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A Study on the Coupling, Coordination, Spatiotemporal Characteristics, and Influencing Factors of New-Quality Productive Forces and Integrated Urban-Rural Development in the Western Regions

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Abstract

Using panel data from various provinces in the western region from 2010 to 2024 as the sample, this paper constructs evaluation indicator systems for the development levels of new-quality productive forces and integrated urban-rural development at the provincial level, respectively. The entropy method is employed to measure the development levels of new-quality productive forces, and a coupling and coordination model is used to evaluate the degree of coupling between these two systems. This paper also examines the spatial clustering of the "new-quality productive forces" and integrated development systems through spatial autocorrelation analysis. To further understand the factors influencing the level of coupling and coordination between the two systems, the Grey Correlation Model was employed to identify the primary factors affecting their coupling and coordination. The study concludes that: 1. In terms of the comprehensive score for new-quality productive forces, overall, the level of new-quality productive forces in most provinces and regions in the western region showed a certain growth trend from 2010 to 2024; however, there were differences in the pace of development and the magnitude of change across different regions, and disparities among regions still persist. 2. In terms of the comprehensive score for urban-rural integration, the level of integration has steadily improved. The average integration score rose steadily from 0.2404 in 2010 to 0.4681 in 2024, an increase of 0.2277 over the 15-year period, with an average annual growth rate of approximately 0.015. 3. The changes in the average coupling coordination index between new-quality productive forces and urban-rural integration show a sustained positive trend, entering a stage of "barely coordinated." The overall average coupling coordination level in the western region rose steadily from 0.382 in 2010 to 0.666 in 2024, an increase of 0.284 over the 15-year period, with an average annual growth rate of approximately 0.019. From 2010 to 2024, the entire province showed a trend of gradually shifting from a level of mild imbalance to a level of preliminary coordination. 4. The results of the spatial autocorrelation analysis show that, with the exception of 2010, the Moran's I index was greater than zero in all other years, indicating the presence of spatial autocorrelation and spatial clustering. 5. The results of the gray correlation model show that the top five indicators with the greatest influence on the coupling coordination index are: urbanization rate; harmless treatment rate of municipal solid waste; per capita disposable income of urban residents; per capita number of people enrolled in unemployment insurance; and environmental protection expenditure. The correlation coefficients for all of these indicators exceed 0.9.

Keywords: new-quality productive forces, coupling coordination index, urban-rural integration

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I. Introduction

The report of the 20th National Congress proposes that "developing new-quality productive forces" be integrated into four key areas: the primary task of high-quality development, the foundational support for revitalizing the nation through science and education, the main focus of building a modern industrial system, and the inherent requirement for green transformation. This forms a closed-loop cycle comprising "technological breakthroughs—factor restructuring—industrial upgrading—institutional safeguards—talent support." As an advanced form of productive forces driven by scientific and technological breakthroughs, new-quality productive forces are not only an inherent requirement for promoting high-quality economic development but also a key driving force for advancing the integrated development of urban and rural areas. The assertion that "we must uphold science and technology as the primary productive force, talent as the primary resource, and innovation as the primary driving force," with the aim of "opening up new fields and new avenues for development, and continuously shaping new momentum and new advantages for development," essentially constitutes a strategic deployment for new-quality productive forces. The Report lists "building a modern industrial system, accelerating the development of the digital economy, and promoting the high-end, intelligent, and green transformation of manufacturing" as core tasks, while emphasizing the need to "promote coordinated regional development and integrated urban-rural development."

China has now entered a new stage of economic development, one in which the new development philosophy must be implemented to drive high-quality development through new-quality productive forces. For a long time, China's urban-rural integration has been characterized by a dualistic structure. In contrast to the rapid growth of urban economies—marked by the continuous accumulation and concentration of factors and resources—rural development, which is primarily agriculture-based, has suffered from slow economic growth, insufficient driving forces, a shortage of factors and resources, and low utilization efficiency. These factors have led to imbalances in China's development across various socioeconomic dimensions.

As a key driver of high-quality economic and social development, the intrinsic link between new-quality productive forces and integrated urban-rural development has increasingly attracted widespread attention in academic circles, with many scholars conducting ongoing research on this topic from various perspectives. With its core characteristics—such as innovation-driven growth and the optimization of production factors—new-quality productive forces offer a theoretical pathway to breaking down the dualistic structure and promoting shared prosperity [1]. Existing research has not only explored the compatibility and coupling relationship between the two at different stages of development from a theoretical perspective but has also revealed the regular patterns and regional imbalances in the spatiotemporal evolution of new-quality productive forces and urban-rural integration by constructing a multidimensional evaluation indicator system [1][2].

At the empirical level, scholars have measured the development levels of new-quality productive forces and urban-rural integration to analyze the dynamic evolution of their coupling and coordination, as well as the patterns of spatial differentiation [2]. Research indicates that new-quality productive forces profoundly influence the process and quality of urban-rural integration through multiple channels, including promoting the free flow of factors of production, facilitating coordinated industrial upgrading, and accelerating the diffusion of technological innovation. However, differences among regions in terms of resource endowments, stages of development, and institutional environments result in significant heterogeneity in the mechanisms and implementation pathways through which new-quality productive forces drive urban-rural integration.

Building upon a systematic review of relevant theories on new-quality productive forces and urban-rural integrated development, as well as a summary of evaluation methods and progress in empirical research, this study constructs a rational and scientifically sound evaluation system based on dimensions such as science and technology innovation-driven development, new-quality factors of production, and new types of production relations to measure and evaluate the new-quality productive forces in the western provinces. Building on the measurement approaches of other researchers, this study constructs an indicator system covering dimensions such as population integration, economic integration,

social integration, ecological integration, and spatial integration to conduct the assessment. On this basis, this paper will further explore differentiated implementation pathways tailored to different regions, as well as institutional safeguards such as policy coordination and risk prevention and control, with the aim of providing theoretical references and practical insights for promoting integrated development.

2. Literature Review

Since the General Secretary proposed the concept of "new-quality productive forces" in 2023, the academic community has actively conducted research on this topic. Some scholars have explored the connotations, measurement, influencing factors, and mechanisms of new-quality productive forces from various research perspectives. This paper provides a literature review focusing on new-quality productive forces, urban-rural integration, and the coupling and coordination between new-quality productive forces and urban-rural integration.

Regarding new-quality productive forces: As a significant development in contemporary theories of productive forces, the conceptual definition of new-quality productive forces must begin with the qualitative leap in productive forces and the characteristics of the era. Against the backdrop of rapid global digitalization and the rapid development of information technology, new-quality productive forces have been jointly driven by technological innovation, the evolution of scientific systems, and changes in market demand. Their distinctive features include informatization, networking, automation, greening, and high efficiency [3]. New-quality productive forces are, in essence, a form of green productive forces, and their theoretical foundation regarding the ecological dimension stems from the assertion of "reconciliation between humanity and nature" in the *Economic and Philosophical Manuscripts of 1844*. This establishes the philosophical foundation of Marxist views on nature and the theory of productive forces for new-quality productive forces, highlighting both their continuity with and innovation over traditional theories of productive forces. At the same time, guided by the New Development Philosophy and driven by green scientific and technological innovation, the new-quality productive forces embody philosophical coherence from concept to practice [4]. The core characteristics of the new-quality productive forces can be interpreted from three dimensions—technological, ecological, and socio-economic—though theoretical disagreements exist across different literature regarding the priority of these characteristics. By driving industrial transformation through digitalization, it has become a key engine for the sustainable development of the Chinese economy [3].

Based on the intrinsic characteristics of new-quality productive forces, this paper proposes constructing an evaluation system from three core dimensions: labor force, means of production, and objects of labor. The labor force dimension emphasizes the enhancement of workers' quality and the cultivation of innovative capabilities; the means of production dimension focuses on technological progress and the level of digitization of production tools; and the objects of labor dimension emphasizes resource

utilization efficiency and environmental sustainability [5]. From a broader perspective, the evaluation of new-quality productive forces should encompass characteristics such as "science and technology innovation-driven development," "high-efficiency, low-consumption, and environmentally sustainable industries," "high-quality living standards and equitable social services," "digital empowerment," and "modernization of national governance capabilities." Together, these characteristics form a multidimensional framework that reflects the comprehensive performance of new-quality productive forces in economic, social, and environmental dimensions [4]. Building on this foundation, driving factors and core indicators have been added, identifying innovation as the primary driving force and the improvement of total factor productivity as the core indicator, with measurement achieved through pathways such as the development of innovation systems, talent pools, industrial foundations, and policy environments [6]. It is evident that the evaluation indicator system for new-quality productive forces includes not only hard technical indicators but also soft institutional and social indicators, reflecting its complexity and systemic nature. Scholars have explored the influencing factors of new-quality productive forces from various perspectives based on their research subjects. Empirical studies have revealed the direct constraining effects of technical factors on the development of new-quality productive forces, particularly issues related to insufficient innovation commercialization and digitalization [7]; other studies have expanded the scope of analysis to include internal and external

socioeconomic and political factors, emphasizing the strategic significance of new-quality productive forces in overcoming the "double trap" [4]; from the perspective of policy pathways, it has been pointed out that influencing factors include not only hard technical conditions but also soft institutional design and the development of the external environment [6].

Overall, enhancing the level of new-quality productive forces requires a multi-pronged approach: internally, strengthening scientific and technological innovation and industrial upgrading; externally, fostering a stable and open international environment; and simultaneously eliminating institutional barriers through policy optimization. These analyses provide a theoretical foundation for formulating targeted policies but also reveal the limitations of current measurement methods, such as the lack of unified standard indicators and long-term dynamic assessments. Future research needs to further integrate macro- and micro-level data to deepen empirical analysis.

Regarding urban-rural integration: The theoretical foundation of urban-rural integration is rooted in a systematic analysis of the relationship between the allocation of spatial resources and social development. Marxist spatial theory provides an important perspective for understanding the essence of this relationship; its core lies in analyzing how social inequalities are reflected in the uneven distribution of spatial power, which in turn leads to the differentiation of spatial structures [8]. Within this framework, urban-rural integration is defined as a process of achieving functional complementarity and coordinated development through the optimization of spatial power structures and resource allocation. This concept not only focuses on the flow of economic factors but also involves the redistribution of public services, social institutions, and spatial power, reflecting a multidimensional and multilevel theoretical integration [8].

From the perspective of driving mechanisms, the theoretical framework of urban-rural integration emphasizes the interaction between government and market behavior. Early theories focused on the spontaneous migration of rural labor, whereas contemporary research pays greater attention to the impact of rational government choices on public service delivery models [9]. The construction of an indicator system for measuring urban-rural integration serves as the foundation for quantitative analysis. Existing research primarily adopts a multidimensional perspective, combining regional characteristics to establish comprehensive evaluation systems. Some scholars have used counties as the basic unit, collecting multidimensional big data to construct a comprehensive measurement system for industrial integration. This system emphasizes the key role of counties as "bridgeheads" for integration and uses multidimensional indicators to reflect the process by which industries transition from independence and fragmentation toward deep urban-rural integration [10]. Other scholars have utilized interprovincial panel data and the entropy method to measure the level of urban-rural integration across Chinese provinces. This method enables objective weighting, avoids subjective bias, and thus accurately depicts the overall progress of urban-rural integration [11]. Addressing the complex conditions of specific regions—such as the natural and economic disparities among the Central, Southern, and Northern regions of Anhui Province—researchers have constructed an indicator system for the ecological efficiency of urban-rural integration. By employing the Super-Efficiency SBM model for non-expected output and the entropy-weighted method for calculation, they have highlighted the importance of ecological efficiency in urban-rural integration [12]. Furthermore, a study based on panel data from China's 31 provinces for the period 2000–2022 analyzed the level of urban-rural integration using methods such as the Dagum Gini coefficient. Its indicator system implicitly covered multiple dimensions, including economic and social aspects, ensuring the comprehensiveness of the spatiotemporal pattern analysis [13]. Overall, although these indicator systems differ in their focus (such as industrial integration, ecological efficiency, or overall levels), they all emphasize the multidimensionality of data and the objectivity of methods, providing a solid foundation for subsequent analyses of spatiotemporal characteristics.

The driving factors of integration primarily include policy orientation, cultural revitalization, and the role of counties as vehicles for integration. First, at the policy level, the Third Plenary Session of the 20th CPC Central Committee explicitly stated that "integrated urban-rural development is an inevitable requirement of Chinese-style modernization," emphasizing its central role in advancing the construction of Chinese-style modernization. This provides top-level design support for urban-rural integration and helps promote long-term social stability, healthy economic development, and social equity and justice [14]. Based on empirical research—such as a study conducted in Hebei Province—measures including

advancing the reform of the rural collective property rights system, developing new forms of rural collective economy, and improving the training system for farmers' knowledge and skills have been identified as key drivers of urban-rural integration. These measures help build a modern economic system and inject momentum into the modernization of agriculture and rural areas [15].

In summary, these driving factors interact to form a multidimensional driving mechanism characterized by policy guidance, cultural empowerment, spatial support, and institutional innovation, which collectively promote integrated development.

Regarding the Coupling and Coordination of New-Quality Productive Forces and Urban-Rural Integration: By promoting the efficient reorganization and optimal allocation of production factors, new-quality productive forces have significantly improved resource utilization efficiency, becoming one of the core mechanisms for promoting integrated urban-rural development. According to a literature review, the role of new-quality productive forces in factor reorganization is primarily manifested at three levels: technological penetration, the improvement of market mechanisms, and institutional innovation. One study employed a method combining theoretical coupling analysis with regional empirical research to reveal that new-quality productive forces, through the mechanism of factor reorganization, promote two-way flows of factors such as capital, labor, and technology, thereby narrowing development gaps [16].

In terms of analytical methods, most studies employ case comparisons and quantitative regression tests to examine the effects of spatial restructuring. One study, using a threshold regression model, found that the impact of new-quality productive forces on integration exhibits increasing marginal returns under conditions of an efficient market and an active government, indicating that spatial restructuring requires policy-market synergy [17]. An empirical study of prefecture-level cities in the Yangtze River Delta region from 2012 to 2022 employed the entropy-weighted method to construct an evaluation index system for new-quality productive forces and integration, and calculated the comprehensive development index and coupling coordination index. The study concluded that although the development level of new-quality productive forces in cities across the Yangtze River Delta region lagged behind the level of integrated development overall during the observation period, its growth rate was significantly higher than that of integration, suggesting that new-quality productive forces possess stronger growth potential and a late-mover advantage, and may become a key variable in advancing urban-rural integration to a deeper level in the future [18].

In summary, regarding the impact of new-quality productive forces on urban-rural integration, there has been extensive research on various aspects, including measurement, mechanism analysis, and regional disparities; these studies lay a solid foundation for this research. Drawing on relevant literature and taking into account the unique characteristics of the western region, this paper selects a reasonable indicator system to measure the levels of new-quality productive forces and urban-rural integration across western provinces. On this basis, the paper employs a coupling coordination model to assess the degree of coupling and coordination between these two systems and to analyze the underlying causes of coordination gaps across different provinces.

3 .Research Design and Methods

3.1Overview of the Study Area

This paper focuses on the western region of China. By constructing a scientific and reasonable indicator system, it measures the new-quality productive forces and the integrated urban-rural development across the western provinces from 2010 to 2024. It then uses a coupling coordination model to analyze the coupling coordination between these two systems and explores the underlying causes. The "Western Region" covered in this study includes the following provinces and municipalities: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, and others.

3.2Data Sources

The study covers the period from 2010 to 2024. Data on new-quality productive forces and urban-rural integration were sourced from the *China Statistical Yearbook*, the *China Science and Technology Statistical Yearbook*, the *China Labor Statistical Yearbook*, and annual statistical yearbooks and statistical bulletins published by local governments. Linear interpolation was used to fill in missing data.

3.3Construction of the Indicator System

This paper reviews the literature on new-quality productive forces, particularly the research findings of Liu Jingyu (2025), Li Yanan (2025), and Zhao Jianji, Yan Mingtao, and Wang Yanhua (2024). Based on the actual conditions of the western regions, this paper identifies "science and technology innovation-driven development," new-quality factors of production, and new production relations as first-level evaluation indicators. Based on this, nine second-level indicators and 27 third-level indicators were further refined to assess the temporal and spatial distribution differences in the development of new-quality productive forces across provinces in the western region from 2010 to 2024. The indicators were standardized using the entropy method to determine the level of new-quality productive forces in each province. Please refer to Table 1 for the specific indicator system constructed.

Table 1 Evaluation Indicator System for New-Quality Prod

Dimension Level	Criteria Level	Metric Level	Weight	Attribute
Driven by Technological Innovation（25.6735%）	Investment in Innovation（17.6489%）	R&D Expenditures A1	1.8341%	+
		Expenditures on Science and Technology A2	7.0447%	+
		Number of Companies Engaged in R&D Activities A3	4.4678%	+
		Number of Companies with R&D Facilities A4	4.3023%	+
	Innovation Outputs（8.0246%）	Number of Domestic Patent Applications Accepted for Three Types of Patents A5	4.6660%	+
		Publishing Scientific Papers A6	3.3586%	+
New-Quality Factors of Production（43.5995%）	New-Type Workers（7.8456%）	Full-time Equivalent (FTE) R&D Personnel B1	3.8117%	+
		Employees in the Information Transmission, Computer Services, and Software Industries B2	4.0339%	+
		Average E-commerce Sales B3	3.6487%	+
	New Types of Labor Objects（21.7693%）	Total Telecommunications Services per Capita B4	5.9355%	+
		Number of Legal Entities in the Information Transmission, Software, and Information Technology Services Sector, by Region B5	4.7603%	+
		Number of Internet Broadband Access Ports per 10,000 People B6	3.4043%	+
		Number of Internet Domains per CapitaB7	4.0205%	+
	New-Type Means of Production（13.9846%）	Electricity Generation from Renewable Energy (Hydropower) B8	6.2625%	+
		Revenue from New Product Sales B9	7.7221%	+
New Production Relations（30.726	Relations of Production（3.883	Expenditures on Technological Upgrades in Industrial Enterprises C1	2.4750%	+

8%）	%）	Industrial Sulfur Dioxide Emission Intensity C2	0.3746%	-
		Percentage of GDP Allocated to Environmental Pollution Control Investments C3	1.0334%	+
	Distribution Relationships（10.4674%）	Value Added in the Financial Sector / GDP C4	0.9246%	+
		Technology Market Transaction Volume C5	8.6132%	+
		Value Added in Transportation, Warehousing, and Postal Services / GDP C6	0.9296%	+
	Allocation Relationship（10.8937%）	Total Imports and Exports of Foreign-Invested Enterprises / GDP C7	7.1339%	+
		Resident Income Ratio C8	0.9293%	-
		Number of People Enrolled in Basic Old-Age Insurance C9	2.8305%	+
	Consumer Relations（5.4827%）	Local Government General Budget Expenditures / GDP C10	0.5148%	-
		Total Retail Sales of Consumer GoodsC11	3.3347%	+
		Per Capita Disposable Income of Urban Residents C12	1.6332%	+

Urban-rural integration is a systemic undertaking that requires a multidimensional, comprehensive, scientific, and accurate assessment of its development level. Drawing on the approaches of Sun Yuanxu et al. [19], Sun Yuhuan et al. [20], and Zhao Wei, Zhu Peixin, and Chen Menggen, this study constructs an evaluation index system for the level of urban-rural integration in the western region

Table 2: Indicator System for Urban-Rural Integration

Primary Indicator	Secondary Indicator	Indicator Definition	Weight	Attribute
Population Integration Y1 (11.4898%)	Proportion of Employment in Non-Agricultural and Agricultural Sectors (%) A11	Second, the ratio of workers in the secondary and tertiary sectors to those in the primary sector	6.4159%	+
	Urbanization Rate (%) A22	Ratio of the Urban Population to the Total Population	2.8417%	+
	Population Density Ratio (%) A33	Ratio of Urban Population Density to Rural Population Density	2.2322%	-
Economic Integration Y2 (11.7174%)	Resident Income Ratio (%) B11	Ratio of urban per capita income to rural per capita income	3.8916%	-
	Per Capita Consumption Ratio of Households, % B22	Ratio of per capita consumption in urban households to per capita consumption in rural households	0.8807%	-
	Industrial Output Value Ratio (%) B33	Second, the ratio of the output value of the secondary and tertiary sectors to that of the primary sector	6.9451%	+
Social Integratio	Public library holdings per capita (volumes per person) C11	Ratio of public library holdings to total population	4.8024%	+

nY3 (25.5595 %)	Ratio of healthcare professionals per 1,000 people C22	Ratio of health care professionals per 1,000 people in urban areas to those in rural areas	2.1574%	-
	Number of Participants in the Urban and Rural Residents' Social Pension Insurance (in ten thousand) C33	The ratio of the number of participants in the urban residents' social pension insurance program to the number of participants in the rural residents' social pension insurance program	12.3617%	+
	Number of Unemployment Insurance Participants per Capita (in ten thousand)C44	Ratio of the number of people enrolled in unemployment insurance to the total population	6.2388%	+
Ecological Integratio n Y4 (7.1207%)	Environmental Protection Expenditures per Sheet D11	Local Government Expenditures on the Environment	6.0689%	+
	Rate of Non-Hazardous Treatment of Municipal Solid Waste (%) D22	Ratio of the volume of municipal solid waste treated in an environmentally sound manner to the volume of municipal solid waste generated	1.0518%	+
	Road area per capita (km² per person) E11	Ratio of Road Area to Population	6.0324%	+
Spatial Integratio n Y5 (44.1121 %)	Per capita park green space, km² per person E22	Ratio of Park and Green Space Area to Population	6.8088%	+
	Transportation Network Density (km/km²) E33	Ratio of Railway Operating Mileage to Total Land Area	14.9428%	+
	Percentage of Built-Up Area /% E44	Ratio of Built-Up Area to Urban Area	16.3281%	+

3.4. Research Methods

3.4.1Entropy Weighting Method

Constructing the Indicator Matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{1n} \\ x_{21} & x_{22} & x_{2n} \\ x_{m1} & x_{m1} & x_{mn} \end{bmatrix} \quad (1)$$

Here, xij (i = 1, 2, ..., n; j = 1, 2, ..., m) represents the value of the Jth indicator in the i-th year.

Data Standardization

Second-level indicators consist of positive and negative indicators. For positive indicators, a higher index value is better; for negative indicators, a lower index value is better. First, this paper standardizes the indicators by converting negative indicators into positive ones. Then, the indicators are de-quantified and standardized. Since the indicators used in this paper have different units, they were standardized prior to analysis.

Positive indicators:

$$Y_{ij}^{`} = \frac{\max(X_i) - X_{iJ}}{\max(X_i) - \min(X_i)} \quad (2)$$

Negative indicators:

$$Y_{ij}^{`} = \frac{(X_{ij} - \min(X_i)}{\max(X_i) - \min(X_i)} \quad (3)$$

Suppose there are n evaluation objects and m evaluation criteria, denoted as X1, X2, ..., Xm. Let Xi = x1, x2, ..., xn, and let the standardized values of each criterion be denoted by Y1, Y2, ..., YM.

Determine the weights of each criterion

$$p_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}} \quad (4)$$

Calculate the information entropy for each indicator

$$E_{J=-\ln(n)}\text{-}1\sum_{i=1}^{n} p_{ij} \ln p_{ij} \quad (5)$$

Calculate the weights for each indicator

$$w_j = \frac{1-E_j}{m-\sum_{j=1}^{m} E_j} \quad (6)$$

Calculate the annual composite index of new-quality productive forces for the provinces in the western region

$$s_i = \sum_{i=1}^{m} w_i Y_{ij} (i=1,2,3...n) \quad (7)$$

3.4.2Coupling and Coordination Model

Calculation of Coupling and Coordination

This paper measures the level of coupling and coordination between new-quality productive forces and the urban-rural integration system, utilizing a coupling and coordination model for analysis. Coupling refers to the mutual influence between two or more systems, representing the dynamic interrelationship that enables coordinated development, and reflects the degree of interdependence and mutual constraint among systems. Coordination refers to the extent of positive coupling within these interactive relationships, indicating the quality of coordination. The calculation formula for this model is as follows:

$$C = 2 * \left[\frac{S_1 * S_2}{(S_1 + S_2)} \right]^{\frac{1}{2}} \quad (8)$$

$$T = \alpha * S_1 + \beta * S_2 \quad (9)$$

$$D = \sqrt{C * T} \quad (10)$$

In this formula, C represents the degree of coupling; T represents the comprehensive coordination index; D represents the degree of coupling coordination; α and β are weighting coefficients that indicate the relative importance of the two systems. S1 and S2 represent the comprehensive scores for new-quality productivity and urban-rural integration, respectively. This paper assumes that the new-quality productivity system and the urban-rural integration system are equally important; therefore, the weighting coefficients for both are set to 0.5.

Classification of Coupling Coordination Stages

This paper classifies coupling coordination into 10 levels. If the coupling coordination degree falls within [0–0.1), the coupling coordination level is classified as "extremely imbalanced"; within [0.1–0.2), "severely imbalanced"; within [0.2–0.3), "moderately imbalanced"; within [0.3–0.4), "slightly imbalanced"; [0.4–0.5), it is near imbalance; [0.5–0.6), it is marginally imbalanced; [0.6–0.7), it is at a preliminary level of coordination; [0.7–0.8), it is at an intermediate level of coordination; [0.8–0.9), it is well-coordinated; [0.9–1), it is highly coordinated.

3.4.3Spatial Autocorrelation Model

This article uses the global Moran's I to analyze spatial correlation among provinces in the western region; it measures the spatial clustering or dispersion of observations. If Moran's I is greater than zero, it indicates positive spatial correlation. The larger the value of Moran's I, the stronger and more pronounced the spatial correlation—that is, similar observations tend to cluster spatially, such as high values adjacent to high values or low values adjacent to low values. If the Moran's I is less than zero, the result is the opposite. If the Moran's I equals zero, it indicates that the spatial distribution is random, with no obvious clustering or dispersion trends.

Global Moran's I:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \overline{y})}{s^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \quad (11)$$

In Equation (11), n represents the total number of samples; yi represents the degree of coupling and coordination between new-quality productive forces and urban-rural integration in each province of the western region; y represents the average degree of coupling and coordination between new-quality productive forces and urban-rural integration; s2 represents the variance of the degree of coupling and coordination between new-quality productive forces and urban-rural integration; and wij represents the spatial weight vector. If the calculated Moran's I is greater than 1 (i.e., a positive value), it indicates a positive spatial correlation between the two provinces; conversely, a negative value indicates a negative correlation.

3.4.4Cold-Hot Spot Analysis Model

This analytical method, based on global spatial autocorrelation, is a technique for testing local spatial correlations. It measures the clustering relationship between each observed unit and the central unit. The purpose of applying this method is to assess the relationship between the coupling coordination of a specific region and the central region, and to identify cold spots and hot spots in the coupling coordination of new-quality productive forces and urban-rural integration among the provinces in the western region.

Local Moran's Index:

$$I = \frac{(y_i - \overline{y})\sum_{j=1}^{n} w_{ij}^{`}(y_i - \overline{y})}{s^2} \quad (12)$$

In Equation (12), n represents the total number of samples; yi represents the degree of coupling and coordination between new-quality productive forces and urban-rural integration in each province of the western region; y represents the average degree of coupling and coordination between new-quality productive forces and urban-rural integration across all regions in the western region; s_2 represents the variance of the comprehensive scores for each province, and wij` represents the spatial weight vector after standardization. If the local Moran's I is greater than zero, it indicates a positive spatial correlation among regions; otherwise, the result is the opposite.

3.4.5Grey Relational Analysis Model

This study employs the Grey Relational Analysis (GRA) method to further investigate the relationship between the degree of coordinated development of new-quality productive forces and urban-rural integration in the western region and its influencing factors. This method can handle samples with unknown distribution patterns. The calculation steps are as follows. First, determine the reference sequence. The reference sequence can be found in the normalized matrix ρmax, as expressed below:

$$\rho=\{\rho（1），\rho（2），\rho（3）\cdots\cdots\rho（j）\} \quad （13）$$

In Equation (13), ρ(j) represents the reference value associated with the jth indicator, which is determined by the maximum normalization of each criterion; therefore, ρ(j) = max ρ(j).

Next, the gray correlation coefficient is calculated using the following formula:

$$\gamma_i(j)=\frac{\min_i \min_j|\rho(j)-\rho_i(j)|+\varsigma \max_i \max_j|\rho(j)-\rho_i(j)|}{|\rho(j)-\rho_i(j)|+\varsigma \max_i \max_j|\rho(j)-\rho_i(j)|} \quad （14）$$

In Equation (14), ζ ($0 \le \zeta \le 1$) is the discrimination coefficient, which represents the importance of a feature; the smaller the value of ζ, the higher the feature's discriminative power. Typically, ζ is set to 0.5, as this value generally provides moderate discriminative power and good stability. Finally, the gray correlation is calculated; it is the weighted sum of the gray correlation coefficients, and the formula is as follows:

$$\gamma_i=\sum_{j=1}^{n}(w_j*\gamma_i(j)),\quad \sum_{j=1}^{n} w_{j=1} \quad （15）$$

4. Results and Analysis

4.1 Analysis of Comprehensive Scores for New-Quality Productive Forces

Table 3 shows the comprehensive development levels of new-quality productive forces and urban-rural integration across the western provinces. Overall, with the exception of Sichuan Province, the average comprehensive score for urban-rural integration in the other provinces is higher than the average comprehensive score for new-quality productive forces, indicating that the level of development of new-quality productive forces lags behind that of urban-rural integration. Looking at the mean values in the far-right column, the score for urban-rural integration (0.361) is nearly double that of new-quality productive forces (0.181).

From a provincial perspective, there is a marked divergence in the average composite scores for new-quality productive forces and urban-rural integration, with Sichuan and Chongqing standing out in both areas; Inner Mongolia and Ningxia excelling solely in urban-rural integration; and Tibet facing the challenge of low scores in both areas.

Sichuan's new-quality productive forces score is 0.434, while Chongqing's is 0.306; both are far ahead and are the only two provinces with scores exceeding 0.3. Chongqing's score for urban-rural integration is 0.509, and Inner Mongolia's is 0.480—the highest scores, demonstrating a solid foundation for coordinated development. Chongqing is the only province to rank among the top three in both dimensions, reflecting its advantage in balanced development. Provinces such as Inner Mongolia and Ningxia have relatively high levels of urban-rural integration, with Inner Mongolia (0.480) and Ningxia (0.445) ranking among the top in overall scores; however, their scores for new-quality productive forces are relatively low. This indicates that while they have achieved significant results in areas such as the

equalization of public services and infrastructure connectivity, they still face shortcomings in fostering new-quality productive forces such as the digital economy and green technologies. Tibet recorded the lowest scores in both the "new-quality productive forces" (0.058) and "urban-rural integration" (0.254) dimensions. This reflects the severe challenges it faces in developing both systems due to constraints imposed by its geography and economic foundation.

Overall, the level of new-quality productive forces in most provinces and regions in the western region showed a certain growth trend between 2010 and 2024, but there were differences in the pace of development and the magnitude of change across different regions, and disparities among regions still persist. As shown in Table 3, the overall trend, based on the average scores across all provinces, indicates sustained growth and a continuous strengthening of momentum. The average level of new-quality productive forces rose from 0.095 in 2010 to 0.2438 in 2024, representing an increase of approximately 1.57 times over the 15-year period, with an average annual growth rate of about 6.5%. This growth trajectory clearly indicates that new-quality productive forces in the western region have moved from the embryonic stage to an accelerated cultivation phase, becoming a key driver of regional economic structural transformation. In terms of growth phases, the trend has been one of steady progress with occasional fluctuations. First, the steady start phase (2010–2017). Growth during this stage was relatively moderate, with the average value gradually rising from 0.095 to 0.174, representing an average annual increase of approximately 0.01. This was a period of policy exploration and technological accumulation for new-quality productive forces, during which new industries such as the digital economy and green energy began to take root in the western regions. Second, the accelerated growth phase (2018–2021). After 2018, the growth rate accelerated significantly, reaching a phase peak of 0.284 in 2021. This may have been driven by the Western Development Policy and the 12th Five-Year Plan. During this period, the Western Development Strategy entered a phase of deepening, with increased investment in infrastructure, education, and science and technology. The 12th Five-Year Plan also called for the development of strategic emerging industries, prompting western provinces to actively expand into sectors of new-quality productive forces such as new energy and the digital economy. The West, with its abundant wind and solar resources, began large-scale development, leading to the rise of the new energy industry (wind power, photovoltaics), which became a key component of new-quality productive forces, contributing to their enhancement. After 2018, as the nation promoted "new infrastructure development" (5G, data centers, artificial intelligence, and the Industrial Internet), western provinces such as Guizhou, Chongqing, and Sichuan emerged as hubs for data centers and cloud computing. Finally, the period from 2022 to 2024 is characterized by a short-term correction followed by an upward trend.

Following a slight correction in 2022, growth rates in 2023–2024 slowed somewhat but remained at a high level of 0.23–0.24. This may reflect the short-term impact of changes in the external environment on emerging industries, but it also indicates that the foundation for the development of new-quality productive forces is becoming more solid.

Looking at the average comprehensive score for new-quality productive forces across all western provinces, the mean is 0.181. Provinces with scores above the mean include Chongqing Municipality, Sichuan Province, Guangxi Province, Yunnan Province, and Shaanxi Province. This may be due to the national push for "new infrastructure development," which has transformed some western provinces—such as Chongqing and Sichuan—into hubs for data centers and cloud computing. Consequently, leveraging this infrastructure, Chongqing and Sichuan rank among the top in terms of new-quality productive forces. The remaining provinces scored below the average and need to take various measures to improve their performance.

At the provincial level, the average scores for new-quality productive forces, ranked from highest to lowest, are: Sichuan Province > Chongqing Municipality > Shaanxi Province > Yunnan Province > Guangxi Province > Guizhou Province > Inner Mongolia > Gansu > Xinjiang > Ningxia > Qinghai Province > Tibet. Since 2018, the national government has promoted the "New Infrastructure Initiative," and some western provinces, such as Chongqing and Sichuan, have become hubs for data centers and cloud computing. Consequently, leveraging this infrastructure, Chongqing and Sichuan rank at the top in terms of new-quality productive forces.

4.2 Analysis of Comprehensive Scores for Development Levels

Based on the comprehensive scores for integrated urban-rural development in western provinces from 2010 to 2024, it is evident that, overall, development levels have shown a sustained upward trend toward higher levels. The average overall score for the western region rose steadily from 0.2404 in 2010 to 0.4681 in 2024, an increase of 0.2277 over the 15-year period, with an average annual growth rate of approximately 0.015.

Analyzing this from the perspective of developmental stages, the overall level has gradually progressed from a relatively low starting stage toward a more mature stage of coordinated development, reflecting the significant achievements made by the western provinces in advancing integration and equalizing public services. This growth trajectory aligns closely with the implementation of national strategies such as "Integrated Development" and "Rural Revitalization," with policy dividends continuing to be realized.

At the provincial level, a distinct tiered structure with a stable pattern is evident. First Tier: Inner Mongolia, Chongqing, and Sichuan

- Inner Mongolia (average 0.4802) and Chongqing (average 0.4802) are tied for first place, with Sichuan (average 0.5093) close behind. These three provinces serve as benchmarks for integrated urban-rural development in the West, benefiting from a strong economic foundation, balanced regional distribution, and effective policy implementation. Second tier: Xinjiang, Ningxia, and Qinghai. Xinjiang (0.4452), Ningxia (0.3570), and Qinghai (0.2792) scored at the upper-middle level. These provinces have made significant progress in infrastructure development and public service coverage, but deep-seated issues such as income disparities remain to be addressed. Third Tier: Tibet, Gansu, Yunnan. Tibet (0.2729), Gansu (0.2540), Yunnan (0.2861) scored relatively low. Possibly due to constraints imposed by geographical conditions, economic structure, and the foundation for development, significant obstacles still exist in the flow of factors of production and the allocation of resources among these regions.

The provinces are ranked by descending average composite scores as follows: Chongqing > Inner Mongolia > Ningxia > Sichuan > Shaanxi > Qinghai > Xinjiang > Guangxi > Yunnan > Gansu > Guizhou > Tibet.

4.3 Analysis of the Results on the Level of Coordinated Development of New-Quality Productive Forces and Urban-Rural Integration in Western Provinces

During the study period, the degree of coordination between new-quality productive forces and urban-rural integration in the western region varied significantly both temporally and spatially.

From a temporal perspective, the overall level of integration and coordination between new-quality productive forces and urban-rural integration showed a sustained upward trend, entering a stage of marginal coordination. The average level of integration and coordination across the western region rose steadily from 0.382 in 2010 to 0.666 in 2024, an increase of 0.284 over the 15-year period, with an average annual growth rate of approximately 0.019.

In terms of developmental stages, the overall level progressed steadily from a state of near-dysfunction (<0.5) in 2010 to a state of marginal coordination (0.5–0.6) after 2015, and has been moving toward a state of preliminary coordination (0.6–0.7) since 2021.

This upward trend indicates that the interactive relationship between the two major systems—new-quality productive forces and urban-rural integration—is continuously improving, and the synergistic effects of their coordinated development are gradually becoming apparent.

At the provincial level, a distinct tiered differentiation is evident, with a trend of the strong getting stronger. For example, in the first tier—Chongqing and Sichuan (intermediate/primary coordination)—Chongqing (average 0.753) and Sichuan (average 0.777) are far ahead, reaching intermediate and primary coordination levels, respectively. They perform exceptionally well on both dimensions of new-quality productive forces and urban-rural integration, forming a "dual-engine drive" model of positive interaction. Second tier: Shaanxi, Inner Mongolia, Guangxi, Yunnan, and Ningxia (barely coordinated). The average coupling coordination index for these provinces ranges from 0.559 to 0.669, placing them in the "barely coordinated" stage. Their development of new-quality productive

forces and urban-rural integration is relatively synchronized, and the effects of policy implementation are becoming evident, though there is still room for improvement. Third tier: Guizhou, Gansu, Qinghai, and Xinjiang (on the verge of imbalance). The average coupling coordination index for these provinces ranges from 0.444 to 0.494, placing them on the verge of imbalance. This may be due to a weak foundation for new-quality productive forces or lagging urban-rural integration, as well as factors such as economic foundations and scientific and technological innovation capabilities, which have prevented the two from forming effective synergy. Fourth Tier: Tibet (Mild Imbalance). Tibet (average 0.319) is the only province in the mild imbalance stage. It has the lowest scores for both new-quality productive forces and urban-rural integration, indicating an extremely weak development foundation that requires targeted support at the national level.

From a dynamic perspective, the trend shows divergent growth trajectories and increasing polarization. Frontrunners are accelerating: Chongqing and Sichuan have continuously expanded their lead over the past 15 years, demonstrating that first-mover advantages have generated stronger growth momentum. Divergence among catch-up provinces: Provinces such as Shaanxi and Inner Mongolia have maintained steady growth, while provinces like Guizhou and Gansu have shown sluggish growth, with the gap between them and the leading group gradually widening. Tibet's long-term lag: Although Tibet's level of coordination and synergy has also been increasing, it remains at the lowest level, reflecting the unique difficulties and challenges it faces in its development.

Table 3: Evolution of the Mean Composite Scores and Coupling Coordination Levels for New-Quality Productive Forces and Integrated Urban-Rural Development in the Western Region

Region/Year	Average Composite Score for New-Quality Productive Forces	Average Composite Score for Urban-Rural Integration	2010 Year	2011 Year	2012 Year	2013 Year	2014 Year	2015 Year	2016 Year	2017 Year	2018 Year	2019 Year	2020 Year	2021 Year	2022 Year	2023 Year	2024 Year	Mean	Degree of Coupling Coordination
Inner Mongolia	0.134	0.480	0.473	0.478	0.535	0.521	0.594	0.538	0.557	0.584	0.612	0.633	0.683	0.617	0.639	0.655	0.661	0.585	A tenuous balance
Guangxi	0.190	0.316	0.410	0.419	0.481	0.477	0.505	0.515	0.524	0.550	0.577	0.614	0.687	0.655	0.664	0.656	0.657	0.559	A tenuous balance
Chongqing	0.306	0.509	0.520	0.572	0.633	0.648	0.695	0.722	0.714	0.777	0.800	0.824	0.864	0.881	0.881	0.879	0.890	0.753	Intermediate Coordination
Sichuan	0.434	0.418	0.561	0.595	0.647	0.659	0.705	0.704	0.715	0.776	0.828	0.868	0.915	0.893	0.922	0.924	0.940	0.777	Intermediate Coordination
Guizhou	0.160	0.273	0.273	0.295	0.360	0.367	0.406	0.417	0.441	0.492	0.548	0.607	0.656	0.625	0.620	0.625	0.639	0.491	On the Verge of Collapse
Yunnan	0.192	0.286	0.365	0.383	0.440	0.440	0.479	0.491	0.520	0.549	0.584	0.621	0.670	0.608	0.628	0.639	0.648	0.538	A tenuous balance
Tibet	0.058	0.254	0.100	0.179	0.175	0.223	0.255	0.281	0.284	0.312	0.358	0.427	0.486	0.406	0.414	0.436	0.443	0.319	Mild Dysregulation
Shaanxi	0.283	0.380	0.495	0.516	0.555	0.558	0.605	0.613	0.621	0.659	0.702	0.740	0.779	0.764	0.794	0.813	0.822	0.669	Basic Coordination
Gansu	0.124	0.279	0.317	0.331	0.376	0.383	0.419	0.434	0.443	0.471	0.508	0.531	0.585	0.521	0.540	0.559	0.564	0.465	On the Verge of Collapse
Qinghai	0.083	0.357	0.328	0.320	0.359	0.355	0.366	0.422	0.416	0.429	0.487	0.525	0.586	0.500	0.511	0.532	0.536	0.445	On the Verge of Collapse
Ningxia	0.101	0.445	0.403	0.402	0.421	0.436	0.466	0.478	0.482	0.518	0.570	0.603	0.640	0.567	0.586	0.596	0.608	0.518	A tenuous balance
Xinjiang	0.111	0.332	0.338	0.350	0.404	0.401	0.433	0.443	0.456	0.476	0.509	0.544	0.612	0.524	0.554	0.582	0.588	0.481	On the Verge of Collapse
Mean	0.181	0.361	0.382	0.403	0.449	0.456	0.494	0.505	0.514	0.549	0.590	0.628	0.680	0.630	0.646	0.658	0.666	0.550	A tenuous balance

4.4 Dynamic Analysis of the Spatial Distribution of the Level of Coupled and Coordinated Development Between New-Quality Productive Forces and Urban-Rural Integration in Western Provinces

Due to space limitations, this study analyzes the degree of systemic coupling and coordination between the two for selected years and summarizes the spatial dynamic trends. Figure 1 presents a spatial distribution analysis of the coupling and coordination between new-quality productive forces and urban-rural integration in western provinces for the years 2010, 2015, 2020, and 2024. The results show that there are significant differences in the coupling and coordination between these two systems across different years and provinces.

In 2010, the coupling coordination between new-quality productive forces and urban-rural integration across the western regions was generally in a state of "mild imbalance," with a mean value of 0.382. In 2010, the leading role of the Chengdu-Chongqing region began to emerge. As the core growth poles of the western region, Sichuan and Chongqing demonstrated stronger synergistic capabilities as early as 2010, which was closely related to the early development of the Chengdu-Chongqing metropolitan area and the effects of industrial agglomeration. The results indicate a spatial differentiation characterized by "strong in the east, weak in the west." The western region as a whole exhibits a gradient pattern of "high in the east, low in the west," with Chongqing, Sichuan, Shaanxi, and Inner Mongolia in the east significantly outperforming Tibet, Qinghai, and Xinjiang in the west. This reflects the profound impact of geographical location, resource endowments, industrial structure, and the lack of smooth factor mobility on the degree of coupling and coordination.

In 2015, the coupling coordination of new-quality productive forces and urban-rural integration across various regions in the western part of the country was generally in a "barely coordinated" state, with an average value of 0.505. Compared to 2010, the following changes occurred. First, in 2015, the systemic coupling and coordination between the two showed an overall improvement while the trend of regional divergence persisted. Although the overall coupling and coordination in the western regions improved from 0.382 in 2010 to 0.505 in 2015, the spatial pattern of "strong in the east, weak in the west" remained fundamentally unchanged, and the leading role of the Chengdu-Chongqing region continued to strengthen. Second, there was a trend of localized breakthroughs and multi-point upgrades. Provinces such as Shaanxi and Inner Mongolia achieved leapfrog upgrades, reflecting that the driving role of new-quality productive forces is beginning to manifest in certain regions, and the level of coupling and coordination between new-quality productive forces and urban-rural integration has further improved. Third, shortcomings remain, requiring targeted measures. Although provinces such as Tibet and Qinghai have shown improvement, they remain at a low level. It is necessary to cultivate new-quality productive forces tailored to regional characteristics while increasing investment in infrastructure to address bottlenecks in the flow of production factors, thereby promoting the systematic and coordinated development of both.

In 2020, the coupling and coordination between new-quality productive forces and urban-rural integration across western regions was generally at the "primary coordination" stage, with an average value of 0.680. In terms of gradient distribution characteristics: High-value zone (dark blue, 0.779001–0.915000): The Chengdu-Chongqing region (Sichuan and Chongqing) saw its coupling coordination index exceed 0.779, entering the "intermediate coordination" range, further solidifying its leading position. Medium-to-high value zone (light blue, 0.687001–0.779000): Shaanxi Province has advanced from the medium-to-high value zone in 2015 and is now in a transitional phase from "primary coordination" to "intermediate coordination." Medium value zone (light green, 0.612001–0.687000): Inner Mongolia, Yunnan, Guangxi, and Ningxia: Their coupling coordination index remained stable in the "primary coordination" range, showing a significant improvement compared to 2015. Low-value range (yellow, 0.486001–0.612000): Xinjiang, Gansu, Qinghai, and Guizhou: These regions jumped from the "on the verge of disharmony" range to the "barely coordinated" range, with the foundation for coordinated development significantly strengthened. Lowest-value zone (red, 0.486000): Tibet Autonomous Region. Although its coupling coordination index has improved compared to 2015, it remains the lowest in the western region. Compared to 2015, its coupling coordination index has shifted from the "barely coordinated" to the "primary coordination" level.

In 2024, the overall level of coordination between new-quality productive forces and urban-rural integration across various regions in the western part of China was in a "primary coordination" state, with an average value of 0.666. In terms of gradient distribution patterns, the high-value zone (dark blue, 0.661001–0.940000) includes: The Chengdu-Chongqing region (Sichuan, Chongqing) + Shaanxi. This

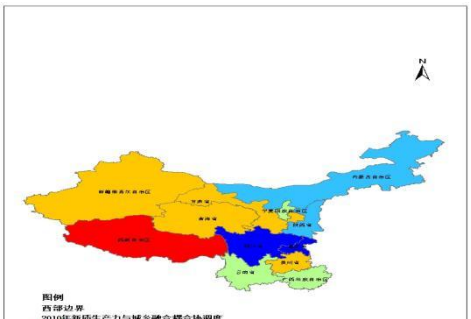
marks the first time a province has joined the high-value tier of the Chengdu-Chongqing region, indicating that the region's radiating and driving effects are beginning to manifest. The medium-to-high-value zone (light blue, 0.608001–0.661000): Inner Mongolia, Yunnan, and Guangxi. These provinces have entered a transitional phase from "primary coordination" to "intermediate coordination," with the quality of their coordinated development steadily improving. Medium-value zone (light green, 0.564001–0.608000): Xinjiang, which has risen from the low-value zone in 2020 to the medium-value zone, has become a key node for the West's "Westward Breakthrough." Low-value zone (yellow, 0.443001–0.564000): Gansu, Qinghai, Ningxia, and Guizhou remain in the "barely coordinated" range, and the foundation for coordinated development still needs to be consolidated. Lowest-value zone (red, 0.443000): The Tibet Autonomous Region, although showing some improvement compared to 2020, remains at the lowest level in the western region. Compared to 2020, the overall coupling coordination level in the western region has continued to improve, with the coverage of the medium- and high-value zones expanding and regional disparities showing a trend toward convergence.

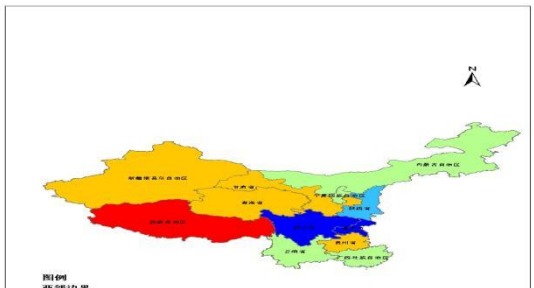
In summary, in terms of spatial distribution characteristics, the spatial distribution of the coupling coordination between new-quality productive forces and urban-rural integration in the western region has undergone profound transformations: from "single-point leadership" to "multi-core drive," from "extreme polarization" to "gradient convergence," and from "strong east, weak west" to "multi-point breakthroughs." The overall changes are as follows: First, the core-led pattern shows a trend shifting from "single-core leadership" to "dual-core drive." 2010–2020: The Chengdu-Chongqing region (Sichuan and Chongqing) remained the sole high-value area, forming a "single-core leadership" pattern, with the gap between it and other provinces continuing to widen. 2024: Shaanxi joined the high-value tier, forming a "Chengdu-Chongqing + Shaanxi" dual-core driven pattern, and the radiating and driving effects of the Chengdu-Chongqing region began to spread to surrounding provinces.

Second, the trend in regional differentiation shifted from "extreme imbalance" to "gradient convergence." 2010: The degree of coupling and coordination among provinces ranged from 0.1 to 0.561—a vast span—reflecting a spatial characteristic of "extreme imbalance." 2015–2020: While the overall level improved, the "high in the east, low in the west" gradient pattern remained unchanged, and regional divergence was still significant. 2024: The medium-to-high-value zones expanded into the central and western regions, with provinces such as Xinjiang achieving breakthroughs; the scope of low-value zones shrank, and the numerical gaps between regions converged significantly.

Third, the direction of spatial expansion has shifted from "strong in the east, weak in the west" to a pattern of "multi-point breakthroughs." 2010–2020: High-value and medium-to-high-value zones were concentrated in the eastern regions of Chengdu-Chongqing, Shaanxi, and Inner Mongolia, while western regions such as Xinjiang and Tibet remained in low-value zones for an extended period, reflecting an "east-strong, west-weak" pattern. In 2024: Xinjiang leaped from the low-value zone to the medium-value zone, while Inner Mongolia, Yunnan, and Guangxi entered the medium-to-high-value zone, forming a multi-point collaborative pattern characterized by "dual cores in the east, support in the center, and breakthroughs in the west," significantly enhancing the overall spatial balance in the west.

From a longitudinal perspective (2010–2024), the overall level of coupling and coordination between the two systems shows an upward trend. The average coupling and coordination index for all provinces in the West rose from 0.382 in 2010 to 0.666 in 2024, shifting from mild imbalance to preliminary coordination, reflecting the continuous optimization of the synergy between the West's new-quality productive forces and urban-rural integration.





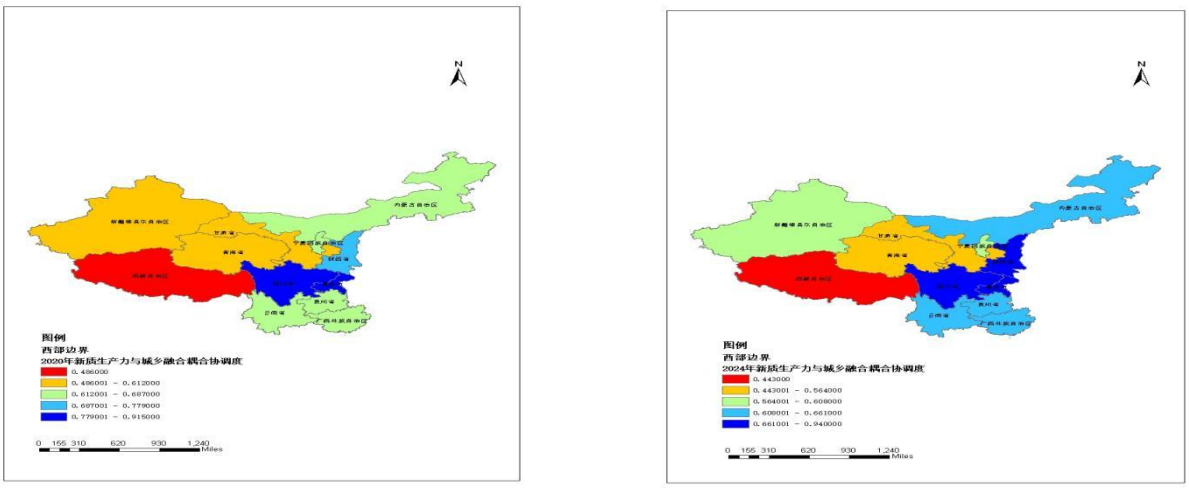


Figure 1 Spatial Distribution of the Coupling and Coordination Between New-Quality Productive Forces and Urban-Rural Integration in the Western Region

4.4.1 Global Spatial Autocorrelation Analysis

The Moran's I index ranges from [–1, 1]. If the value of Moran's I is significantly greater than 0, it indicates that new-quality productive forces and the coupling and coordination of urban-rural integration are positively correlated and clustered in space; if the Moran's I value is significantly less than 0, it indicates that the new-quality productive forces and the degree of coordination in urban-rural integration are negatively correlated and dispersed spatially—that is, high values are adjacent to low values; if the Moran's I value equals 0, it indicates that there is no correlation within the spatial units.

Based on panel data from 2010 to 2024, this study examines the spatial autocorrelation characteristics of the variables using the global Moran's I index. The results show that during the study period, the global Moran's I index ranged from -0.006961 to 0.29261, remaining at a relatively low level overall, indicating that the variables exhibit only weak spatial autocorrelation.

Specifically, with the exception of 2010, the Moran's I index was positive in the remaining years, indicating a certain positive trend of spatial clustering for the variables; however, the values were generally less than 0.3, reflecting a weak clustering effect. Only in 2010 did negative spatial autocorrelation occur, suggesting a localized phenomenon of alternating high and low values, though this was also extremely mild.

In terms of statistical significance, with the exception of 2010, the Moran's I index was positive for all other years, indicating that new-quality productive forces and urban-rural integration in various regions of the western part of the country exhibit global spatial autocorrelation. There is also a global-level spatial spillover effect: from a global perspective, changes in new-quality productive forces in neighboring regions influence urban-rural integration in the region under study, resulting in a

relatively high degree of systematic coupling and coordination between the two. In regions where the coupling and coordination between new-quality productive forces and urban-rural integration are high, the coupling and coordination in neighboring regions are also relatively high. In terms of significance, in 2010, 2011, 2012, 2013, and 2015, the p-values of the Moran's I index were greater than 0.1 at the 10% significance level, indicating that the global spatial distribution relationships in these years were random. For the majority of the remaining years, starting in 2016, the p-values were significant at the 10% significance level ($p < 0.1$), indicating that, beginning in 2016, the coupling and coordination between these two systems exhibited spatial clustering. Please refer to Table 4 for specific results.

Table 4: Global Moran's I for the Coupling and Coordination of New-Quality Productive Forces and Urban-Rural Integration in the Western Region

Year	Moran I Index	z-score	p-value
2010 Year	-0.006961	0.493324	0.621784
2011 Year	0.186428	1.515903	0.129544
2012 Year	0.193655	1.601794	0.109201
2013 Year	0.204925	1.631047	0.10288
2014 Year	0.226586	1.726503	0.084257
2015 Year	0.187703	1.547113	0.121836
2016 Year	0.228026	1.768959	0.076901
2017 Year	0.260334	1.949366	0.051252
2018 Year	0.269727	2.012255	0.044193
2019 Year	0.268181	1.993643	0.046191
2020 Year	0.237024	1.833158	0.066779
2021 Year	0.29261	2.104239	0.035358
2022 Year	0.260924	1.934273	0.05308
2023 Year	0.223169	1.727295	0.084115
2024 Year	0.228131	1.757333	0.078861

Note: The p-value represents the probability of observing the current value of Moran's I under the null hypothesis (spatial random distribution); the Z-value represents the degree to which Moran's I deviates from the null hypothesis, measured in standard deviations.

4.4.2 Analysis of Local Spatial Autocorrelation

The distribution of the four quadrants of the local Moran's I index values corresponds to the respective spatial distribution patterns. Specifically, the first quadrant exhibits a distribution pattern in which high index values are surrounded by other high values, that is, a high-high (H-H) clustering pattern; In the second quadrant, a distribution pattern is observed where low index values are surrounded by high values, indicating a low-high (L-H) encircling pattern; in the third quadrant, a distribution pattern is observed where low index values are surrounded by other low values, indicating a low-low (L-L) clustering pattern; In the fourth quadrant, high index values are surrounded by low values, exhibiting a high-low (H-L) clustering pattern. Combining Moran's I scatter plots with LISA clustering maps provides a comprehensive illustration of the spatial evolution of the coupling and coordination between new-quality productive forces and urban-rural integration across western provinces.

Due to space limitations, this paper selects the years 2010, 2015, 2020, and 2024 for local spatial analysis.

The spatial distribution reveals that the spatial clustering of new-quality productive forces and the degree of coordination between urban-rural integration varies across different years.

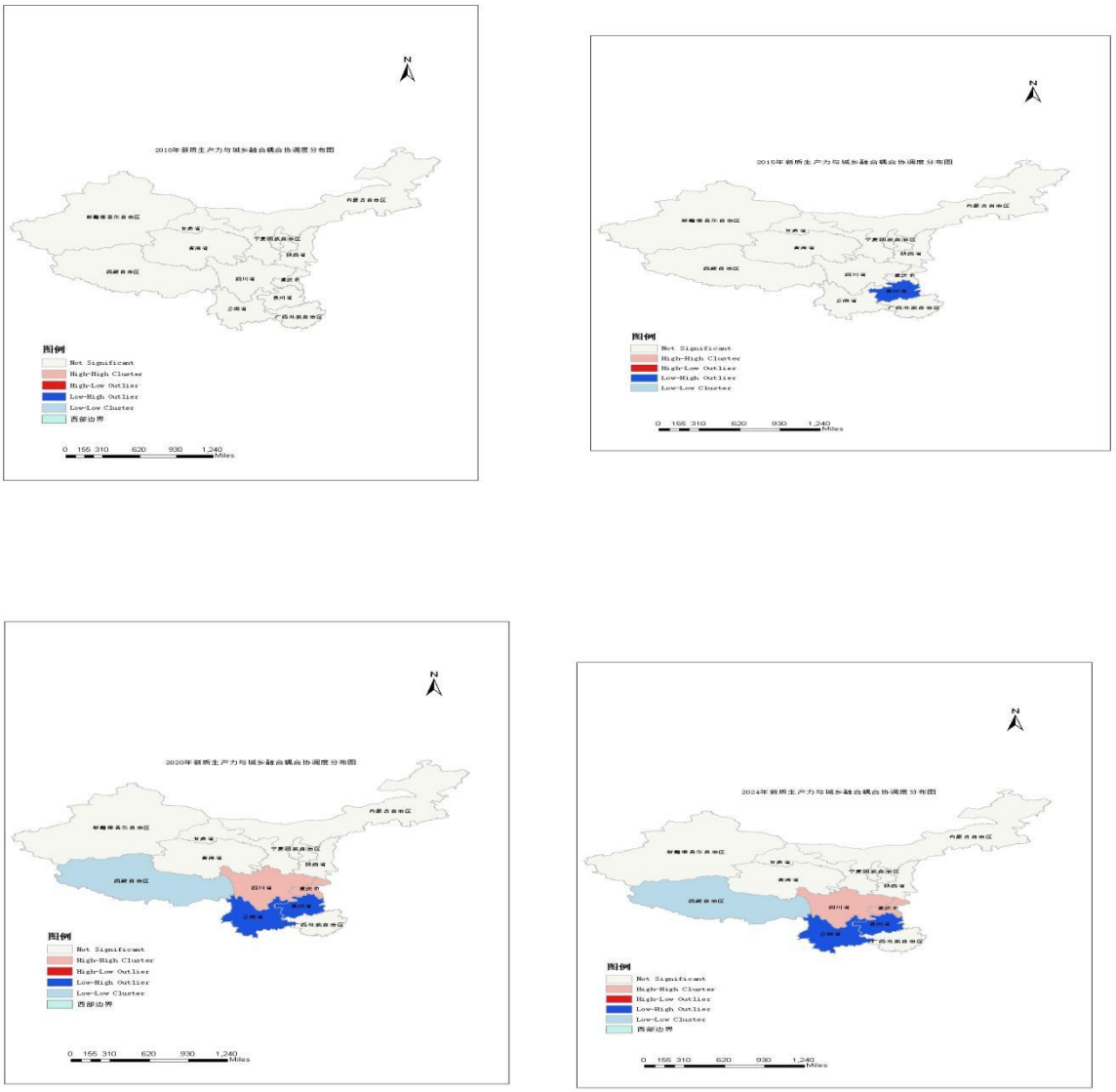


Figure 2 Analysis of Local Spatial Autocorrelation of the Coupling Coordination Between New-Quality Productive Forces and Urban-Rural Integration in Western China

As shown in Figure 2, the analysis of local spatial autocorrelation of the coupling coordination between new-quality productive forces and urban-rural integration in Western China in 2010 reveals that spatial autocorrelation was not significant in all study units. This indicates that, at the beginning of the study period, the spatial distribution of the coupling coordination degree in the western region exhibited random characteristics; it had not formed any significant clusters of high values (HH) or low values (LL), nor were there any obvious outliers such as isolated high-value (HL) or low-value (LH) points. This result reflects that, in 2010, the development levels of new-quality productive forces and urban-rural integration in the western region were spatially independent of one another; mechanisms for coordinated

regional development and spatial spillover effects had not yet been established, providing important empirical evidence for the formulation of subsequent regional coordinated development policies.

A local spatial autocorrelation analysis of the coupling coordination between new-quality productive forces and urban-rural integration in the western region in 2015 revealed that Guizhou Province exhibited a significant "low-high outlier" (Low-High Outlier), while the remaining provinces all showed no significant spatial autocorrelation (Not Significant). This result indicates that while Guizhou Province itself has a relatively low level of coupling and coordination, the coordination levels of its neighboring provinces (such as Chongqing, Sichuan, and Guangxi) are relatively high, forming a typical "depression effect." This result reflects that, by 2015, the development pattern in the western region had shifted from the completely random distribution observed in 2010 to one characterized by localized spatial differentiation. Imbalances in regional development and spatial interconnections gradually became apparent, providing an important basis for the targeted implementation of subsequent regional coordinated development policies.

A 2020 analysis of the local spatial autocorrelation of the coupling and coordination levels between new-quality productive forces and urban-rural integration in the western region revealed that the spatial pattern exhibited a distinct "hotspot-coldspot" binary structure. Among these, Sichuan and Chongqing formed a prominent "High-High Cluster" hotspot area, becoming the core growth poles driving regional development; Tibet, on the other hand, formed a distinct "low-low cluster" cold spot, jointly constituting a contiguous area of lagging development with neighboring provinces. Meanwhile, Guizhou and Yunnan exhibited characteristics of "low-high outliers," with relatively low coordination levels themselves but surrounded by high-value areas, forming a typical "depression effect." This indicates that the development pattern in the western region has gradually evolved from an early stage of random distribution to a complex pattern characterized by both spatial agglomeration and differentiation, providing important empirical evidence for formulating precise policies for coordinated regional development.

A 2024 analysis of the local spatial autocorrelation of the coupling coordination between new-quality productive forces and urban-rural integration across western provinces reveals that the spatial pattern exhibits a stable ternary structure of "core leadership, trough reception, and cold spot lag." Sichuan and Chongqing have formed distinct "High-High Cluster" hotspots, with their leading role continuing to strengthen; Guizhou and Yunnan exhibit "Low-High Outlier" patterns, where the "depression effect" remains pronounced; Tibet, meanwhile, has formed a "Low-Low Cluster" cold spot, with a stable pattern of developmental lag. In summary, after more than a decade of development, the spatial structure of the western region has evolved from an initial random distribution to a relatively solidified ternary pattern. Regional development imbalances and spatial interconnections have significantly increased, providing an important basis for spatial governance to foster a new pattern for the Western Development Strategy and promote coordinated regional development in the new era.

4.5 Grey Relational Analysis of Coupling Coordination

Based on the aforementioned grey relational model and drawing on the research findings of Wang Yujin and Li Mengyu [22], grey relational degrees are classified into four levels: the low relational degree interval [0, 0.35), the medium relational degree interval [0.35, 0.65), the higher correlation interval [0.65, 0.85), and the high correlation interval [0.85, 1.0].

The results show that the values of the gray correlation coefficient range from 0 to 1; the closer the value is to 1, the stronger the correlation between the evaluation item and the reference sequence, and the more significant the impact.

The top five indicators with the strongest correlation to the coupling and coordination between new-quality productive forces and urban-rural integration are as follows: The first indicator is A22 (urbanization rate) in the population integration system, with a correlation of 0.98, ranking first. This indicates that this urbanization indicator has the strongest influence on the coupling and coordination between new-quality productive forces and population integration; The second indicator is D22 (rate of harmless treatment of household waste, %) in the ecological integration system, with a correlation coefficient of 0.975, ranking second. This indicator reflects improvements in environmental quality;

providing residents with a better green living environment has the second-strongest impact on the coupling degree between the two systems. The third-ranked indicator is C12 (per capita disposable income of urban residents) in the new production relations system, with a correlation coefficient of 0.973. This indicates that the development of new-quality productive forces helps increase residents' disposable income, thereby promoting better coordinated urban-rural integration and development; the fourth-ranked indicator is C44 (per capita number of people enrolled in unemployment insurance) in the social integration system, with a correlation coefficient of 0.968; The fifth-ranked indicator is D11 (environmental protection expenditure) in the ecological integration system, with a correlation coefficient of 0.967. The correlation coefficients for all of the above indicators exceed 0.9, indicating a high degree of correlation between these indicators and the degree of coupling and coordination. This suggests that these indicators are key factors influencing the relationship between new-quality productive forces and urban-rural integration, and we can use them to better promote the coupled and coordinated development of the two systems.

The grey correlation results show that some indicators have a relatively weak relationship with the coupling and coordination of new-quality productive forces and urban-rural integration. The bottom five indicators are as follows: C7 (Total Imports and Exports of Foreign-Invested Enterprises / GDP): correlation coefficient 0.884, ranked 42nd; C5 (Technology Market Transaction Volume): correlation coefficient 0.885, ranked 41st; A2 (Expenditures on Science and Technology): correlation coefficient 0.893, ranked 40th;

B9 (Revenue from New Product Sales): correlation coefficient 0.893, ranked 39th; B8 (Renewable Energy (Hydropower Generation) Output): correlation coefficient 0.857, ranked 38th; This indicates that the aforementioned indicators act as obstacles to the coordinated development of new-quality productive forces and urban-rural integration.

The low correlation of the above indicators suggests that, in the process of fostering new-quality productive forces and advancing urban-rural integration in western provinces, the market-oriented transformation of technological achievements (C5), the efficiency of science and technology investment (A2), the efficiency of emerging industry output (B9), the quality of foreign investment utilization and synergy with opening-up (C7), and green energy support (B8)—are insufficiently aligned with the coupling requirements of the dual systems. Consequently, they have failed to effectively provide positive support for "new-quality productive forces empowering the flow of factors and urban-rural integration fostering industrial upgrading," and instead have become constraining factors hindering the improvement of coupling and coordination levels.

Table 5 Results of the Grey Correlation Model

Evaluation Criteria	Indicators	Relevance	Ranking	Evaluation Criteria	Indicators	Relevance	Ranking
A1	R&D Expenditures A1	0.96	9	C8	Resident Income RatioC8	0.96	11
A2	Expenditures on Science and Technology A2	0.893	40	C9	Number of People Enrolled in Basic Old-Age InsuranceC9	0.94	19
A3	Number of Companies Engaged in R&D Activities A3	0.921	32	C10	Local Government General Budget Expenditures / GDPC10	0.927	28
A4	Number of Companies with R&D Facilities A4	0.925	30	C11	Total Retail Sales of Consumer GoodsC11	0.937	21
A5	Number of Domestic Patent Applications Accepted for Three Types of PatentsA5	0.919	33	C12	Per Capita Disposable Income of Urban Residents C12	0.973	3
A6	Publishing Scientific Papers A6	0.936	23	A11	Proportion of Employment in Non-Agricultural and Agricultural Sectors (%)A11	0.962	6
B1	Full-Time Equivalent R&D Personnel B1	0.929	27	A22	Urbanization Rate (%)A22	0.98	1

B2	Employees in the Information Transmission, Computer Services, and Software Industries B2	0.905	37	A33	Population Density Ratio (%)A33	0.944	17
B3	Average E-commerce Sales B3	0.926	29	B11	Resident Income Ratio (%) B11	0.953	16
B4	Total Telecommunications Services per Capita B4	0.91	36	B22	Per Capita Consumption Ratio of Households, %B22	0.961	8
B5	Number of Legal Entities in the Information Transmission, Software, and Information Technology Services Sector, by Region B5	0.916	34	B33	Industrial Output Value Ratio (%)B33	0.96	10
B6	Number of Internet Broadband Access Ports per 10,000 People B6	0.934	24	C11	Public library holdings per capita (volumes per person) C11	0.955	14
B7	Number of Internet Domains per Capita B7	0.932	26	C22	Ratio of healthcare professionals per 1,000 people C22	0.941	18
B8	Electricity Generation from Renewable Energy (Hydropower) B8	0.897	38	C33	Number of Participants in the Urban and Rural Residents' Social Pension Insurance (in ten thousand) C33	0.933	25
B9	Revenue from New Product SalesB9	0.893	39	C44	Number of Unemployment Insurance Participants per Capita (in ten thousand)C44	0.968	4
C1	Expenditures on Technological Upgrades in Industrial Enterprises C1	0.936	22	D11	Environmental Protection Expenditures/ D11	0.967	5
C2	Industrial Sulfur Dioxide Emission Intensity C2	0.88	43	D22	Rate of Non-Hazardous Treatment of Municipal Solid Waste (%)D22	0.975	2
C3	Percentage of GDP Allocated to Environmental Pollution Control Investments C3	0.937	20	E11	Road area per capita (km² per person) E11	0.955	15
C4	Value Added in the Financial Sector / GDP C4	0.962	7	E22	Per capita park green space, km² per person E22	0.955	13
C5	Technology Market Transaction Volume C5	0.885	41	E33	Transportation Network Density (km/km²)E33	0.914	35
C6	Value Added in Transportation, Warehousing, and Postal Services / GDPC6	0.957	12	E44	Percentage of Built-Up Area /%E44	0.924	31
C7	Total Imports and Exports of Foreign-Invested Enterprises / GDP C7	0.884	42				

5. Conclusions and Discussion

5.1 Conclusions

This paper focuses on the western region as its research subject. By developing indicators to measure new-quality productive forces and urban-rural integration, it uses the entropy method to assess the levels of new-quality productive forces and urban-rural integration from 2010 to 2024.

In terms of the comprehensive score for new-quality productive forces, overall, most provinces and regions in the western region exhibited a certain trend of growth in the level of new-quality productive forces between 2010 and 2024. However, there were differences in the pace of development and the magnitude of change across different regions, and disparities among regions still persist. As shown in Table 3, the overall trend, as reflected by the average score across all provinces, indicates sustained growth and continuously strengthening momentum. The average new-quality productive forces score rose from 0.095 in 2010 to 0.2438 in 2024, representing an increase of approximately 1.57 times over the 15-year period, with an average annual growth rate of about 6.5%. This growth trajectory clearly indicates that new-quality productive forces in the western region have transitioned from an embryonic stage to an accelerated development phase, becoming a key driver of regional economic structural transformation. Ranked from highest to lowest, the average new-quality productive forces are as follows: Sichuan Province > Chongqing Municipality > Shaanxi Province > Yunnan Province > Guangxi Province > Guizhou Province > Inner Mongolia > Gansu > Xinjiang > Ningxia > Qinghai Province > Tibet. Since 2018, the national push for "new infrastructure development" has transformed some western provinces,

such as Chongqing and Sichuan, into hubs for data centers and cloud computing. Consequently, leveraging this infrastructure, Chongqing and Sichuan rank at the forefront in terms of new-quality productive forces.

In terms of the comprehensive score for urban-rural integration, the overall level of integrated urban-rural development has shown a sustained upward trend toward higher levels. The average score for urban-rural integration in the western region rose steadily from 0.2404 in 2010 to 0.4681 in 2024, an increase of 0.2277 over the 15-year period, with an average annual growth rate of approximately 0.015.

At the provincial level, the rankings are clearly tiered and the overall pattern is stable. First Tier: Inner Mongolia, Chongqing, and Sichuan. Inner Mongolia (average 0.4802) and Chongqing (average 0.4802) tied for first place, with Sichuan (average 0.5093) close behind. These three provinces serve as benchmarks for urban-rural integration in the western region, thanks to their strong economic foundations, balanced regional development, and effective policy implementation. Second Tier: Xinjiang, Ningxia, and Qinghai. Xinjiang (0.4452), Ningxia (0.3570), and Qinghai (0.2792) scored at the upper-middle level. These provinces have made significant progress in infrastructure development and public service coverage, but deep-seated issues such as income disparities remain to be addressed. Third Tier: Tibet, Gansu, and Yunnan. Tibet (0.2729), Gansu (0.2540), Yunnan (0.2861) scored relatively low. Possibly due to constraints imposed by geographical conditions, economic structure, and the foundation for development, significant obstacles still exist in the flow of factors of production and the allocation of resources among these regions.

In terms of the coordination level between new-quality productive forces and urban-rural integration, the overall coordination level has shown a sustained improvement, entering a stage of modest coordination. The average coupling and coordination level for the western region as a whole has risen steadily from 0.382 in 2010 to 0.666 in 2024, an increase of 0.284 over the 15-year period, with an average annual growth rate of approximately 0.019.

At the provincial level, a distinct tiered differentiation is evident, with a trend of the strong getting stronger. For example, in the first tier—Chongqing and Sichuan (intermediate/basic coordination)—Chongqing (average 0.753) and Sichuan (average 0.777) are far ahead, reaching intermediate and basic coordination levels, respectively. They perform exceptionally well on both dimensions of new-quality productive forces and urban-rural integration, forming a “dual-engine” model of positive interaction. Second tier: Shaanxi, Inner Mongolia, Guangxi, Yunnan, and Ningxia (barely coordinated). The average coupling coordination index for these provinces ranges from 0.559 to 0.669, placing them in the “barely coordinated” stage. Their development of new-quality productive forces and urban-rural integration is relatively synchronized, and the effects of policy implementation are becoming evident, though there is still room for improvement. Third tier: Guizhou, Gansu, Qinghai, and Xinjiang (on the verge of imbalance). The average coupling coordination index for these provinces ranges from 0.444 to 0.494, placing them on the verge of imbalance. This may be due to a weak foundation for new-quality productive forces or lagging urban-rural integration, as well as factors such as economic foundations and scientific and technological innovation capabilities, which have prevented the two from forming effective synergy. Fourth Tier: Tibet (Mild Imbalance). Tibet (average 0.319) is the only province in the mild imbalance stage.

From the perspective of stage progression, the overall level has steadily advanced from “on the verge of imbalance” (<0.5) in 2010 to “barely coordinated” (0.5–0.6) after 2015, and has been moving toward “primary coordination” (0.6–0.7) since 2021.

This upward trend indicates that the interactive relationship between the two major systems—new-quality productive forces and urban-rural integration—is continuously improving, and the synergistic development effects of both are gradually becoming apparent.

In terms of spatial distribution characteristics, the spatial distribution of the coupling coordination between new-quality productive forces and urban-rural integration in the western region has undergone profound transformations: from “single-point leadership” to “multi-core drive,” from “extreme polarization” to “gradient convergence,” and from “strong in the east, weak in the west” to “multi-point breakthroughs.”

Results from the global spatial autocorrelation analysis show that, with the exception of 2010, the Moran's I index was positive in all other years, indicating a certain positive spatial clustering trend for the variables; however, the values were generally less than 0.3, reflecting a weak clustering effect. Only in 2010 did negative spatial autocorrelation occur, suggesting a localized phenomenon of alternating high and low values, though this was also extremely low in magnitude. The results of local spatial autocorrelation indicate that, after more than a decade of development, the spatial structure of the western region has evolved from an initial random distribution to a relatively solidified tripartite pattern. Regional development imbalances and spatial interconnections have significantly intensified, providing an important basis for spatial governance to foster a new pattern for the Western Development Strategy and promote coordinated regional development in the new era.

Based on the results of the coupling coordination model, this paper analyzes the coupling coordination of each province in the western region. From a longitudinal perspective (2010–2024), the overall level of coupling coordination between the two systems shows an upward trend. The average coupling coordination index across all western provinces rose from 0.382 in 2010 to 0.666 in 2024, shifting overall from mild imbalance toward preliminary coordination, reflecting the continuous optimization of the synergy between the new-quality productive forces and urban-rural integration in the West. Given the relatively low coupling coordination index and the significant differences among provinces in terms of economic foundations, infrastructure, policies, the level of industrial structure optimization, urbanization, environmental quality, and many other factors, variations in the coupling coordination index between the two systems exist across provinces. Therefore, to better understand the factors influencing the level of coupling coordination, the grey correlation model was employed for analysis. The results of the grey correlation analysis show that the coupling coordination between new-quality productive forces and urban-rural integration is jointly driven by multidimensional factors including population, economy, society, and ecology. The correlation coefficients for the top five indicators all exceed 0.9, indicating a highly significant positive correlation; these are the core driving factors influencing the synergistic evolution of the two systems. Among them, the urbanization rate ranks first with the highest correlation coefficient, indicating that population mobility and spatial agglomeration are the primary drivers of coordinated development; the rate of harmless treatment of household waste and environmental protection expenditures reflect the critical supporting role of ecological and environmental construction in system coupling, while the level of green development profoundly influences the quality of urban-rural integration; per capita disposable income of urban residents demonstrates that economic development and income growth are important foundations for the coordination of the two systems; and the number of people per capita enrolled in unemployment insurance reveals that the equalization of social security and public services plays a significant role in promoting social integration. Overall, the coordinated and coupled development of new-quality productive forces and urban-rural integration relies on the synergistic efforts of population agglomeration, income growth, ecological optimization, and the improvement of social security. The aforementioned core indicators can serve as key levers and policy targets for enhancing the level of coupling and coordination between the two systems.

5.2 Recommendations

Based on the issues identified through theoretical and empirical findings in this paper, the following recommendations are proposed.

First, precisely identify the points of convergence between new-quality productive forces and the coordinated development of urban-rural integration.

Due to various factors, the composite score for the development of new-quality productive forces in western provinces is lower than that for integrated urban-rural development. Therefore, to achieve better coordinated development between these two systems, it is necessary to precisely identify appropriate points of integration. The results of the gray correlation model in this paper indicate that sales revenue from new products is one of the factors constraining the coupling and coordination between the two systems. Consequently, this paper suggests that fostering demand-driven emerging industries and increasing sales revenue from these new industries can promote the coordinated development of the two systems. Establish a tiered layout for emerging industries: Core high-value zones should focus on core industries of new-quality productive forces, such as high-end manufacturing and the digital economy, extending industrial chains to the county level (e.g., Chongqing's electronic information industry

expanding supporting segments to surrounding counties) to drive industrial synergy; In the medium-value transition zones, leverage resource endowments to develop distinctive emerging industries (e.g., green energy equipment in Inner Mongolia and big data support industries in Guizhou), forming industrial linkages through the "urban headquarters + county-level production + rural raw material bases" model; In the peripheral low-value zones, develop eco-friendly emerging industries (e.g., ecological tourism in Tibet and clean energy processing in Qinghai), using industrial employment to drive income growth. Establish an integrated production-to-sales linkage system: Set up exhibition and trading centers for new-quality productive forces products, and utilize e-commerce platforms to broaden sales channels for new products from county-level areas; in the core and intermediate zones, implement a "urban consumption-based poverty alleviation + rural product upgrading" mechanism to guide emerging industry products to align with consumer demand, thereby enhancing market recognition and sales revenue.

Second, strengthen the equalization of public services. This study found that the average level of coupling and coordination between new-quality productive forces and urban-rural integration in the western regions remains low. Therefore, this paper argues that the level of coupling and coordination between these two systems can be enhanced by improving public service levels across different provinces, as well as between rural and urban areas. The equalization of public services serves as a vital bridge connecting new-quality productive forces with the coordinated development of urban-rural integration. The advancement of new-quality productive forces is often accompanied by growing demand for high-quality public services such as education and healthcare, while disparities in public services have long been one of the key factors constraining the integrated development of urban and rural areas. By focusing on points of convergence, investment in public service facilities in rural areas can be increased. Leveraging digital technologies—such as telemedicine and online education, which are service models derived from new-quality productive forces—can enhance the level of public services in rural areas, narrow the public service gap, and create a fair and high-quality development environment for practitioners of new-quality productive forces as well as rural residents, thereby promoting the in-depth development of urban-rural integration.

Third, enhance the flow of factors of production between different regions.

To achieve the coordinated development of new-quality productive forces and urban-rural integration, enhancing the flow of factors of production between different regions is the only way forward. In this new stage of economic development, the enhancement of productive forces relies not only on the accumulation of traditional factors but also on the synergistic contribution of new-quality factors such as innovation, talent, and capital. Coordinated urban-rural integration requires breaking down the barriers of the dual structure to promote the free flow and rational allocation of factors of production between urban and rural areas and across different regions. Cities possess advanced technology, financial resources, and talent, but if these resources remain concentrated solely in urban areas, they cannot achieve maximum efficiency and may even lead to a further widening of the gap. Therefore, the level of coupling and coordination between the two systems must be enhanced through the free flow of factors of production across regions. Although rural areas possess vast tracts of land, abundant natural resources, and unique ecological environments, they face relative shortages in the input of factors of production, which constrains their development potential. Only by strengthening the flow of factors of production between different regions—allowing urban capital to flow into rural areas and be invested in rural revitalization projects; enabling the transformation and application of urban scientific and technological achievements in agricultural production to advance agricultural modernization; and allowing rural resources such as land and the ecosystem to attract urban talent, thereby injecting new vitality into rural development—can we achieve shared prosperity.

Fourth, strengthen the cultivation and development of new-quality productive forces. The composite scores for "new-quality productive forces" and "integrated urban-rural development" in this paper show that, in most years, the composite score for new-quality productive forces is lower than that for integrated urban-rural development. Therefore, to achieve the systematic and coordinated development of both, efforts must be intensified to foster and develop new-quality productive forces. In the western regions, strengthening the cultivation of new-quality productive forces first requires increasing investment in science and technology, building integrated industry-academia-research platforms, attracting high-quality scientific research resources, and stimulating innovation to empower the transformation of traditional industries and the rise of emerging industries through technology. At the same time, the

business environment must be optimized to provide fertile ground for the growth of emerging industries, attract high-end talent and capital, and foster clusters of new-quality productive forces with core competitiveness.

Integrated and coordinated development is a key objective for the western region. The cultivation of new-quality productive forces must be closely aligned with this objective. In urban areas, the industrial capacity of cities should be enhanced by developing emerging industries such as high-end manufacturing and the digital economy; in rural areas, the development of new-quality industries—including agricultural modernization and rural tourism—should be promoted to achieve coordinated industrial progress. By strengthening infrastructure development, breaking down barriers created by the urban-rural dichotomy, and promoting the free flow of factors of production, we can use new-quality productive forces as a link to achieve industrial complementarity and resource sharing, enabling cities and rural areas to mutually promote and integrate with one another in the course of development.

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Zulipinur Yimamu,Maiyila Tursun, Kong Xinyue, designed the research framework for this paper, building upon and enriching existing research in the field based on previous studies. They developed metrics to measure new-quality productive forces and the level of urban-rural integration, and assessed the degree of systematic coupling and coordination between the two, using data from relevant statistical yearbooks to support the conclusions of this study. This paper focuses on the western region of China, calculating the levels of new-quality productivity and the degree of coordination between urban and rural integration across different provinces, with a view to providing theoretical and practical guidance on how to enhance the coordination between these two systems in the region.

Conflict of Interest

There are no conflicts of interest declared by authors.

Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author on

request.

Competing Interests

The authors declare no competing interests.

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