

# Study on Evaluation System of Urban-rural Integration in County Under Factor Flow

Ruyi Guo, Xiaodong Niu

School of Architecture and Engineering, North China University of Science and Technology University, Tangshan 063000, China

## Abstract

**In the context of integrated urban-rural development and rural revitalization strategies, the flow of factors plays a crucial role in the integration and coordinated development of urban and rural resources within counties. Based on research into the indicators for urban-rural integration, this paper takes the flow of factors as its starting point to reveal the interactive relationship between population, land, capital, and technology flows and the level of urban-rural integration. It summarizes an overall evaluation indicator system comprising 27 specific indicators across seven dimensions: population integration, land integration, capital integration, technological integration, production integration, living integration, and ecological integration. Through mathematical models and empirical analysis, the feasibility and applicability of this evaluation indicator system and method are verified.**

## Keywords

**Factor flow, urban-rural integration of counties, evaluation index.**

## 1. Introduction

China is currently in the deepening stage of urbanization, with an urbanization rate reaching 65.2% in 2022. However, the "city-first" model has widened the gap between urban and rural areas (the income ratio between urban and rural residents is approximately 2.5:1). The 19th National Congress proposed the Rural Revitalization Strategy, which calls for integrating urban and rural areas to break down the dual structure. Counties, as the "end of cities and beginning of towns," have become key carriers for policy implementation.

The National New-Type Urbanization Plan (2021-2035) and the Opinion on Establishing and Improving the Mechanism and Policy System for Integrated Urban-Rural Development both emphasize "urban-rural integration within counties." In 2022, the Opinion on Promoting Urbanization with Counties as Key Carriers further positions counties as core hubs for the flow of urban-rural elements. Research on urban-rural integration within counties is a critical area that responds to national strategic needs, addresses practical development challenges, and fills academic gaps. Its findings have both theoretical and practical value for achieving Chinese-style modernization.

## 2. Research on the Evaluation System of Urban-rural Integration in Counties at Home and Abroad

### 2.1. Introduction to foreign evaluation system

Research on urban-rural integration abroad mainly focuses on developed countries and regions such as Europe, America, Japan, and South Korea. The evaluation indicators are relatively simple, with more emphasis on spatial integration. For example, foreign scholars like Herold M [1] use the combined application of remote sensing images, spatial measurement, and spatial

modeling to extract multi-period land use data, analyzing the characteristics of urban-rural spatial patterns and their evolution processes. Foreign scholars Batten[2] Taking the Netherlands and Japan as examples, this paper analyzes the characteristics of urban-rural spatial pattern and its evolution process from the perspective of regional core-periphery structure.

## 2.2. Introduction to the domestic evaluation system

The construction of indicator systems for urban-rural integration at both provincial and municipal levels in China is relatively comprehensive. However, the evaluation indicator system for urban-rural integration within counties remains a weak link in current research. Continuing the mindset of constructing indicators for the level of urban-rural integrated development, from a county perspective, there are two approaches to building the indicator system. First, using sub-systems such as population integration, economic integration, social integration, spatial integration, and ecological integration as dimensions, a comprehensive evaluation indicator system for urban-rural regions can be constructed. For example, Wang Ping[3] Taking the 18 cities and counties of Hainan Province as research subjects, an indicator system was constructed from urban-rural economic, social, spatial, and ecological dimensions to explore the main influencing factors of urban-rural integration in Hainan. Second, the level of urban-rural integration is indirectly evaluated by measuring the coupling coordination degree between urban and rural geographic systems. As Zhang Haipeng et al[4] Methods such as variance-based decision-making method and coupling coordination degree model were used to quantitatively calculate the spatial evolution characteristics of urban-rural integration in the capital region from 1995 to 2015. Liu Guobin and Teng Ziyi[5] Lu Yangchun et al[6] By constructing a coupling coordination degree model, scholars measured the urban-rural integration degree in China and each region.

## 2.3. Analysis of domestic and foreign evaluation systems

Due to the lack of in-depth understanding of the concept and connotation of urban-rural integration within counties, as well as the constraints of data and methods, the indicator system at the county scale is not perfect.[7] For the evaluation system of urban-rural integration at the county level, foreign studies mainly focus on single indicators, while domestic research primarily continues to use provincial and municipal urban-rural integration evaluation systems. However, the construction of an indicator system for element flow under the essence of county-level urban-rural integration is not yet clear. Based on this, this paper, after gaining a deep understanding of the internal connection between element flow and county-level urban-rural integration, enriches the content of research on the level of county-level urban-rural integration by establishing an evaluation indicator system based on element flow.

# 3. The Establishment of Evaluation Index System for Urban-rural Integration in Counties

## 3.1. Construction principles

When constructing the evaluation index system for the integrated development of urban and rural areas in county units, a series of principles should be followed to ensure that the selected indicators can accurately reflect the actual level of urban-rural integration and ensure the reliability and effectiveness of the evaluation results. The following principles should be followed when selecting evaluation indicators:

### 3.1.1. Comprehensiveness and focus

The evaluation indicators should comprehensively cover all aspects of the evaluated object to ensure the integrity and accuracy of the assessment. This requires that the indicator system not

only reflects the main characteristics and status of the evaluated object but also avoids overlooking important aspects. On the basis of comprehensiveness, the evaluation indicators should highlight key points and focus on the core aspects of the evaluated object. This helps enhance the relevance and effectiveness of the evaluation.

### **3.1.2. Scientificity and feasibility**

The selection of evaluation indicators should be based on scientific methods and theories, ensuring that the indicators can objectively and truly reflect the characteristics and conditions of the evaluated object. The construction of the indicator system should also have a hierarchical structure, progressing from top to bottom, from macro to micro, layer by layer. At the same time, the evaluation indicators should be operational, facilitating data collection and processing. The calculation methods for the indicators should be simple and easy to understand, ensuring that the evaluation process proceeds smoothly.

## **3.2. Interpretation of factor flow theory and policy**

### **3.2.1. Theory of factor flow**

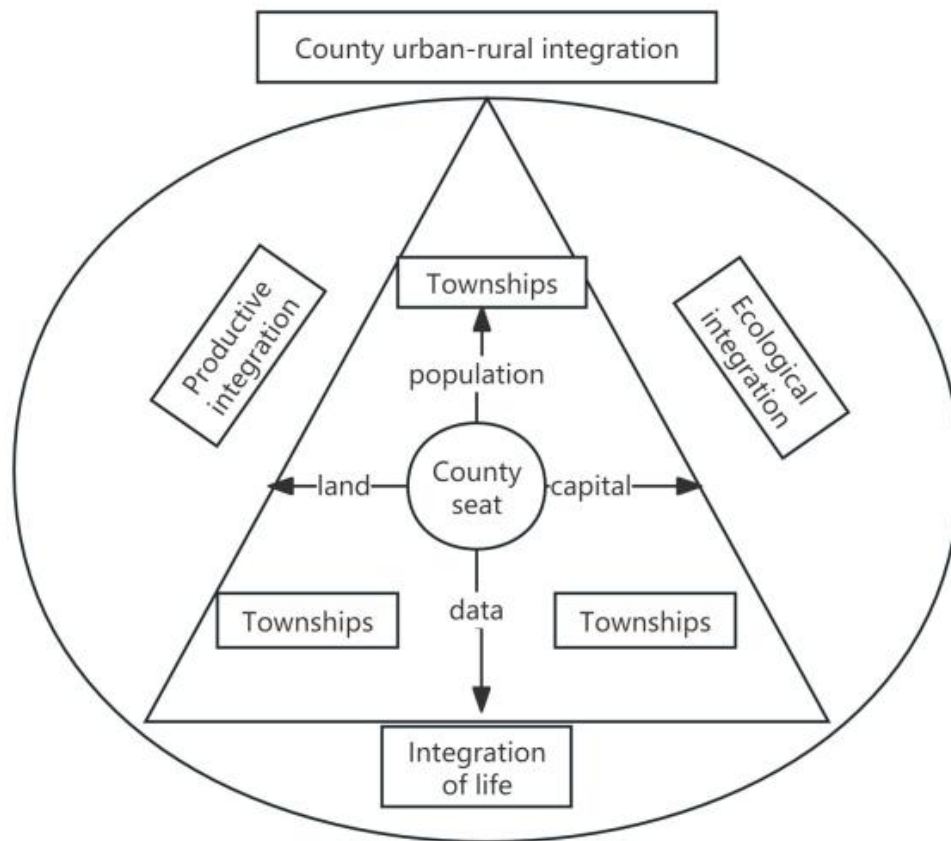
In economic activities, the theory of factor mobility refers to the free flow and exchange of resources such as capital, land, technology, personnel, and services between different regions, industries, or economic entities. This process is an inevitable phenomenon under market economy conditions and is also an important means of optimizing resource allocation and improving economic efficiency. Especially in the integrated development of urban and rural areas, the smoothness of factor mobility directly affects the economic balance and social coordinated development between regions. From the perspective of factors, the integration of urban and rural areas at the county level involves cities and villages leveraging their respective endowments and comparative advantages to transform the scarcity of factors into complementarity.[8]At present, the coordinated development of land, talent and capital are the key factors to break the imbalance between urban and rural development.

### **3.2.2. Policy interpretation**

The "National New-Type Urbanization Plan" proposes to accelerate the development of small and medium-sized cities as the main focus for optimizing the scale structure of towns and cities. It emphasizes strengthening municipal infrastructure and public service facilities, tilting the allocation of educational and medical resources towards small and medium-sized cities and county towns. The plan also guides higher education institutions and vocational schools to set up branches in these areas, promoting the establishment of high-quality educational and medical institutions in small and medium-sized cities, thereby enhancing their appeal for attracting elements. As can be seen from this, urban-rural integration at the county level should not only focus on basic factors such as population, land, capital, and technology but also pay attention to the county's capacity, strengthening public infrastructure and basic public services in both urban and rural areas, to achieve free and comprehensive human development.

## **3.3. The connotation of integrated urban and rural development in counties**

This article defines the integrated development of urban and rural areas within counties as a process where, under the premise that resources are increasingly allocated from major cities to counties, the county serves as a carrier to continuously enhance its capacity. Taking the county as the basic unit of development, with the county town at its core, it radiates to townships. By achieving free flow and optimal allocation of talent, land, capital, and technology between urban and rural areas, this process promotes the integration of production, life, and ecology, ultimately forming an integrated pattern of integrated development between urban and rural areas within counties. The conceptual framework for the integration of urban and rural areas within counties is shown in Figure 1.



**Figure 1.** Conceptual framework of urban-rural integration in counties

### 3.4. Pre-selection of evaluation indicators

Given the limited number of existing studies evaluating the integrated development of urban and rural areas in regions, this paper, based on a clear understanding of the concept of county-level urban-rural integration, proposes to construct a multi-level indicator evaluation system for county-level urban-rural integration from seven dimensions: population integration, land integration, capital integration, technological integration, production integration, living integration, and ecological integration. Combining expert opinions and data availability, the initial 46 reference indicators have been compiled (as shown in Table 1).

### 3.5. Establishment of evaluation index system for urban-rural integration in counties

According to the selection results of the indicators mentioned earlier (excluding those with fewer than 10 votes), and adhering to the principles of comprehensiveness, focus, scientificity, and feasibility, we have summarized an overall evaluation indicator system comprising 27 specific indicators across seven dimensions: urban-rural population integration, land integration, capital integration, technological integration, production integration, living integration, and ecological integration. The evaluation indicator system is shown in Table 2.

**Table 1.** Summary of expert voting results

Target layer	The calibration layer	vote	Whether to select
Population integration A	Urbanization rate of registered population A1	16	yes
	The urban-rural population ratio is A2	10	yes
	Urban permanent population growth rate A3	6	deny
	Population density (10,000 / km <sup>2</sup> ) A4	15	yes
	Number of rural talents A5	8	deny
	The number of urban and rural employees is A6	13	yes
	Non-farm employment ratio A7	9	deny
	Agricultural employment growth rate A8	6	deny
Land integration B	The area of cultivated land accounts for B1 of the administrative region	12	yes
	Urban space expansion rate B2	10	yes
	Facility agriculture covers an area of B3	6	deny
	Facility agriculture accounts for B4	10	yes
Capital integration C	The ratio of urban and rural construction land to B5 is 1	4	deny
	County capital investment growth rate C1	4	deny
	Urban-rural capital input ratio C2	13	yes
	Rural investment growth rate C3	6	deny
	Number of urban-rural technical cooperation projects C4	5	deny
	Urban-rural capital integration degree C5	10	yes
Data fusion D	The ratio of urban and rural broadband access users D1	5	deny
	Agricultural mechanization level D2	11	yes
	The input-output ratio of agricultural science and technology is D3	13	yes
	Internet penetration rate D4	11	yes
	E-government penetration rate D5	6	deny
	Urban-rural per capita traffic and communication comparison coefficient D6	13	yes
Production integrates E	The proportion of the first output value E1	11	yes
	Agriculturalization level E2	13	yes
	Per capita GDP E3	17	yes
	Urban-rural dual production comparison coefficient E4	16	yes
	Non-farm output ratio E5	10	yes
	Agricultural output value growth rate E6	12	deny
	The per capita disposable income of urban and rural areas is E7	14	yes
	Urban and rural per capita consumption expenditure is E8	13	yes
	Per capita fiscal revenue E9	9	deny
	The average output level of industrial enterprises is E10	11	yes
Life Fusion F	Comparison of the number of middle and primary schools in urban and rural areas F1	7	deny
	Comparison of the number of urban and rural hospitals F2	6	deny
	The number of health personnel per 1,000 people in urban and rural areas F3	6	deny
	Urban-rural education investment F4	11	yes
	The coverage level of "social security insurance" is F5	13	yes
	Regional road network density F6	9	deny
	Urban and rural health resources balance F7	11	yes
Ecosystem integration G	Green coverage rate in built-up areas G1	4	deny
	The harmless treatment rate of urban and rural household garbage is G2	11	yes
	Public toilet penetration rate G3	15	yes
	Special industrial G4	7	deny
	Energy consumption per unit of total agricultural output value G5	11	yes

**Table 2.** Evaluation index system of urban-rural integration in counties

Primary indicator	Secondary indicators	Indicator description	attribute
Population integration A	The urban-rural population ratio is A1	Urban population / rural population	forward direction
	Urbanization rate of registered population A2	(End-of-year total population-rural population)/registered population	forward direction
	The ratio of urban and rural employed persons is A3	Number of employees in urban units / number of rural employees	forward direction
	Population density A4	Permanent population / administrative area	negative direction
Land integration B	The area of cultivated land accounts for B1 of the administrative region	Common cultivated land area / administrative area land area	forward direction
	Facility agriculture accounts for B2	Facility agriculture area / common cultivated land area	forward direction
Capital integration C	Urban space expansion rate B3	Administrative area land area / total sown area of crops	forward direction
	Urban and rural fixed asset investment is C1	Urban fixed asset investment completed / total social fixed asset investment	forward direction
	Urban-rural capital integration degree C2	Resident savings deposit balance / year-end financial institutions loan balance	forward direction
Technology integration D	Agricultural mechanization level D1	Total power of agricultural machinery / number of rural workers	forward direction
	The input-output ratio of agricultural science and technology is D2	Total output value of agriculture, forestry, animal husbandry and fishery / total power of agricultural machinery	forward direction
	Urban-rural per capita transportation and communication comparison coefficient D3	Urban residents per capita expenditure on transportation and communication / rural residents expenditure on transportation and communication	forward direction
	Internet penetration rate D4	Number of broadband access users / total number of households at the end of the year	forward direction
Production integrates E	The proportion of primary industry E1	Value added of primary industry/ regional GDP	negative direction
	Per capita GDP E2	per capita GDP	forward direction
	Agriculturalization level E3	Agricultural added value/added value of primary industry	forward direction
	The average output level of industrial enterprises is E4	Total output value of industrial enterprises above designated size / number of industrial enterprises above designated size	forward direction
	The per capita disposable income of urban and rural areas is E5	Urban per capita disposable income / rural per capita disposable income	negative direction
	The expenditure ratio of urban and rural residents is E6	Per capita consumption expenditure of urban residents/per capita consumption expenditure of rural residents	negative direction
	Urban-rural dual production comparison coefficient E7	(GDP of primary industry / number of people employed in primary industry) / (GDP of secondary and tertiary industries / number of people employed in secondary and tertiary industries)	negative direction
Life Fusion F	Urban and rural education investment F1	Education expenditure/fiscal expenditure	forward direction
	Urban and rural health resources balance F2	Per capita medical care expenditure of urban residents/rural residents	forward direction
	Urban and rural old-age insurance coverage F3	Number of people insured for old-age insurance for urban and rural residents/number of permanent residents	forward direction
	Unemployment insurance coverage F4	Number of people participating in unemployment insurance / number of permanent residents	forward direction
Ecosystem integration G	The harmless treatment rate of domestic garbage is G1	immediate data	forward direction
	Energy consumption per unit of total agricultural output value G2	Total power of agricultural machinery / total output value of agriculture, forestry, animal husbandry and fishery	negative direction
	Public toilet penetration rate G2	Public toilets per 10,000 people	forward direction

## 4. Empirical Analysis

### 4.1. Research object

According to the "Several Opinions of the Central Committee of the Communist Party of China and the State Council on Promoting the Rise of the Central Region," the "Opinions of the State Council on Several Policy Measures for the Large-Scale Development of the West," and the spirit of the report from the 16th National Congress of the Communist Party of China, China's economic regions are divided into four major areas: eastern, central, western, and northeastern. This study randomly sampled 17 key counties in these regions for analysis. In a broad sense, counties refer to county-level administrative regions, including districts under cities, counties, autonomous counties, ethnic autonomous counties, and county-level cities. This paper takes the broad definition of counties as its research object, and the sampling results are shown in Table 3.

**Table 3.** County sample table

region	province	County (district)	region	province	County (district)
	Shanxi International Gong and Drum Festival	Qingxu County		Beijing Municipality	Huairou District
central section	Anhui Province	Shushan District		Hebei Province	Gaocheng District
	Jiangxi Province	Yudu County	east	a folk art form popular in Shandong	Weishan County
	Hunan Province	Changsha County		Zhejiang Province	Yongjia County
	Chongqing City	Jiangjin District		Fujian Province	Xiang an District
	Sichuan Province	Dayi County		Hainan Province	Lingshui Li Autonomous County
west	Yunnan Province	Songming County		Guangdong Province	Huilai County
	the Ningxia Hui Autonomous Region	Hongshibao District	northeast	Jilin Province	Nongan County
	the Xinjiang Uygur Autonomous Region	Jiashi County			

### 4.2. Data collection

This paper takes county-level units as the research object and selects data from sample county-level units between 2018 and 2022 for analysis. The original data sources are divided into three aspects: ① Regional statistical materials. This mainly includes the statistical yearbooks, bulletins, and yearbooks of provinces, cities, and counties extracted from 2019 to 2023. ② Specialized statistical materials. This mainly includes the "China County Statistical Yearbook," "China City Statistical Yearbook," "China Rural Statistical Yearbook," and "China Labor Statistical Yearbook" from 2019 to 2023. ③ Comprehensive databases. This mainly includes the websites of provincial governments, municipal governments, county (city, district) governments, and the China Big Data Research Platform for Economic and Social Sciences.

### 4.3. The level of urban-rural integration in counties based on global principal component analysis

#### 4.3.1. Applicability test of global principal component analysis

Before conducting principal component analysis, it is necessary to validate the applicability of the data through KMO (Kaiser-Meyer-Olkin) test and Bartlett's sphericity test (Bartlett's Test of Sphericity). The KMO test aims to assess the partial correlation between variables, determining whether the sample data is suitable for dimensionality reduction analysis; the Bartlett's sphericity test verifies the significance of the variable correlation matrix, confirming whether there is sufficient correlation among variables to support factor extraction. The test results are shown in Table 4.

**Table 4.** KMO and Bartlett test

	KMO price	0.611
	Approximately chi-square	5015.311
Bartlett Spherical test	df	351
	P	0.000***

This study is based on the co-development integration index data of 17 county-level urban-rural units from 2018 to 2022, with a calculated KMO value of 0.511 and a Bartlett's test statistic of 0.000\*\*\*, where P is less than 0.05, indicating a significance level of 1%. The null hypothesis was rejected. The sample data meet the prerequisites for principal component analysis, and subsequent steps can involve eigenvalue extraction and factor rotation to further refine the core dimensions of urban-rural integration development.

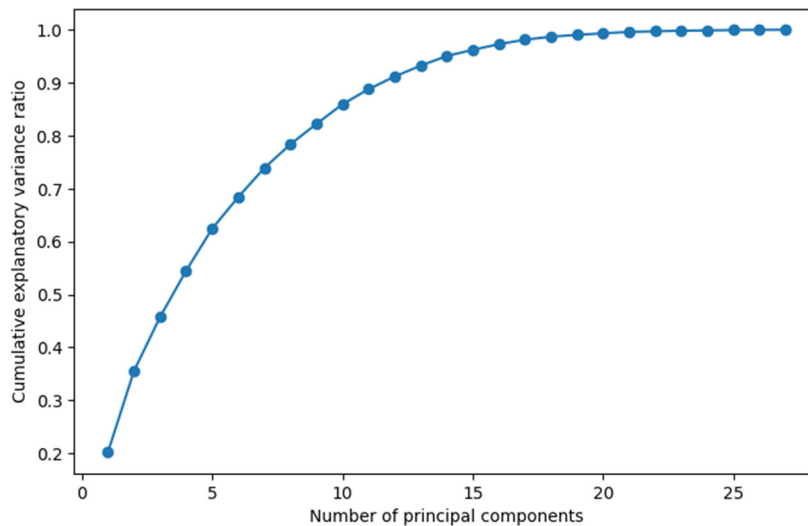
#### 4.3.2. Variance explained

The core purpose of principal component analysis is to reduce data complexity through dimensionality reduction while retaining as much original information as possible. By calculating the proportion of variance explained by each principal component, it becomes clear which components contain the most information and which have relatively less. The cumulative proportion of variance further reveals how much total variability in the data can be explained by the first few principal components together, thus providing a basis for selecting principal components and simplifying models. In this study, a PCA() object was created to build a principal component analysis model, and pca.fit() was used to fit the standardized data, extracting the principal components from the data. The explained\_variance\_ratio attribute returns the proportion of total variance that each principal component can explain, indicating its weight in the overall data variability. The results are shown in Table 5.

The cumulative variance contribution method is the core criterion for determining the number of principal components in principal component analysis. The academic community generally considers an interval of 80%-90% cumulative variance contribution as a typical reference standard. This range effectively reduces data dimensions while avoiding excessive loss of key information. If the research field has higher requirements for data reconstruction accuracy or explanatory depth, the threshold can be appropriately increased to enhance model interpretability. As shown in the table above, when the number of principal components is 11, the eigenvalue explaining total variance is less than 1, and the contribution rate of variable explanation reaches 88.773%, as illustrated in Figure 2.

**Table 5.** Variance explained

Component number	characteristic root		
	characteristic root	Variance explained rate (%)	Cumulative variance explained rate (%)
1	5.456	20.207	20.207
2	4.145	15.352	35.56
3	2.748	10.179	45.738
4	2.361	8.743	54.482
5	2.148	7.956	62.437
6	1.611	5.966	68.404
7	1.479	5.476	73.88
8	1.211	4.486	78.366
9	1.04	3.852	82.217
10	1.004	3.717	85.934
11	0.766	2.839	88.773
12	0.648	2.398	91.171
13	0.553	2.05	93.221
14	0.492	1.821	95.042
15	0.315	1.168	96.21
16	0.289	1.071	97.281
17	0.228	0.843	98.124
18	0.154	0.571	98.696
19	0.089	0.33	99.026
20	0.083	0.309	99.335
21	0.07	0.26	99.595
22	0.032	0.12	99.715
23	0.028	0.103	99.818
24	0.018	0.068	99.886
25	0.016	0.059	99.945
26	0.009	0.034	99.979
27	0.006	0.021	100



**Figure 2.** Cumulative variance ratio curve

The calculated factor weights are shown in Table 6.

**Table 6.** Factor weights table

name	weight (%)	name	weight (%)
PC1	23.515	PC6	6.943
PC2	17.865	PC7	6.373
PC3	11.845	PC8	5.22
PC4	10.174	PC9	4.482
PC5	9.258	PC10	4.325

#### 4.3.3. Factor loading coefficient table

In multivariate statistical analysis, factor loading coefficients serve as key parameters to quantify the strength and direction of association between original variables and principal components (or common factors). Their role is primarily reflected in two aspects: First, they reveal the explanatory contribution of variables to the principal component; the larger the absolute value of the loading coefficient, the higher the information carrying capacity of the variable in the principal component, which plays a crucial role in defining its practical significance. Second, through the positive or negative signs and numerical distribution of the loading coefficients, the intrinsic structural characteristics of the principal component can be interpreted, thereby mapping the abstract results of mathematical dimensionality reduction onto the semantic dimensions of specific research questions. In the measurement of urban-rural integration, analyzing the loadings of indicator variables on the core principal component can identify key drivers of urban-rural integration, and refine the theoretical connotations of the principal component, providing interpretable data support for subsequent construction of comprehensive evaluation systems and policy analysis.

From the factor loading matrix, it can be seen that the main high-load variables of PC1 include "per capita regional GDP," "urbanization rate of registered population," and "unemployment insurance coverage." PC1 primarily reflects the comprehensive factors of regional economic development and urbanization levels. PC2 has higher loadings on "population density," "balance of medical and health resources between urban and rural areas," and "expenditure ratio between urban and rural residents," indicating its representation of population concentration and distribution characteristics of social security resources. The high-load indicators of PC3 are "agricultural technology input-output ratio" and "degree of capital flow between urban and rural areas," suggesting that it more prominently reflects agricultural modernization and capital circulation conditions. PC4 carries significant weight in "the proportion of commonly used farmland to administrative area size" and "investment in education between urban and rural areas," possibly reflecting issues related to land use efficiency and educational disparities between urban and rural areas. The harmless treatment rate of household waste and the popularization rate of public toilets exhibit cross-dimensional loadings across multiple principal components, hinting at the systemic impact of environmental governance on urban-rural integration. Other principal components also reveal comprehensive information from different dimensions, such as the structure of urban-rural employment, infrastructure popularization rates, and resource allocation balance. In summary, these principal components effectively extract key information from the original variables and can reveal the underlying meanings behind each principal component through high-load variables.

**Table 7. Factor loadings**

metric	PC1	PC2	PC3	PC4	PC5
Urban-rural population ratio	0.2446	0.0829	-0.3131	0.0948	0.1456
Urbanization rate of registered population	0.3806	0.1015	0.1348	0.1604	-0.0028
Urban-rural employment ratio	0.0735	0.0803	-0.1575	-0.2169	-0.135
density of population	-0.089	0.329	-0.0354	0.0842	-0.2307
The ratio of cultivated land to administrative area	-0.2039	-0.1526	0.0512	0.3707	0.2873
Facility agriculture share	-0.0131	0.0055	-0.0416	-0.297	0.18
Urban spatial expansion rate	0.3432	0.2166	-0.1381	0.0306	0.0472
Urban-rural fixed asset investment ratio	0.1585	-0.264	-0.2114	-0.2575	-0.0582
The degree of capital integration between urban and rural areas	0.0178	-0.1038	0.3946	-0.0811	0.265
level of farming mechanization	-0.1862	0.1929	0.0134	-0.143	-0.2761
Input-output ratio of agricultural science and technology	0.1117	-0.1138	0.4702	-0.1177	0.0531
Urban-rural comparative coefficient of transportation and communication	0.1173	0.0916	0.059	0.1878	-0.0236
Internet penetration rate	0.1909	-0.2157	0.1728	-0.0774	0.2436
The proportion of primary industry	0.241	-0.0896	-0.332	-0.0038	0.1918
Per capita GDP	0.4011	0.109	-0.0177	-0.0035	0.0127
Agriculturalization level	0.1177	-0.2001	-0.1952	-0.1761	-0.1135
Average output level of industrial enterprises	0.072	-0.2004	0.0497	0.2168	0.1528
Urban-rural per capita disposable income ratio	0.0993	-0.2091	0.0276	0.2844	-0.3985
The ratio of urban and rural residents expenditure	0.0701	-0.2898	-0.1379	0.3123	-0.1829
Urban-rural dual production comparison coefficient	-0.0305	0.2533	-0.0512	0.0121	0.4585
Investment in urban and rural education	0.1507	-0.2668	0.0654	-0.3251	-0.0485
Balance of urban and rural medical and health resources	-0.0944	0.3283	0.0023	-0.2625	0.0536
Coverage of old-age insurance for both urban and rural residents	-0.2593	-0.2429	-0.232	-0.0555	0.2196
Unemployment insurance coverage	0.3499	0.2274	0.1329	0.0658	0.0396
The rate of harmless treatment of domestic garbage	0.0963	-0.0965	-0.0879	-0.0156	0.0102
Energy consumption per unit of total agricultural output value	0.1218	-0.1368	0.2097	-0.2858	-0.1863
Public toilet penetration	-0.0215	-0.0523	-0.2799	-0.125	0.1104
metric	PC6	PC7	PC8	PC9	PC10
Urban-rural population ratio	0.2589	0.0353	0.0663	0.0113	0.2416
Urbanization rate of registered population	-0.0378	0.0345	0.0543	-0.0338	-0.0229
Urban-rural employment ratio	0.5176	-0.0568	-0.1744	0.0129	-0.3978
density of population	-0.0923	0.2216	-0.3756	0.0522	0.0495
The ratio of cultivated land to administrative area	0.0787	0.1118	0.0355	0.0756	-0.1733
Facility agriculture share	-0.2512	-0.3324	0.0747	0.2358	-0.1933
Urban spatial expansion rate	-0.004	0.096	-0.0634	0.1175	-0.0899
Urban-rural fixed asset investment ratio	0.025	0.2471	-0.0049	-0.1978	-0.0625
The degree of capital integration between urban and rural areas	0.1534	-0.0398	-0.1617	0.1321	-0.3896
level of farming mechanization	0.3203	0.063	-0.2704	0.1374	-0.0523
Input-output ratio of agricultural science and technology	-0.0262	0.0138	-0.1013	-0.0285	0.2753
Urban-rural per capita transportation and communication comparison coefficient	-0.3631	-0.2366	-0.3069	-0.2964	-0.2149
Internet penetration rate	-0.0396	0.205	-0.2923	0.0908	-0.0392
The proportion of primary industry	-0.0409	-0.2142	-0.0501	-0.2795	0.0337
Per capita GDP	0.0426	-0.0003	0.0765	0.0954	-0.0492
Agriculturalization level	-0.1955	0.3688	-0.1961	-0.1277	0.0031
Average output level of industrial enterprises	0.1427	0.4411	-0.0401	0.2022	0.1714
Urban-rural per capita disposable income ratio	-0.0032	-0.0094	0.1782	0.1629	-0.2824
The ratio of urban and rural residents expenditures	0.0964	-0.246	-0.005	0.1342	-0.0636
Urban-rural dual production comparison coefficient	0.2534	0.0137	0.0344	-0.1534	-0.1288
Investment in urban and rural education	-0.0161	-0.1078	-0.2163	-0.0347	-0.0356
Balance of urban and rural medical and health resources	-0.1617	0.1055	0.1671	0.1627	0.1198
Coverage of old-age insurance for both urban and rural residents	0.1188	-0.1026	-0.0182	-0.058	0.1062
Unemployment insurance coverage	0.0321	-0.0436	0.1118	0.1213	0.0013
The rate of harmless treatment of domestic garbage	0.0825	-0.3687	-0.3181	0.4905	0.4207
Energy consumption per unit of total agricultural output value	0.1931	-0.0182	0.4787	-0.0574	0.0818
Public toilet penetration	-0.3222	0.1989	0.1476	0.4962	-0.2812

#### 4.3.4. Overall score

Further, the scores of urban-rural integrated development in different dimensions and the comprehensive development scores of each region were calculated. The results are shown in Table 8.

**Table 8.** Comprehensive scores of urban-rural integration in counties by region from 2018 to 2022

a particular year	Northeast China	east	middle part	the west area
2018	0.2454	0.3469	0.1652	0.1917
2019	0.273	0.3665	0.1766	0.2118
2020	0.3238	0.3598	0.1573	0.1876
2021	0.3123	0.371	0.1654	0.2017
2022	0.3189	0.3681	0.174	0.2077

The eastern region has consistently led the way, with its composite score steadily increasing from 0.3469 to 0.3681 over five years, highlighting its sustained advantages as an economically advanced area in terms of urban-rural factor mobility and infrastructure connectivity. The northeastern region showed a significant catch-up trend, with its score rising from 0.2454 to 0.3189, averaging an annual increase of 5.8%, particularly breaking through the 0.32 threshold in 2020. The western region maintained a steady upward trend, increasing by 8.3% over five years but experiencing a brief dip in 2020. The central region saw relatively slow growth and remained in a regional development lowland. Notably, in 2020, the northeastern and eastern regions formed a development scissors gap, while the central and western regions exhibited a synchronized downward trend.

## 5. Conclusion

This paper constructs an evaluation index system for the integration of urban and rural areas in counties and conducts empirical research on sample counties. The evaluation index system is well-structured with clear objectives, reflecting the direction of urban-rural integration development under the flow of factors. It can serve as an evaluation tool for the level of urban-rural integration in counties, and has positive implications for the quantitative assessment and indicator-based management of land, population, capital, and data flows, as well as peoples production, living, and ecological activities. This system can promote the scientific and standardized development of urban-rural integration in counties. Additionally, this evaluation system can be adjusted and optimized according to practical application needs to meet the requirements of urban-rural integration at different stages and in different regions.

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