and input–output linkage intensity, suggesting a mutually reinforcing relationship between these two dimensions.

The city pair with the strongest political connection is Hangzhou–Wenzhou in Zhejiang Province within the official network. Other pairs with the second strongest political connection include Nanjing–Yangzhou and Nanjing–Suqian in Jiangsu Province, Jinan–Zibo and Yantai–Dezhou in Shandong Province, Quanzhou–Zhangzhou in Fujian Province, and Changsha–Hengyang in Hunan Province. Notably, frequent mayor rotations and the resulting strong political connections occur predominantly within provincial boundaries, indicating that inter-city official rotations largely respect and reinforce existing administrative divisions. Moreover, these highly connected pairs typically link provincial capitals (e.g., Hangzhou, Nanjing, Jinan, Changsha) with economically significant prefecture-level cities (e.g., Wenzhou, Yangzhou). This pattern suggests that officials participating in such rotations often possess considerable potential for political advancement—exemplified, for instance, by the rotation from Wenzhou to Hangzhou. In subsequent empirical analyses, to ensure robustness, I exclude observations involving official rotations between cities of different administrative ranks, thereby mitigating potential endogeneity issues arising from political promotion.

While conventional measures of production connectivity often overlook directionality, this paper also examines seven specific city pairs to explore associations between political connections and directional input–output linkages. I construct scatter plots of directional input–output connections (forward and backward) for each city pair in 2012, 2015, and 2017, as shown in Figure 2. Given the large sample size, observations are grouped into quantile-based categories, and the average directional linkage is computed per group. These values are compared with the linkages of the seven focal city pairs. Figure 2 highlights the top 1% and top 5% sample groups, along with the seven politically connected pairs. The results show that directional input–output connections—in both directions—for city pairs with strong political ties are substantially higher than those of the top 5% group. Most exceed the top 2%, and some fall within the top 1%, indicating a strong positive association between political connections and input–output linkage strength.

Before constructing the inter-city production network, I develop a more granular "triple circulation" indicator based on multi-regional input–output tables for 313 Chinese cities. The specific values are shown in Table 1.

In terms of intermediate inputs, the total values were 116,877.6 billion CNY in 2012, 144,653.4 billion in 2015, and 149,339.4 billion in 2017, with an average annual growth rate of 4.2%. The foreign portion of intermediate inputs (i.e., exports) fluctuated, averaging 11.0% of the total. The intra-city share continued to decline, falling from 43.2% in 2012 to 42.9% in 2015 and further to 40.7% in 2017. In contrast, the inter-city share increased steadily from 45.1% in 2012 to 48.3

Regarding intermediate demand, the total values were 112,624.4 billion CNY in 2012, 142,322.8 billion in 2015, and 147,863.3 billion in 2017, with an average annual growth rate of 4.6%. The foreign share of intermediate demand (i.e., imports) continued to rise, increasing from 8.4% in 2012 to 10.1% in 2017. The intra-city share consistently declined, from 44.8% in 2012 to 43.7% in 2015 and down to 41.1% in 2017. Meanwhile, the inter-city share grew from 46.8% in 2012 to 48.8% in 2017.

Overall, both intermediate inputs and demand exhibited a consistent upward trend in the inter-city share. The inter-city share was slightly higher than the intra-city share, though both were broadly comparable. Aggregating across 2012, 2015, and 2017, the foreign share of China's national economic circulation during this period was 10.1%, the inter-city share was 47.2%, and the intra-city share was 42.7%. In other words, nearly 90% of the national economic circulation was domestic.

We further focus on inter-city production circulation. After excluding cities with missing covariates and low input–output flow, 188 cities are selected as nodes. A comprehensive inter-city production network is constructed using the Jaccard index transformation. Following relevant tests, the network is binarized using the 60th percentile of the Jaccard index as the threshold, resulting in a binary network suitable for ERGM, TERGM, and VCERGM analysis. For the binary inter-city production network, I present statistics on static structural characteristics and dynamic stability tests. Table 2 shows descriptive statistics for node out-degree, eigenvector centrality, transitivity, and diameter in 2012, 2015, and 2017.

From a static perspective, the inter-city production network exhibits the following structural features: each annual network from 2012 to 2017 contained 14,138 directed edges, with a network density of 0.402, indicating a highly dense structure. The network displays clear structural patterns, notably reciprocity and transitivity. The average reciprocity over the three years was 52.7%—defined as the proportion of bidirectional edges to all edges—suggesting significant mutual linkage structures. The average transitivity was 74.3%, measuring the proportion of closed triangles to all possible triangles, indicating notable clustering through transitive triads.

We further examine the dynamic stability of the network structure using the method proposed by Auerbach (2022). The null hypothesis is that the inter-city production networks at two time points are generated by the same stochastic model, implying no significant structural change. The first test is regression-based, comparing network statistics between time points with significance tests on coefficient estimates. Table 3 reports significance tests for differences in three network statistics: out-degree, eigenvector centrality, and transitivity. The results show no significant differences in these measures between 2012–2015, 2015–2017, or 2012–2017.

Since regression-based tests only examine specific local structures, I also employ a randomization test based on operator norms—analogous to a two-sample Kolmogorov–Smirnov test—to assess overall network stability (Auerbach, 2022). Table 4 reports p-values for six statistics: absolute differences in average out-degree, mean squared differences in node out-degree and eigenvector centrality, absolute differences in transitivity and diameter, and the $2 \to 2$ norm. Overall, absolute differences in average out-degree, transitivity, and diameter are consistent with the null hypothesis of stable network generation. However, significant differences are found in node out-degree and eigenvector centrality between any two time points. Most importantly, the test based on the $2 \to 2$ norm clearly rejects the null hypothesis, indicating that the inter-city production network exhibits significant time-varying structural features.

Before econometric analyses of the inter-city production network and the official rotation network, I examine their structural similarity. The null hypothesis states that both networks are generated by the same stochastic model, implying no significant structural differences. The randomization test based on operator norms (Auerbach, 2022) serves as the key method. Table 5 reports p-values for six test statistics: absolute differences in average out-degree, mean squared differences in node out-degree, mean squared differences in eigenvector centrality, absolute differences in transitivity, absolute differences in diameter, and the $2 \to 2$ norm statistic. The results indicate that for all three years—2012, 2015, and 2017—the differences between the production network and the official network are statistically significant across all measured metrics. Consequently, the two networks are not structurally similar, providing evidence against the presence of common confounding factors that might interfere with causal interpretation in subsequent empirical analysis.

4 Theoretical Model and Econometric Framework

4.1 Simplified Linked Game Model

Within the dimension of intra-governmental incentives, the interregional rotation of officials serves to mitigate information asymmetry between central and local governments, while simultaneously strengthening local officials' motivation to implement central policies and participate in regional cooperation. This mechanism effectively reduces transaction costs between the principal (the central government) and its agents (local officials) (Huang, 2002). Building on this logic, the present paper investigates how interregional official rotations and the local political connections they create reduce transaction costs within inter-city input-output linkages.

Guided by the core tenets of transaction cost economics, the effectiveness of informal political connections in lowering transaction costs within inter-city input-output linkages ultimately depends on their ability to mitigate issues of bounded rationality, curb opportunism, and manage the asset specificity inherent in these economic linkages. The interregional rotations of officials establish a significant information channel and a sustained political influence channel between their regions of origin and destination. The information channel, supported by empirical evidence from New Structural Economics, highlights local officials' superior knowledge of regional economic conditions. This mechanism helps overcome information asymmetries, facilitates policy-guided optimization of input-output allocation across cities, and reduces sectoral asset specificity by broadening potential trade partnerships. Simultaneously, rotated officials retain residual political influence in their former regions, a phenomenon empirically observed in the case of retired officials by Jiang et al. (2024) and logically extendable to rotated officials. This influence helps lower institutional barriers between cities, while their ongoing connections with enterprises and incumbent officials in their origin regions serve to discourage opportunism among actors involved in input-output transactions. Together, these dual channels, information and political influence, comprehensively illustrate how local political connections lower both information costs and institutional friction costs, with credible commitments serving as the critical facilitator underlying both mechanisms.

The theoretical framework of this paper is built upon an integrated foundation of transaction cost economics, social network theory, and embeddedness analysis. The effective credible commitment inherent in informal political connections originates from the embeddedness of interregional official rotations within formal institutions. Specifically, such connections, forged through official rotations, effectively link the promotion tournament among local officials with the community game of local governance, thereby creating a structure of interconnected games. Aoki (2001) demonstrates that linking two distinct games, i.e., forming a linked game, can generate effective credible commitments and significantly relax incentive constraints. The equilibrium structure of such linked games closely approximates the concept of social embeddedness advanced by Granovetter (1985), a connection formally conceptualized by Spagnolo (1999). Consider the following simplified game-theoretic model:

The model considers an economy composed of N heterogeneous cities, where each city contains a unique set of sectors, denoted as S_i ($i \in 1, 2, \ldots, N$). Under conditions of complete information and absence of institutional barriers, all urban sectors engage in trade according to their comparative advantages. The total benefit from trade for the sector set S_i in city i is B_{i,S_i}, and the total cost is C_{i,S_i}. For every city $i \in 1, 2, \ldots, N$, it holds that $B_{i,S_i} \geq C_{i,S_i}$. Owing to differences in initial resource endowments across cities, which generate distinct comparative advantages, the heterogeneous net benefit across cities, representing the economic performance of each city i is:

$$Y_i = B_{i,S_i} - C_{i,S_i}. \tag{1}$$

This paper further incorporates the characteristic Chinese official promotion tournament (**?**). Assume each city i has a principal official, denoted as P_i ($i \in 1, 2, \ldots, N$). Suppose the promotion of official P_i depends primarily on the economic performance Y_i of their jurisdiction, and officials can influence trade only by establishing institutional barriers. Since the promotion tournament is inherently zero-sum, officials in a mixed-competition environment have incentives to pursue positive economic gains only if the net benefits from trade do not alter their relative rankings; otherwise, they exhibit protectionist tendencies. In an infinite-horizon promotion game, officials P_i strategically decide whether to erect institutional barriers to influence inter-city sectoral trade, thereby affecting economic performance and relative rankings. Let the cost for official P_i of establishing such barriers be C_{i,P_i}. In the absence of institutional barriers, each official's per-period payoff in the promotion game is defined as a ranking function $B_{i,P_i}(Y_i)$ of their city's economic performance, and aggregate welfare for the economy is $\sum_{i=1}^{N} Y_i$. If n officials erect institutional barriers, the per-period payoff for each of the remaining $(N-n)$ officials becomes

$$B_{i,P_i}(Y_i - \sum_{j=1}^{n} d_{ji}), \tag{2}$$

where d_{ji} captures the negative spillover effect of institutional barriers on economic performance. For each of the n officials who establish barriers, their per-period payoff is

$$B_{j,P_j}(Y_j - \sum_{i=1}^{N} d_{ij}) - C_{j,P_j}, \text{ for } j \in 1, 2, \ldots, n, \tag{3}$$

where d_{ij} represents the direct negative effect of the barriers they impose.

Given that trade is non-zero-sum, I assume $d_{ji} > 0$, $d_{ij} > 0$, and $d_{jj} > 0$ without loss of generality. Although $Y_j - \sum_{i=1}^{N} d_{ij} < Y_j$, the function $B_{j,P_j}(\cdot)$ is rank-based. Therefore, due to spillover effects on other cities' performance, it is possible that

$$B_{j,P_j}(Y_j - \sum_{i=1}^{N} d_{ij}) > B_{j,P_j}(Y_j). \tag{4}$$

Under this scenario, aggregate welfare becomes:

$$\sum_{i=1}^{N-n} \left(Y_i - \Sigma_{j=1}^{n} d_{ji}\right) + \sum_{j=1}^{n} [Y_j - \sum_{i=1}^{N} d_{ij} - C_{j,P_j}]. \tag{5}$$

Crucially, an official will choose to erect institutional barriers only if

$$B_{j,P_j}(Y_j - \Sigma_{i=1}^{N} d_{ij}) > B_{j,P_j}(Y_j) + C_{i,P_i}, \text{ for } j \in 1, 2, \ldots, n. \tag{6}$$

Overall, aggregate welfare declines due to the strategic interactions in the promotion game. The total welfare loss is quantified as

$$\sum_{i=1}^{N-n} \sum_{j=1}^{n} d_{ji} + \sum_{j=1}^{n} \sum_{i=1}^{N} d_{ij} + \sum_{j=1}^{n} C_{j,P_j}. \tag{7}$$

The interregional rotations of local officials introduce vertical relative performance evaluation across successive administrative tenures within the same city, thereby complementing the conventional horizontal relative performance evaluation among contemporaneous officials in different cities. This dual evaluation mechanism effectively mitigates local protectionism and curbs excessive competition (Zhou, 2002). Specifically, under conditions of anticipated yet highly uncertain official rotation, local officials who choose to cooperate with others cultivate community-specific reputations. These reputational assets enable them to collaborate not only with their successors in their regions of origin but also with incumbent officials in their destination regions post-rotation, thereby securing future benefits within the official community. Such gains arise from the flexibility inherent in vertical performance evaluation: officials motivated primarily by political promotion are evaluated in part through comparison with their predecessors in new posts. This generates positive returns from cooperative relationships maintained with both successors in their origin regions and peers in their destination regions.

This paper formalizes the above mechanism through a game-theoretic framework. The interregional rotation system endogenously constructs an interactive community that encompasses all officials across the N cities, which simultaneously functions as a community game. In this game, each official P_i strategically decides whether to cooperate with other officials P_j $(i \neq j)$. Let the cost of cooperative effort for official P_i be $C^{'}_{i,P_i}$, and the resulting reputation-enhanced promotion benefit be modeled as a non-decreasing function $B^{'}_{i,P_i}(Y_i, n^{'})$ of both the economic performance Y_i of their current city and the number of cooperative peers $n^{'}$. When the community game is infinitely repeated in isolation, the incentive compatibility condition for official P_i to sustain cooperative effort in exchange for future benefits is

$$C^{'}_{i,P_i} < \delta B^{'}_{i,P_i}(Y_i, N), \tag{8}$$

where δ denotes the discount factor. When officials are sufficiently patient (i.e., $\delta \to 1$), this condition holds with slackness:

$$Z_i = \delta B^{'}_{i,P_i}(Y_i, N) - C^{'}_{i,P_i}. \tag{9}$$

The interregional rotation of officials effectively links the promotion game among local officials with the community game. Under such a rotation mechanism, the promotion game and the community game are repeated infinitely in sequence, with strategies in each stage contingent on outcomes from previous interactions. This intertemporal linkage gives rise to the following equilibrium.

Theorem 4.1 (Equilibrium Strategy Profile)**.** *In the infinitely repeated game with official rotations:*

1. *If an official previously erected institutional barriers in the promotion game, they will per-*

sist with this strategy in all subsequent promotion games and adopt non-cooperation in all subsequent community games.

2. *If an official has never erected institutional barriers, they will continue to refrain from doing so in all future promotion games and adhere to cooperation in all future community games.*

3. *Any official who has ever established institutional barriers will be permanently excluded from future cooperative interactions in the community game by all other officials. This exclusion applies only to those with a history of creating institutional barriers.*

This paper formalizes the conditions under which deviations from the aforementioned equilibrium strategy profile are unprofitable for any official P_i. Given the benefit of refraining from establishing institutional barriers is

$$C_{i,P_i} + \delta B'_{i,P_i}(Y_i, N), \tag{10}$$

while the cooperative cost is

$$B_{i,P_i}(Y_i - \sum_{j=1}^{N} d_{ji}) - B_{i,P_i}(Y_i) + C'_{i,P_i}, \tag{11}$$

the incentive compatibility constraint that ensures officials abstain from erecting institutional barriers is

$$C_{i,P_i} + \delta B'_{i,P_i}(Y_i, N) > B_{i,P_i}(Y_i - \Sigma_{j=1}^{N} d_{ji}) - B_{i,P_i}(Y_i) + C'_{i,P_i}, \tag{12}$$

which simplifies to:

$$Z_i = \delta B'_{i,P_i}(Y_i, N) - C'_{i,P_i} > B_{i,P_i}(Y_i - \Sigma_{j=1}^{N} d_{ji}) - B_{i,P_i}(Y_i) - C_{i,P_i}. \tag{13}$$

For all officials P_i abstaining from establishing institutional barriers, they have

$$B_{i,P_i}(Y_i - \Sigma_{j=1}^{N} d_{ji}) \leq B_{i,P_i}(Y_i) + C_{i,P_i}, \tag{14}$$

therefore, the slackness

$$B_{i,P_i}(Y_i - \Sigma_{j=1}^{N} d_{ji}) - B_{i,P_i}(Y_i) - C_{i,P_i} < Z_i < 0 \tag{15}$$

ensures the continued validity of the aforementioned incentive constraint.

In an isolated community game, the condition $Z_i = \delta B_{\mathrm{i,P_i}'}(Y_i, N) - C'_{\mathrm{i,P_i}} > 0$ constitutes the incentive compatibility condition for local officials to sustain a cooperative equilibrium. Crucially, the linked game framework enabled by inter-regional rotation relaxes the incentive constraint against institutional barrier creation. This occurs because rotation provides a credible commitment mechanism to lower transaction costs in inter-city input-output linkages, thereby aligning short-run strategic choices with long-run cooperative gains.

4.2 Network-Based Quantitative Trade Model

Building upon the quantitative trade models proposed by Eaton and Kortum (2002) and Jiang and Mei (2020), this paper introduces the following model setup. I further innovatively integrate generalized forms of information costs, institutional friction costs, and the official rotation network into the quantitative trade framework.

Let G denote the adjacency matrix of the inter-city official network (a binary network) constructed from historical cross-city official rotations, where $G^{[i,j]} \in \{0, 1\}$ represents network edges. Specifically, $G^{[i,j]} = 1$ indicates the existence of an official rotation from city i to city j. Given China's rapidly developed transportation infrastructure in recent years, I first posit a relatively low baseline transport cost parameter d^k_{ji}. Building on the tradable-nontradable dichotomy established in preceding sections, my analysis systematically examines equilibrium outcomes under varying magnitudes of information costs and institutional friction costs. I examine the scenario where $\tau^k_{ji} + \vartheta^k_{ji} = \infty$, indicating extreme market segmentation with severely constrained factor mobility. Consequently, $\Sigma^k_{ji} = \infty$, rendering intermediate goods ω^k produced in city j non-tradable relative to city i. Conversely, when only geographical distance costs d^k_{ji} exist, these goods become tradable.

This paper investigates the scenario where $d^k_{ji} < \tau^k_{ji} \ll \infty, d^k_{ji} < \vartheta^k_{ji} \ll \infty$, implying that information costs and institutional friction costs dominate geographical distance costs in total iceberg trade costs. Crucially, this configuration reflects a realistic degree of market segmentation and interregional factor mobility barriers. Consequently, intermediate goods ω^k produced in city j are always tradable relative to city i , with total iceberg trade costs given by

$$\beth^k_{ji} = d^k_{ji} + \tau^k_{ji} + \vartheta^k_{ji}. \tag{16}$$

Let transaction costs

$$tc^k_{ji}(G^{[j,i]} = 0) = \tau^k_{ji} + \vartheta^k_{ji} \tag{17}$$

incorporate the mitigation effect of politically connected official networks. I posit that edges aligned with trade directions partially offset information costs and institutional friction costs:

$$tc^k_{ji}(G^{[j,i]} = 1) = \rho' tc^k_{ji}(G^{[j,i]} = 0) \text{ for } \rho' \in (0, 1). \tag{18}$$

And the mitigation effects are invariant across city pairs. To preserve generality, I abstain from parametric assumptions on ρ', instead constraining their ranges to ensure directional consistency. The revised total iceberg trade cost becomes:

$$\aleph^k_{ji} = d^k_{ji} + tc^k_{ji}(G^{[j,i]}). \tag{19}$$

This paper establishes that intermediate goods ω^k produced in city j are always tradable relative to city i, with equilibrium prices determined by

$$min_j(c^k_j \aleph^k_{ji}/z^k_j(\omega^k)) = min_j(c^k_j(d^k_{ji} + tc^k_{ji}(G^{[j,i]}))/z^k_j(\omega^k)). \tag{20}$$

Maintaining the theoretical framework's core assumptions, the price of composite intermediate goods is

$$P^k_i = A^k \{\sum_{j=1}^{N} \lambda^k_j [c^k_j(d^k_{ji} + tc^k_{ji}(G^{[j,i]}))]^{-\theta^k}\}^{-1/\theta^k}. \tag{21}$$

I further reveal that distinct equilibrium outcomes emerge from heterogeneous official network structures under fixed parameters $l_i, D_i, \lambda^k_j, d^k_{ji}$. This quantifies how interregional official rotation networks fundamentally reshape inter-city input-output trade equilibrium through their topological configurations.

I generalize to arbitrary indegree $indegree_i(G) \in \{1, 2, \cdots, N-2\}$. Let $N^i = \{j{:}G^{[j,i]} = 1\}$ and $N^{-\mathrm{i}} = \{j{:}G^{[\mathrm{j,i}]} = 0\}$ denote the set of all network nodes excluding city i. The price of composite intermediate goods is then

$$P^k_i = A^k \{\sum_{j \in N^i} \lambda^k_j [c^k_j(d^k_{ji} + \rho' \tau^k_{ji} + \rho' \vartheta^k_{ji})]^{-\theta^k} + \Sigma_{j \in N^{-i}} \lambda^k_j (c^k_j \beth^k_{ji})^{-\theta^k}\}^{-1/\theta^k}. \tag{22}$$

Building on the Fréchet distribution properties, first denote M as

$$\sum_{j\in N^i} \lambda_j^k [c_j^k (d_{ji}^k + \rho^{'} \tau_{ji}^k + \rho^{'} \vartheta_{ji}^k)]^{-\theta^k} + \sum_{j\in N^{-i}} \lambda_j^k (c_j^k \beth_{ji}^k)^{-\theta^k}, \tag{23}$$

I derive:

$$\begin{aligned} \pi_{ji}^k &= \frac{\lambda_j^k [c_j^k (d_{ji}^k + \rho^{'} \tau_{ji}^k + \rho^{'} \vartheta_{ji}^k)]^{-\theta^k}}{M}, j \in N^i \\ \pi_{ji}^k &= \frac{\lambda_j^k (c_j^k \beth_{ji}^k)^{-\theta^k}}{M}, j \in N^{-i} \end{aligned} \tag{24}$$

This reveals that cities with interregional official rotations to city i exhibit significantly higher probabilities of directed trade flows to city i.

Given that

$$d_{ji}^k + \rho' \tau_{ji}^k + \rho' \vartheta_{ji}^k < \beth_{ji}^k = d_{ji}^k + \tau_{ji}^k + \vartheta_{ji}^k, \tag{25}$$

this paper demonstrates that any non-trivial official network structure inherently enhances inter-city input-output trade flows at equilibrium, without requiring extreme assumptions.

4.3 Network Econometric Framework

The theoretical model for the formation and evolution of the inter-city production network developed in this paper extends the framework of Gaonkar and Mele (2023) by incorporating a directed network structure and emphasizing distinct endogenous mechanisms. While Gaonkar and Mele (2023) focus on undirected networks with an emphasis on homophily and popularity, this analysis examines the directed production network, prioritizing transitivity and reciprocity as key endogenous dependencies. To this end, the model further draws on the directed network formulation in Mele (2017).

The payoff function consists of both deterministic and stochastic components, consistent with the random utility framework (Heckman, 1978), which are specified additively. The model considers an economy comprising n cities, where each municipality i is characterized by a vector of observable attributes x_i—including per capita urban road area, the degree of product market development, the degree of factor market development, per capita GDP, the proportion of the primary industry in GDP, the population size, and the number of college students per 10,000 people. By integrating exogenous covariates with endogenous structures such as edges, transitivity, and reciprocity, the model offers a comprehensive analytical tool for understanding the formation and evolution of the production network, providing valuable insights for both researchers and policymakers in international higher education.

The deterministic component of the payoff for municipality i, given a network configuration g and attributes x, is defined as the sum of net benefits across all edges:

$$U_i(g, x; \theta) = \sum_{j=1}^{n} g_{ij} \left(a_0 + a_1 \cdot g_{ji} + a_2 \cdot t_{ij} \right), \tag{26}$$

where $t_{ij} = \sum_{k \neq i,j} \mathbf{1}\{g_{ik} \cdot g_{jk} = 1\}$ denotes the number of common partners between municipalities i and j—that is, the number of closed transitive triangles in the production network in which both $i \to k$ and $j \to k$ are present. The parameter vector $\theta = (a_0, a_1, a_2)$ includes: a_0, the baseline payoff (or cost) of forming a link; a_1, the marginal payoff due to reciprocity; and a_2, the marginal payoff from transitivity.

From equation (26), the marginal payoff for municipality i from a directed edge to municipality j is:

$$MP_{ij} = a_0 + a_1 \cdot g_{ji} + a_2 \cdot \sum_{k \neq i,j} \mathbf{1}\{g_{ik} \cdot g_{jk} = 1\}. \tag{27}$$

The random component of the payoffs corresponds to a matching quality ϵ_{ij} between municipalities i and j. Thus, municipality i will form a directed edge to municipality j if and only if the sum of the marginal payoff and the matching quality is nonnegative:

$$g_{ij} = 1 \quad \text{if and only if} \quad MP_{ij} + \epsilon_{ij} \geq 0, \tag{28}$$

or equivalently,

$$U_i(g_{ij} = 1, g_{-ij}, x; \theta) + \epsilon_{g_{ij}=1} \geq U_i(g_{ij} = 0, g_{-ij}, x; \theta) + \epsilon_{g_{ij}=0}, \tag{9}$$

where g_{-ij} denotes the network configuration excluding the edge from i to j (i.e., the rest of the production network).

I assume the matching quality ϵ_{ij} is independently and identically distributed (i.i.d.) according to a logistic distribution. The conditional probability that municipalities i and j form a directed edge from i to j is given by:

$$P(g_{ij} = 1 \mid g, x, \theta) = \frac{\exp(MP_{ij})}{1 + \exp(MP_{ij})}. \tag{29}$$

This conditional probability model satisfies the three key assumptions in Mele (2017). If this edge formation process is observed over a sufficiently long time horizon, the long-run probability of observing a particular production network configuration g is:

$$\pi(g \mid x, \theta) = \frac{\exp(Q(g, x; \theta))}{c(\theta, x)}, \tag{30}$$

where $\theta = (a_0, a_1, a_2)$ is the parameter vector to be estimated, and $Q(g, x; \theta)$ represents the potential function:

$$Q(g, x; \theta) = a_0 \cdot \mathit{edges} + a_1 \cdot \mathit{reciprocity} + a_2 \cdot \mathit{transitivity}. \tag{31}$$

In the econometric specification, I incorporate a set of exogenous covariates to obtain the marginal benefit for municipality i from forming a directed edge to municipality j in the production network:

$$\begin{aligned}
MP_{ij} = a_0 &+ a_1 \cdot g_{ji} + a_2 \cdot l_{ij} \\
&+ \beta_1 |RSper_i - RSper_j| + \beta_2 RSper_i + \beta_3 RSper_j \\
&+ \beta_4 |PM_i - PM_j| + \beta_5 PM_i + \beta_6 PM_j \\
&+ \beta_7 |FM_i - FM_j| + \beta_8 FM_i + \beta_9 FM_j \\
&+ \beta_{10} |GDPper_i - GDPper_j| + \beta_{11} GDPper_i + \beta_{12} GDPper_j \\
&+ \beta_{13} |AGDPpercent_i - AGDPpercent_j| + \beta_{14} AGDPpercent_i + \beta_{15} AGDPpercent_j \\
&+ \beta_{16} |POP_i - POP_j| + \beta_{17} POP_i + \beta_{18} POP_j \\
&+ \beta_{19} |USnum_i - USnum_j| + \beta_{20} USnum_i + \beta_{21} USnum_j \\
&+ \gamma_1 distance_{ij} + \gamma_2 rotation_{ij},
\end{aligned} \tag{32}$$

where $RSper_i$ is the per capita road area in city i; PM_i is the degree of product market development in city i; FM_i is the degree of factor market development in city i; $GDPper_i$ is the per capita GDP of city i; $AGDPpercent_i$ is the proportion of primary industry in GDP of city i; POP_i is the population size of city i; $USnum_i$ is the number of college students per 10,000 people in city i;

$rotation_{ij}$ measures the local political connection between cities i and j (essentially the cumulative number of official rotations between the two cities); and $distance_{ij}$ measures the geographical distance between cities i and j.

Within the framework of strategic network formation as proposed by Gaonkar and Mele (2023) and Mele (2017), the equilibrium of the production network is characterized by an exponential random graph. This equilibrium can be empirically analyzed using econometric network models such as Exponential Random Graph Models (ERGM), Temporal Exponential Random Graph Models (TERGM), and Varying-Coefficient Exponential Random Graph Model (VCERGM), which yield parameter estimates with direct economic interpretations.

5 Econometric Analysis

Based on the theoretical model, I empirically analyze the impact of official rotations on the production network using the classic gravity model, spatial econometric models, and various network econometric techniques, including QAP network regression, ERGM, TERGM, and VCERGM.

5.1 Benchmark Analysis

This paper employs the classic gravity model to examine the impact of local political connections on inter-city input-output linkages. Jiang and Mei (2020) previously applied the gravity model to empirically analyze how cross-provincial official rotations influence interprovincial trade flows, using binary dummy variables derived from the mobility patterns of provincial party secretaries and governors to capture trade friction. Following the empirical approach of Jiang and Mei (2020), this paper investigates how inter-city official rotations, which create local political connections, shape input-output linkages between Chinese cities. In contrast to their work, however, this paper utilizes more comprehensive input-output data rather than aggregated trade flow statistics and shifts the analytical focus from the provincial to the municipal level, allowing for finer-grained insight into urban economic networks.

Specifically, the specification of the gravity model used in this paper is as follows:

$$logIO_{ij,t} = \alpha_0 + \alpha_1 rotation_{ij,t} + \beta_X X_{ij,t} + f_{ij} + f_{i,t} + f_{i,t} + u_{ij,t}, \tag{33}$$

where $IO_{ij,t}$ denotes the flow of intermediate goods trade from city i to city j at time t; $rotation_{ij,t}$ is a core dummy variable indicating the presence of a local political connection, constructed such that $rotation_{ij,t} = 1$ if the mayor of city i at time t has previously served as the mayor of city j; $X_{ij,t}$ is a vector of control variables influencing input-output trade flows between cities i and j, including the absolute differences in per capita urban road area, the level of product market development, the level of factor market development, per capita GDP, the share of primary industry in GDP, population size, and the number of college students per 10,000 people; f_{ij} represents city-pair fixed effects, incorporating the geographical distance between cities i and j; $f_{i,t}$ denotes origin-year fixed effects, which control for time-varying characteristics of the exporting city i, including its per capita urban road area, product market development, factor market development, per capita GDP, primary industry share, population size, and number of college students per 10,000 people in year t; and $f_{j,t}$ refers to destination-year fixed effects, analogously capturing time-varying features of the importing city j. The coefficient of interest is α_1.

To thoroughly investigate the guidance, adjustment, and reshaping effects of political connections on input-output linkages, this paper employs the gravity model to derive reliable causal inferences. A central identification challenge, however, is whether including cross-regional official rotations and the resulting official networks as a measure of local political connections introduces endogeneity. Specifically, the concern is whether the inter-city rotations of officials in mainland China may be correlated with unobserved variables, captured in the error term, that also affect input-output linkages.

The empirical framework and the econometric model adopted in this paper are subject to minimal endogeneity concerns. In practice, cross-regional rotations of officials are primarily determined exogenously by higher-level party committees and governments. These rotations are motivated by political and organizational objectives such as introducing advanced governance experience, reducing regional disparities, mitigating local factionalism, preventing rent-seeking, dampening vicious competition, and strengthening promotion incentives (Zhou, 2002). They are not typically influenced by factors likely to affect inter-city input-output linkages, such as cultural patterns of labor division or the size of inter-city migrant populations. Therefore, official rotations and the resulting official networks can be considered exogenous variables shaped by political institutional design, exhibiting a low risk of endogeneity within our econometric specification. Moreover, existing literature often treats cross-regional official rotations as quasi-experimental exogenous shocks to identify causal effects. Jiang and Mei (2020), for instance, assumed orthogonality between provincial leader rotations and unobserved determinants of bilateral trade flows when applying the gravity model, and subsequently validated this identification assumption through multiple robustness tests.

Table 6 presents the corresponding regression results. The findings indicate that such political connections exert a significant and positive influence on inter-city input–output linkages. Specifically, when the mayor of city i in period t had previously served as mayor of city j, this connection is associated with a significant increase in intermediate goods trade flows from city i to city j during the same period.

Building upon the traditional trade gravity model employed by Jiang and Mei (2020), this paper further adopts spatial econometric models to examine spatial spillover effects of inter-city input-output linkages within the official network. Specifically, I investigate whether forward and backward linkages of a city are influenced by spillovers from corresponding linkages of other cities within the official network. Forward linkage captures the economic relationships between a specific sector and its downstream sectors, that is, where the sector sells its outputs. Conversely, backward linkage reflects connections with upstream sectors from which the sector purchases inputs. In addition to analyzing forward and backward linkages separately, this paper constructs a composite measure by taking the simple average of these two indicators to evaluate the spatial spillover effects of average input-output linkage strength across cities within the official network.

This paper integrates the Spatial Autoregressive Model (SAR) and the Spatial Error Model (SEM) by incorporating both a spatial lag term and a spatial error term into a Spatial Linear Regression (SLR) framework, following the general specification of the SARAR model (Anselin, 1988). The specific model formulation in matrix notation is given as follows:

$$
\begin{aligned}
&Linkage_{it} = \rho W_1 Linkage_{it} + X_{it}\beta_0 + \mu_{i0} + \alpha_{t0}\mathbf{1}_i + U_{it} \\
&U_{it} = \lambda W_2 U_{it} + V_{it},
\end{aligned}
\tag{34}
$$

where $Linkage_{it}$ represents the forward or backward linkage of each city; X_{it} includes urban characteristics such as per capita road area, product market development, degree of factor market development, per capita GDP, proportion of primary industry in GDP, population size, and number of college students per 10,000 people; μ_i denotes time-invariant unobserved city heterogeneity; α_t indicates unobserved year heterogeneity that does not vary across individuals; W_1 and W_2 are $i \times i$ spatial weight matrices constructed based on the inter-city official rotation network. The coefficients ρ and λ are the primary focus of this paper, capturing spillover effects of input-output linkages and error shocks from politically connected cities on the input-output linkages of a given city.

Compared to the gravity model, spatial econometric models entail more complex identification challenges. Specifically, whereas the spatial error term affects only the variance of the dependent variable, the spatial lag term introduces endogeneity that renders ordinary least squares (OLS) estimates inconsistent. Multiple estimation approaches have been proposed in the literature to address these issues and obtain reliable parameter estimates, including Maximum Likelihood Estimation (MLE), Quasi-Maximum Likelihood Estimation (QMLE), M-Estimation, and the Generalized Method of Moments (GMM) (Huber, 1964; Kelejian and Prucha, 1999; Lee, 2004).

For spatial panel data featuring both individual and time fixed effects, Lee and Yu (2010) developed a transformed QMLE procedure based on direct QMLE. This method, however, requires the spatial weight matrix to be both time-invariant and row-standardized. In this paper, the official network used to construct the spatial weights is time-invariant, yet row-standardization is infeasible due to the presence of isolated city nodes. Given the documented limitations of row-standardization discussed by Kelejian and Prucha (2010), I employ the Adjusted Quasi-Score Estimation (M-estimation) method proposed by Yang (2018). This estimator only requires that the row and column sums of the spatial weight matrix be bounded, accommodates time-varying weights, and does not rely on row-standardization. Importantly, it effectively accounts for potential heteroskedasticity in spatial panel models, a critical advantage in my empirical context. By adopting this approach, I effectively mitigate the endogeneity concerns inherent in the spatial econometric model.

Using both standard M-estimation and heteroskedasticity-robust MH-estimation, I analyze the spatial spillover effects of forward linkages, backward linkages, and average input-output linkages within official networks across cities. Table 7 presents the corresponding results.

Given the high likelihood of heteroskedasticity, I focus primarily on the robust MH-estimation results. The analysis reveals that in both forward linkages and average input-output linkages, the coefficients of the spatial error term are consistently positive and statistically significant. This indicates that error shocks related to these linkages from politically connected cities exert significantly positive spillover effects. In contrast, backward linkages show no statistically significant spatial spillover effects within official networks.

I also observe that the spatial lag term coefficients for forward and average input-output linkages are negative, though not statistically significant at conventional levels. This suggests a potential structural contradiction between the spatial lag and error terms, possibly due to their shared spatial weight matrix. To address this, I conduct robustness checks using spatial lag models that include only the lag term. Table 8 shows that all spatial lag coefficients remain positive and significant, confirming the positive spillover effects of political connections on inter-city input-output linkages.

Finally, to examine the spatial spillover effects of intra-city input-output self-linkages and better elucidate the causal mechanisms through which political connections influence inter-city linkages, I replace the dependent variable with cities' input-output self-linkages. I estimate both SARAR models (with both spatial terms) and SAR models (with only spatial lag terms) using heteroskedasticity-robust estimation. Table 9 presents the results, which show significant positive spatial spillover effects of self-linkages within official networks. This finding, considering the strategic substitutability between intra-city and inter-city production cycles, further corroborates the spatial spillover effects of inter-city input-output linkages through political connections.

Building on social network theory and embeddedness, this paper thoroughly investigates how political connections guide, adjust, and reshape the interconnected economic circulation between cities. To achieve this, it employs a series of network econometric models to derive reliable causal inferences. A central identification issue is whether the official network satisfies the modeling requirements for an exogenous covariate network, that is, whether it introduces endogeneity concerns in the econometric model where the dependent variable is the inter-city production network constructed from input-output trade data between cities. In other words, the question is whether the cross-regional mobility of officials among mainland Chinese cities is correlated with unobserved variables (captured in the error term) that may also affect the structure of the inter-city production network. As noted before, in practice, cross-regional official rotations are exogenously determined by higher-level authorities based on broader political and organizational goals (Zhou, 2002). The key identification assumption—that these rotations are orthogonal to unobserved factors influencing input-output networks—is supported by the robustness tests of Jiang and Mei (2020). It can therefore be concluded that the results of the network econometric analysis are reliable.

First, I employ QAP regression to analyze the effect of the official rotations on the production network. This method is appropriate because the presence of an input-output linkage between two cities depends not only on dyadic characteristics but also on the attributes of other cities and the broader network structure. Consequently, the observed network data are inherently interdependent, rendering traditional statistical inference invalid. QAP addresses this issue by preserving the network dependence structure during permutation-based significance testing.

QAP maintains the structure of the independent variable network constant, randomly permutes the rows and columns of the dependent variable network's adjacency matrix, and conducts inference by comparing the observed estimator against the distribution of estimators from the permuted networks. The model is specified as follows:

$$ION_{ij} = \alpha_0 + \alpha_1 PN_{ij} + X_{ij}\beta + u_{ij}, \tag{35}$$

where ION_{ij} indicates the input-output linkage from city i to city j, PN_{ij} indicates the local political connection between city i and city j, and the control variables include: per capita urban road area in the origin city, per capita urban road area in the destination city, and the convergence in per capita urban road area; product market development level in the origin city, product market development level in the destination city, and the convergence in product market development level; factor market development level in the origin city, factor market development level in the destination city, and the convergence in factor market development level; GDP per capita in the origin city, GDP per capita in the destination city, and the convergence in GDP per capita; share of primary industry in GDP in the origin city, share of primary industry in GDP in the destination city, and the convergence in the share of primary industry; population size of the origin city, population size of the destination city, and the convergence in population size; number of college students per 10,000 people in the origin city, number of college students per 10,000 people in the destination city, and the convergence in the number of college students per 10,000 people; as well as the geographical distance between the origin and destination cities.

The estimation results of the QAP model are presented in Table 10. Across all three time points, local political connections are statistically significant at the 1% level, with an average coefficient of 0.238. This implies that the presence of political connections increases the probability of forming input-output linkages by approximately 23.8%. Most control variables also exhibit signs consistent with theoretical expectations. Taking 2012 as an example: higher product market development is associated with a lower probability of cities being senders or receivers of input-output linkages; greater factor market development increases the likelihood of cities being senders; higher GDP per capita makes cities more likely to be senders; a larger share of primary industry in GDP reduces the probability of cities being senders or receivers; larger population size increases the probability of cities being senders; greater geographical distance significantly inhibits the formation of input-output linkages between cities.

ERGM is an econometric method for statistical inference of social networks (Holland and Leinhardt, 1981; Wasserman and Pattison, 1996), which is more suitable for describing bilateral or multilateral relationships. Compared with the traditional regression model, ERGM and TERGM can not only reflect the impact of exogenous variables on the production network but also effectively take into account the node attributes (city characteristics), bilateral attributes (the relationship between two cities), and multilateral attributes (the endogenous network structure of multiple cities) in the social network. The basic goal of ERGM is to construct a probability distribution that generates specific network structure features (Cranmer and Desmarais, 2011). The model is set as follows:

$$P(N, \boldsymbol{\theta}) = \frac{\exp\left\{\boldsymbol{\theta}' \mathbf{h}(N)\right\}}{\sum_{N^* \in \mathcal{N}} \exp\left\{\boldsymbol{\theta}' \mathbf{h}(N^*)\right\}}, \tag{36}$$

where $\boldsymbol{\theta}'$ is the parameter vector, N is the observed network and N_{ij} represents the flows of international students from country i to country j, $\mathbf{h}(N)$ is the statistics related to the network N, which mainly includes local endogenous network structure, exogenous network, node properties and bilateral properties. The variables of ERGM (and later TERGM) include local political connections, per capita urban road area, product market development, factor market development, GDP per capita, primary industry share, population size, and number of college students per 10,000 people, as well as various network structure variables and time statistics unique to TERGM. Under the framework of the ERGM general model, the social selection effect includes convergence, sender effect, and receiver effect.

Table 11 presents the ERGM estimation results for the three selected time points (2012, 2015, and 2017). Across all periods, the coefficients for local political connections are positive and statistically significant at the 0.001 level, indicating a strong facilitative effect on the formation of inter-city input-output linkages. The estimated coefficients suggest that when a political connection exists between cities, it substantially increases the odds of an input-output linkage. For instance, in 2012, the coefficient for political connection is 1.647, implying that the presence of such a connection increases the odds of an input-output edge by approximately 419% ($\exp(1.647) \approx 5.19$). The strongest effect is observed in 2015 ($\exp(1.759) \approx 5.80$, or 480% increase), while the weakest effect occurs in 2017 ($\exp(1.628) \approx 5.09$, or 409% increase). These results demonstrate that local political connections significantly promote the formation of input-output linkages between cities, providing robust support for the core hypothesis that cities connected through official rotations are more likely to develop economic ties.

This paper does not extensively interpret the coefficients for endogenous network structures, social selection effects, or other exogenous covariates. Notably, the transitivity coefficients are consistently positive and significant across all three time points, while the reciprocity coefficient is significantly positive in 2012 but significantly negative in 2015. This pattern suggests that the inter-city production network tended to form significant transitive and reciprocal structures in its early stages, but the prevalence of reciprocal structures shows a declining trend over time. The ERGM coefficient estimates differ from expectations, primarily because this analysis examines the static network structure of the inter-city production network at specific time points (2012, 2015, and 2017) rather than its dynamic structural evolution.

ERGM can only analyze the cross-sectional network structure at a specific time point, whereas it cannot reflect the dynamic, time-varying characteristics of the network. I further adopt TERGM (Cranmer et al., 2020) to take the network observed in the past as conditions. TERGM models and analyzes the network observed at multiple time points. The probability distribution of the network probability for the t period is

$$P(N^t|N^{t-K},...,N^{t-1},\boldsymbol{\theta}) = \frac{\exp\left\{\boldsymbol{\theta}'\mathbf{h}(N^t,N^{t-1},...,N^{t-K})\right\}}{c(\boldsymbol{\theta},N^{t-K},...,N^{t-1})}. \tag{37}$$

Compared with ERGM, the international sanction coefficient $\boldsymbol{\theta}$ in TERGM measures the common inhibitory effect of the official networks in the previous k period. Whenever the previous k period networks all increase an additional official rotation in the same direction relationship of the input-output linkage, then the conditional odds ratio of the production network is $\exp(\theta)$. Pool the models' overall observation periods to obtain the pooled TERGM model:

$$P(N^{K+1},...,N^T|N^1,...,N^K,\boldsymbol{\theta}) = \prod_{t=K+1}^{T} P(N^t|N^{t-K},...,N^{t-1},\theta). \tag{38}$$

To characterize the time-varying features of the dynamic inter-city production network, this study pools the networks observed in 2012, 2015, and 2017 and conducts empirical analysis using

TERGM, obtaining the baseline regression results. This paper examines the endogenous mechanisms of the network by sequentially incorporating edges, edges with reciprocity, and edges with transitivity. Additionally, the estimation method is switched to Markov Chain Monte Carlo Maximum Likelihood Estimation (MCMC-MLE) (Leifeld et al., 2018) to verify the robustness of the empirical findings further. These specifications correspond to columns (1) through (5) in Table 12, respectively.

From the baseline TERGM results, the coefficient for local political connections is significantly positive, indicating that political connections exert a significant and dynamically positive effect on the formation of inter-city input-output linkages. Cities connected through official rotations are more likely to establish input-output ties. Unlike the ERGM results reported earlier, the coefficients for endogenous network structures in the TERGM suggest that the inter-city production network does not exhibit a strong tendency toward transitive or closed structures overall; instead, reciprocal input-output linkages between cities have become more common. This paper does not extensively interpret the series of coefficients for social selection effects and other exogenous covariates, as their economic implications are consistent with the earlier QAP analysis.

Compared to the baseline TERGM specification in columns (1) for the inter-city production network, the estimates in columns (2)–(4) further confirm the robustness of the endogenous formation mechanisms—namely, reciprocity and transitivity. Meanwhile, the specification in column (5), which alters the estimation method to MCMC-MLE, yields results highly consistent with the baseline model, indicating that the core findings of this paper are robust.

As mentioned earlier, in the analysis framework of TERGM, the endogenous formation mechanisms of edges, transitivity, and reciprocity in the production network are robust. Due to TERGM ignoring the heterogeneity of network structure, it cannot fully capture the time-varying patterns of network structure (Lee et al., 2020).

I further use the VCERGM method to characterize the heterogeneity of edges, transitivity, and reciprocity structures in a total of six production networks (2012-2017). In this paper, given the availability of data for three years (2013, 2014, and 2016), linear interpolation is employed to estimate missing input-output values between cities. Based on the completed data, three additional binary (0-1) inter-city production networks are constructed. Because TERGM can degenerate into a set of independent and identically distributed ERGM models, I compare the coefficients obtained from VCERGM analysis of the production network with those obtained from cross-sectional ERGM analysis to better reflect the dynamic changes in the edges, transitivity, and reciprocity structures of the production network. The results are shown in Figure 3.

From Figure 3, it can be visually observed that the coefficient fluctuation amplitude obtained from cross-sectional ERGM analysis is significantly higher than that of VCERGM, and the latter is also more computationally efficient, which confirms the simulation-based conclusions in Lee et al. (2020). I further found that the coefficient of edges remained negative, with its absolute value showing an overall trend of first decreasing and then increasing. The coefficient of reciprocity remained positive and exhibited a pattern of first decreasing and then increasing, indicating that the inter-city production networks tend to form reciprocal structures of bidirectional input-output linkages, reaching a trough in 2015. The coefficient of transitivity remained negative and fluctuated considerably, suggesting that the networks do not tend to form significant transitive structures or closure trends, and the existing closed transitive triads were formed historically.

5.2 Heterogeneity Analysis

The previously constructed inter-city production network, which reflects input–output linkages between cities, was based on aggregated sectoral data from interregional input–output tables across 188 mainland Chinese cities. It did not differentiate specific industrial sectors, nor did it account for potential heterogeneous effects of transaction cost savings resulting from local political connections across sectors. In this subsection, rather than aggregating the input–output tables, I focus on four specific sectors: Agriculture, Forestry, Animal Husbandry, and Fishery Products and Services (Sector 1); Information Transmission, Software, and Information Technology Services (Sector 2); Education, Scientific Research, and Technical Services (Sector 3); and Education (Sector 4). For each sector, I derive corresponding intermediate input and demand matrices and construct four distinct inter-city production networks based on these single-sector data.

Table 13 reports TERGM results examining the relationship between inter-city input–output linkages and local political connections—measured through the mayor transfer network—for these four sectors in 2012, 2015, and 2017. The results show that local political connections exert a statistically significant effect on input–output linkages across all sectors, though the magnitude of this effect varies substantially. Specifically, the effect is strongest in Information Transmission, Software, and Information Technology Services, and smallest in Education.

Moreover, the official transfer network used in prior analyses to measure informal local political connections was constructed from inter-city mobility trajectories of mayors across 188 cities between 2000 and 2023. Given that the leadership of the Communist Party of China is a defining feature of socialism with Chinese characteristics, and that the municipal Party committee secretary serves as the unequivocal "first-in-command" within China's power structure, I further construct a municipal Party committee secretary network to capture informal local political connections. This allows an analysis of heterogeneous impacts on input–output linkages. Additional empirical results on the effects of a combined official network—incorporating both secretary and mayor transfers—are provided in the Appendix. For robustness, I use two methods to characterize this combined network: first, a non-binary aggregated network formed by summing the secretary and mayor networks, reflecting the strength of political connections; second, a binarized version where all non-zero elements in the adjacency matrix are set to 1.

Table 14 presents TERGM results analyzing the relationship between inter-city input–output linkages and local political connections—measured via the secretary transfer network—for the aggregate network and the four single sectors across the three years. The results are highly consistent with those from the mayor network: secretary-formed political connections also significantly affect input–output linkages across all sectors, with effect sizes again exhibiting clear heterogeneity. The strongest effect remains in Information Transmission, Software, and Information Technology Services, and the weakest in Education. A further horizontal comparison reveals that, except in Education, the effect size of political connections formed by mayors is generally larger than that formed by secretaries. This pattern reflects the unique characteristics of China's political system regarding the division of labor between the Party and the government.

5.3 Mechanism Analysis

Geographical distance is a key factor influencing input–output linkages, as it affects both the transport costs of physical goods and the information costs of intangible flows. Greater distance typically raises the information costs required to establish input–output linkages. To investigate the specific mechanism through which local political connections facilitate these linkages, I introduce an interaction term between local political connections and geographical distance into the baseline TERGM specification. I initially expected a significantly positive coefficient on this term, indicating that political connections weaken the inhibiting effect of distance.

Additionally, using data from the "2017 Ranking of Government-Business Relations in Chinese Cities"—released by the Center for Government-Business Relations and Industrial Development at Renmin University of China—I construct an inter-city political distance network. This network is based on differences in the Government-Business Relations Health Index between 188 cities, serving as a measure of formal institutional distance. A larger difference (greater political distance) implies lower institutional friction for establishing input–output linkages. I incorporate this political distance network into the baseline TERGM and further include an interaction term between local political connections and political distance. Since both factors may reduce institutional friction, I expected their effects to be substitutable: a positive coefficient for political distance, a positive coefficient for political connections, and a negative coefficient for their interaction.

Table 15 presents the empirical results. Contrary to initial expectations, the interaction term between local political connections and geographical distance is significantly negative, while geographical distance itself remains negative and significant. This suggests that local political connections strengthen, rather than mitigate, the negative effect of geographical distance on input–output linkages. When a political connection exists, geographical proximity becomes even more influential. This counterintuitive result suggests that such connections do not significantly reduce information costs associated with distance. The reason may lie in the pattern of municipal-level official transfers, which occur primarily between geographically close cities (within the same province). Thus, while political connections overall promote input–output linkages, they do so mainly between nearby cities, thereby exacerbating the inhibitory effect of distance on linkages between farther cities.

On the other hand, the results for political distance and its interaction with political connections align with hypotheses. The coefficient for political distance is significantly positive, indicating that greater differences in government–business relations reduce institutional friction and facilitate input–output linkages. The coefficient for local political connections remains positive and significant, and the interaction term is significantly negative. This confirms that the mechanism through which informal local political connections promote linkages is substitutable with the effect of political distance. Thus, local political connections facilitate input–output linkages primarily by reducing institutional friction costs in inter-city trade.

In summary, this mechanism analysis provides deeper insight into the channels through which local political connections influence input–output linkages. In the context of this study and its data, the primary mechanism is the reduction of institutional friction costs, not information costs. The limited role of information cost reduction is closely tied to the spatial patterns of official transfers in China.

6 Counterfactual Analysis

This paper proposes a novel methodological framework for network counterfactual analysis to rigorously examine how interregional official rotations—which establish local political connections—affect urban input–output linkages within a production network framework.

As noted previously, coefficient estimates from the ERGM reflect the marginal effects of network statistics on the likelihood of edge formation in the production network, thereby capturing primarily static and local effects—that is, the direct influence of official rotations on inter-city input–output linkages. However, due to endogenous network structures and time-varying dependencies, official rotations may also indirectly affect input–output linkages between other cities and propagate throughout the network. These ripple effects, known as indirect or spillover effects, are not captured by conventional ERGM estimates but emerge through the interconnected and dynamic nature of the production network.

Figure 4, which incorporates the transitivity structure established in the model, visually illustrates the mechanism of network spillover effects. Consider three city nodes (i, j, k) in the production network during period t, where initially a one-directional input–output linkage exists from i to j, and both i and k have recently received officials rotated from city j. If the rotated officials from j to i and from j to k facilitate interjurisdictional cooperation, the input–output linkages between j and i and between j and k strengthen, representing the direct effect of official rotations. Subsequently, a reciprocity structure emerges between i and j. Although this endogenous structure does not propagate beyond these cities, it produces a spillover effect on the original linkage from i to j. Moreover, due to transitivity closure within the triangular structure, the input–output linkage $i \to k$ is facilitated through the established paths $i \to j$ and $j \to k$.

This change constitutes an indirect spillover effect resulting from the official rotations. Such effects may persist and propagate throughout the network until a new equilibrium is reached. It is important to note, however, that while official rotations increase the probability of edge formation, they do not guarantee actual linkage realization. Therefore, in the model, an edge in the production network is assumed to form only when the predicted probability exceeds a predefined threshold.

To investigate both direct and spillover effects of official rotations, I extend the ERGM specification by applying an inverse logistic transformation, analogous to binary response models. This extension facilitates the derivation of change statistics and enables computation of the predicted probability of an edge between any two nodes, given the estimated coefficients (Harris, 2013). Using these ERGM-based predicted probabilities, variations in edge formation likelihood can be assessed by constructing counterfactual scenarios involving official rotations. Guided by a predefined threshold for edge formation, this counterfactual approach is employed within a causal inference framework to quantify both direct and spillover effects of official rotations on inter-city input–output linkages in the short and long term.

The general procedure for the counterfactual analysis is as follows. Suppose the connection between cities i and j in the official network S changes from 0 to 1—that is, an official rotates from i to j—while all other exogenous variables remain unchanged. Using change statistics (Harris, 2013), I compute the updated probability of an input–output linkage from i to j in the production network, denoted $P^{(1)}(N_{ij} = 1)$. At this stage, connection probabilities among all other city pairs remain unchanged. Let the observed production network be $N^{(0)} = N$. I define a threshold ω such that if $P^{(1)}(N_{ij} = 1) \geq \omega$, the edge $i \to j$ is updated from 0 to 1, yielding $N^{(1)}$ with $N_{ij}^{(1)} = 1$. Using this updated network, I recalculate change statistics and update probabilities for all other edges. This process is repeated iteratively until the network exhibits no further structural changes (convergence) or enters a cycle (divergence). The final network allows me to quantify various causal effects: the short-term direct effect is defined as the change in connection probability from N_{ij} to $N_{ij}^{(1)}$; the long-term direct effect corresponds to the change from N_{ij} to $N_{ij}^{(n)}$; the short-term spillover effect is measured as the average change in connection probabilities from N_{-ij} to $N_{-ij}^{(2)}$ across all other city pairs; and the long-term spillover effect is given by the average change from N_{-ij} to $N_{-ij}^{(n)}$ over all non-focal dyads.

For illustrative purposes, the 2012 ERGM results serve as the baseline for counterfactual analysis, though the methodology applies to any time point within the study period. A counterfactual approach is employed—following the iterative steps outlined above—to analyze the interplay between the production network and the official network. Specifically, the short-term direct effects of official rotations are examined by simulating a scenario in which all directed rotations present in the year 2012 are simultaneously removed. For each affected node pair (i, j), the original predicted probability of edge formation $P^{(0)}(N_{ij} = 1)$ is compared against the new probability

$P^{(1)}(N_{ij} = 1)$ obtained immediately after removing rotation effects but before accounting for any network spillovers. The aggregate short-term direct effect is calculated as:

$$\frac{\Sigma_{(i,j)\in(i,j)|S_{ij}=1}[P^{(1)}(N_{ij} = 1) - P^{(0)}(N_{ij} = 1)]}{|(i,j)|S_{ij} = 1|}. \tag{39}$$

In the data, a total of 125 city pairs subject to directed rotations are simultaneously affected. The results indicate that, in the absence of official rotations, the probability of forming input–output linkages between cities that actually had such connections would decrease by an average of 30.19%. This represents the short-term direct effect of political connections on the overall inter-city production network—a substantial effect that should not be overlooked.

Furthermore, from a micro perspective, this paper employs counterfactual simulations to measure both the direct effect of the Hangzhou–Wenzhou political connection on their bilateral input–output linkage and its spillover effect on linkages among other city pairs, and ultimately on the entire production network. The analysis focuses specifically on the impact of removing the political connection formed through official rotations between Hangzhou and Wenzhou.

A counterfactual analysis is conducted to measure the effects of removing the political connection between Hangzhou and Wenzhou. The formation threshold is set at the 99th percentile of the original predicted probabilities ($P^{(0)}(N_{\star\star} = 1)$) across all node pairs to ensure substantive meaningfulness of simulated structural changes. The iterative process converged after 7 iterations, beginning with the initial removal of the connection (Iteration 1). The simulation exhibited notable fluctuations in network structure during the transient phase before reaching equilibrium. As summarized in Table 16, the first iteration resulted in the removal of two edges between Hangzhou and Wenzhou, while subsequent iterations introduced considerable volatility in connectivity, with both significant increases and decreases in edge counts. The process stabilized by Iteration 7, with no further changes occurring.

Table 17 reports the direct and spillover effects of removing the Hangzhou–Wenzhou political connection. The short-term direct effect is defined as the change in the predicted probability of edge formation between Hangzhou and Wenzhou from the original network ($P^{(0)}$) to the network after the first iteration ($P^{(1)}$); the long-term direct effect is the change from $P^{(0)}$ to the probability in the final converged network ($P^{(7)}$). The short-term spillover effect is the average change in predicted probabilities across all other city pairs from $P^{(0)}$ to $P^{(2)}$, and the long-term spillover effect is the average change from $P^{(0)}$ to the final network.

Specifically, in the short term, the direct effects are negative (-0.1779 and -0.5702), indicating that removing the political connection inhibits the formation of input–output linkages between the two cities, with a stronger inhibitory effect on the linkage from Wenzhou to Hangzhou. This asymmetry is intuitively explained by the differing political-economic statuses of the two cities: without a political connection, the probability of forming an input–output link from the less advantaged Wenzhou to the more central Hangzhou is significantly reduced. The short-term spillover effect is positive (0.0050), suggesting that linkages among other city pairs become more likely, reflecting a degree of substitutability in inter-city production connections. In the long term, the direct effects remain unchanged, indicating that subsequent structural changes did not further alter the linkage probabilities between Hangzhou and Wenzhou. The spillover effect diminishes to 0.0005. In both the short and long term, the direct effect outweighs the spillover effect, which is consistent with expectations given that the spillover mechanisms in the model—reciprocity and transitivity, as illustrated in Figure 4—only propagate secondary effects to a limited extent.

7 Conclusions and Discussions

7.1 Research Conclusions

This paper contributes to the literature by addressing the undersocialized view of traditional transaction cost economics through the integration of social network theory and embeddedness analysis. I develop a novel theoretical framework that explains how local governments can strategically adapt and reshape the structure of national economic circulation. Using a simplified game-theoretic model, I show that interregional rotations of officials reduce transaction costs by relaxing incentive constraints and serving as credible commitments to lower institutional barriers. Furthermore, a multi-sector, multi-region general equilibrium trade model that explicitly incorporates official networks demonstrates that local political connections significantly shape inter-city input-output trade equilibrium.

Empirically, I draw on comprehensive data concerning official rotations and inter-city input-output flows, and employ gravity models and spatial econometric techniques to show that a mayor with prior administrative experience in another city significantly boosts trade in intermediate goods between those cities. I identify three distinct mechanisms of spatial spillover: a forward linkage, a backward linkage, and the average input-output correlation within official networks, in addition to self-reinforcing intra-city production linkages. My findings highlight the crucial role of political network embeddedness in facilitating regional economic interactions within China's distinctive institutional context.

The analysis confirms that cities connected through official rotations develop stronger input-output linkages. The overall inter-city production network shows no significant transitivity; rather, reciprocal production relationships are widespread. Reciprocity coefficients are persistently positive, indicating mutual reinforcement of bilateral production ties, while transitivity coefficients are consistently negative, suggesting that transitive triangular structures reflect historical patterns rather than actively emerging ones. Aggregating across all sectors, I find that political connections exert a significant and dynamically positive effect on inter-city input-output linkages, with connections formed by mayors exerting a stronger influence than those formed by municipal party secretaries.

My heterogeneity analysis across four sectors reveals substantial variation in effect sizes. Political connections exert the strongest influence on input-output linkages in information transmission, software, and IT services, and the weakest in education. In all sectors except education, mayors' political connections produce larger effects than those of party secretaries.

Mechanism tests further indicate that informal political connections enhance inter-city input-output linkages primarily by reducing institutional friction costs, rather than information costs. Moreover, I find that this mechanism serves as a substitute for the role of political distance.

Through counterfactual simulations that eliminate the political connection between Hangzhou and Wenzhou, I find a negative short-term direct effect but a positive short-term spillover effect. The long-term direct effect remains similar in magnitude to its short-term counterpart, while the long-term indirect effect diminishes. Overall, the direct effect outweighs the indirect effect, resulting in a net positive total welfare loss.

7.2 Policy Implications

These findings offer several policy implications for adjusting the structure of national economic circulation, shaping inter-city input-output linkages, promoting domestic market integration, and fostering new, high-quality productive forces:

Given that a mayor's prior administrative experience in another city significantly enhances intermediate goods trade, superior governments should strategically design and implement inter-regional rotation systems. Doing so would capitalize on the role of rotations in reducing transaction costs, establish political connections between cities with complementary industrial structures, and actively shape more efficient input-output networks.

Current rotation practices are often constrained by provincial boundaries, which is suboptimal. To fully unleash the spatial spillovers of production linkages, rotations should be planned according to cities' functional positions within the national economic cycle—such as manufacturing hubs, processing bases, or innovation cores—ensuring that political resources are allocated to strengthen relevant forward or backward linkages and enhance macroeconomic coordination.

As political connections most strongly boost input-output linkages in information transmission, software, and IT services, targeted rotations between cities with complementary digital economies should be prioritized. This can stimulate high-quality development in the digital sector and provide new momentum for cultivating modern, advanced productive forces.

At present, rotations reinforce the constraining effect of geographical distance and do not significantly reduce information costs, functioning mainly through lowering institutional friction. To unlock the potential of political connections in reducing information asymmetry, rotation policies should extend beyond geographically proximate pairs within the same province, encouraging input-output linkages across broader regions and facilitating the formation of a unified national market.

Although the direct effect of political connections is positive and larger than the negative spillover effect—implying some degree of substitutability between bilateral ties—central and provincial authorities should adopt a holistic planning perspective. Rotation policies should account for economy-wide network effects to maximize positive direct impacts while mitigating adverse spillovers that could hinder the emergence of a fully integrated domestic market.

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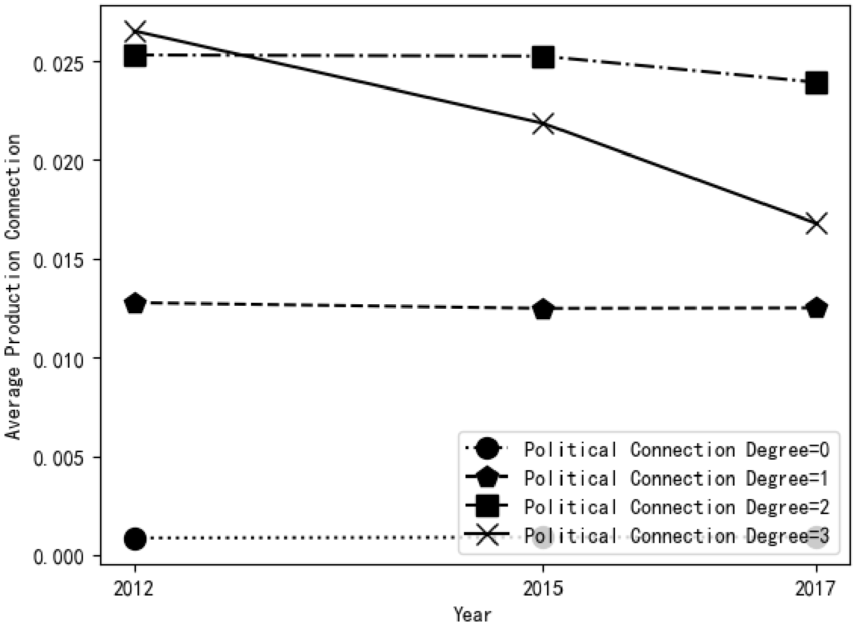
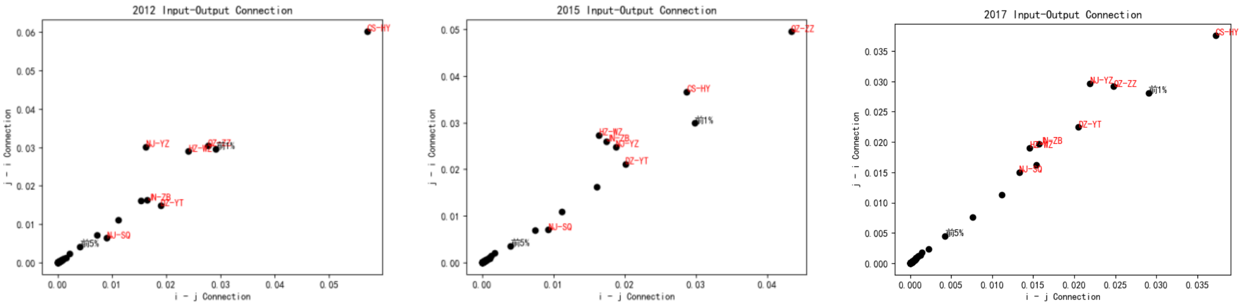
Figures and Tables

Figure 1: Political Connections and Average Input-Output Linkages



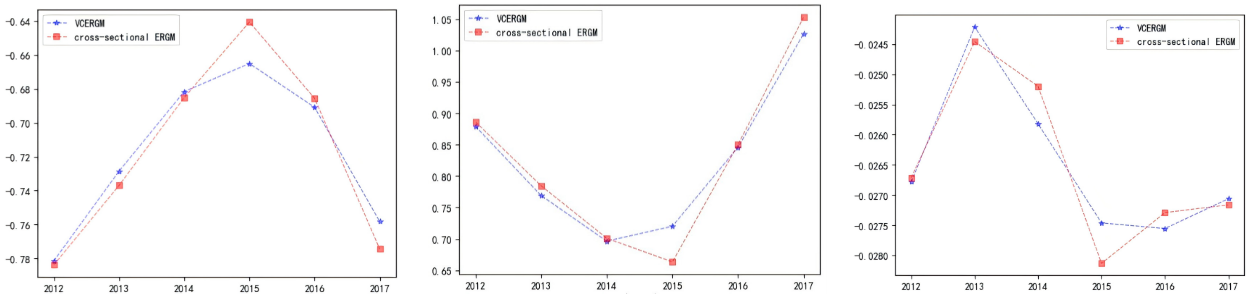
Note: On average, a positive correlation is observed between the strength of political connections and average input-output linkages, suggesting a mutually reinforcing relationship between these two dimensions.

Figure 2: Quantile Scatter Plots of Input-Output Linkages



Note: The Figure shows that directional input-output linkages—in both directions—for city pairs with strong political connections are substantially higher than those of the top 5% group. Most exceed even the top 2%, and some fall within the top 1%, indicating a strong positive association between political connections and input-output linkages.

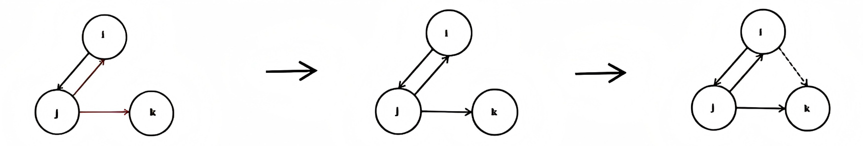
Figure 3: VCERGM Analysis: Dynamic Coefficients of Endogenous Structures in Inter-City Production Networks (2012-2017)



(a) Edge Number (b) Reciprocity (c) Transitivity

Note: The figure shows the heterogeneity of edge, reciprocity, and transitivity structures across a total of 6 inter-city production networks from 2012 to 2017. It compares the coefficients obtained from the VCERGM analysis of these networks with the corresponding coefficients from cross-sectional ERGM analyses to better reflect the dynamic changes in their structures.

Figure 4: Illumination: Network Spillover Effects of Official Rotations on the Production Network



Note: Consider three city nodes (i, j, k) in the actual production network during period t, where initially only a one-directional input-output linkage exists from i to j, and both i and k have recently received officials rotated from city j. If the rotated officials from j to i and from j to k begin to facilitate interjurisdictional cooperation, the strength of input-output linkages between j and i and between j and k increases, thereby reinforcing these linkages. This change represents the direct effect of official rotations. Subsequently, a reciprocity structure forms between i and j in the inter-city network. Although this endogenous structure does not propagate beyond these cities, it produces a spillover effect on the original economic linkage from i to j. Moreover, due to the property of closed transitivity in triangular structures, the formation of the input-output linkage $i \rightarrow k$ is facilitated through the established linkages $i \rightarrow j$ and $j \rightarrow k$.

Table 1: International, Inter-city, and Intra-city Production Circulation in Input-Output Analysis

Year	Indicator	Intermediate Inputs	Intermediate Demand
2012	Total (100 million CNY)	1168776	1126244
	Foreign Total	136666	94134
	Domestic Production Circulation	1032110	1032110
	Inter-city Share	45.1%	46.8%
	Intra-city Share	43.2%	44.8%
	International Circulation (Foreign Share)	11.7%	8.4%
2015	Total (100 million CNY)	1446534	1423228
	Foreign Total	148448	125143
	Domestic Production Circulation	1298086	1298085
	Inter-city Share	46.8%	47.6%
	Intra-city Share	42.9%	43.7%
	International Circulation (Foreign Share)	10.3%	8.8%
2017	Total (100 million CNY)	1493394	1478633
	Foreign Total	163847	149086
	Domestic Production Circulation	1329547	1329547
	Inter-city Share	48.3%	48.8%
	Intra-city Share	40.7%	41.1%
	International Circulation (Foreign Share)	11.0%	10.1%

Note: Unit: 100 million CNY. Data source: Multi-regional input-output tables for 313 Chinese cities in 2012, 2015, and 2017, compiled and released by CEADs.

Table 2: Descriptive Statistics of the Inter-City Production Network (2012, 2015, 2017)

Metric	2012	2015	2017
Out-degree	75.202 (57.145)	75.202 (53.980)	75.202 (56.716)
Eigenvector Centrality	0.519 (0.236)	0.523 (0.225)	0.541 (0.244)
Transitivity	0.740	0.748	0.743
Diameter	3	4	3

Table 3: Regression-Based Structural Stability Tests: Estimates and P-values

Inter-City Production Network	Out-degree	Eigenvector Centrality	Transitivity
2012 vs 2015			
Intercept	75.202 (0.000)	0.519 (0.000)	0.824 (0.000)
Slope	0.000 (1.000)	0.005 (0.836)	-0.010 (0.390)
2015 vs 2017			
Intercept	75.202 (0.000)	0.523 (0.000)	0.814 (0.000)
Slope	0.000 (1.000)	0.017 (0.482)	0.010 (0.404)
2012 vs 2017			
Intercept	75.202 (0.000)	0.519 (0.000)	0.824 (0.000)
Slope	0.000 (1.000)	0.022 (0.375)	-0.001 (0.969)

Table 4: Randomization Test for Structural Stability: P-values

Inter-City Production Network	2012 vs 2015	2015 vs 2017	2012 vs 2017
Average Out-degree	1.000	0.960	0.990
Node Out-degree	0.010	0.010	0.010
Eigenvector Centrality	0.010	0.010	0.010
Transitivity	0.010	0.208	0.475
Diameter	0.327	0.505	1.000
$2\rightarrow2$ Norm	0.010	0.010	0.010

Table 5: Randomization Test for Structural Similarity: Production Network vs. Official Network

	P-value		
	2012	2015	2017
Average Out-degree	0.010	0.010	0.010
Node Out-degree	0.010	0.010	0.010
Eigenvector Centrality	0.010	0.010	0.010
Transitivity	0.010	0.010	0.010
Diameter	0.010	0.010	0.010
2→2 Norm	0.010	0.010	0.010

Note: This table presents p-values from randomization tests (Auerbach, 2022) examining structural similarity between the inter-city production network and the official rotation network. The null hypothesis posits that both networks are generated by the same stochastic model. All reported p-values are statistically significant at conventional levels, indicating rejection of the null hypothesis and suggesting substantial structural differences between the two networks across all examined years.

Table 6: Gravity Model Estimation Results

	$logIO_{ij,t}$				
$rotation_{ij,t}$	0.394***	0.244***	0.214**	0.230**	0.368***
	(0.100)	(0.091)	(0.090)	(0.094)	(0.097)
$X_{ij,t}$	N	N	N	Y	Y
f_{ij}	N	N	Y	Y	Y
$f_{i,t}$	N	N	N	N	Y
$f_{i,t}$	N	N	N	N	Y
Time FE	N	Y	Y	Y	Y

Note: Robust standard errors in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table 7: Spatial Econometric Model Estimation Results

	M-estimation		MH-estimation (Robust)	
Parameters	Coefficient	Std. Error	Coefficient	Std. Error
Forward Linkages				
ρ (Spatial Lag)	0.0032	0.0354	-0.0931	0.0465
λ (Spatial Error)	0.1096	0.0358	0.2031	0.0224
Backward Linkages				
ρ (Spatial Lag)	-0.0087	0.0355	0.1008	1.0785
λ (Spatial Error)	0.1100	0.0399	0.0001	1.2580
Average Input-Output Linkages				
ρ (Spatial Lag)	-0.0019	0.0349	-0.0934	0.0441
λ (Spatial Error)	0.1119	0.0373	0.2021	0.0233
City FE	Yes			
Time FE	Yes			
Additional Controls	Yes			

Note: This table presents estimation results from spatial econometric models incorporating both spatial lag (ρ) and spatial error (λ) terms. MH-estimation provides heteroskedasticity-robust standard errors. Coefficients of the spatial error term for forward linkages and average input-output linkages are consistently positive and statistically significant, indicating positive spatial spillover effects through official networks.

Table 8: Robustness Check: Spatial Lag Model Results

	M-estimation		MH-estimation (Robust)	
Parameters	Coefficient	Std. Error	Coefficient	Std. Error
Forward Linkages				
ρ (Spatial Lag)	0.0936	0.0300	0.1087	0.0354
Backward Linkages				
ρ (Spatial Lag)	0.0809	0.0303	0.0927	0.0327
Average Input-Output Linkages				
ρ (Spatial Lag)	0.0887	0.0303	0.0010	0.0344
City FE	Yes			
Time FE	Yes			
Additional Controls	Yes			

Note: This table presents robustness check results using spatial lag models. All spatial lag coefficients are positive and statistically significant, confirming positive spatial spillover effects of political connections on inter-city input-output linkages.

Table 9: Spatial Analysis of Input-Output Self-linkage

	M-estimation		MH-estimation (Robust)	
Parameters	Coefficient	Std. Error	Coefficient	Std. Error
SARAR Model				
ρ (Spatial Lag)	0.0467	0.0289	0.0101	0.0464
λ (Spatial Error)	0.1343	0.0312	0.1794	0.0340
SAR Model				
ρ (Spatial Lag)	0.1443	0.0288	0.1579	0.0394
City FE		Yes		
Time FE		Yes		
Additional Controls		Yes		

Note: This table presents results from spatial econometric models examining input-output self-linkages. The significant positive coefficients indicate strong spatial spillover effects of self-linkages within official networks, supporting the strategic substitutability between intra-city and inter-city production cycles.

Table 10: QAP Regression Results of Inter-City Input-Output Linkages

	2012	2015	2017
$rotation_{ij}$	0.255***	0.232***	0.227***
	(0.000)	(0.000)	(0.000)
$RSper_i$	0.003	0.001	0.004
	(0.341)	(0.452)	(0.287)
$RSper_j$	0.002	0.003	0.001
	(0.402)	(0.378)	(0.476)
$\|RSper_i - RSper_j\|$	-0.001	-0.002	-0.001
	(0.491)	(0.423)	(0.467)
PM_i	-0.105***	-0.068***	-0.027*
	(0.000)	(0.000)	(0.074)
PM_j	-0.096***	-0.076***	-0.067***
	(0.000)	(0.000)	(0.000)
$\|PM_i - PM_j\|$	-0.044***	-0.042***	-0.054***
	(0.000)	(0.000)	(0.000)
FM_i	0.024***	0.004	0.022***
	(0.000)	(0.391)	(0.000)
FM_j	0.006	0.004	0.007
	(0.291)	(0.387)	(0.278)
$\|FM_i - FM_j\|$	0.014***	0.001	0.007
	(0.009)	(0.482)	(0.201)
$GDPper_i$	0.346***	0.457***	0.043
	(0.000)	(0.000)	(0.162)
$GDPper_j$	-0.065	-0.106	-0.031
	(0.183)	(0.105)	(0.324)
$\|GDPper_i - GDPper_j\|$	0.058	-0.014	-0.060
	(0.156)	(0.412)	(0.174)
$AGDPpercent_i$	-0.011**	-0.007*	-0.018***
	(0.012)	(0.083)	(0.000)
$AGDPpercent_j$	-0.004*	-0.005*	-0.005
	(0.092)	(0.087)	(0.234)
$\|AGDPpercent_i - AGDPpercent_j\|$	0.006**	0.005**	0.009***
	(0.017)	(0.023)	(0.000)
POP_i	0.319***	0.361***	0.435***
	(0.000)	(0.000)	(0.000)
POP_j	0.023	-0.032	0.001
	(0.342)	(0.287)	(0.491)
$\|POP_i - POP_j\|$	-0.004	0.036	0.037
	(0.478)	(0.254)	(0.241)
$USnum_i$	0.040	0.099***	0.081*
	(0.178)	(0.000)	(0.051)
$USnum_j$	-0.045*	-0.017	-0.073*
	(0.086)	(0.392)	(0.062)
$\|USnum_i - USnum_j\|$	-0.019	-0.043	0.010
	(0.378)	(0.241)	(0.432)
$distance_{ij}$	-0.126***	-0.123***	-0.119***
	(0.000)	(0.000)	(0.000)

Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. P-values are shown in parentheses.

Table 11: ERGM Estimation Results for Input-Output Linkages and Political Connections

	2012	2015	2017
Edges	2.090^{+}	-1.408^{***}	1.079^{***}
Reciprocity	0.207^{**}	-0.590^{+}	-0.023
Transitivity	0.082^{+}	0.104^{+}	0.114^{+}
$rotation_{ij}$	1.647^{+}	1.759^{+}	1.628^{+}
$\lvert RSper_i - RSper_j \rvert$	0.001	-0.003	-0.001
$\lvert PM_i - PM_j \rvert$	-0.195^{+}	-0.192^{+}	-0.232^{+}
$\lvert FM_i - FM_j \rvert$	0.063^{+}	0.008	0.037^{+}
$\lvert GDPper_i - GDPper_j \rvert$	0.202^{***}	-0.242^{+}	-0.176^{+}
$\lvert AGDPpercent_i - AGDPpercent_j \rvert$	0.008^{*}	0.013^{+}	0.009^{**}
$\lvert POP_i - POP_j \rvert$	0.023	0.141^{+}	0.085^{**}
$\lvert USnum_i - USnum_j \rvert$	-0.151^{+}	-0.237^{+}	-0.014
$RSper_i$	0.006^{**}	-0.003	0.011^{+}
PM_i	-0.469^{+}	-0.229^{+}	-0.018
FM_i	0.151^{+}	0.018^{***}	0.113^{+}
$GDPper_i$	1.773^{+}	2.392^{+}	0.263^{+}
$AGDPpercent_i$	-0.086^{+}	-0.031^{+}	-0.113^{+}
POP_i	1.726^{+}	1.830^{+}	2.358^{+}
$USnum_i$	0.213^{+}	0.527^{+}	0.565^{+}
$RSper_j$	0.006^{**}	0.010^{+}	-0.005^{**}
PM_j	-0.318^{+}	-0.224^{+}	-0.292^{+}
FM_j	-0.030^{+}	0.005	-0.028^{+}
$GDPper_j$	-0.873^{+}	-1.278^{+}	-0.267^{+}
$AGDPpercent_j$	0.010^{**}	-0.010^{***}	0.033^{+}
POP_j	-0.499^{+}	-0.857^{+}	-1.043^{+}
$USnum_j$	-0.321^{+}	-0.292^{+}	-0.547^{+}
$distance_{ij}$	-0.560^{+}	-0.522^{+}	-0.482^{+}

Note: This table presents ERGM coefficients estimating the formation of inter-city input-output linkages. $^{+}$, ***, **, and * denote significance at the 0.001, 0.01, 0.05, and 0.1 levels, respectively.

Table 12: TERGM Baseline and Robustness Check Results

	(1)	(2)	(3)	(4)	(5)
Edges	3.154	4.012	3.152	3.928	4.392^{+}
Reciprocity	1.122^{+}		1.173^{+}		1.143^{+}
Transitivity	-0.024^{+}			-0.029^{+}	-0.050^{+}
$rotation_{ij}$	1.664^{+}	1.875^{+}	1.647^{+}	1.885^{+}	1.724^{+}
$\lvert RSper_i - RSper_j \rvert$	-0.002	-0.002^{*}	-0.002^{*}	-0.002	-0.002
$\lvert PM_i - PM_j \rvert$	-0.282^{+}	-0.338^{+}	-0.279^{+}	-0.339^{+}	-0.254^{+}
$\lvert FM_i - FM_j \rvert$	0.053^{**}	0.069^{**}	0.059^{**}	0.062^{**}	0.059^{+}
$\lvert GDPper_i - GDPper_j \rvert$	-0.150	-0.154	-0.168	-0.136	-0.077^{*}
$\lvert AGDPpercent_i - AGDPpercent_j \rvert$	0.027^{+}	0.034^{+}	0.028^{+}	0.032^{+}	0.028^{+}
$\lvert POP_i - POP_j \rvert$	0.209^{+}	0.238^{***}	0.210^{***}	0.237^{+}	0.299^{+}
$\lvert USnum_i - USnum_j \rvert$	-0.150^{***}	-0.132^{**}	-0.127^{**}	-0.159^{**}	-0.127^{+}
$RSper_i$	0.010^{***}	0.009^{+}	0.009^{***}	0.011^{+}	0.009^{+}
PM_i	-0.187^{*}	-0.250^{**}	-0.185	-0.249^{**}	-0.149^{+}
FM_i	0.064^{**}	0.064^{**}	0.065^{**}	0.063^{**}	0.057^{+}
$GDPper_i$	0.987^{*}	0.781	0.974^{*}	0.810	0.958^{+}
$AGDPpercent_i$	-0.093^{+}	-0.106^{+}	-0.100^{+}	-0.098^{+}	-0.084^{+}
POP_i	2.118^{+}	1.995^{+}	2.100^{+}	2.023^{+}	1.954^{+}
$USnum_i$	0.433^{+}	0.346^{+}	0.413^{+}	0.373^{+}	0.393^{+}
$RSper_j$	0.004	0.007^{**}	0.004	0.007^{*}	0.003^{**}
PM_j	-0.347^{+}	-0.377^{+}	-0.343^{+}	-0.380^{+}	-0.353^{+}
FM_j	-0.010	0.005	-0.005	-0.001	-0.012^{**}
$GDPper_j$	-0.864^{+}	-0.572^{+}	-0.853^{+}	-0.594^{+}	-1.039^{+}
$AGDPpercent_j$	-0.013^{*}	-0.031^{+}	-0.016^{**}	-0.027^{+}	-0.013^{+}
POP_j	-0.479^{+}	-0.023	-0.484^{+}	-0.038	-0.627^{+}
$USnum_j$	-0.352^{+}	-0.234^{+}	-0.340^{+}	-0.254^{+}	-0.375^{+}
$distance_{ij}$	-0.546^{+}	-0.657^{+}	-0.541^{+}	-0.657^{+}	-0.537^{+}

Note: This table presents complete TERGM coefficients from the baseline model and robustness checks. Column (1): Baseline TERGM. Column (2): Model with edges only. Column (3): Model with edges and reciprocity. Column (4): Model with edges and transitivity. Column (5): MCMC-MLE estimation. $^{+}$, ***, **, and * denote significance at the 0.001, 0.01, 0.05, and 0.1 levels, respectively.

Table 13: TERGM Heterogeneity Analysis: Impact of Mayor Network by Sector

	Aggregate	Sector 1	Sector 2	Sector 3	Sector 4
$rotation_{ij}$	1.664^{+}	1.085^{+}	1.228^{+}	1.036^{+}	0.485^{+}
Edges	3.154	0.907	2.069	-1.489	3.256^{**}
Reciprocity	1.122^{+}	0.157	-0.587^{**}	-0.763^{+}	1.319
GWESP	-0.024^{+}	0.001	-0.023	-0.004	-0.084^{**}
$\lvert RSper_i - RSper_j\rvert$	-0.002	-0.002	0.015^{**}	0.007	-0.015^{*}
$\lvert PM_i - PM_j\rvert$	-0.282^{+}	-0.146^{**}	-0.385^{+}	0.018	-0.279
$\lvert FM_i - FM_j\rvert$	0.053^{**}	-0.027^{*}	-0.007	-0.060^{+}	0.059^{+}
$\lvert GDPper_i - GDPper_j\rvert$	-0.150	-0.082	0.044	-0.394^{**}	-0.206^{**}
$\lvert AGDPpercent_i - AGDPpercent_j\rvert$	0.027^{+}	-0.011^{+}	-0.004^{+}	0.015^{*}	0.019^{+}
$\lvert POP_i - POP_j\rvert$	0.209^{+}	0.080	0.285^{**}	0.274^{+}	0.200^{**}
$\lvert USnum_i - USnum_j\rvert$	-0.150^{***}	-0.260^{**}	-0.278^{+}	-0.066	-0.101
$RSper_i$	0.010^{***}	-0.001	-0.003	0.008	-0.001
PM_i	-0.187^{*}	-0.283	-0.452^{+}	-0.137	-0.247
FM_i	0.064^{**}	-0.142^{*}	0.017	-0.166^{+}	0.058
$GDPper_i$	0.987^{*}	0.192	0.290^{**}	0.406	0.061
$AGDPpercent_i$	-0.093^{+}	0.060^{+}	0.025^{+}	-0.001	-0.006
POP_i	2.118^{+}	0.428^{+}	1.606^{+}	1.163^{+}	0.082
$USnum_i$	0.433^{+}	0.766^{+}	0.485^{***}	0.754^{+}	0.028
$RSper_j$	0.004	0.017^{+}	-0.016^{***}	-0.007	0.007
PM_j	-0.347^{+}	0.013	-0.016	0.047^{+}	-0.050
FM_j	-0.010	0.081^{+}	0.019^{*}	-0.030^{+}	-0.181^{+}
$GDPper_j$	-0.864^{+}	0.185	-0.484^{+}	0.089	0.027
$AGDPpercent_j$	-0.013^{*}	0.005	-0.017^{*}	-0.006	-0.018^{**}
POP_j	-0.479^{+}	0.128	-0.129^{+}	0.077	-0.213
$USnum_j$	-0.352^{+}	-0.190^{*}	0.197^{*}	-0.033	0.387
$distance_{ij}$	-0.546^{+}	-0.467^{+}	-0.273^{***}	-0.429^{***}	-0.196^{+}

Note: This table presents TERGM coefficients estimating the effects of local political connections (mayor network) on the inter-city production network, disaggregated by sector. Sector 1: Agriculture, Forestry, Animal Husbandry, and Fishery; Sector 2: Information Transmission, Software, and IT Services; Sector 3: Education, Scientific Research, and Technical Services; Sector 4: Education. $^{+}$, ***, **, and * are significant at the levels of 0.001, 0.01, 0.05, and 0.1, respectively. The results indicate significant heterogeneity in the effect of political connections across sectors.

Table 14: TERGM Heterogeneity Analysis: Impact of Secretary Network by Sector

	Aggregate	Sector 1	Sector 2	Sector 3	Sector 4
$rotation_{ij}$	1.505^{+}	0.877^{+}	0.950^{+}	0.753^{+}	0.631^{+}
Edges	3.164	0.916	2.072	-1.470	3.241^{**}
Reciprocity	1.121^{+}	0.160	-0.583^{**}	-0.760^{+}	1.320
GWESP	-0.024^{+}	0.001	-0.023	-0.004	-0.085^{**}
$\lvert RSper_i - RSper_j \rvert$	-0.002	-0.003	0.015^{**}	0.007	-0.015^{*}
$\lvert PM_i - PM_j \rvert$	-0.281^{+}	-0.145^{**}	-0.384^{+}	0.018	-0.278
$\lvert FM_i - FM_j \rvert$	0.053^{**}	-0.028^{*}	-0.008	-0.061^{+}	0.059^{+}
$\lvert GDPper_i - GDPper_j \rvert$	-0.131	-0.072	0.057	-0.383^{**}	-0.199^{**}
$\lvert AGDPpercent_i - AGDPpercent_j \rvert$	0.027^{+}	-0.011^{+}	-0.004^{***}	0.015	0.019^{+}
$\lvert POP_i - POP_j \rvert$	0.214^{+}	0.081	0.287^{**}	0.276^{+}	0.201^{**}
$\lvert USnum_i - USnum_j \rvert$	-0.143^{***}	-0.254^{**}	-0.272^{+}	-0.061	-0.098
$RSper_i$	0.010^{***}	-0.001	-0.003	0.008	-0.001
PM_i	-0.186^{*}	-0.283	-0.450^{+}	-0.137	-0.247
FM_i	0.064^{**}	-0.142^{*}	0.017	-0.166^{+}	0.058
$GDPper_i$	0.980^{*}	0.190	0.288^{**}	0.404	0.060
$AGDPpercent_i$	-0.093^{+}	0.060^{+}	0.024^{+}	-0.001	-0.006
POP_i	2.113^{+}	0.430^{+}	1.606^{+}	1.165^{+}	0.082
$USnum_i$	0.431^{+}	0.764^{+}	0.483^{***}	0.752^{+}	0.028
$RSper_j$	0.004	0.017^{+}	-0.016^{***}	-0.007	0.007
PM_j	-0.346^{+}	0.013	-0.015	0.048^{+}	-0.050
FM_j	-0.010	0.081^{+}	0.019^{*}	-0.029^{+}	-0.181^{+}
$GDPper_j$	-0.860^{+}	0.183	-0.484^{+}	0.088	0.026
$AGDPpercent_j$	-0.013	0.005	-0.017^{*}	-0.006	-0.018^{**}
POP_j	-0.478^{+}	0.130	-0.128^{+}	0.079	-0.213
$USnum_j$	-0.352^{+}	-0.191^{*}	0.196^{*}	-0.035	0.387
$distance_{ij}$	-0.546^{+}	-0.468^{+}	-0.274^{+}	-0.431^{***}	-0.193^{+}

Note: This table presents TERGM coefficients estimating the effects of local political connections (secretary network) on the inter-city production network, disaggregated by sector. Sector definitions are identical to Table 13. $^{+}$, ***, **, and * are significant at the levels of 0.001, 0.01, 0.05, and 0.1, respectively. The effect sizes are generally smaller than those of the mayor network, except for the Education sector, reflecting the distinct roles within China's political system.

Table 15: TERGM Mechanism Analysis: Local Political Connections and Input-Output Linkages

	Baseline	Political Distance	Dual Mechanism
$rotation_{ij}$	1.664^{+}	1.662^{+}	9.863^{+}
Geographical Distance	-0.546^{+}	-0.547^{+}	-0.540^{+}
Political Distance		0.056^{+}	0.057^{+}
$rotation_{ij}$ × *Geographical Distance*			-1.322^{+}
$rotation_{ij}$ × *Political Distance*			-0.157^{*}
Edges	3.154	3.134	3.114
Reciprocity	1.122^{+}	1.121^{+}	1.119^{+}
GWESP	-0.024^{+}	-0.024^{+}	-0.025^{+}
$\|RSper_i - RSper_j\|$	-0.002	-0.002	-0.002
$\|PM_i - PM_j\|$	-0.282^{+}	-0.282^{+}	-0.281^{+}
$\|FM_i - FM_j\|$	0.053^{**}	0.053^{**}	0.053^{**}
$\|GDPper_i - GDPper_j\|$	-0.150	-0.158	-0.157
$\|AGDPpercent_i - AGDPpercent_j\|$	0.027^{+}	0.026^{+}	0.026^{+}
$\|POP_i - POP_j\|$	0.209^{+}	0.200^{+}	0.198^{+}
$\|USnum_i - USnum_j\|$	-0.150^{***}	-0.152^{***}	-0.154^{***}
$RSper_i$	0.010^{***}	0.010^{***}	0.010^{***}
PM_i	-0.187^{*}	-0.187^{*}	-0.187^{*}
FM_i	0.064^{**}	0.063^{**}	0.064^{**}
$GDPper_i$	0.987^{*}	0.993^{*}	0.991^{*}
$AGDPpercent_i$	-0.093^{+}	-0.092^{+}	-0.092^{+}
POP_i	2.118^{+}	2.114^{+}	2.114^{+}
$USnum_i$	0.433^{+}	0.428^{+}	0.429^{+}
$RSper_j$	0.004	0.004	0.004
PM_j	-0.347^{+}	-0.346^{+}	-0.347^{+}
FM_j	-0.010	-0.010	-0.010
$GDPper_j$	-0.864^{+}	-0.857^{+}	-0.859^{+}
$AGDPpercent_j$	-0.013^{*}	-0.013	-0.013
POP_j	-0.479^{+}	-0.484^{+}	-0.483^{+}
$USnum_j$	-0.352^{+}	-0.358^{+}	-0.358^{+}

Note: This table presents TERGM coefficients analyzing the mechanisms through which local political connections affect inter-city input-output linkages. Model 1 is the baseline. Model 2 adds the political distance network. Model 3 includes interaction terms between local political connections and both geographical and political distance. $^{+}$, ***, **, and * denote significance at the 0.001, 0.01, 0.05, and 0.1 levels, respectively. The interaction term $rotation_{ij}$ × *Geographical Distance* is significantly negative, while $rotation_{ij}$ × *Political Distance* is significantly negative, indicating contrasting moderating effects.

Table 16: Iteration Process of the Counterfactual Simulation: Removal of Hangzhou–Wenzhou Political Connections

Iteration	Updated Node Pairs	Net Edge Change
1	2	-2
2	21	+21
3	19	+3
4	5	+3
5	6	+2
6	1	+1
7	0	0

Note: This table summarizes the iterative adjustments of the inter-city production network following the removal of the political connection between Hangzhou and Wenzhou. Iteration 1 corresponds to the direct removal of two edges between the two cities. The process converges at Iteration 7, with no further structural updates.

Table 17: Counterfactual Simulation Results: Effects of Removing the Hangzhou-Wenzhou Political Connections

	City Pair		
	HZ $\rightarrow$ WZ	WZ $\rightarrow$ HZ	Other Node Pairs
Original Probability	0.9984	0.9902	0.2788
Short-Term			
Direct Effect	0.8205 (-0.1779)	0.4200 (-0.5702)	
Spillover Effect			0.2838 (+0.0050)
Long-Term			
Direct Effect	0.8205 (-0.1779)	0.4200 (-0.5702)	
Spillover Effect			0.2793 (+0.0005)

Note: This table presents the direct and spillover effects of removing the political connection between Hangzhou (HZ) and Wenzhou (WZ) on inter-city input-output linkages. The direct effect shows the change in linkage probability between HZ and WZ, while the spillover effect represents the average change across all other city pairs. Values in parentheses indicate the magnitude of change from the original probability.