# Coupled Coordinated Development of China's New Infrastructure and Regional Resilience: Spatiotemporal Differences and Evolutionary Trends (Postprint)

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## Abstract

The coupled and coordinated development of new infrastructure and regional resilience is an effective pathway for achieving new-type urbanization. This study constructs an evaluation index system for new infrastructure and regional resilience, measures the development indices and coupling coordination levels of new infrastructure and regional resilience for 31 provinces from 2013 to 2020 based on a combination weighting method and coupling coordination degree model, and analyzes their spatiotemporal differences and evolution trend characteristics using the Dagum Gini coefficient, spatial autocorrelation, and Markov chain. The results reveal that: (1) Both the new infrastructure and regional resilience development indices show an upward trend, and their coupling coordination state has transformed from mild imbalance to barely coordinated. (2) The coupling coordination level exhibits spatial non-equilibrium, with the overall disparity showing a decreasing trend, and inter-regional differences constituting the primary source of overall disparity. (3) The coupling coordination level demonstrates significant spatial agglomeration characteristics, mainly manifested as high-value clusters in the eastern region and low-value clusters in the western region. (4) The coupling coordination exhibits a probabilistic tendency to transition to higher levels, yet it is difficult to achieve leapfrog development; high-value provinces demonstrate significant positive spillover effects on neighboring provinces. This research reveals the current development status of new infrastructure and regional resilience, which helps provide theoretical support and decision-making references for planning and management among multiple stakeholders.

## Full Text

# Coupling and Coordinated Development of New Infrastructure and Regional Resilience in China: Spatio-temporal Differences and Evolution Trends

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### Abstract

Coupling and coordinated development of new infrastructure and regional resilience represents an effective pathway to achieving new urbanization. This study constructs an evaluation index system for new infrastructure and regional resilience, measures the development index and coupling coordination level of new infrastructure and regional resilience across 31 Chinese provinces from 2013 to 2020 based on combination weighting and a coupling coordination degree model, and analyzes spatio-temporal differences and evolution trend characteristics using the Dagum Gini coefficient, spatial autocorrelation, and Markov chain. The results reveal: (1) Both the new infrastructure and regional resilience development indices show upward trends, with the coupling coordination state transitioning from mild imbalance to narrow coordination. (2) The coupling coordination level exhibits spatial non-equilibrium; although overall differences have decreased, interregional differences remain the primary source of overall disparity. (3) The coupling coordination level demonstrates pronounced spatial agglomeration characteristics, mainly manifested as high-value agglomeration areas in the east and low-value agglomeration areas in the west. (4) Coupling coordination tends to progress toward higher levels, though leapfrog development remains challenging; high-value provinces exert significant positive spillover effects on neighboring provinces. This study illuminates the development status of new infrastructure and regional resilience, providing theoretical support and decision-making references for multi-agent planning and management.

**Keywords:** new infrastructure; regional resilience; coupling coordination degree; spatial differences; evolution trend

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## 1. Coupling Mechanism Between New Infrastructure and Regional Resilience

Regional resilience construction requires support and promotion from new infrastructure, while the continuous development of new infrastructure also needs guidance and assurance from regional resilience. The two complement and promote each other, aligning with sustainable development and construction requirements, and constituting an effective pathway to new urbanization. Figure

1 illustrates the coupling and coordinated development mechanism between new infrastructure and regional resilience.

New infrastructure provides robust technical support for regional resilience, serving as the dynamic engine and foundational underpinning for resilience building. Its driving and enhancing effects on regional economic development, social services, and ecological governance manifest in several ways: Smart manufacturing, logistics, and artificial intelligence industries can inject new momentum into regional development, promote economic structural transformation and upgrading, create new employment opportunities and economic growth points, and guide new consumption patterns through new business forms and models, thereby enhancing regional economic competitiveness. Big data and cloud computing technologies can improve resource utilization efficiency, deliver higher-quality public services in healthcare, education, and culture, and facilitate data sharing, interaction, and analysis to smooth regional factor flows and efficient allocation, enhance urban operational efficiency, and refine crisis management and emergency response precision. Green technology innovations in clean energy, intelligent transportation, and sewage treatment help optimize resource allocation and energy consumption, promote energy conservation, emission reduction, and environmental protection, and build diversified urban ecosystems.

As the practical carrier of new infrastructure, regional resilience construction provides a safe development space for new infrastructure and offers real-time feedback. Compared with traditional infrastructure, new infrastructure with digital characteristics has a more complex technical structure. Regions with strong resilience can better adapt to various environmental changes and uncertainties, providing security guarantees for new infrastructure, cultivating various market investment entities, and accelerating the layout of new infrastructure and strategic emerging industries. The regional resilience index can guide investment decisions for new infrastructure, direct its construction orientation, and enable sustainable, intelligent, and efficient operation. New infrastructure requires adequate resource and financial support, and resilient cities can provide necessary core factor inputs by allocating innovative ecosystems and high-quality data resources, thereby seizing digital transformation opportunities and promoting the application and upgrading of regional digital, intelligent, and green technologies, ultimately forming a virtuous cycle and organic integration.

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## 2. Data and Methods

**2.1 Index System Construction** In 2020, China' s National Development and Reform Commission clarified the connotation of "new infrastructure": an infrastructure system led by new development concepts, driven by technological innovation, based on information networks, serving high-quality development needs, and providing digital transformation, intelligent upgrading, and integrated innovative services. New infrastructure encompasses information infrastructure, converged infrastructure, and innovative infrastructure, which can be further refined into communication networks, new technologies, computing power, intelligent transportation, smart energy, major science and technology, science and education, and industrial technology innovation. Based on relevant domestic policies and drawing on previous research [3,30-33], this study selects indicators such as the number of mobile phone base stations to characterize new infrastructure development levels.

Regional resilience involves multiple dimensions of economy, society, and ecology. Economic resilience can be understood as the ability of an economy to cope with external disturbances, manifested as regional economic level and industrial structure diversification. Social development emphasizes people-oriented principles, with social resilience reflected in improved population quality, social stability, and perfected security systems. Ecological resilience includes adaptability, sustainability, and pollution control capabilities for ecological protection and restoration. From a complex systems perspective, resilience across different dimensions collectively constitutes the overall resilience of the regional development system. Referencing existing literature on resilience measurement [19,22,37], this study constructs a regional resilience evaluation system from economic resilience, social resilience, and ecological resilience subsystems, with specific indicators shown in Table 1.

**2.2 Data Sources** Taking 31 Chinese provinces (excluding Hong Kong, Macao, and Taiwan due to data unavailability) as research samples, the observation period of 2013-2020 was selected considering data availability and accuracy for "new infrastructure." In the index system, the number of industrial internet, artificial intelligence, ultra-high voltage, and new energy charging pile enterprises comes from the Qichacha official platform; other data are sourced from the *China Statistical Yearbook*, *China Torch Statistical Yearbook*, and *China Science and Technology Statistical Yearbook*, with missing values supplemented using linear interpolation. Following National Bureau of Statistics standards, the 31 provinces are divided into eastern, central, western, and northeastern regions.

### 2.3 Research Methods

**2.3.1 Combination Weighting Method** Objective weighting determines indicator weights based on data attributes (i.e., relative degree of variation) using methods such as entropy weighting, coefficient of variation, and CRITIC. These methods offer credibility and precision but fail to consider hierarchical importance relationships among indicators and exhibit strong sample dependence. The order relation method [38] is a subjective weighting approach based on expert experience for qualitative ranking followed by rational value assignment for importance degree. Compared with the AHP method, it requires no consistency test and involves simpler calculation operations.

To effectively avoid one-sidedness from single weighting and fully consider both intrinsic statistical patterns and authoritative values among indicator data, this study selects the entropy weight method and coefficient of variation method to determine objective weights, obtains subjective weights through the order relation method, and calculates final modified weights ($F_j^*$) using formula (1), then computes the new infrastructure and regional resilience development index ($S_{it}$) for each province using formula (2). The specific formulas are as follows:

$$F_j^* = \frac{R_j \times W_j}{\sum_{j=1}^{m} R_j \times W_j}$$

$$S_{it} = \sum_{j=1}^{m} L_{ijt} F_j^*$$

where $m$ is the number of indicators; $R_j$ and $W_j$ represent the subjective weight and the weights from entropy method and coefficient of variation method for indicator $j$, respectively; $L_{ijt}$ is the standardized value of indicator $j$ for province $i$ in year $t$.

**2.3.2 Coupling Coordination Degree Model** Referencing the coupling concept in physics, the intensity of mutual influence between two systems can be reflected through coupling degree, while the level of collaborative development must be judged by coupling coordination degree [39]. The coupling coordination degree model is:

$$C = 2 \times \frac{\sqrt{U_1 \times U_2}}{U_1 + U_2}$$

$$T = \alpha U_1 + \beta U_2$$

$$D = \sqrt{C \times T}$$

where $C$ is the coupling degree; $D$ is the coupling coordination degree; $T$ is the comprehensive coordination index; $U_1$ and $U_2$ are the new infrastructure and regional resilience development indices, respectively; $\alpha$ and $\beta$ are parameters to be determined. Regional resilience construction represents a more crucial component of China' s medium- and long-term economic and social development strategy. Referencing studies by Yu Jie [40] and Yang Yuhuan [41], we set $\alpha = 0.4$ and $\beta = 0.6$. Based on $D$ values, the coupling coordination degree between new infrastructure and regional resilience is classified as shown in Table 2.

**2.3.3 Dagum Gini Coefficient** Compared with difference measurement methods such as the Theil index and Herfindahl index, the Gini coefficient decomposition method proposed by Dagum can decompose overall differences into sources, offering advantages in accurately identifying contributions of intra-regional differences, inter-regional differences, and transvariation density to overall disparity [42]. The model is as follows:

$$G = \sum_{j=1}^{k}\sum_{h=1}^{k}\sum_{i=1}^{n_j}\sum_{r=1}^{n_h}\frac{|y_{ji}-y_{hr}|}{2n^2\bar{y}}$$

where $G$ is the Gini coefficient; $k$ is the number of regions; $n_j$ and $n_h$ are the numbers of provinces in regions $j$ and $h$, respectively; $y_{ji}$ and $y_{hr}$ are the coupling coordination degrees of any province in regions $j$ and $h$, respectively; $\bar{y}$ is the mean value; $n$ is the total number of provinces; $G_w$, $G_{nb}$, and $G_t$ represent the contribution rates of intra-regional differences, inter-regional differences, and transvariation density, respectively.

**2.3.4 Exploratory Spatial Data Analysis** Exploratory spatial data analysis can explore the spatial correlation characteristics of coupling coordination degree. The global spatial autocorrelation model is shown in formula (7), where $w_{uv}$ is the spatial weight matrix; $X^2$ is the sample variance; $D_u$ and $D_v$ are the coupling coordination degrees of adjacent provinces; $\bar{D}$ is the mean coupling coordination degree. The local Moran' s $I$ statistic identifies the location of agglomeration centers, calculated as shown in formula (8):

$$I = \frac{n}{X^2}\sum_u\sum_v w_{uv}(D_u-\bar{D})(D_v-\bar{D})$$

$$I_i = \frac{D_v-\bar{D}}{X^2}\sum_u w_{uv}(D_v-\bar{D})$$

where $\bar{D}=\frac{1}{n}\sum_v D_v$, $X^2=\frac{1}{n}\sum_u(D_u-\bar{D})^2$. Moran' s $I$ ranges from $[-1,1]$, with values closer to 1 indicating stronger spatial positive correlation in coupling coordination degree between regions.

**2.3.5 Spatial Markov Chain** The Markov chain reflects the transfer direction and probability of coupling coordination levels between new infrastructure and regional resilience. The $n$-step probability transfer matrix has elements $P_{ij}$ representing the probability that a province with coupling coordination degree class $i$ in period $t$ transitions to class $j$ in period $t+1$, calculated as:

$$P_{ij} = \frac{n_{ij}}{n_i}$$

where $n_{ij}$ is the number of provinces whose coupling coordination degree transitions from class $i$ to class $j$ during the study period; $n_i$ is the number of provinces in class $i$.

The spatial Markov chain introduces a "spatial lag" condition based on the traditional Markov chain, using the spatially weighted average of neighboring provinces' attribute values as the spatial lag value to analyze state transition trends under spatial factors [43]. The spatial lag value is calculated as:

$$\text{Lag}_a = \sum_b Y_b W_{ab}$$

where $Y_b$ is the coupling coordination degree of province $b$; $W_{ab}$ is the spatial weight matrix determined by the adjacency principle (1 for adjacent regions, 0 for non-adjacent regions).

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## 3. Results and Analysis

**3.1 Development Index of New Infrastructure and Regional Resilience** Using formula (2), we calculate the new infrastructure and regional resilience development indices (Table 3). Overall, both indices show upward trends during the study period, increasing from 0.141 to 0.383 and from 0.182 to 0.336, respectively. Using ArcGIS natural breaks classification, we divide the average indices of new infrastructure and regional resilience into four tiers to reveal their spatial differentiation characteristics (Figure 2). The results show significant spatial heterogeneity in both new infrastructure and regional resilience levels, generally presenting an east-to-west gradient decreasing pattern. For new infrastructure, Guangdong and Jiangsu rank in the national first tier, Beijing, Zhejiang, and Shandong in the second tier, while most western and northeastern provinces fall in the fourth tier. For regional resilience, Guangdong, Beijing, Jiangsu, Zhejiang, and Shandong lead the national first tier, far ahead of the fourth tier composed of western provinces. This result is largely consistent with findings from other scholars [19,44-45] and aligns with the distribution characteristics of China' s regional resilience construction. The national mean values for new infrastructure and regional resilience development indices are 0.238 and 0.254, respectively, with only 11 and 12 provinces exceeding these means, indicating considerable potential for improvement in both new infrastructure and regional resilience development.

**3.2 Temporal Evolution of Coupling Coordination Degree** Using formulas (3)-(5), we calculate the coupling coordination degree between new infrastructure and regional resilience (Table 4). Nationally, the mean coupling coordination degree shows a stable upward trend, increasing from 0.371 in 2013 to 0.521 in 2020, transitioning from mild imbalance to narrow coordination status, reflecting China' s effective new infrastructure and resilience construction and continuously improving synergistic development levels. Standard deviation and coefficient of variation are commonly used statistical indicators to describe data dispersion, applied here to measure regional differences in coupling coordination degree. The coefficient of variation shows a fluctuating downward trend, opposite to the standard deviation trend, indicating that relative differences in coupling coordination degree among provinces are gradually decreasing.

At the provincial level, only Guangdong, Jiangsu, Shandong, Zhejiang, and other 8 provinces had coupling coordination degrees above the national average in 2020, with Guangdong and Jiangsu having already achieved good coordination status. These provinces have convenient coastal locations, high economic development levels, and dense high-tech industries, providing favorable human and material foundations for new infrastructure development, with both new infrastructure and regional resilience indices ranking nationally advanced. In 2020, Tibet, Qinghai, Ningxia, Gansu, Xinjiang, and Guizhou remained in imbalance status, with Tibet and Qinghai ranking lowest nationally. New infrastructure development in these provinces lags behind, with insufficient support for urban resilience improvement, resulting in long-term moderate imbalance between new infrastructure and urban resilience. These provinces are located in western China, constrained by geographical location and resource endowments, with relatively backward economic, social, and technological innovation development, weak foundations for new infrastructure and regional resilience construction, and low coupling coordination levels. Overall, the number of provinces achieving narrow coordination or above is gradually increasing, reflecting certain achievements in the coupling and coordinated development of China' s new infrastructure and regional resilience, with an improving overall synergy level. Future efforts should strengthen top-level design and adopt differentiated policies for lagging regions to address weaknesses and accelerate integrated development of new infrastructure and regional resilience coordination.

**3.3 Regional Differences and Source Decomposition of Coupling Coordination Degree** The Dagum Gini coefficient and its decomposition method are used to measure and decompose spatial differences in coupling coordination degree between new infrastructure and regional resilience from 2013 to 2020, with results shown in Figure 3.

**(1) Overall and intra-regional differences**

Figure 3(a) shows the overall Gini coefficient and intra-regional Gini coefficients for coupling coordination degree. The overall Gini coefficient ranges between 0.148-0.168, with the dynamic curve roughly showing an "inverted N" shape and a significant downward trend, consistent with the coefficient of variation results. Intra-regional differences vary across regions: eastern and western regions show larger internal differences, followed by the central region, with the smallest differences in the northeastern region. The Gini coefficient within the eastern region shows a fluctuating downward trend, decreasing from 0.141 in 2013 to 0.112 in 2020, indicating narrowing internal differences and enhanced coordinated development. The western region' s Gini coefficient continued rising from 2018 to 2020, indicating widening gaps among western provinces in coupling coordination development. The northeastern region' s Gini coefficient remains at a low level, with relatively small differences among Heilongjiang, Jilin, and Liaoning provinces, showing a "club convergence" phenomenon.

**(2) Inter-regional differences**

Figure 3(b) illustrates differences in coupling coordination development levels among the four major regions. Observing inter-regional differences, the coupling coordination level ranks highest in the eastern region, followed by central, northeastern, and western regions. The gaps between east-west, east-central, and northeast-west regions all show narrowing trends, with inter-regional Gini coefficients decreasing at average annual rates of 1.97%, 2.31%, and 4.48%, respectively. Conversely, gaps between east-northeast and central-northeast regions show increasing trends, with average annual growth rates of 1.22% and 5.16%. All four regions have improved their coupling coordination development levels between new infrastructure and regional resilience, with relatively slower development in the northeastern and western regions.

**(3) Sources and contribution rates of regional differences**

Figure 3(c) describes the sources and contribution rates of overall differences in coupling coordination degree between new infrastructure and regional resilience. Inter-regional differences contribute the most, with contribution rates ranging from 67%-69% and showing a slight downward trend. Intra-regional difference contribution rates range from 21%-23%, with a slight upward trend in recent years. Transvariation density contributes 9%-11% to overall differences, with a relatively stable trend, indicating that spatial overlapping effects have minimal impact on overall differences. Evidently, inter-regional differences in coupling coordination levels between new infrastructure and regional resilience will remain the primary source of overall differences for some time, while intra-regional differences cannot be ignored either. Breaking geographical barriers and promoting balanced development both between and within regions is key to advancing coupling coordination to higher levels.

**3.4 Spatial Correlation of Coupling Coordination Degree** Table 5 shows that the global Moran' s $I$ for coupling coordination degree is positive during the study period, with all $p$-values less than 0.01, passing the 1% confidence level significance test, indicating significant spatial positive correlation in coupling coordination degree between new infrastructure and regional resilience—i.e., provinces with similar coordination levels exhibit agglomeration distribution. Moran' s $I$ fluctuates over time, decreasing from 0.306 in 2013 to 0.266 in 2015, then rising to 0.346 by 2020, with enhanced global autocorrelation agglomeration trends and narrowing gaps in coupling coordination degree among provinces. Since "new infrastructure" was first proposed at the 2018 Central Economic Work Conference, intensive deployment of new infrastructure policies across regions has achieved initial success, with regional resilience levels subsequently improving and spatial correlation showing an enhancing trend.

ArcGIS and Geoda software are used to plot LISA agglomeration maps of coupling coordination degree (Figure 4), revealing spatial agglomeration and evolution characteristics. The results show significant spatial agglomeration in coupling coordination degree between new infrastructure and regional resilience, primarily manifested as high-value agglomeration areas in the east and low-value agglomeration areas in the west.

Eastern coastal provinces consistently remain in high-high agglomeration areas, with slight changes in spatial patterns. Central provinces such as Hunan and Shanxi evolved from non-significant and low-high agglomeration to high-high agglomeration and non-significant types, respectively, reflecting that high-value provinces in eastern coastal areas have radiation-driven effects on surrounding provinces, particularly more significant in the east-west direction. Low-low agglomeration areas show no obvious transition, mainly including Tibet, Xinjiang, Qinghai, and Gansu—four provinces where special geographical environments and human factors are unfavorable for emerging technology industry development, resulting in weak new infrastructure and resilience construction and eventually forming a "Matthew effect" where "the high remain high and the low remain low."Future efforts should implement the Western Development Strategy, seize opportunities from the Belt and Road Initiative, strengthen inter-regional integration and exchange, and promote coordinated integrated development.

### 3.5 State Transition Characteristics of Coupling Coordination Degree

Using the quartile method, the coupling coordination level between new infrastructure and regional resilience is divided into four grades: low (L), medium-low (ML), medium-high (MH), and high (H). The spatial distribution map of provincial state transitions is plotted (Figure 5), and a Markov state transition probability matrix is constructed (Table 6).

The Markov state transition probability matrix reveals the following characteristics of coupling coordination degree transitions without considering spatial interaction: (1) There is a probability tendency to transition to higher levels. During the study period, no provinces transferred downward; provinces at low, medium-low, and medium-high levels have probabilities of 33.3%, 23.8%, and 14.3% to transition to higher levels, respectively, showing a positive dynamic evolution trend. (2) Leapfrog transitions are difficult to achieve, with transitions only occurring between adjacent levels. The probability of direct transition from low to medium-high or high levels is nearly zero, indicating that coupling coordination development is a gradual process. (3) Values on the main diagonal represent the probability of maintaining the original state, which are significantly larger than off-diagonal values, indicating stability in maintaining the original state during coupling coordination evolution.

The global Moran' s index shows significant spatial correlation in coupling coordination degree, so spatial Markov chain is used to explore changes in transition probability under spatial interaction. Table 6 shows that when a province is adjacent to high-grade provinces, its transition probability changes: the probability of transitioning from medium-low to medium-high increases from 23.8% to 28.6%; when adjacent to low-grade provinces, the transition probability decreases to 20.0%. When adjacent to high-grade provinces, the probability of transitioning from medium-high to high increases from 14.3% to 25.0%; when adjacent to low-grade provinces, it rises to 16.7%. This reveals that the existence of spatial spillover effects creates a club convergence phenomenon where coupling coordination development between new infrastructure and regional resilience shows overall divergence but local convergence in space.

## 4. Discussion and Conclusions

**4.1 Discussion** Against the backdrop of slowing global economic growth and China's shift to high-quality development, this study directly focuses on the coupling and coordinated development of new infrastructure and regional resilience, measuring and analyzing spatio-temporal differences and evolution trends in their coupling coordination degree, filling gaps in existing research and helping reveal the development status of new infrastructure and regional resilience to provide theoretical support and decision-making references for multi-agent planning and management. The findings show that both new infrastructure and regional resilience exhibit an "east-high, west-low" spatial distribution pattern, consistent with existing research. The overall coordination development trend is positive, but many provinces remain in imbalance status, with severe spatial inequality. Therefore, we must recognize the spatial heterogeneity in coupling coordination development between and within regions, adopt differentiated policies from a top-level design perspective, and promote balanced global development.

For the eastern region with high coupling coordination levels, we should continue leveraging innovation highland advantages, vigorously promote digital and intelligent new infrastructure layout, accelerate organic integration of new technologies, industries, and business forms, and strengthen economic and social operation guarantee capabilities. We should smooth channels for co-construction, sharing, and coordinated interaction, fully exerting spillover-driven effects on surrounding regions. For the central region, we should strengthen regional emergency cooperative governance, actively undertake technology and industrial transfers from the eastern region, enhance coupling support of new infrastructure for regional resilience, and leverage central location advantages as a bridge to promote a spatial interaction pattern of "east driving central, central driving west." For the lagging northeastern and western regions, we should seize opportunities from the Belt and Road Initiative and "East Data West Computing" project, balance new and traditional infrastructure, use policy support to increase innovation resource input and achievement transformation, accelerate digital technology integration into modern system construction, actively explore "latecomer advantages,"avoid blind resource input causing serious disconnect between new infrastructure and urban development, and steadily promote the transition of new infrastructure and regional resilience toward coordinated development.

This study has several limitations and areas for deeper research. Due to data limitations, this study only covers the provincial level. Future research could extend to more refined urban or grid scales with more representative indicators when data become available, yielding more specific and comprehensive results. Additionally, due to space constraints, this study does not deeply analyze relationships and differences among internal subsystems of new infrastructure and regional resilience; relationships and interaction mechanisms among various subfields could be explored in future work. As economy and society develop, the connotation and extension of new infrastructure will continue to evolve, and its coupling coordination with regional development will remain an important research direction.

**4.2 Conclusions** Based on combination weighting and a coupling coordination degree model, this study measures China' s new infrastructure and regional resilience development indices and their coupling coordination level, and analyzes spatial differences and evolution trends using the Dagum Gini coefficient, spatial autocorrelation, and Markov chain. The main conclusions are:

(1) Both new infrastructure and regional resilience levels have significantly improved, roughly presenting an east-to-west gradient decreasing pattern with notable spatial heterogeneity.

(2) The coupling coordination degree between new infrastructure and regional resilience has steadily increased, with the coordination state improving from mild imbalance to narrow coordination, demonstrating positive coordinated development momentum.

(3) The overall Gini coefficient for coupling coordination degree shows significant decline followed by fluctuation, indicating a certain convergence trend. Intra-regional differences are largest in eastern and western regions, followed by the central region, with the smallest in the northeastern region. Inter-regional gaps between northeast-east and northeast-central regions continue expanding, with inter-regional differences being the primary source of overall disparity.

(4) The coupling coordination degree exhibits pronounced spatial agglomeration characteristics, mainly manifested as high-value agglomeration areas in the east and low-value agglomeration areas in the west.

(5) The coupling coordination state tends to transition to higher levels, though leapfrog development remains difficult; high-value provinces exert significant positive spillover effects on neighboring provinces.

## References

[1] Proposal of the Central Committee of the Communist Party of China on formulating the 14th Five-Year Plan for National Economic and Social Development and the Vision Goals for the Year 2035 [C]//China Enterprise Reform and Development Research Association. China Enterprise Reform and Development 2020 Blue Book. Beijing: China Commerce and Trade Press, 2020: 16.

[2] Wang Haoyu, Wang Yongjie. Connectivity and segregation: The duality of infrastructure and its policy implications [J]. Chinese Public Administration, 2021, 37(10): 146-154.

[3] Zhang Pei, Wang Yue, Xiao Fan. Spatial evolution and determinants of new infrastructure development in China [J]. Progress in Geography, 2023, 42(2): 209-220.

[4] Yu Ping, Xu Zhiqi. The impact of digital new infrastructure on the green technology innovation efficiency of strategic emerging industries [J]. Journal of Industrial Technological Economics, 2023, 42(1): 62-70.

[5] Yang Na. Research on new infrastructure boosting industrial structure upgrading and optimization: Comment on *New Infrastructure: New Structural Forces in the Digital Age* [J]. Journal of Commercial Economics, 2022(6): 2.

[6] Li Haigang. Digital new infrastructure, spatial spillover and high-quality economic development [J]. Inquiry into Economic Issues, 2022(6): 28-39.

[7] Huo Chunhui, Lü Mengxiao, Zhang Yindan. Research on the impact of new digital infrastructure on domestic value chain circulation [J]. Contemporary Finance & Economics, 2023, 459(2): 120-131.

[8] Liu Fengqin, Su Congcong. Theoretical analysis and empirical research on new infrastructure helping China's high-quality economic development [J]. Shandong Social Sciences, 2021(5): 136-141.

[9] Zhu Wanjing, Gao Xiaoping. Resilience governance of urban public security driven by blockchain technology: A theoretical interpretation [J]. Administrative Tribune, 2023, 30(2): 101-110.

[10] Sun Yuewen. Big data: New strategy of public security governance in modern cities [J]. Urban Development Studies, 2017, 24(2): 79-83.

[11] He Yuchang. How much impact will the new infrastructure acceleration have in 2020 [J]. People' s Tribune, 2020(21): 24-26.

[12] Holling C S. Engineering resilience versus ecological resilience [M]//Schulze P. Engineering within Ecological Constraints. Washington, D C: National Academic Press, 1996: 31-44.

[13] Walker B, Gunderson L, Kinzig A, et al. A handful of heuristics and some propositions for understanding resilience in social-ecological systems [J]. Ecology and Society, 2006, 11(1): 709-723.

[14] Li Liangang, Zhang Pingyu, Tan Juntao, et al. Review on the evolution of resilience concept and research progress on regional economic resilience [J]. Human Geography, 2019, 34(2): 1-7, 151.

[15] Nystrom K. Regional resilience to displacements [J]. Regional Studies, 2018, 52(1): 4-22.

[16] He Canfei, Sheng Hantian. Regional economic resilience: A review and future development outlook [J]. Human Geography, 2023, 38(1): 1-10.

[17] Chen Tian, Wang Yixuan. Review on hot topics of resilient city research and practice in 2022 [J]. Science & Technology Review, 2023, 41(1): 202-214.

[18] Song Yuchen, Sun Hongyuan. Dynamic evolution characteristics and regional differences of China' s economic resilience [J]. Statistics & Decision, 2023, 39(9): 109-114.

[19] Zhang Sisi, Ma Xiaoyu, Cui Qi. Spatial-temporal dynamic evolution of urban resilience and its influencing factors in China [J]. Statistics & Decision, 2023, 39(3): 110-115.

[20] Fang Yudong, Wang Wen, Zhang Zhi, et al. Strategies for disaster prevention and mitigation in safety and resilient cities [J]. Strategic Study of CAE, 2023, 25(1): 1-9.

[21] Huang Menghan, Zhang Weiguo. Comparison of resilience levels and development strategies of four types of resource-based cities in China [J]. Economic Geography, 2023, 43(1): 34-43.

[22] Wen Chuanhao, Tan Junyin, Hu Yuling, et al. Research on impact of new infrastructure construction on urban green transformation in upper reaches of Yangtze River: Based on perspective of production-living-ecological space [J]. Resources and Environment in the Yangtze Basin, 2022, 31(8): 1736-1752.

[23] Guo Chaoxian, Wang Jiaqi, Liu Haorong. Studies on how new infrastructure empowers high-quality development of China' s economy [J]. Journal of Beijing University of Technology (Social Sciences Edition), 2020, 20(6): 13-21.

[24] Tan Haofang, Zhang Shoufu. New digital infrastructure, financial resource allocation and high-quality economic development [J]. Journal of Yunnan Minzu University (Philosophy and Social Sciences Edition), 2023, 40(1): 134-142.

[25] Li Yue. Promote high-quality transformation and development of resource-based regions with new infrastructure [J]. Theoretical Exploration, 2021(4): 100-106.

[26] Qiu Dong, Chen Mingli. Research on mechanism of digital platform ecosystem driving the development of regional resilience [J]. Studies in Dialectics of

Nature, 2020, 36(10): 37-41.

[27] Li Xiaohua. New infrastructure construction and policy orientation for a smart society [J]. Reform, 2020(5): 34-48.

[28] Cui Wenjun. Spatial differences and dynamic evolution of China' s new infrastructure development potential [J]. Henan Social Sciences, 2022, 30(11): 88-99.

[29] Zhang Pei, Sun Yong. Spatial pattern and influencing factors of the coupling and coordinated development of new infrastructure and industrial upgrading [J]. Resources and Environment in the Yangtze Basin, 2023, 32(3): 464-477.

[30] Gao Xiaoling, Lu Wenyue. New infrastructure, industrial agglomeration and green technology innovation: An empirical analysis based on the data of manufacturing enterprises [J]. R & D Management, 2023, 35(4): 19-33.

[31] Wu Xianfu, Huang Xiao, Zhong Peng. Measurement and coupling mechanism of the coupling and coordinated development of new infrastructure construction and strategic emerging industries [J]. Scientia Geographica Sinica, 2021, 41(11): 1969-1979.

[32] Zhang Yang, Chen Yulu, Zhang Yang, et al. Spatial-temporal pattern and coupling coordination analysis of production-living-ecological space in Chengdu-Chongqing urban agglomeration [J]. Areal Research and Development, 2022, 41(5): 119-125.

[33] Yan Xuxian, Guo Wei. How digital infrastructure affects regional economic resilience? [J]. Modern Economic Research, 2023(10): 33-42.

[34] Liu Li, Lu Sen. Digital economy, financial development and economic resilience [J]. Finance and Trade Research, 2023, 34(7): 67-83.

[35] Jiang Zhengyun, Liu Qingfang, Song Jinping. Pattern characteristics and evolution mechanism of China' s regional economic resilience [J]. Economic Geography, 2023, 43(6): 1-12.

[36] Zou Jianqin, Ming Qingzhong, Wei Junfeng, et al. The spatio-temporal evolution of urban tourism system resilience and its influencing factors from the perspective of socio-ecological coupling [J]. Resource Development & Market, 2023, 39(3): 368-376.

[37] Liu Qiyuan, Fan Zhongqi. Regional resilience evaluation and spatio-temporal evolution and coupled coordination analysis from a demand level perspective [J]. Ecological Economy, 2023, 39(3): 213-222.

[38] Wang Xuejun, Guo Yajun. Analyzing the consistency of comparison matrix based on G1 method [J]. Chinese Journal of Management Science, 2006, 14(3): 65-70.

[39] Yu Jie. Evaluation and optimization of the coordinative degree between

tourism industry and regional economy in Shandong Province [J]. China Population, Resources and Environment, 2014, 24(4): 163-168.

[40] Yang Yuhuan, He Jianxiong, Zhang Xinhong, et al. Spatial differentiation characteristics and influencing texture of the coupling coordinated development of agro-culture-tourism in China [J]. Arid Land Geography, 2023, 46(3): 448-459.

[41] Zhang Jiyang. Spatial difference and convergence of innovative development in Yangtze River delta: Based on Dagum Gini coefficient and decomposition [J]. Resources and Environment in the Yangtze Basin, 2023, 32(2): 235-249.

[42] Li Deli, Tian Wei, Tian Gang. Interval differences and dynamic evolution of high-quality development of China' s tourism economy [J]. Statistics & Decision, 2022, 38(24): 84-88.

[43] Xu S, Wang X, Zhu R, et al. Spatio-temporal effects of regional resilience construction on carbon emissions: Evidence from 30 Chinese provinces [J]. Science of The Total Environment, 2023, 887, 164109, doi: 10.1016/j.scitotenv.2023.164109.

*Note: Figure translations are in progress. See original paper for figures.*