Measurement of Urban-Rural Integration Development in Chongqing and Analysis of Influencing Factors

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Abstract: Taking Chongqing Municipality as a case study, this research utilizes relevant data on urban-rural integration from 2011 to 2022 to construct a measurement index for integrated urban-rural development. Employing a coupling coordination model and grey relational analysis, it investigates the level of integrated urban-rural development in Chongqing and its influencing factors.

Keywords: Chongqing municipality; Urban-rural integration; Coupling coordination model; Grey relational analysis

1. Introduction

The level of urban-rural integration is an essential requirement for achieving common prosperity and coordinated regional development. Chongqing, a major first-tier city in China's western region, is situated in the core economic zone of the middle and upper reaches of the Yangtze River. It shoulders key tasks under the Western Development Strategy and possesses critical geographical positioning and significant strategic importance. However, Chongqing's unique topography features extensive mountainous areas across much of its territory, resulting in a certain disparity in development levels between urban and rural areas. To better enhance Chongqing's economic standing, it is essential to deepen urban-rural integration, narrow the urban-rural gap, share the fruits of modernization, and tap into distinctive rural industries to strengthen endogenous drivers of rural economic development. These efforts constitute vital components for achieving coordinated socioeconomic development and enhancing public well-being.

Current research relevant to this paper primarily focuses on two aspects. On one hand, research on measuring the level of integrated urban-rural development. Zhang and Gao establish an evaluation indicator system for integrated urban-rural development with "foundation," "process," and "performance" as primary indicators [1].

Yang *et al.* assessed the level of integrated urban-rural development across five dimensions: population, economy, spatial layout, ecology, and society[2]. On the other hand, research on urban-rural influencing factors has primarily focused on network infrastructure, human capital, business environment, government guarantee, and external communication and so on [3–7].

Based on this, this paper scientifically assesses and objectively evaluates the degree of urban-rural integration in Chongqing, explores the factors influencing it, and proposes evidence-based policy recommendations. This research holds significant theoretical and practical implications for advancing high-quality economic development in Chongqing.

2. Research design

2.1. Selection of indicators

Based on the characteristics of Chongqing's urban-rural integration and reference the research by Wang *et al.*, two primary indicators economic integration and social integration were established [8]. Economic integration is measured by indicators including the proportion of the tertiary industry (Positive), per capita regional GDP (Positive), the ratio of urban to rural residents' consumption expenditure (Negative), the ratio of urban to rural residents' consumption income (Negative), and the registered urban unemployment rate (Negative). Social integration is measured by indicators including the proportion of local fiscal expenditure allocated to education (Positive), social pension insurance coverage rate (Positive), unemployment insurance coverage rate (Positive), operational mileage of highways (Positive),and forest coverage rate (Positive).

The selection of influencing factors includes five categories: internet penetration (broadband internet subscribers), human capital (enrollment in regular higher education institutions), business environment (total retail sales of consumer goods), government support (general public service expenditure), and external communication (total imports and exports of foreign-invested enterprises).

2.2. Data sources

The data for this study primarily comes from the China Urban Statistical Yearbook, the Chongqing Statistical Yearbook, and the National Bureau of Statistics. The statistical period covered in this article spans from 2011 to 2022.

2.3. Model construction

2.3.1. Comprehensive development level assessment model for economic and social integration

This study employs the entropy method to assess economic and social integration within Chongqing's urban-rural integrated development. Dimensionality is first removed through extremum standardization. Subsequently, the entropy method is applied to calculate the weighting of each indicator, thereby measuring the comprehensive development level of both systems. In the following **Equation 1**, i denotes the year, j denotes the indicator, the original data is x_{ij}, and the standardized data is x_{ij}'.

$$\text{Positive indicators: } x_{ij}' = \frac{x_{ij} - min(x_{1j}, x_{2j}, ..., x_{mj})}{max(x_{1j}, x_{2j}, ..., x_{mj}) - min(x_{1j}, x_{2j}, ..., x_{mj})} + 0.001 \tag{1}$$

$$\text{Negative indicators: } x_{ij}' = \frac{max(x_{1j}, x_{2j}, ..., x_{mj}) - x_{ij}}{max(x_{1j}, x_{2j}, ..., x_{mj}) - min(x_{1j}, x_{2j}, ..., x_{mj})} + 0.001$$

max($x_{1j}, x_{2j}, ..., x_{mj}$) and min($x_{1j}, x_{2j}, ..., x_{mj}$) represent the maximum and minimum values of each indicator. Simultaneously, all indicators are non-negativized by uniformly adding 0.001.

Based on the standardized x_{ij}, calculate its indicator weight p_{ij}. Then compute the information entropy value e_j. Derive the utility value g_j from the information entropy value e_j. Finally, compute the indicator weight number w_j from the utility value g_j.

$$p_{ij} = x'_{ij} / \sum_{i=1}^{m} x'_{ij} \tag{2}$$

$$e_j = -\frac{1}{lnm} \sum_{i=1}^{m} p_{ij} \, lnp_{ij} \tag{3}$$

$$g_j = 1 - e_j \tag{4}$$

$$w_j = g_j / \sum_{i=1}^{n} g_j \tag{5}$$

The linear weighted method is used to calculate the system comprehensive development level index U_i.

$$U_i = \sum_{i=1}^{n} w_j * x'_{ij} \tag{6}$$

2.3.2. Model for measuring the level of integrated urban-rural development

The coupling coordination model effectively measures the synergistic effects and overall utility between coupled systems, enhancing the analysis of how coupling degree influences interactions between systems. Its formula is as follows:

$$T = \alpha U_1 + \beta U_2 \tag{7}$$

$$C = \sqrt{U_1 * U_2} / (U_1 + U_2) \tag{8}$$

$$D = \sqrt{C * T} \tag{9}$$

Among these, U_1 and U_2 represent the comprehensive development indices for economic integration and social integration in Chongqing, respectively. T denotes the overall coordination index between systems, while α and β denote undetermined weighting coefficients such that $\alpha + \beta = 1$. Based on relevant literature, $\alpha = \beta = 0.5$ is adopted, indicating equal contributions from the economic integration system and the social integration system to Chongqing's urban-rural integrated development [9]. C represents the coupling degree between systems, and D denotes the level of urban-rural integrated development.

To more intuitively present the degree of coupled coordination between the two systems, drawing on relevant research, the coupling coordination level is categorized into 10 types: [0–0.09] indicates extreme imbalance, [0.10–0.19] severe imbalance, [0.20–0.29] moderate imbalance, [0.30–0.39] mild imbalance, [0.40–0.49] represents on the verge of imbalance, [0.50–0.59] denotes barely coordinated, [0.60–0.69] indicates primary coordination, [0.70–0.79] signifies intermediate coordination, [0.80–0.89] reflects good coordination, and [0.90–1.00] indicates high-quality coordination [10].

2.3.3. Grey relational degree model

Due to differences in measurement units, the initialization method was employed to perform dimensionless processing on all raw data:

$$x_j'(c) = x_j(x)/x_j (1) \tag{10}$$

x$_j$(c) represents the raw data, x$_j$(1) denotes the initial value of the raw data, and x$_j$'(c) signifies the normalized data.

Subsequently, the gray correlation coefficient is calculated using the normalized data:

$$\triangle_j(c) = \left| x_j'(c) - x_0 \right| \tag{11}$$

$$\triangle_{max} = max_j max_c \triangle_j(c) \tag{12}$$

$$\triangle_{min} = min_j min_c \triangle_j(c) \tag{13}$$

$$\varphi_j = (\triangle_{min} + \mathcal{E}\triangle_{max})/(\triangle_j(c) + \mathcal{E}\triangle_{max}) \tag{14}$$

$\triangle_j$(c) represents the absolute value of the sequence difference, where x$_0$ is the reference series. $\triangle_{max}$ and $\triangle_{min}$ denote the maximum and minimum values of the sequence difference, respectively. φ_j is the grey correlation coefficient, and ε is the discrimination coefficient ranging from 0 to 1, with a value of 0.5.

The grey correlation degree γ_j is calculated as follows:

$$\gamma_j = \frac{1}{n}\sum_{i=1}^{n} \varphi_j(c) \tag{15}$$

3. Empirical analysis

3.1. Analysis of Chongqing's urban-rural integration development level

Empirical analysis reveals the development levels of economic integration (U$_1$) and social integration (U$_2$) from 2011 to 2022, generating the integrated urban-rural development level as shown in **Table 1**. The comprehensive development level of economic and social integration exhibits a fluctuating upward trend. From 2011 to 2014, the level of social integration development exceeded that of economic integration. From 2015 to 2022, the level of economic integration development surpassed that of social integration. In 2022, economic integration reached its peak at 0.966, while social integration peaked at 0.729. Chongqing's urban-rural integration level progressed from 0.213 in 2011 to 0.739 in 2022, yet it has not yet reached the high-quality coordination stage. The empirical research indicates that Chongqing's urban-rural integration has achieved initial scale, but social integration remains a relatively weak link.

Table 1. Level of integrated urban-rural development in Chongqing municipality

Year	Economic integration U$_1$	Social integration U$_2$	Urban-rural integration D	Coordination level	Type of coordination
2011	0.074	0.300	0.213	Moderate imbalance	Lagging economic integration
2012	0.087	0.352	0.241	Moderate imbalance	Lagging economic integration
2013	0.180	0.290	0.280	Moderate imbalance	Lagging economic integration
2014	0.263	0.325	0.335	Mild imbalance	Lagging economic integration
2015	0.379	0.362	0.399	Mild imbalance	Lagging social integration
2016	0.498	0.356	0.441	On the verge of imbalance	Lagging social integration

Table 1 (Continued)

Year	Economic integration U_1	Social integration U_2	Urban-rural integration D	Coordination level	Type of coordination
2017	0.610	0.339	0.471	On the verge of imbalance	Lagging social integration
2018	0.700	0.433	0.541	barely coordinated	Lagging social integration
2019	0.820	0.634	0.659	Primary coordination	Lagging social integration
2020	0.762	0.703	0.666	Primary coordination	Lagging social integration
2021	0.909	0.700	0.711	Intermediate coordination	Lagging social integration
2022	0.966	0.729	0.739	Intermediate coordination	Lagging social integration

3.2. Analysis of factors influencing integrated urban-rural development

Based on the above formula, the correlation coefficients between each influencing factor and urban-rural integration were calculated, as shown in **Table 2**. The closer the coefficient approaches 1, the stronger the correlation. The calculations reveal that the coefficients for all factors cluster between 0.691 and 0.930. The factors' influence on urban-rural integration, ranked by correlation strength, are business environment, internet penetration, government support, human capital, and external communication.

Table 2. Analysis of influencing factors

Influencing factors	Business environment	Internet penetration	Government support	Human capital	External communication
Correlation coefficient	0.93	0.841	0.72	0.698	0.691

4. Research findings and policy recommendations

4.1. Research findings

Chongqing's levels of economic integration and social integration have shown a fluctuating upward trend. From 2011 to 2014, the level of social integration exceeded that of economic integration, while from 2015 to 2022, economic integration surpassed social integration. Furthermore, Chongqing's current level of urban-rural integration is at an intermediate stage of coordination, falling short of high-quality coordination. Among the numerous factors influencing urban-rural integrated development, the business environment and internet penetration exert relatively strong impacts, while government support, human capital, and external communication demonstrate weaker influence.

4.2. Policy recommendations

Based on the research findings, policies are recommended as follows:

(1) Chongqing should further increase internet penetration in rural areas and advance digital infrastructure development;

(2) Talent attraction policies should be introduced to strengthen rural human capital, while expanding rural investment and financing channels to improve the business environment;

(3) Actively advance the development of inclusive financial systems to provide funding guarantees for rural economic development. The government should allocate preferential fiscal resources to rural areas

in sectors such as education, healthcare, and social security;

(4) Improve rural infrastructure and enhance openness to the outside world. The government should actively promote rural infrastructure development, upgrading the quality of rural roads, networks, and related facilities.

Disclosure statement

The author declares no conflict of interest.

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