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Synergistic development study of urban-rural integration and ecosystem resilience

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Abstract: *In order to analyze the status of the synergistic high-quality development of urban-rural integration and ecological environment in China, the variability of regional coordination levels and the influencing factors, this paper selected panel data of 30 Chinese provinces from 2004-2020 and measured the development levels of urban-rural integration and ecological environment separately using the entropy value method. On this basis, the Dagum Gini coefficient decomposition was used to investigate the regional differences and influencing factors of coordinated development of urban-rural integration and ecological environment in China in depth. It is found that: (1) The overall trend of urban-rural integration and ecosystem resilience level is on the rise, but there are obvious divergent characteristics. (2) The coordinated development level of urban-rural integration and ecosystem resilience is lower in western and northeastern China. (3) At the national level, the relative difference in the coordination level between urban-rural integration and ecosystem resilience is gradually decreasing, but the gap between regions is increasing. Regional differences are still the reason for the difference in the coordination development level. Therefore, the government should increase the implementation of urban-rural integration and green development strategies, increase the implementation of coordinated regional development strategies.*

Keywords: *Urban-rural integration; Ecosystem resilience; Regional differences*

1. Introduction

With the accelerated pace of new urbanization, urban population growth and spatial expansion have led to a serious imbalance between urban development speed and resource and environmental carrying capacity in some areas, and the urban and rural ecological environment is under unprecedented pressure[1]. In turn, ecological environment destruction can be a duress to urban-rural development. Therefore, how to coordinate the relationship between urban-rural integration development and ecological environment and find the best balance between the level of urban-rural integration development and ecological environment, it is necessary to reveal the mechanism of their interaction and analyze the coupling relationship between the two systems of urban-rural integration and ecological environment. Meanwhile, the level of synergistic development between urban-rural integration and ecosystem resilience in China should show significant differences due to the influence of urban-rural dual structure, unbalanced regional economic development degree, and differences in regional resource endowment, etc. What is the source of such variability? Is it influenced by the differences between regions? The answers to these questions are beneficial to promote the implementation of the strategy of urban-rural integration and coordinated regional development in China, as well as to promote the sustainability of the ecological environment.

2. Data sources and study design

2.1. The construction of the index system

2.1.1. Measurement of urban-rural integration level

The factor flow and industrial interaction between urban and rural areas is is a prerequisite for the realization of integrated urban-rural development. Its significance is to achieve reasonable distribution of resources between urban and rural areas and improve resource allocation efficiency through orderly and free flow of capital, labor, technology and other factors as well as linkage development between industries[2]. The information network, transportation network and environment are the driving force of

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urban-rural integrated development and the carrier to realize the flow of factors between urban and rural areas. The ultimate goal of urban-rural integrated development is to improve and coordinate the living consumption of urban and rural residents as well as to improve the equalization of basic public services. Here, drawing on the previous ideas, 22 indicators are selected from three dimensions of urban-rural integration: preconditions, dynamics and results, and the evaluation index system of urban-rural integration level is constructed using the entropy weight method[3], and the specific indicators are shown in Table 1.

Table 1: Urban-rural integration evaluation index system.

First level indicators	Second Level indicators	Third level indicators	Properties
Urban-rural integration	Urban-rural integration prerequisites	Differences in urban and rural fixed asset investment by region	-
		The proportion of financial support to agriculture by region	+
		Cargo turnover by region	+
		Total passenger turnover by region	+
		Total passenger traffic by region	+
		Ratio of science and technology expenditure to fiscal expenditure	+
		Total power of agricultural machinery / arable land area	+
		Effective irrigated agricultural area by region	+
		Contribution of secondary and tertiary industries to GDP by region	+
		Differences in price indices of agricultural and industrial products by region	+
	Urban-rural integration power	Railroad operating mileage by region	+
		Highway mileage by region	+
		Length of long-distance fiber optic cable lines by region	+
		Investment in industrial pollution control as a share of GDP	+
		Forest cover	+
	Urban-rural integration results	GDP per capita by region	+
		Differences in urban and rural per capita consumption expenditure by region	-
		Differences in urban and rural per capita disposable income by region	-
		Differences in medical levels between urban and rural areas	-
		Pension insurance coverage by region	+
		Unemployment Insurance by Region	+
		Differences in education levels between urban and rural areas	-

2.1.2. Evaluation index system of ecosystem resilience

Table 2: Ecosystem resilience evaluation index system.

First level indicators Level Indicators	Second Level indicators	Third level indicators	Properties
Ecosystem Resilience	Resistance	Industrial wastewater emissions per unit of GDP	-
		SO2 emissions of per square kilometer	-
		Fertilizer use per unit area	-
		Pesticide per unit area	-
		Unit area of plastic film	-
	Adaptability	Harmless disposal rate of domestic waste	+
		The ratio of nature reserves to the area of the jurisdiction	+
		Rural biogas possession per capita	+
		Rural per capita solar energy utilization	+
	Recovery	Greening coverage of built-up areas	+
		Green space per capita	+
		Afforestation area per capita	+

"Resilience" contains the meaning of both resilience and recovery, and is more about the ability to

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bounce back under the influence of risks, as well as the ability to prevent, respond and recover from extreme disasters[4-5]. There is no unified rating model on ecological resilience, and scholars have mostly focused on the level of urban resilience, while little research has been reported on urban and rural ecological resilience. Therefore, in this paper, following the principles of scientificity and operability, etc., and drawing on the studies of relevant scholars, we construct the rating indexes of urban and rural ecosystem resilience containing 12 three-level indicators from three levels of resistance, adaptability and recovery, which are detailed in Table 2.

2.2. Data source and processing

Considering the availability of data and the accuracy of the empirical results, the panel data of 30 Chinese provinces (excluding Tibet, Hong Kong, Macao and Taiwan) from 2004 to 2020 are selected for the study. The relevant research data are obtained from the China Statistical Yearbook, China Rural Statistical Yearbook, China Environmental Statistical Yearbook, and the statistical yearbooks of each province (autonomous region and municipality directly under the central government), and some missing data are completed by interpolation method.

2.3. Research Methodology

2.3.1. Coordinated Development Degree Measurement

Referring to the existing literature[6], the coupling degree of urban-rural integration and ecosystem resilience is calculated as follows:

$$C = \sqrt{\frac{U_1 \times U_2}{(U_1+U_2)^2}} \tag{1}$$

Among them, U1 and U2 represent the development level of urban-rural integration and ecosystem resilience, respectively. C is the coupling degree of urban-rural integration and ecosystem resilience.

$$T = \alpha U_1 + \beta U_2 \tag{2}$$

$$D = \sqrt{C \times T} \tag{3}$$

Equation (2) and (3) are the calculation formula of the coordinated development level of urban-rural integration and ecosystem resilience. Considering the mutual influence and synergistic development between urban-rural integration and ecosystem resilience, therefore, this paper goes to the equal weight of synergistic development,α=β=1/2. D is the level of coordinated development of urban-rural integration and ecosystem resilience, and its value range is [0,1]. The larger D is, the stronger the interaction between urban-rural integration and ecosystem resilience. Vice versa, the weaker.

2.3.2. Gini coefficient decomposition

Dagum Gini coefficient decomposition is a method to decompose the imbalance between regions according to subgroups. Compared with the traditional Gini coefficient and Thayer index, it is more accurate in dealing with regional imbalances and other issues[7]. Therefore, this paper uses the Dagum Gini Coefficient to analyze the regional variability in the level of coordinated development of urban-rural integration and ecosystem resilience. Its calculation process is as follows:

$$G = \frac{\sum_{j=1}^{h}\sum_{h=1}^{k}\sum_{i=1}^{nj}\sum_{r=1}^{nh}|y_{ji}-y_{hr}|}{2n^2\overline{y}}$$

Where J and h represent different regions, i and r represent provinces or municipalities directly under the central government in the region, n is the total number of provinces, n_j and n_h represent the number of provinces in different regions, y_{ji} and y_{hr} represent the coordinated development level of urban-rural integration and ecosystem resilience in provinces i or r in region j or h, and represent the average composite score of all provinces.

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3. Analysis of the coordinated development level of urban-rural integration and ecosystem resilience

3.1. Measurement results and analysis of urban-rural integration and ecosystem resilience

3.1.1. Overall characteristics of urban-rural integration

Table 3: Urban-rural integration and ecosystem resilience levels in China, 2004-2020.

Region	Urban-rural integration		Ecosystem Resilience		Region	Urban-rural integration		Ecosystem Resilience	
	2004	2020	2004	2020		2004	2020	2004	2020
Beijing	0.368	0.455	0.324	0.401	Henan	0.387	0.431	0.468	0.496
Tianjin	0.434	0.285	0.552	0.269	Hubei	0.317	0.383	0.323	0.357
Hebei	0.414	0.373	0.529	0.442	Hunan	0.386	0.406	0.419	0.412
Shanxi	0.296	0.286	0.297	0.233	Guangdong	0.477	0.539	0.455	0.636
Neimenggu	0.301	0.323	0.238	0.242	Guangxi	0.265	0.298	0.251	0.338
Liaoning	0.407	0.286	0.356	0.294	Hainan	0.189	0.241	0.242	0.299
Jilin	0.270	0.249	0.251	0.253	Chongqing	0.209	0.256	0.254	0.242
Heilongjiang	0.376	0.319	0.303	0.309	Sichuan	0.364	0.403	0.396	0.317
Shanghai	0.410	0.376	0.309	0.421	Guizhou	0.190	0.303	0.267	0.298
Jiangsu	0.438	0.494	0.482	0.571	Yunnan	0.244	0.269	0.257	0.222
Zhejiang	0.483	0.485	0.501	0.502	Shaanxi	0.279	0.307	0.292	0.272
Anhui	0.308	0.457	0.394	0.511	Gansu	0.206	0.222	0.279	0.292
Fujian	0.350	0.348	0.288	0.365	Qinghai	0.165	0.190	0.249	0.189
Jiangxi	0.299	0.339	0.303	0.351	Ningxia	0.266	0.237	0.255	0.223
Shandong	0.456	0.431	0.556	0.482	Xinjiang	0.259	0.268	0.289	0.276

Note: Due to space limitations, this paper only reports data for 2004 and 2020

Table 3 reports the level of urban-rural integration in China in 2004 and 2020. Comparative analysis shows that: (1) The macro pattern of urban-rural integration level in China from 2004 to 2020 changes more significantly, with an overall upward trend. Specifically, the level of urban-rural integration in China in 2004 is mainly located in the range of (0.165, 0.483), while the level of urban-rural integration in 2020 is mainly located in the range of (0.364, 0.651), indicating that the overall level of urban-rural integration development in China has increased. This is mainly because in order to promote urban-rural development, the 18th National Congress of the Communist Party of China proposed "promoting the integration of urban and rural development", and the 19th Congress proposed "promoting the integrated development of urban and rural areas" again. In addition, in order to solve the "three rural problems" and narrow the gap between urban and rural areas, China has implemented strategies such as rural revitalization and new urbanization, and a series of policies and measures have created conditions for promoting the integrated development of urban and rural areas. (2) The level of urban-rural integration in China shows relatively obvious divergent characteristics. Specifically, the regions with a higher level of urban-rural integration are mainly concentrated in the eastern region, and gradually decreasing in the north and west directions with this as the core. The level of urban-rural integration in the western region is generally lower, showing obvious urban-rural development differences and a prominent dualistic structure. This is mainly because the eastern region has leading advantages in economic and social development, urbanization level and implementation of rural revitalization strategy, while the western region is backward in economic development level and poor in infrastructure conditions, and has much room for progress in promoting urban-rural integration development. (3) Although the overall level of urban-rural integration in China has improved, compared with the overall growth trend of urban-rural integration development in other provinces, the growth trend in the northeast and some western regions is slower and even degraded in some areas. This is mainly due to the urban bias and priority development strategy of heavy industry chosen by the Northeast region at a specific stage of development, which has led to the rapid advancement of urban industry and economic development in the Northeast while agriculture has been developing slowly for a long time, and the urban-rural dual structure has been gradually formed and strengthened continuously. In addition, the urban and industrial biased investment strategy has led to the widening gap between urban and rural areas in the Northeast in terms of technology, medical care, education, employment and other infrastructure, which is also one of the reasons for the slow level of urban-rural integration development in the Northeast. The western region is mainly lagging behind in the development of comprehensive economic strength, innovation level, and talents, thus the level of urban-rural integration is relatively slow.

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3.1.2. General characteristics of ecosystem resilience

Table 3 similarly reports the distribution characteristics of China's ecosystem resilience levels in 2004 and 2020. The comparative analysis shows that: (1) Although the overall ecosystem resilience level in China has improved, there are still some regions where the ecosystem resilience has degraded. Such as Inner Mongolia, Jilin, Shaanxi, Qinghai and other provinces. This is mainly due to the low level of economic development in this region, which makes it difficult to balance ecological and environmental benefits in the process of promoting economic development. (2) China's ecosystem resilience shows more obvious divergent characteristics. Specifically, most of the eastern and some of the central regions have higher levels of ecological and environmental resilience, while the western and northeastern regions as a whole have lower levels of ecosystem resilience. This is mainly due to the fact that the western region is more backward in terms of economic development and lacks sufficient funds for environment-friendly investments such as environmental restoration and pollution prevention, thus its ecosystem resilience level is lower.

3.2. Coordinated development level of urban-rural integration and ecosystem resilience

3.2.1. General characteristics of the coordinated development level of urban-rural integration and ecosystem resilience

Table 4: Average coordination level of urban-rural integration and ecosystem resilience in each province from 2004 to 2020.

Regional	Level	Regional	Level	Regional	Level	Regional	Level
Beijing	0.514	Jiangsu	0.577	Guangdong	0.590	Qinghai	0.367
Tianjin	0.498	Zhejiang	0.578	Guangxi	0.436	Ningxia	0.393
Hebei	0.554	Anhui	0.544	Hainan	0.402	Xinjiang	0.455
Shanxi	0.422	Fujian	0.472	Chongqing	0.393	Eastern Region Average	0.528
Neimenggu	0.418	Jiangxi	0.455	Sichuan	0.463	Western Region	0.414
Liaoning	0.491	Shandong	0.581	Guizhou	0.403	Central Region	0.494
Jilin	0.412	Henan	0.551	Yunnan	0.389	Northeast Region Average	0.454
Heilongjiang	0.461	Hubei	0.482	Shaanxi	0.430	National Average	0.472
Shanghai	0.519	Hunan	0.508	Gansu	0.406		

Table 4 reports the average level of coordinated development of urban-rural integration and ecosystem resilience for each province, region and the whole country during the period 2004-2020. It can be seen that: (1) The coordinated development of urban-rural integration and ecosystem resilience in nearly half of the provinces exceeds the national average. (2) Most western and northeastern regions, such as Qinghai and Ningxia, have a lower level of coordinated development of urban-rural integration and ecosystem resilience, while eastern regions have a higher level of coordinated development of urban-rural integration and ecosystem resilience. This may be due to the large gap between urban and rural dual structure in Ninghai and Qinghai, and the large gap between urban and rural infrastructure construction, medical care, pension and other social security compared with the eastern region, coupled with the more backward economic development, lax environmental protection supervision and low popularity of the application of environment-friendly technologies in the western region, thus the coordination level of urban-rural integration and ecosystem resilience is not high.

3.2.2. Regional differences in the coordinated development level of urban-rural integration and ecosystem resilience

In order to further reveal the evolution trend and regional differences in the level of coordinated development of urban-rural integration and ecosystem resilience, this paper measured the Gini coefficient of the level of coordinated development of urban-rural integration and ecosystem resilience in four major regions of China: east, central, west and northeast, and the specific results are shown in Table 5.

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Table 5: National and regional Gini coefficient values for 2004-2020.

Year	OVeral	In the region				Inter-regional					
		Eastern Region	Central Region	Western Region	Northeast Region	East-Central	East-West	East-Northeast	Central-West	Central-Northeast	West-Northeast
2004	0.074	0.068	0.047	0.034	0.040	0.068	0.084	0.072	0.054	0.047	0.042
2005	0.081	0.070	0.050	0.037	0.049	0.074	0.092	0.075	0.056	0.052	0.047
2006	0.078	0.070	0.050	0.030	0.049	0.072	0.087	0.073	0.053	0.050	0.045
2007	0.086	0.061	0.050	0.048	0.051	0.072	0.097	0.074	0.063	0.052	0.054
2008	0.084	0.061	0.051	0.040	0.046	0.071	0.096	0.072	0.060	0.052	0.048
2009	0.088	0.067	0.063	0.042	0.045	0.077	0.097	0.079	0.064	0.061	0.048
2010	0.078	0.056	0.051	0.038	0.036	0.063	0.088	0.061	0.062	0.048	0.049
2011	0.08	0.062	0.058	0.044	0.040	0.067	0.089	0.067	0.065	0.055	0.054
2012	0.081	0.062	0.060	0.045	0.038	0.068	0.091	0.068	0.069	0.057	0.048
2013	0.086	0.059	0.066	0.044	0.055	0.067	0.093	0.066	0.075	0.065	0.048
2014	0.094	0.050	0.066	0.094	0.050	0.064	0.105	0.061	0.096	0.064	0.049
2015	0.081	0.063	0.064	0.041	0.040	0.068	0.089	0.070	0.069	0.062	0.050
2016	0.086	0.066	0.076	0.035	0.031	0.074	0.091	0.070	0.075	0.070	0.045
2017	0.078	0.059	0.063	0.031	0.024	0.066	0.086	0.067	0.063	0.058	0.036
2018	0.074	0.072	0.066	0.035	0.038	0.071	0.076	0.073	0.064	0.065	0.039
2019	0.076	0.072	0.066	0.034	0.031	0.072	0.081	0.073	0.064	0.062	0.039
2020	0.08	0.072	0.069	0.044	0.024	0.074	0.086	0.078	0.070	0.067	0.042

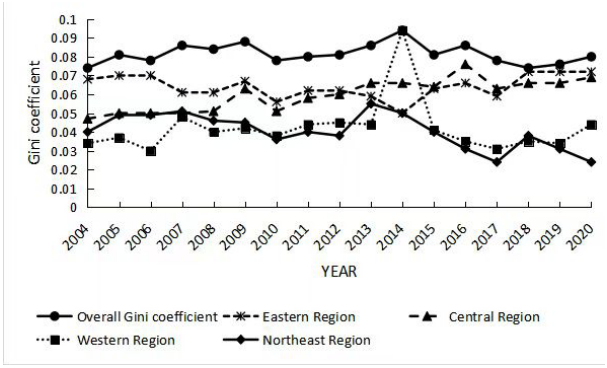

Figure 1: Overall and regional Gini coefficients.

In order to visualize the trends and differences in the Dagum Gini coefficients of the coordinated development levels of urban-rural integration and ecosystem resilience in China and each region from 2004 to 2020, the line graphs of the Gini coefficients at the national and regional levels are presented in Figure 1. As can be seen in Figure 1, the overall Gini coefficient shows an alternating trend of "increasing-decreasing", indicating that the fluctuating trend of the relative differences in the level of coordinated development of urban-rural integration and ecosystem resilience across the country is obvious. The inter-provincial variability in the level of coordinated development of ecological and ecosystem resilience increased, with the Gini coefficient rising from 0.074 to 0.094. However, after 2014, the inter-provincial Gini coefficient decreased, mainly because China closely focuses on the main line of promoting coordinated regional development and deeply implements the overall strategy of regional development. Therefore, the difference in the level of coordinated development of urban-rural integration and ecosystem resilience between the provincial levels has increased. The difference in the coordination level of ecological and ecosystem resilience gradually decreases.

In addition, Figure 1 also presents the Gini coefficients within the four regions of East, Central, West and Northeast. It can be seen that the level of coordinated development of urban-rural integration and ecosystem resilience in the eastern region shows an overall trend of "increasing-decreasing", and the regional differences in the eastern region are the greatest. The Gini coefficient of the central region shows an upward trend in general. The Gini coefficient of the western region is the most volatile, rising from 0.044 to 0.094 between 2013 and 2014. In the Northeast region, the gap between regions has been gradually decreasing in general since 2013.

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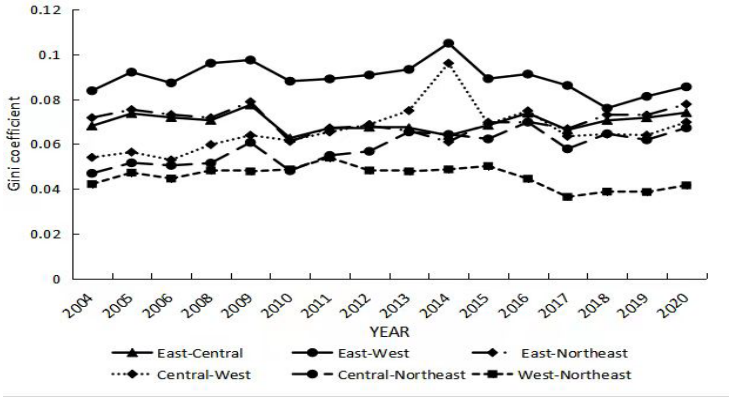

Figure 2: Variability between regions.

In order to analyze the differences in the level of synergistic development among the four regions of East, Central, West and Northeast and their evolution trends, Figure 2 shows the Gini coefficients among the regions. As can be seen from Figure 2, the regional differences between the East, Central, West and Northeast regions show an overall trend of "increasing-decreasing" fluctuation, but the overall gap between regions is increasing. The regional differences between the central, western, and northeastern regions have been on an upward trend. Only the regional disparity between the western and northeastern regions is decreasing.

Table 6: Sources of variation in Gini coefficients.

Year	Overall Gini coefficient	Intra-regional Gini coefficient		Region-to-region Gini coefficient		Hypervariable density Gini coefficient	
		Contribution Value	Contribution Rate	Contribution Value	Contribution Rate	Contribution Value	Contribution Rate
2004	0.074	0.015	20.025	0.048	64.165	0.012	15.809
2005	0.081	0.016	19.246	0.056	69.088	0.010	11.666
2006	0.078	0.015	19.272	0.053	68.044	0.010	12.684
2007	0.086	0.016	18.177	0.061	70.247	0.010	11.576
2008	0.084	0.015	17.773	0.062	74.036	0.007	8.192
2009	0.088	0.017	18.905	0.061	69.869	0.010	11.232
2010	0.078	0.014	17.916	0.057	72.823	0.007	9.261
2011	0.080	0.016	19.751	0.055	68.730	0.009	11.519
2012	0.081	0.016	19.632	0.056	69.241	0.009	11.127
2013	0.086	0.016	18.655	0.057	67.065	0.012	14.280
2014	0.094	0.020	21.340	0.042	45.002	0.031	33.658
2015	0.081	0.016	19.576	0.053	65.316	0.012	15.108
2016	0.086	0.016	19.148	0.057	66.025	0.013	14.826
2017	0.078	0.014	18.176	0.056	71.411	0.008	10.414
2018	0.074	0.016	22.302	0.041	55.765	0.016	21.933
2019	0.076	0.016	21.455	0.047	61.283	0.013	17.262
2020	0.080	0.018	21.986	0.050	62.077	0.013	15.937

Table 6 shows the decomposition of the regional differences in the overall Gini coefficient and their sources. As can be seen from Table 6, the evolution of intra-regional Gini coefficient region-to-region Gini coefficient and hypervariable density Gini coefficient and overall differences have basically the same trend. Among them, the interregional disparity has the highest contribution to the overall Gini coefficient, which indicates that interregional is still the main source of variability in the level of coordinated development of inter-provincial urban-rural integration and ecological and environmental resilience in the country, and the highest contribution to the overall variability of 74.036% during the observation period, which also indicates that regional differences in the east, central, west and northeast are still the cause of variability in the level of coordinated development of inter-provincial urban-rural integration and ecosystem resilience in China the main source of the difference.

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4. Conclusions and Policy Recommendations

This paper empirically examines the level of coordinated development and regional differences between urban-rural integration and ecosystem resilience using entropy method, coupled coordination model, and Gini coefficient decomposition for 30 Chinese provinces during 2004-2020. It was found that: (1) The level of urban-rural integration and ecosystem resilience generally showed an increasing trend, but showed obvious divergent characteristics. In addition, the level of urban-rural integration and ecosystem resilience in some provinces shows degradation characteristics. (2) The coordinated development of urban-rural integration and ecosystem resilience in nearly half of Chinese provinces exceeds the national average, while the coordinated development of urban-rural integration and ecosystem resilience in some western and northeastern regions is lower. (3) At the national level, the relative difference in the coordination level between urban-rural integration and ecosystem resilience is gradually decreasing, but the gap between regions is increasing. Regional differences are still the reason for the difference in the coordination development level between urban-rural integration and ecosystem resilience in China.

Based on the above analysis, the following countermeasures are proposed: (1) Increase the implementation of urban-rural integration and green development strategies to promote the continuous improvement of urban-rural integration and ecosystem resilience. (2) Increase the policy guidance and financial support to the western and northeastern regions to promote the coordinated development of urban-rural integration and ecosystem resilience in the western and northeastern regions. (3) Increase the implementation of regional coordinated development strategy to promote the improvement of urban-rural integration and ecosystem resilience coordinated development.

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