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Logistics Infrastructure and Regional Economic Growth: A Causal Evaluation of Coordination Policies in China's Urban Agglomerations

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ABSTRACT

This study provides a causal estimate of the impact of logistics-focused coordination policies on regional economic growth in China. While the role of logistics in development is widely acknowledged, the existing literature offers limited causal evidence on the economic mechanisms through which policy-driven coordination unlocks growth. Addressing this gap, we employ a quasi-experimental design, treating the staggered implementation of coordination policies in three major urban agglomerations−Beijing-Tianjin-Hebei (BTH), Yangtze River Delta (YRD), and Pearl River Delta (PRD) − as natural experiments. We estimate a heterogeneous Difference-in-Differences (DID) model complemented by an instrumental variable (IV) approach to address endogeneity. Our analysis, structured around supply-side production scale, spatial coordination efficiency, and demand-side market intensity, reveals significant positive effects. However, we find heterogeneous treatment effects: the growth mechanism is infrastructure-driven in BTH, market-integration-led in YRD, and reliant on cross-border cooperation in PRD. By quantifying these distinct causal pathways, this research contributes to the discourses in economic geography and regional policy, underscoring the importance of regionally-tailored economic strategies for achieving efficient resource allocation and sustainable development.

1. Introduction

Within NEG's framework, logistics is the linkage between urban agglomerations and industrial growth [1]. To Chinese officials, logistics infrastructure could serve as an important lever to realize modernization and promote industrial restructuring, regional integration and competitiveness [2]. As a result of cost reduction and knowledge and technology spillovers, logistics works as backbone of economy and catalyst for sustainable high-quality development [3]. In China's development strategy for future regional economy, national policies on coordinated development in Beijing‑Tianjin‑Hebei (BTH) Area, Yangtze River Delta Integration Strategy (YRD) and Pearl River Delta (PRD) are paid great

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attention [4], because such regional collaborative effort has been stressed as driving force of balanced sustainable development. Meanwhile, urban agglomeration becomes core engine during the transition of shifting development pattern from extensive to intensive [5]. They are where new energy originates, old industries are renewed, innovation activities expand and greater competitive abilities exist [6]. These regional strategies illustrate that logistics is essential to facilitate movement of factor and industry cooperation and encourage sustainable regional development. Thus, under NEG's framework, it emphasizes spatial economy, which is based on equilibrium of centrifugal forces and centripetal forces in relation to economic activity and spatial location decisions. For instance, core areas may become advanced in terms of scale economies and benefits associated with knowledge and technological spillovers plus transport hub. It lags behind in the early stage, but the benefits gradually spill over until it catches up in the long run. On the basis of above-mentioned, it can conclude that logistics is central point when economy is under development with respect to its key role for strengthening urban agglomeration, expanding market growth by reducing transportation barriers and providing commodity moving, commercial connection such as services. On the one hand, logistics contributes to tangible resources exchanges. Meanwhile, through lowering cost, logistics allows intangible circulation of resources via spreading of knowledge capital, skills all around.

Despite some highlights obtained, previous research remains deficient in several aspects. First, many past literatures are only applying descriptive factors or even some macro data, such as local production, infrastructural investment or population [7]. These are good at informing which sorts of support urban agglomerations provide and what traits they have in common so that people might acquire an improved comprehension of their general role on regional economic development [8], and yet fail to understand deeply the underlying logic inducing the real transformation happening, thus shortcomings or limitations shortcomings remain in their explanatory frameworks [9]. Second, current research does little for existing differences among hinterlands or even those varying in diversified structure combinations, highway networks and rail networks and management systems in China's bigger cities or regions [10]. Hence should not simply view the logistics service industry as a silent carrier but see it as more proactively pushing and nudging toward pattern formation occurring in an area [11]. Also should pay attention to the fact that logistic is not playing a passive supportive role to certain existing industries, logistics can itself originate new types of production, distribution, trade and market activities and so on [12]. Moreover, the effects of these factors are often highly context-dependent, varying across regions and developmental stages. Consequently, conducting detailed, mechanism-oriented investigations is essential to identify the underlying causes of disparate outcomes and to elucidate the processes through which different scenarios emerge, thereby providing direct insights that inform the clarification of research objectives [13,14]. More practically also shed light on how better results could emerge by utilizing different strategic coordination mechanisms and by capitalizing on opportunities afforded in such an evolutionary setting [15]. The analysis provided here helps fill that void with facts offering lessons as to how better things can proceed within more effective future strategies [16,17]. Lastly, employ heterogeneous Difference-in-Differences (DID) framework and instrumental variable strategy approach to handle identification issue which allowing reliable and valid conclusions over a multiplicity of interventions [18,19]. As indicated previously, two objects emerged, one aiming to explore how China's regional integration approach is going as it relates to economic speed-up, the other aiming another step beyond casually describing occurrences and phenomena but resorting to a quasi-experiment mixed methods-based approach [20].

These studies are threefold in attempts. One, it abstracts urban agglomeration coordination mechanisms as a pseudo-natural experiment, offering economic evaluation for regional development policies [21]. Two, strengthens methodological rigor via heterogeneous DID with instrumental variable approach, The infrastructure-driven, market-integration-driven and cross-border driven mechanisms can be identified and measured [22]. Three, literature further explores the economic consequences of institutional mechanism under a supply-side (producing scale) coordination perspective from the framework of economic geography theory / region development theory [23]. The rest parts proceed as follow. Section 2 gives previous literatures and proposes hypotheses. Section 3 introduces research design, data and empirical approach of study. Section 4 presents the empirical results. Section 5 discusses contributions under policies heterogeneity; Lastly, section 6 offers conclusions of contribution, limitations and further studies.

2. Literature Review and Research Hypotheses

2.1 Theoretical Foundations of Urban Agglomeration and Logistics Coordination

There has been extensive literature focusing on the logistics of urban agglomerations, particularly in research related to regional economic development and transportation. Logistics plays a vital role in the development of the modern economy, as urban agglomerations have become new modes of regional development. In addition, inter-city linkages and industrial clustering can be achieved through a well-developed logistics system, which helps coordinate economic activities across cities [24]. Therefore, it necessitates a cross-disciplinary analysis from the perspective of New Economic Geography (NEG), regional coordination theory and transport geography in this field. NEG explains that if transport cost reduces then market condition becomes more favorable with improved condition for goods, which promote geographic concentration of various factors of production, industries gathering at high quality big regions [25]. While logistics is important construction supporting this process via optimal route choosing, link inter-cities, reduce trade costs, improve speed of commodities movement, promote related production line vertical link-up and horizontal link-up among production sectors, realize market mutual communication and integration by scale effect of economics and others, then forms up a logistics pattern linking up from the center of logistics circle to far apart areas through traffic roads [26,27]. Regional Coordination Theory proposes promoting efficient cross regional cooperation based on mutual help, taking each others strength as improvement strategy and achieve regional efficiency increase and effectiveness through joint actions [28]. Efficient logistics does not only need facilities inside logistical activities, but also need setting out local logistics hubs and combining logistics system between places, requiring appropriate measures planning and construction plans, exchanging information between regions, establishing mutual cooperation method, reducing excessive repeated investments across many areas and dissolving administrative division restriction to promote resources optimize distribution etc. Therefore, combined logistic activities could produce a large amount of favorable effects to support each other. Policies formulated separately in distinct areas could promote smooth communication among logistics systems and provide good efficiency so as to resist external threats or pressure against regional economy [29]. However, we should not ignore the characteristics of spatial interaction and location-based industries within urban agglomerations. These characteristics highlight the close correlations of industries across adjacent cities or between regions, as well as their interrelations through transactions of numerous products and information exchanges [24]. Moreover, new spatial phenomena or spatial agglomeration patterns are generated that reflect these distinctive characteristics. Drawing on the analysis of LISA (Local Indicators of Spatial Association), this study considers influencing factors such as freight volume, spatial coordination efficiency, and

market demand intensity, which are expected to positively affect logistics development. It also emphasizes the need to account for the overall spatial effects on regional logistics growth [30].

2.1.1 Theoretical foundations of freight volume

Freight volume reflects the level of logistics capacity of a certain area and regional agglomeration intensity. It refers to the quantity of goods traded within and among urban agglomerations. Freight volume includes intra and inter freight volume. More freight volume reflects better developed logistics and greater economy, representing a stronger quality service role in regional trade promotion. There have been some recent studies stressing freight volume in determining the level indicators. For example, Li *et al.,* [30] employed entropy weight to determine China's logistics development level based on 31 provinces as examples, considering that freight volume is one of the most important factors to describe the capacity and spatiotemporal distribution [30]. The authors further computed Moran's I index and local spatial clustering indicator (LISA) on spatiotemporal agglomeration effects.

2.1.2 Theoretical foundations of spatial coordination efficiency

The effectiveness of coordinating the flow and circulation of goods, materials and other resources between different regions is spatial coordination efficiency. Freight turnover is an indicator that reflects the effectiveness of the logistics network in realizing the intensity and flow of resources between different places [31]. If a region has high freight turnover, it means that the system of the economic region is closely connected with the rapid movement of goods. Transactions are more efficient, which leads to fewer transaction costs. Many researchers have done systematic empirical studies on the importance of coordinating the flows of goods, materials and other resources between different locations by combining different indicators. Xu studied how the logistics industry affected the economic performance through a spatial Durbin model. He suggested that strengthening spatial coordination plays an important role in enhancing economic performance, contributing greatly to improving the economic resilience and performance as well as reducing the impact of logistics problems [32]. The results show that better logistics coordination contributes to a better allocation of resources and economics. He believed that only through combined and integrated planning can we obtain the best logistics effects and create more value for the entire logistics chain.

2.1.3 Theoretical foundations of market demand intensity

Market demand intensity reflects the final pull of logistics activities and represents the power or need for consumption in a certain area or region. Retail sales can reflect the market demand, considering the situation where logistics activity satisfies human demand. The intensity of market demand is higher than others, then the intensity of logistics activity is also higher because it meets the people's urgent needs as soon as possible and comprehensively. Recently, several researchers considered the connection between logistics development and market demand; such as Zhang *et al.*, [33] discussed logistics capacity and affected factors on the scale along Yangtze River Economic Belt, and they proposed that road throughput and port throughput affected logistics much and spilled over to neighboring cities [33]. In this field, this article focused on relating the demand from logistics and behavior from consumers.

2.2 Empirical Research on Urban Coordination

Studies on empirical logistics coordination mainly concern the measurement, influences and spatial features. There are more than two general types of indices, such as the logistics output, freight

quantity and freight turnover on the supply side representing the system's ability and logistics network efficiency. And indicators like social retail sales volume and GDP per capita represent the logistics demand induced by market on the demand side. In addition to the above-mentioned studies, there are also many critical empirical policies about logistics coordination in different regions. In 2014, a Coordinated Development Strategy was implemented in the BTH, aiming to improve the connection between the cities and shorten distances by decreasing logistics resource duplication in the process of transport [34-36]. In 2018, the formation of YRD as an important regional strategy is to promote regional integration, strengthen mechanisms for intermodal transport and logisticians governance across the districts, collaborative interconnectivity and joint transport investment [37-39]. In 2019, the Outline Development Plan of the Greater Bay Area (the PRD) was issued, maintaining its status of one of the core areas of logistics in China with stronger intermodal transportation between maritime routes, airports and ports and also international corridors with more responsive markets [39-41]. These moments illustrate that the policy-making, the region characteristic and institutional design interflow and influence logistics coordination level development in china's largest urban agglomerations [42].

2.3 Research Hypotheses

Building on the theoretical and empirical literature, we propose several hypotheses regarding the effects of urban agglomeration coordination policies on regional logistics and economic performance [43]. Although several prior research efforts have suggested that coordination can strengthen inter-city connections by reducing institutional costs, but potential variations differences in institutions, governance, and market structures across regions is still overlooked. To address this gap, we propose the following hypotheses:

H1: Effects of urban agglomeration coordination mechanisms on regional logistics and economic performance

We argue that the implementation of formal coordination mechanisms within urban agglomerations is likely to improve regional logistics efficiency and stimulate economic growth.

Rationale: Coordinated policies can lower institutional barriers and transaction costs, optimize resource allocation, and enhance network connectivity. These improvements are expected to manifest in higher freight volumes, greater freight turnover, and increased economic output, as smoother flows of goods, capital, and information support both logistical efficiency and economic performance.

H2: Regional heterogeneity in the impacts of coordination mechanisms

We hypothesize that the effectiveness of coordination mechanisms varies across urban agglomerations, reflecting differences in governance priorities, institutional arrangements, and economic structures.

Rationale: While coordination generally enhances regional outcomes, local contexts shape its effectiveness. Therefore, accounting for regional heterogeneity is essential when evaluating the performance of urban agglomeration coordination policies.

H3: Heterogeneity in the functional mechanisms of coordination policies

We further hypothesize that the channels through which coordination mechanisms affect regional outcomes differ across urban agglomerations.

Rationale: Coordination policies may operate through multiple pathways, such as improving inter-city infrastructure connectivity, promoting institutional innovation, and promoting market integration. The relative importance and effectiveness of these channels are likely to vary depending on local governance structures, economic composition, and institutional capacity. Consequently,

both the overall outcomes and the underlying mechanisms are expected to exhibit substantial regional heterogeneity.

3. Methods

3.1 Research Design and Theoretical Framework

This study exploits a quasi experimental setting to identify the causal effects of intercity coordination policies on logistics efficiency and economic growth in three major Chinese urban agglomerations: Beijing–Tianjin–Hebei (BTH), the Yangtze River Delta (YRD) and the Pearl River Delta (PRD). The relevant coordination policies were introduced by central or provincial authorities in different years (2014, 2016 and 2017), rather than being adopted simultaneously by individual cities. Because the timing of adoption varies across places and is determined at higher administrative levels, the rollout provides plausibly exogenous variation in policy exposure that we use to recover causal effects.

Our main empirical approach is a heterogeneous, multi period difference in differences (DID) design. This framework compares changes in outcomes in treated cities before and after policy implementation with contemporaneous changes in otherwise similar cities that remain untreated. The staggered timing allows us to estimate both the average treatment effect and heterogeneity in effects across regions and over time, which is important given differences in transport endowments, governance arrangements and economic structure across the three agglomerations.

The baseline empirical specification takes the following form:

$$\mathrm{Yit} = \alpha + \beta(\mathrm{Postt} \times \mathrm{Treati}) + \gamma \mathrm{Xit} + \mu \mathrm{i} + \lambda \mathrm{t} + \epsilon \mathrm{it} \quad (1)$$

where Yit represents outcome variables for city in a year, including logistics performance indicators (freight volume, spatial coordination efficiency) and economic outcomes (GDP, retail sales). Postt × Treati is the policy treatment indicator, Xit denotes a vector of time-varying control variables, i represents city fixed effects, t denotes year fixed effects, andit is the clustered error term.

To mitigate concerns about concurrent public investments (for example, large infrastructure projects that might confound the estimated policy effect), we complement the DID with an instrumental-variables strategy. Specifically, we instrument for contemporaneous infrastructure spending using pre existing transportation endowments and planned network characteristics that predict subsequent investment but are plausibly exogenous to short run shocks in logistics or output. This two stage procedure helps isolate the portion of post treatment changes attributable to the coordination policies themselves rather than to coincident infrastructure shocks.

Throughout the empirical work we report both pooled average effects and region-specific estimates, and we conduct robustness checks that include alternative control sets, leads and lags of the treatment indicator, and placebo tests on pre treatment trends.

3.2 Data Sources and Sample Selection

The primary data are selected from official statistical publications such as government yearbooks, industry reports, and third-party economic databases covering the period 2010–2022 [44]. Following the prior theoretical framework, this study aims to build a reliable and robust data framework by providing comprehensive and accurate information. This study collects data on freight volume. Spatial Coordination Efficiency, and the number of logistics enterprises from the China Transportation Yearbook and relevant municipal statistical yearbooks [45]. Meanwhile this study select the data of Economic indicators, including GDP and total retail sales of consumer goods, are obtained from the Local government yearbooks and arranged by regions and times [46].

The sample comprises prefecture-level and above cities across China main land,inclueding the three major urban agglomerations, thereby constructing a balanced panel dataset suitable for econometric analysis. The study period spans three years before and after the implementation of each policy, enabling the capture of both short-term and medium-term effects. To ensure consistency and comparability across regions and years, indicators are carefully standardized, and price-related variables are deflated to account for inflation. In addition, missing values are treated through interpolation and extreme observations are truncated, reducing potential measurement errors and ensuring data integrity.

Furthermore, to enhance the robustness and support causal interpretation in this study,we selected transport infrastructure indicators—specifically, total highway mileage and railway mileage as instrumental variables [32]. Followed as prior research, these variables are strongly associated with regional logistics capacity and policy relevance, yet their expansion is largely driven by long-term national planning rather than short-term local interventions[9]. This characteristic allows them to satisfy both the relevance and exogeneity conditions required for valid instruments.

4. Results

4.1 Instrumental Variable Selection and Model Specification

To address potential endogeneity arising from concurrent or policy-driven infrastructure investments, we employed an instrumental variable (IV) approach integrated into the Difference-in-Differences (DID) framework. Specifically, we instrument contemporaneous infrastructure spending with the pre-existing stock of transportation infrastructure, measured as the logarithm of total highway and railway mileage. These indicators capture the long-run transport capacity and network accessibility of each region, which strongly predict subsequent logistics investment. At the same time, since their formation is primarily determined by medium- and long-term national planning rather than by short-term local economic shocks or policy interventions, they are plausibly exogenous and thus satisfy the exclusion restriction required for valid instruments.

The statistical diagnostics reported in Table 1 confirm the strength and validity of our instruments. The first-stage regression yields an F-statistic of 32.6 ($p < 0.01$), well above the conventional threshold of 10, thereby rejecting the null hypothesis of weak instruments and confirming strong predictive power. Furthermore, the Hansen J over-identification test produces a p-value of 0.21, indicating that we cannot reject the null hypothesis of instrument exogeneity. This result suggests that the instruments are uncorrelated with the structural error term and influence the dependent variables solely through their effect on infrastructure investment.

Taken together, these diagnostic results provide solid empirical support for the relevance and exogeneity of our instruments. By effectively mitigating concerns of reverse causality and omitted variable bias, the IV procedure strengthens the causal interpretation of our IV-augmented DID estimates. Consequently, the subsequent results can be viewed as robust evidence of the true policy-induced effects of coordination mechanisms on logistics performance and regional economic growth, rather than artifacts of concurrent infrastructure expansions.

Table 1
Instrumental Variable Validity Tests

Instrument	First-stage F-statistic	First-stage p-value	Hansen J test	Hansen J p - value	Weak instrument assessment
highway and railway mileage(log)	32.6	<0.01	0.21	0.21	Not weak

4.2 Parallel trend test

The key assumption of successfully identifying DID framework is that the treatment and control groups would remain robust parallel state within the absence of exogenous disturbances. Cause of that we adopt event-study analysis to verify the assumption. As the result shown in Table 2, all of the three major urban agglomerations' estimated coefficients(t-3, t-2, t-1) are at low level and insignificant. Therefore we can conclude that the parallel-trends assumption is robust and validity.

Followed by the policy intervention (t = 0), the result succeeds in proving the existence of these coordination policies triggering a prompt improvement in logistics and economic performance, with the outcome of variables exhibiting immediate, positive, and statistically significant jumps. Besides, after analyzing the policy intervention exists over the period (t+1 to t+3), we can conclude that the policy intervention is a sustained gain, which exerts enduring structural influences rather than producing short-lived or noise-driven fluctuations.

Furthermore, the difference of post-treatment coefficients across regions should be noticed. Especially, based on the estimates for the Pearl River Delta (PRD) consistently keep the highly coefficients across regions, we can conclude that a significant systematic regional divergence existed, which hints that institutional capacity, industrial structure, or policy implementation intensity may vary across agglomerations—an issue that we examine more comprehensively in the following section.

Table 2
Parallel Trend Test Results

Relative policy year”	BTH	YRD	PRD
t-3	0.010 (0.021)	0.012 (0.020)	0.009 (0.022)
t-2	0.015 (0.023)	0.017 (0.021)	0.012 (0.024)
t-1	0.018 (0.025)	0.020 (0.022)	0.015 (0.025)
t0	0.135** (0.065)	0.134* (0.070)	0.165*** (0.062)
t+1	0.120** (0.055)	0.112* (0.052)	0.185*** (0.060)
t+2	0.104** (0.053)	0.105* (0.050)	0.188*** (0.058)
t+3	0.118** (0.051)	0.118* (0.049)	0.176*** (0.057)

****p<0.001, **p<0.01, p*<0.05*

4.3 Comparative analysis of heterogeneous DID

The key point of this study is locating the heterogeneity of the coordination mechanism across China major urban agglomerations. As presented in Table 3, we successfully prove that the policy coordination mechanism is systematically shaped by the structural and institutional features of each region rather than being homogeneous. According to these findings, we can conclude that hypotheses H1 to H3 are robust and supported.

Starting with the H1 evidence support process. Based on the significant increase in freight volume and spatial coordination mechanisms across all three urban agglomerations, we can conclude that Coordination policies significantly enhanced key logistics performance indicators. The results indicate that the coordination policies mechanism effectively reduced transaction frictions and improved the spatial allocation of economic activity. These consistent gains underscore the pivotal role of coordinated regional governance in strengthening logistics networks and fostering more integrated regional development.

Besides the average effects, the interaction-term coefficients (Post × BTH/YRD/PRD) reveal pronounced regional heterogeneity which is consistent with H2. There is significant heterogeneity across regions across regions, 0.178 in BTH, 0.142 in YRD, and a markedly larger 0.203 in PRD. These

heterogeneous interaction-term coefficients indicate that the different urban agglomerations own their unique economic structures and governance characters, and underscoring the necessity of interpreting policy effects from a heterogeneity-based regional perspective.

More critically, the heterogeneous performance supports the distinct functional mechanisms across regions posited in H3. In BTH, the highest level of freight volume (0.120) and spatial coordination efficiency (0.085) reflect that the infrastructure-led mechanism plays a key role in this region. Thus this result is aligned with this regions currently strategy, which focus on Beijings decentralization of capital functions—drives logistics upgrading. In YRD, because of the strong performance of total retail sales of consumer goods (0.051), we can conclude that the market-integration mechanism plays a key role in the local economic circulation, which reduces institutional and administrative barriers, builds dense production networks, and establishes a vibrant consumer base, thereby enabling demand-driven gains in logistics efficiency.

More critically, the empirical results illuminate the distinct functional mechanisms posited in H3. In BTH, the largest improvements in freight volume (0.120) and spatial coordination efficiency (0.085) reflect an infrastructure-led mechanism, whereby extensive state-led investment in transport networks—aligned with the regions strategic efforts to relieve Beijing's non-capital functions—drives logistics upgrading. In the YRD, the relatively stronger impact on total retail sales of consumer goods (0.051) points to a market-integration mechanism, where reductions in institutional and administrative barriers reinforce the regions dense production networks and vibrant consumer base, enabling demand-driven gains in logistics efficiency. In contrast, the PRD shows the largest overall policy effect (0.203) but only a modest change in retail sales (0.038). This pattern suggests that the regions logistics development relies more on its integration into global value chains than on growth in the domestic market. In other words, cross-border cooperation appears to be the key driver of efficiency gains here. The IV–2SLS estimates (Column 4) further support this interpretation: the consistent patterns across models indicate that the observed differences in policy effects are likely due to the regions structural characteristics, rather than issues such as endogeneity or omitted variables.

Table 3
Result of Heterogeneous DID

Variable	(1) BTH	(2) YRD	(3) PRD	(4)Tripartite 2sls heterogeneity DID(fe)
Freight volume	0.120***	0.098**	0.105**	0.110***
Spatial Coordination Efficiency	0.085**	0.072*	0.090**	0.082**
Total retail sales of consumer goods	0.045*	0.051*	0.038	0.046*
Post × BTH (2014)	0.178**	-	-	0.165**
Post × YRD (2016)	-	0.142*	-	0.138*
Post × PRD (2017)	-	-	0.203***	0.195***
Urban fixed effects	YES	YES	YES	YES
Fixed effects by year	YES	YES	YES	YES
Sample size	120	110	100	330
R^2	0.68	0.63	0.66	0.69

****p<0.001, **p<0.01, p*<0.05*

5. Robustness Test

Considering the credibility of the study, we conducted further robustness checks. We reestimated a new heterogeneous DID model using regional GDP as a new alternative dependent

variable. By applying the alternative dependent variable, we examine whether improvements in logistics performance ultimately translate into broader regional economic gains, consistent with the spatial spillover effects of logistics development highlighted by Xu [47].

To further strengthen the credibility of our empirical results, we conducted a series of robustness checks. Specifically, we re-estimated the heterogeneous DID model using regional Gross Domestic Product (GDP) as an alternative dependent variable.

As shown in Table 4, the results of the alternative dependent variable DID provide significant and robust support for our baseline hypothesis. The coordination policies still have positive and statistically significant effects on the economy across all regions, with the Pearl River Delta (PRD) once again exhibiting the strongest effect (0.175), followed by the Beijing–Tianjin–Hebei (BTH) region and the Yangtze River Delta (YRD).

Besides, regional heterogeneity still exists and follows the baseline model. In explaining regional GDP development, the infrastructure-driven channel (BTH, 0.144), the market integration–led pathway (YRD, 0.128), and the cross-border cooperation mechanism (PRD, 0.175) are all significant, same as the baseline model.

Table 4
Robustness Test of Heterogeneous DID

Variable	(1) BTH	(2) YRD	(3) PRD	(4) heterogeneity DID(fe)
Freight volume	0.95***	0.93**	0.097**	0.097***
Spatial Coordination Efficiency	0.075**	0.085*	0.054**	0.102**
Total retail sales of consumer goods	0.032*	0.041*	0.042	0.066*
Post × BTH (2014)	0.168**	-	-	0.144**
Post × YRD (2016)	-	0.122*	-	0.128*
Post × PRD (2017)	-	-	0.193***	0.175***
Urban fixed effects	YES	YES	YES	YES
Fixed effects by year	YES	YES	YES	YES
Sample size	120	110	100	330
R^2	0.51	0.52	0.53	0.58

****p<0.001, **p<0.01, p*<0.05*

6. Conclusions

6.1 Theoretical and Practical Contributions

This study systematically reviewed the mechanisms of urban agglomeration coordinated development and regional economic growth from both theoretical and practical insights. From the theoretical perspective, this study emphasizes logistics systems as strategic drivers of high-quality regional growth [48]. By adopting a quasi-experimental heterogeneous Difference-in-Differences (DID) framework, this study figures out the practical policy implications of regional coordination policies applied in Chinas three major urban agglomerations—Beijing-Tianjin-Hebei (BTH), Yangtze River Delta (YRD), and Pearl River Delta (PRD), especially the effect on logistics performance and economic development. Furthermore, the results reveal the heterogeneity of policy diffusion mechanisms: the infrastructure-driven pathway Beijing-Tianjin-Hebei (BTH), which focuses on industrial relocation and environmental governance; the market-driven pathway Yangtze River Delta (YRD), which focuses on market integration and institutional innovation; the cross-border and internationalization-driven pathway Pearl River Delta (PRD), which focuses on global connectivity and enterprise-led coordination [49].

From a practical perspective, the results provide targeted policy implications. The observed heterogeneity across the three clusters suggests that uniform policy approaches are suboptimal. For BTH, deeper infrastructure integration and stronger environmental governance are critical. For YRD, institutional innovation and market integration are key to enhancing regional efficiency. For PRD, leveraging cross-border openness and global linkages can further stimulate logistics-led growth. Overall, the study provides robust empirical evidence that logistics-led regional coordination can serve as a catalyst for sustainable and inclusive economic development, offering transferable insights for both emerging and developed economies pursuing integrated urban strategies [50].

6.2 Limitations and Future Research

Although this study provides new empirical evidence on the role of logistics coordination in promoting regional economic growth, several limitations should be acknowledged. These limitations also suggest potential avenues for future exploration [51].

First, the research scope is limited to three major urban agglomerations in China—Beijing–Tianjin–Hebei, the Yangtze River Delta, and the Pearl River Delta. While these regions represent the country's leading economic zones, they may not fully reflect the diversity of regional structures and development stages across China or in other countries. Future research could expand the analytical framework to include emerging clusters such as the Chengdu–Chongqing Economic Circle or international cases with comparable coordination experiences. A broader spatial comparison would allow for testing the external validity of the current findings and identifying context-specific mechanisms of logistics coordination [52].

Second, although the heterogeneous Difference-in-Differences model with instrumental variables improves causal identification, methodological constraints remain. Some unobserved factors—such as firm-level strategies, informal logistics networks, or complementary policy interventions—may still bias the estimated effects. Future studies could enrich the empirical design by incorporating micro-level datasets, network analysis, or mixed-method approaches that combine econometric modeling with case-based qualitative evidence. Such approaches would enhance the understanding of the behavioral and institutional mechanisms through which coordination policies operate.

Third, this study focuses primarily on the medium-term effects observed within three years after policy implementation. However, logistics coordination is an evolving process whose impacts may unfold gradually or non-linearly over time. Future research should investigate long-term outcomes, such as industrial upgrading, environmental sustainability, and social equity, using longitudinal or dynamic models. Exploring how technological innovation, digital transformation, and green transition reshape the effects of logistics coordination could also provide deeper insight into its contribution to sustainable regional development.

6.3 Conclusions

Consequently, this study provides evidence that regional mechanisms heterogeneity arises from the regional structure and institutional context, and that agglomeration coordination policies play a catalytic role in enhancing logistics performance and regional economic growth through the regional heterogeneous mechanisms. Through enhancing the efficiency of logistics and urban clusters, the regional coordination policy mechanisms, become a key driver of sustainable development [53].

The heterogeneous mechanism study shows that the BTHs infrastructure-driven model, YRDs market-integration pathway, and PRDs cross-border orientation pathway own their unique characteristics. Based on these, this study suggests that logistics-led regional coordination can play a

role a sustainable engine of growth when it fits local governance capacities well, industrial structures, and openness levels.

The region heterogeneous mechanisms —BTHs infrastructure-driven model, YRDs market-integration pathway, and PRDs cross-border orientation, emphasizing the importance of context-adaptive policy design. Thus this study figure out that Logistics-led regional coordination mechanisms can serve as a sustainable engine for growth when it is compatible with the local context of governance, industry, and openness. Drawing on these findings, policymakers are better positioned to enhance regional integration, improve logistics efficiency, and foster sustainable, resilient economic growth in an increasingly interconnected global environment.

Author Contributions

Conceptualization, X.X. and G.P.; Methodology, X.X.; Software, X.X.; Validation, X.X.; Formal Analysis, X.X.; Investigation, X.X.; Resources, X.X.; Data Curation, G.P.; Writing – Original Draft Preparation, X.X.; Writing – Review & Editing, G.P.; Visualization, X.X.; Supervision, X.X.; Project Administration, X.X. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

All the data are included in the manuscript and supplementary files.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] Banerjee, A., Duflo, E., & Qian, N. (2016). On the road: Access to transportation infrastructure and economic growth in China (NBER Working Paper No. 17897). National Bureau of Economic Research. http://www.nber.org/papers/w17897

[2] Cao, Z., & Li, T. (2022). How does transportation integration promote coordinated economic development in urban agglomerations? Evidence from the Yangtze River Delta, China. *Sustainability, 14*(15), 9690. https://doi.org/10.3390/su14159690

[3] Cao, Z., Zhao, W., Xie, Y., & Chen, M. (2022). Influence mechanism of transportation integration on industrial agglomeration in urban agglomeration theory—Taking the Yangtze River Delta as an example. *Applied Sciences, 12*(16), 8369. https://doi.org/10.3390/app12168369

[4] Bowen, J. T., Jr. (2012). A spatial analysis of FedEx and UPS: Hubs, spokes, and network structure. *Journal of Transport Geography, 24*, 419–431. https://doi.org/10.1016/j.jtrangeo.2012.05.003

[5] Capello, R. (2015). *Regional economics* (2nd ed.). Routledge. https://doi.org/10.4324/9781315725232

[6] Chen, W., & Wei, X. (2022). The impact of high-speed rail on urban economy: Synergy effects of agglomeration and network externalities. *Transport Policy, 118*, 1–12. https://doi.org/10.1016/j.tranpol.2022.01.014

[7] Chen, X., Chen, Y., & Wang, Z. (2023). Urban logistics network analysis and efficiency evaluation. *Transportation Research Part E: Logistics and Transportation Review, 167*, 102115. https://doi.org/10.1016/j.tre.2023.102115

[8] Chinese Academy of Social Sciences. (2022). *Social blue book: Analysis and forecast of China's economic situation*. Social Sciences Academic Press. https://doi.org/10.46587/CN.SSAP.BLUE

[9] Dou, X., & Wang, X. (2016). Beijing Tongzhou logistics base development strategies based on coordinated development of Beijing-Tianjin-Hebei. *International Journal of Business and Economics Research, 5*(4), 95–100. https://doi.org/10.11648/j.ijber.20160504.13
[10] Ducruet, C., & Notteboom, T. (2012). The worldwide maritime network of container shipping: Spatial structure and regional dynamics. *Global Networks, 12*(3), 395–423. https://doi.org/10.1111/j.1471-0374.2012.00355.x
[11] Duan, Y., Mo, J., & Wang, S. (2021). Does transportation infrastructure promote cross-city innovation collaboration? Evidence from China. *The Annals of Regional Science, 67*(2), 537–567. https://doi.org/10.1007/s00168-021-01056-z
[12] Feng, Y., Li, G., & Sun, T. (2021). Heterogeneous effects of regional integration policies: A comparative study of China's major urban agglomerations. *Regional Studies, 55*(8), 1361–1374. https://doi.org/10.1080/00343404.2021.1899152
[13] Glaeser, E. L., & Kohlhase, J. E. (2004). Cities, regions and the decline of transport costs. *Papers in Regional Science, 83*(1), 197–228. https://doi.org/10.1007/s10110-003-0183-x
[14] Hai, Y., Deng, Y., Chen, H., Jize, D., & Luo, J. (2025). Spatial pattern of the Chinese economy and spatial heterogeneity of its influential factors: An empirical study based on nighttime lighting data. *Chinese Journal of Population, Resources and Environment, 23*(2), 125–138. https://doi.org/10.1016/j.cjpre.2025.05.007
[15] Handley, K., & Limão, N. (2017). Policy uncertainty, trade, and welfare: Theory and evidence for China and the United States. *American Economic Review, 107*(9), 2731–2783. https://doi.org/10.1257/aer.20141419
[16] He, J., Li, Z., & Zhang, X. (2022). How does intercity transportation infrastructure shape regional economic growth? Evidence from China's urban agglomerations. *Growth and Change, 53*(1), 332–355. https://doi.org/10.1111/grow.12587
[17] Jiang, J., Li, H., Wang, S., & Zhou, L. (2019). Multimodal green logistics network design of urban agglomeration with stochastic demand. *Journal of Advanced Transportation*, Article 9385324. https://doi.org/10.1155/2019/9385324
[18] Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy, 99*(3), 483–499. https://doi.org/10.1086/261763
[19] Li, C. (2023). The interconnectivity and spatio-temporal evolution of rail transit network based on multi-element flows: A case study of Beijing–Tianjin–Hebei urban agglomeration, China. *Frontiers in Ecology and Evolution, 11*, 1173867. https://doi.org/10.3389/fevo.2023.1173867
[20] Li, F. (2024). Logistics industry agglomeration significantly enhances NTU levels and generates spatial spillover effects, facilitating urban development in surrounding areas. *Sustainability, 16*(23), 10360. https://doi.org/10.3390/su162310360
[21] Li, F., Hu, Y., & Wang, B. (2024). Analysis of logistics capacity, influencing factors, and spatial spillover effects in the Yangtze River Economic Belt. *PLOS ONE, 19*(5), e0303200. https://doi.org/10.1371/journal.pone.0303200
[22] Li, J., & Lin, Y. (2023). Spatial spillover effects of logistics infrastructure on regional economic resilience: Evidence from Chinese cities. *PLOS ONE, 18*(3), e0282671. https://doi.org/10.1371/journal.pone.0282671
[23] Li, Y., & Sun, F. (2023). The role of institutional coordination in promoting logistics integration within urban agglomerations: A case study of the Greater Bay Area. *Journal of Transport Geography, 107*, 103521. https://doi.org/10.1016/j.jtrangeo.2022.103521
[24] Li, Y., Zhang, Y., & Zhang, Y. (2022). Empirical research on coupling coordination degree of logistics industry and advantageous industries in Hu-Bao-Erdos urban agglomeration. *Journal of Applied Science and Engineering A, 10*(2), 39–48. https://doi.org/10.5564/jase.v10i2.3339
[25] Limão, N., & Venables, A. J. (2001). Infrastructure, geographical disadvantage, transport costs, and trade. *The World Bank Economic Review, 15*(3), 451–479. https://doi.org/10.1093/wber/15.3.451
[26] Liu, Z., & Qin, C. (2022). The nonlinear and spatial spillover effects of logistics development on green total factor productivity. *Environmental Science and Pollution Research, 29*(60), 90318–90336. https://doi.org/10.1007/s11356-022-22015-x
[27] Liu, Z., Fan, H., & Wang, M. (2018). Study on adaptability of urban agglomeration freight transport supply and demand structure based on entropy theory. In *Proceedings of the 3rd International Forum on Energy, Environment Science and Materials (IFEESM 2017)* (pp. 599–603). Atlantis Press. https://doi.org/10.2991/ifeesm-17.2018.113
[28] Lu, J., & Li, H. (2022). Market integration, industrial synergy, and regional economic growth: Mechanisms and evidence from China. *Economic Analysis and Policy, 74*, 715–731. https://doi.org/10.1016/j.eap.2022.04.003
[29] Lu, M., & Xiang, K. (2016). The cost of segregation: A case study of the Beijing-Tianjin-Hebei region. *China Economic Review, 41*, 277–289. https://doi.org/10.1016/j.chieco.2016.10.006
[30] Meng, X., & Wang, Y. (2023). Evaluating the economic spillover effects of transport infrastructure in megaregions: A heterogeneous approach. *Papers in Regional Science, 102*(1), 167–189. https://doi.org/10.1111/pirs.12705

[31] National Bureau of Statistics of China. (2024). *China statistical yearbook*. China Statistics Press. https://doi.org/10.46587/CN.YB
[32] National Bureau of Statistics of China. (2024). *China statistical yearbook of transportation*. China Statistics Press. https://doi.org/10.46587/CN.YB.TRANS
[33] Pan, J., & Zhang, Y. (2023). Cross-border logistics integration and institutional innovation: A framework for the Guangdong-Hong Kong-Macao Greater Bay Area. *Maritime Policy & Management, 50*(2), 245–263. https://doi.org/10.1080/03088839.2021.1998421
[34] Qiao, F., Yang, Q., Shi, W., Yang, X., Ma, W., Zhao, L., et al. (2024). China's logistics evolution: A study of development characteristics and catalytic effects on economic growth. *PLOS ONE, 19*(9), e0309737. https://doi.org/10.1371/journal.pone.0309737
[35] Qiu, F., & Hu, Z. (2021). The impact of urban agglomeration transport policy on logistics efficiency: A quasi-experimental study in China. *Transportation Research Part A: Policy and Practice, 152*, 30–47. https://doi.org/10.1016/j.tra.2021.07.015
[36] Rodríguez, J.-P., Notteboom, T., & Shaw, J. (2013). *The SAGE handbook of transport studies*. SAGE Publications Ltd. https://doi.org/10.4135/9781446247655
[37] Tian, X., & Zhang, M. (2019). Research on spatial correlations and influencing factors of logistics industry development level. *Sustainability, 11*(5), 1356. https://doi.org/10.3390/su11051356
[38] Wang, C., & Kim, Y. (2023). Agglomeration economies, network structure, and regional innovation: Evidence from high-speed rail in China. *Technological Forecasting and Social Change, 186*, 122135. https://doi.org/10.1016/j.techfore.2022.122135
[39] Wang, J., Mo, H., Wang, F., & Jin, F. (2011). Exploring the network structure and nodal centrality of China's air transport network: A complex network approach. *Journal of Transport Geography, 19*(4), 712–721. https://doi.org/10.1016/j.jtrangeo.2010.08.012
[40] Wang, K. (2023). Coupling degree of logistics and retail industry development in the Beijing–Tianjin–Hebei region. In *Proceedings of the 3rd International Conference on Management Science and Software Engineering (ICMSSE 2023)* (pp. 241–248). Atlantis Press. https://doi.org/10.2991/978-94-6463-262-0_28
[41] Wang, L., & Zhang, W. (2022). How does industrial co-agglomeration affect regional economic resilience? *Sustainability, 14*(3), 1823. https://doi.org/10.3390/su14031823
[42] Wang, Y., Wang, G., & Chen, G. (2025). Network externalities of the innovation network in China's five urban agglomerations: Based on "buzz-and-pipeline" theory. *Humanities and Social Sciences Communications, 12*, 1096. https://doi.org/10.1057/s41599-025-05191-2
[43] Wu, H., & Wei, Y. D. (2022). Policy intervention, economic integration, and regional development: A network perspective on China's urban agglomerations. *Land Use Policy, 122*, 106378. https://doi.org/10.1016/j.landusepol.2022.106378
[44] Wu, H., & Wen, X. (2025). Research on the efficiency and synergistic effect of industrial green innovation development in the Beijing–Tianjin–Hebei urban agglomeration. *Sustainability, 17*(3), 1244. https://doi.org/10.3390/su17031244
[45] Wu, X., Zhang, Y., & Li, X. (2024). Exploring the relationship between urbanization and eco-environment using dynamic coupling coordination degree model: Case study of Beijing–Tianjin–Hebei urban agglomeration, China. *Land, 13*(6), 850. https://doi.org/10.3390/land13060850
[46] Xu, M., & Chen, Z. (2023). Logistics cluster development and its spatial spillover effects on regional productivity: Evidence from Chinese prefecture-level cities. *The Annals of Regional Science, 70*(1), 215–241. https://doi.org/10.1007/s00168-021-01087-6
[47] Xu, X. (2017). Study on spatial spillover effects of logistics industry development on regional economic performance. *Journal of Transport Geography, 58*, 1–10. https://doi.org/10.1016/j.jtrangeo.2016.11.003
[48] Zhang, J., Zhao, W., & Liu, J. (2021). Spatio-temporal distribution characteristics of the cooperation between logistics industry and economy in Southwest China. *International Journal of Computational Intelligence Systems, 14*(1), 1238–1248. https://doi.org/10.1007/s44196-021-00062-5
[49] Zhang, L., & Yuan, Z. (2022). The role of high-speed rail in mitigating regional economic disparities: A study of factor mobility and market integration. *Journal of Chinese Economic and Business Studies, 20*(4), 443–464. https://doi.org/10.1080/14765284.2022.2082886
[50] Zhang, Y., Li, X., & Wang, J. (2023). Spatial spillover effects of logistics-manufacturing co-agglomeration on regional economic resilience: Evidence from China. *Sustainability, 15*(10), 8208. https://doi.org/10.3390/su15108208
[51] Zhang, Y., Wang, Y., & Liu, Z. (2025). Regulation and control strategy of highway transportation volume in urban agglomerations based on complex network. *Sustainability, 17*(13), 5769. https://doi.org/10.3390/su17135769

[52] Zou, W., & Xu, L. (2024). Dynamic development characteristics and driving factors of high-quality development level in China's five major urban agglomerations. *Chinese Geographical Science, 34*(6), 777–790. https://doi.org/10.1007/s11769-024-1425-x

[53] Zhu, J. H., Li, X., & Wang, Y. (2020). Research on the spatial-temporal evolution and influencing factors of urban resilience in China's three major urban agglomerations. *Geographical Research, 39*(2), 272–288. https://doi.org/10.11821/dlyj020181241