Article

Unveiling the Spatio-Temporal Dynamics and Driving Mechanism of Rural Industrial Integration Development: A Case of Chengdu–Chongqing Economic Circle, China

Yun Shen 1,*, Ghulam Raza Sargani 2, Rui Wang 3 and Yanxi Jing 1

1 School of Economics, Sichuan Agricultural University, Chengdu 611130, China; jingyanxi@stu.sicau.edu.cn
2 School of Economics and Management, Northwest Agricultural and Forestry University, Yangling 712199, China; drazasargani14@mwfau.edu.cn
3 School of Economics, Southwestern University of Finance and Economics, Chengdu 611130, China; wangrui@stu.sicau.edu.cn

* Correspondence: shenyun@sicau.edu.cn

Abstract: China’s urban–rural dichotomy has resulted in a widening gap between urban and rural areas, posing significant challenges to rural development. This study aims to investigate the spatio-temporal differentiation and driving mechanisms of rural industry integration within the Chengdu–Chongqing Economic Circle in China. Using panel data from 2011 to 2020, we employed the entropy weight TOPSIS method to construct a comprehensive index that charts the evolution of rural industry integration across various districts and counties. Additionally, we utilized fixed-effect and spatio-temporally weighted regression models to analyze the underlying driving forces behind this integration. Our findings reveal a dynamic and varied landscape of rural industry integration, with different levels of depth and breadth across various subsystems. Spatially, we observed a transition from a dispersed to a more concentrated agglomeration pattern within the Chengdu–Chongqing Economic Circle. This shift suggests a diffusion effect emanating from core metropolitan areas, as well as an attracting force exerted by adjacent metropolitan circles. In terms of drivers, market demand, openness level, financial development, policy support, and agricultural insurance breadth significantly contribute to rural industry integration. However, technological progress and rural human capital exhibit a weaker correlation. Notably, our models identified pronounced spatial–temporal heterogeneity among these influencing factors, highlighting a nuanced and dynamic relationship between them. Overall, our study emphasizes the crucial role of rural industry integration in bridging the urban–rural divide and fostering sustainable agricultural development and rural revitalization. The insights gained from this research provide valuable guidance for policymakers and stakeholders seeking to optimize rural development strategies and unlock the potential of integrated rural industries.

Keywords: rural industrial integration; driving mechanism; GTWR; TOPSIS; rural revitalization

1. Introduction

The enduring imbalance between urban and rural areas, coupled with the inadequate transfer of resources and factors from urban hubs to rural regions, constitutes a prevalent challenge confronting nations across the globe [1,2]. Therefore, the existing imbalance between rural and urban development has given rise to numerous challenges [3], such as agricultural weakness, farmland circulation, landscape hollowing out, and rural poverty. This urban–rural divide has restricted the urban economy, especially as the emphasis on urbanization and industrialization has led to the population growth of cities and the decline of rural areas. To address these issues, several European countries began to pursue “urban–rural integration”. In Japan, the concept of “sixth industry” was introduced to promote the integration of agriculture and industry. Drawing on Japan’s experience, South Korea has
emphasized the integration of primary, secondary, and tertiary industries in rural areas. The United States has promoted rural economic diversification through new industrial forms such as bio-agriculture, digital agriculture, ecological agriculture, and tourism agriculture. France has achieved the integration of agriculture and tourism through the cooperative management model. The integrated development of rural industries has gradually become a crucial strategy for enhancing the rural economy and mitigating the imbalance between urban and rural development [4,5]. This integration can be achieved through industrial linkage, agglomeration, technology penetration, and institutional innovation.

The Chengdu–Chongqing Economic Circle (CCEC) is a pivotal economic region in western China, established as part of the country’s regional development strategy to balance the eastern and western economic disparities. It was identified as a new growth pole, following other major economic circles like the Beijing–Tianjin–Hebei region, the Yangtze River Delta, and the Guangdong–Hong Kong–Macao Greater Bay Area. Historically, the CCEC has been instrumental in connecting the rural hinterland of Sichuan and Chongqing to broader markets, thereby playing a significant role in the economic upliftment of the western region. The theoretical underpinnings of RIID are grounded in development economics, where the integration of rural industries is seen as a catalyst for enhancing agricultural economic resilience. This integration is based on the multidirectional extension of the agricultural industry chain, diversified expansion of industrial scope, and the transformation of industrial functions through new technologies and business models. Theoretical frameworks also emphasize the importance of spatial spillover effects and spatio-temporal heterogeneity in understanding the impact of transport infrastructure on rural industrial integration. The CCEC serves as an exemplary case study due to its unique position as a national strategy and its robust political and economic foundation for fostering rural industrial integration and growth. By examining the CCEC, the study can provide insights into the effectiveness of state policies in promoting RIID and the circle’s role in the overall quality of rural revitalization. Additionally, the case study’s significance lies in its potential to offer empirical insights and innovative pathways for enhancing county-level rural industrial integration. By doing so, the agricultural industrial chain can be strengthened, leading to job creation, increased farmers’ income, and reduced rural poverty [6]. Therefore, it is imperative to prioritize the integration of rural tertiary industries to bridge the urban–rural divide, foster sustainable agricultural development, and ultimately achieve rural revitalization.

China’s rural industrial integration development (RIID) originated in 1978 with the inception of the reform and opening-up policies, marked by the emergence of township enterprises. This period initiated the breakdown of the fragmented development among the primary, secondary, and tertiary industries. Since then, the integration has evolved through three distinct developmental stages: the joint operation of agriculture and industry, agricultural industrialization, and rural industrial integration. China’s agricultural modernization has consistently lagged behind the processes of industrialization and urbanization, which has constrained rural economic development [7]. This imbalance in rural–urban regional development has been a persistent challenge. However, rural industrial integration presents an opportunity to address these shortcomings and promote balanced development between urban and rural areas [8]. According to the theories of industrial integration and regional economics, the dynamic process of industrial integration, driven by institutional innovation, technological progress, and market demand, extends the agricultural–cultural industry chain and enhances its value [9]. This integration stimulates the inherent vitality and dynamism of the rural economy, facilitating the gradual integration and unified development of production factors (labor and capital) among cities, counties, and villages [10]. This initiative underscored the importance of not confining solutions to China’s rural issues within the realm of traditional agriculture.

In recent years, China has experienced rapid integration of its three industries. To further promote this integration, the state has implemented specific measures aimed at facilitating the integrated development of rural industries. Numerous studies have highlighted RIID as a fundamental pillar for consolidating and expanding the gains made
through poverty alleviation efforts and rural revitalization \[11,12\]. It also serves as an effective means to promote comprehensive rural revitalization and establish a new paradigm of mutual promotion and development between urban and rural industrial economies \[13,14\]. Therefore, prioritizing RIID is imperative for achieving sustainable and balanced urban–rural development.

Regional synergistic development is an objective law and a world trend in the development of urban agglomerations \[15\]. According to Growth Pole Theory, urban agglomerations represent the spatial manifestations of economic growth centers. These agglomerations act as pivotal hubs, linking domestic and international markets, and serve as core drivers of national economic development, thereby shaping a country’s global competitive advantages. The CCEC is a major national strategy in China designed to meet the demands of economic modernization, efficiency enhancement, balanced development, and openness and synergy. Small counties play a crucial role in connecting their rural hinterland to domestic and global markets \[16\], serving as both a hub for industrial activities in medium-sized and large cities and a spatial vehicle for industrial chain extension in rural areas. In this dynamic quest for talent, land, capital mobility, and regional harmony between urban and rural settings, counties have emerged at the forefront of new urbanization and rural revitalization efforts \[17\].

The CCEC was selected as the research focus primarily due to its strategic importance as a new hub for reform and opening in western China \[18\]. This region boasts significant advantages in multi-factor combinations and a robust political and economic foundation conducive to the integration and growth of rural industries \[19,20\]. The emergence of new forms and models of rural industries, along with the establishment of the “new six industries” framework in agriculture, exemplifies this area’s pioneering role in rural industrial integration. In addition, there exists a significant disparity in economic development between the central cities and other counties and cities within the CCEC, with counties outside its core experiencing generally lower development levels, thus reflecting a typical urban–rural economic structure \[21,22\]. By introducing the entropy weight TOPSIS method to measure and comprehensively assess the county-level RIID and exploring its evolutionary trend and spatio-temporal divergence characteristics, we can uncover potential challenges facing rural industrial integration development, especially within the metropolitan area. This analysis holds crucial significance for identifying and addressing issues related to industrial integration development in counties within metropolitan regions and offers valuable guidance for promoting the integrated development of urban and rural areas, with counties serving as key carriers.

Compared to other relevant works, our primary contributions are outlined below: Firstly, we delve into the theoretical implications of RIID, focusing on both the breadth and depth of RIID. This expands the research scope of urban–rural integrated industrial development. Secondly, this paper introduces an evaluation index system that covers the breadth and depth of RIID. This system quantifies the level of rural industrial integration, analyzing the comprehensive and aspect-specific indices of rural industrial integration development in the CCEC at the county level from 2011 to 2020. These findings provide empirical insights into the actual state of RIID at the county level. Thirdly, we utilize Moran’s I index and Dagum’s Gini coefficient to assess and analyze the dynamic evolution and spatio-temporal differentiation patterns of RIID at the county level, along with their sources of variation. These results offer a solid foundation for enhancing county-level rural industrial integration and identifying innovative pathways.

2. Literature Review and Theoretical Foundations

The inevitable trend of industrial integration is a testament to the progress of social productivity and the refinement of industrial structures \[23\]. This integration often begins with technological linkages between industries \[24\]. Early research primarily focused on technological convergence, which marks the initial stage of industrial integration. Rosenberg \[25\] posited that the utilization of identical technologies in distinct industries can lead
to convergence across industries. From a technological perspective, Lei [26] emphasized that industrial convergence entails the reduction in or elimination of barriers between industries. Additionally, scholars have pointed out that industrial integration, as an economic phenomenon, involves a multifaceted and evolving blend of industrial processes and technology [27]. Recent research has explored the impact of road traffic accessibility on economic growth within the CCEC, using spatial econometric models to highlight the importance of transport infrastructure in regional development [1]. Another study has analyzed the objectives and planning rationales behind the construction of CCEC, emphasizing its role in China’s dual circulation development paradigm [28]. These studies contribute to understanding the dynamics of similar economic regions and can provide comparative insights for your research on the CCEC.

Gaps in Current Research: While the existing literature has made significant strides in defining IID and its importance, there are notable gaps that our study aims to fill:

Firstly, Economic Impact Indicators. Current RIID indicators primarily reflect the mode or means of integration, lacking measures that capture the economic impacts, such as employment opportunities, income generation, and urban–rural integration [27].

Secondly, Spatial Evolutionary Trends. Most studies have been conducted at the national and provincial levels, which may not accurately represent the gradual process of rural industrial integration at the county level.

Thirdly, Spatial Evolution Mechanism. There is limited research examining the spatial evolution mechanism and patterns of RIID’s breadth and depth, which are crucial for understanding the dynamics of integration over time and space.

By addressing these gaps, the study offers a more nuanced understanding of RIID, particularly at the county level, and contributes to the development of a comprehensive indicator system that captures both the process and outcomes of rural industrial integration. Additionally, exploring the spatial evolution mechanisms can provide valuable insights into the factors driving the integration process and its varying impacts across different regions.

The integration of industries is anticipated to spawn novel technologies, ventures, and business models [29]. This integration facilitates the cross-border flow of resource elements and optimizes the industrial layout. Nowadays, research on industrial integration has become more systematic, primarily focusing on the analysis of secondary and tertiary industries and their internal integration [30,31]. However, research related to the integration of agricultural industries has lagged.

In the late 1990s, Japanese agricultural expert Nara Sen Imamura introduced the “Six Industries Theory” and systematically established a theoretical framework for the deep integration of rural industries [32], thereby officially integrating agriculture into the realm of industrial integration research. The practice of agricultural industrialization in China commenced in the mid-1990s. With the deepening of significant reforms in China’s rural areas, the increasing penetration of new technologies, and the continuous breakthroughs and innovations in rural industrial systems and organizational methods, industrial integration has emerged as a crucial avenue for enhancing rural productivity [13].

A range of scholars have delved into the implications of rural industrial integration, encompassing the intersection, integration, and reorganization among rural primary, secondary, and tertiary industries [29]. Scholars emphasize that industrial integration transcends mere labor division and resource integration. It demands cross-border collaboration among business entities, facilitating the internalization of transaction costs between industries and sectors by strengthening the core of multi-functional integrated agricultural development [33].

Specifically, RIID requires the extension of the agricultural industry chain by continuously improving the deep processing of agricultural products and enhancing the added value of agricultural products, leveraging advanced technology and services [19]. RIID is also expected to give rise to new technologies, new business forms, and new models [23]. For instance, the convergence of the agricultural and service industries has given rise to tourism agriculture and creative agriculture [34,35]. Simultaneously, the integration of
Agriculture with high-tech sectors has led to the development of intelligent and digital agriculture [36]. In summary, the integrated development of rural industries can be categorized into four distinct groups: internal agricultural integration, industrial chain extension integration, agricultural function expansion integration, and new technology penetration integration, as previously stated in reference.

RIID plays a crucial role in addressing agricultural development challenges, revitalizing the rural economy [37], and promoting balanced urban–rural development [38]. Agricultural growth can drive the development of the secondary and tertiary sectors, while the demand increase that sustains agricultural growth is spurred by the expansion of these other sectors [39]. Strengthening the dynamic interaction between agriculture and the secondary and tertiary sectors, facilitating the two-way flow of production factors between urban and rural areas, and enhancing the efficiency of factor allocation are crucial strategies for reducing regional inequalities [40]. Bao et al. [41] reached a similar conclusion, highlighting that coordinated regional development emphasizes the inter-industry sharing and updating of technology between urban and rural areas. This process is facilitated through the complementarity of strengths and resource sharing, which accelerates technological advancement in both urban and rural settings. Some scholars have also pointed out that China’s urban and rural resource allocation remains irrational, and a two-way interaction of inter-industry factor flows has not yet been established [42]. China’s industrialization and urbanization processes have highlighted crucial challenges, such as rural hollowing, arable land relinquishment, and the aging of the agricultural workforce [43–45]. To address these issues, RIID at the county level has emerged as a significant strategy. Both theoretical and practical research underscores the importance of RIID at the county level on aspects of the rural economy and rural–urban relations. From a micro perspective, RIID can contribute to optimizing industrial structure by enhancing the utilization of production factors [46], bolstering rural community resilience to external risks [47], fostering rural economic growth, and improving the quality of life for farming families [48]. From a macro perspective, RIID fosters novel ecosystems, fostering balanced and inclusive urban–rural development [49].

The integrated development of rural and urban areas supports the transformation and modernization of both urban and rural consumption structures, subsequently driving demand for new agricultural industries and businesses. This, in turn, promotes the seamless flow of talent, capital, technology, and other resource factors between urban and rural regions [50]. Zhan (2023) highlights the important role of rural industrial development in improving the spatial dichotomy of the region [51], using the example of Shandong province in China. This view is supported by many scholars [42,52,53]. However, some scholars have also emphasized the significance of institutional factors, resource endowment, and basic conditions in influencing the realization of industrial synergies [19]. Promoting rural industrial integration without proper planning may lead to resource wastage and exacerbate regional disparities [54].

The measurement of RIID remains a challenging task as there is no universally accepted method or indicator system. The existing literature classifies rural industrial integration indicator systems into three types: effect-oriented, process-oriented, and coupled. The effect-oriented system emphasizes the outcomes of rural industry integration, measuring its efficiency through the DEA–Malmquist index method [10]. The process-oriented system focuses on the types of rural industrial integration and the relationships between industries, typically utilizing methods like the Delphi method, hierarchical analysis, and entropy TOPSIS [53] to assess factors like the extension of the agricultural industry chain, agricultural multifunctionality, and economic benefits [19]. The coupled type involves constructing indicators for the primary, secondary, and tertiary industries separately, employing models like the density dependence logistic model, a VAR model [55], or a coupled coordination degree model [56] for measurement. Additionally, interdisciplinary research methods, such as combining big data technologies to construct input–output analysis models for RIID [57], are gaining popularity.
A review of the existing literature reveals a focused scholarly effort on delineating the concept of industrial integration development (IID), elucidating its importance, and quantifying the extent of rural industrial integration development (RIID). However, several areas remain relatively unexplored. Firstly, the current set of indicators for RIID primarily reflects the mode or means of rural industrial integration rather than encompassing its economic impacts, such as employment opportunities, income generation, and urban–rural integration [58]. In other words, the existing indicator system falls short of effectively gauging the accomplishments achieved through integrated rural industrial development. Secondly, most studies have been conducted at the national and provincial levels, overlooking the fact that rural industrial integration is a gradual process. Measurements at these levels often fail to capture the underlying spatial evolutionary trends. Thirdly, there is a dearth of research examining the spatial evolution mechanism and patterns of RIID’s breadth and depth across counties over time. This gap hinders a comprehensive understanding of regional disparities in urban–rural integrated development.

Therefore, this paper introduces an evaluation index system that encompasses both the breadth and depth of integration. It also presents a comparative analysis of RIID levels in the CCEC, a nationally recognized urban–rural integration demonstration area, and explores the spatial and temporal evolution characteristics of RIID. By addressing these gaps, your study can offer a more nuanced understanding of RIID, particularly at the county level, and contribute to the development of a comprehensive indicator system that captures both the process and outcomes of rural industrial integration. Additionally, exploring the spatial evolution mechanisms can provide valuable insights into the factors driving the integration process and its varying impacts across different regions.

3. Material and Methods

3.1. Data Collection Resources

Since the approval of the Regional Planning for the CCEC by the State Council in 2011, followed by the official unveiling of the Outline of the Planning for CCEC in 2021, the CCEC has witnessed remarkable growth over the past decade. This progress not only mirrors the evolution of urban industrial integration but also marks a significant milestone in the transformation of rural industrial integration patterns at the county level, holding profound implications for the harmonious development of urban and rural areas.

Leveraging panel data from the CCEC spanning 2011 to 2020, this study aims to quantify trends in the level of RIID and uncover its spatio-temporal dynamics within the region. As outlined in the planning document, the economic circle predominantly encompasses the central city of Chongqing, comprising 27 districts (counties) and select areas of Kaizhou and Yunyang. In Sichuan Province, it covers districts such as Chengdu, Zigong, Luzhou, Deyang, Mianyang (excluding Pingwu County and Beichuan County), Suining, Neijiang, Leshan, Nanchong, Meishan, Yibin, Guang’an, Dazhou (excluding Wanyuan City), Ya’an (excluding Tianquandao and Baoxing County), and Ziyang.

The research data are sourced from various reliable repositories, including the Statistical Yearbooks and Bulletins of the respective districts and counties within the CCEC for the period 2011–2020. Additionally, the Easy Professional Superior (EPS) Database, the China Education & Expo (CEE) Website, the Sichuan Rural Statistical Yearbook (2011–2020), and the Chongqing Rural Statistical Yearbook (2011–2020) have provided valuable insights. Recognizing challenges such as incomplete data and inconsistencies in statistical standards across certain districts and counties during the sampling period, a thorough data re-collection process was undertaken. This involved direct engagement with each district and county statistical office to restore and ensure the authenticity of missing or omitted data. To further enhance the quality of the dataset, multiple imputation and processing techniques leveraging the MI algorithm were employed. This resulted in a total of 28,350 valid sample data points, thereby ensuring consistency and validity across all districts and counties and strengthening the reliability and accuracy of the statistical analysis.
3.2. Model Building
3.2.1. Entropy-Weighted TOPSIS Method

The evaluation index system of RIID is a comprehensive framework encompassing multiple indicator systems. To assess its performance, it is crucial to adopt a multi-indicator evaluation approach that condenses various metrics into a singular, manageable index. Compared to other multi-indicator assessment methods like Analytic Hierarchy Process (AHP) or Gray Correlation Analysis, the entropy weight TOPSIS method offers a more comprehensive consideration of inter-indicator correlations while also sidestepping the subjectivity and uncertainty inherent in the weight determination process. Consequently, this study employs the entropy-weighting method to assign weights and calculate the composite score of RIID.

First is data standardization. Prior to evaluation, data standardization is paramount. The presence of positive and negative indicators, along with varying units among specific indicator variables, precludes direct comparisons. To address this, the study utilizes the maximum–minimum method to standardize the raw data for each indicator, removing any dimensional differences. Additionally, the normalized data are shifted to prevent zero values that could potentially skew the indicator matrix. The formula used for this standardization is provided below:

Positive indicator: \[ Y_{ij} = \frac{X_{ij} - X_{min}}{X_{max} - X_{min}} \] (1)

Negative indicator: \[ Y_{ij} = \frac{X_{max} - X_{ij}}{X_{max} - X_{min}} \] (2)

where the subscript \( i \) represents countries. \( X_{ij}, X_{min}, X_{max}, \) and \( Y_{ij} \) are the original, minimum, maximum, and standardized values of the \( j \)th evaluation indicator, respectively.

Secondly, calculate the entropy of each index. There are \( m \) indicators and \( n \) objects to evaluate in a single year. And the entropy of the \( i \)th indicator is as follows:

\[ h_i = -k \sum_{j=1}^{n} f_{ij} \ln f_{ij} \] (3)

where \( f_{ij} = \frac{Y_{ij}}{\sum_{j=1}^{n} Y_{ij}} \), \( k = \frac{1}{\ln n} \), the variable \( n \) represents the number of possible states the system can be, and \( f_{ij} \) represents the probability that the system is in each state.

Thirdly, calculate entropy weights. After defining the entropy of the \( i \)th indicator, the entropy weight of the \( i \)th indicator can be obtained:

\[ w_i = \frac{1 - h_i}{m - \sum_{i=1}^{m} h_i} \quad (0 \leq w_i \leq 1, \sum_{i=1}^{m} w_i = 1) \] (4)

Fourthly, build a normative evaluation matrix for industrial integration:

\[ Z = \begin{bmatrix} Y_{11}w_1 & \cdots & Y_{1n}w_n \\ \vdots & \ddots & \vdots \\ Y_{m1}w_1 & \cdots & Y_{mn}w_n \end{bmatrix} \] (5)

Determine the degree of difference between the assessment item and the “positive and negative ideal solution”:

Positive ideal distance: \[ D^+_j = \sqrt{\sum_{i=1}^{m} (z^+_i - z_{ij})^2} \] (6)

Negative ideal distance: \[ D^-_j = \sqrt{\sum_{i=1}^{m} (z^-_i - z_{ij})^2} \] (7)
where \( z_i^+ \) and \( z_i^- \) are the maximum and minimum values, respectively, of the \( n \)th column of the standardized weight matrix.

Lastly, calculate a composite evaluation index of rural industrial integration:

\[
C_j = \frac{D_j^-}{D_j^+ + D_j^-}
\]

where \( C_j \) is the region’s composite evaluation index in year \( j \) and is bounded between 0 and 1. The higher \( C_j \) means the level of RIID in the county is higher.

### 3.2.2. Moran’s I Index Measure

Based on a comprehensive evaluation index of RIID at the county level, this study measures its spatial effects in the CCEC regarding global spatial autocorrelation and local spatial autocorrelation. The global spatial autocorrelation Moran’s I index is utilized to analyze the overall trend of the rural industrial integration development pattern, while the local spatial autocorrelation Moran’s I scatterplot and LISA map are used to analyze the local spatial characteristics of different districts and counties within the CCEC. Moran’s I is chosen for its ability to measure spatial autocorrelation, provide clear visualizations, support both global and local analysis, and offer stability across different data scales.

First, create a weighted spatial matrix. Given that the area studied is a contiguous economic area, the first-order Adjacency Matrix is used:

\[
W_{ij} = \begin{cases} 
1 & \text{County } i \text{ and } j \text{ are neighbors} \\
0 & \text{County } i \text{ and } j \text{ are not neighbors}
\end{cases}
\]

County \( i \) refers to the central county, and county \( j \) refers to the adjacent county of \( i \).

Second, perform a global spatial autocorrelation analysis. We calculate the global Moran’s I index and analyze the direction and degree of global spatial autocorrelation of the level of RIID in this region by determining whether the integrated development level is clustered or distributed in different districts and counties. The global Moran’s index is calculated as follows:

\[
I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} (X_i - \overline{X}) (X_j - \overline{X})}{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} \sum_{i=1}^{n} (X_i - \overline{X})^2}
\]

The global Moran’s I index value is between \(-1\) and 1. The Moran’s I value significantly above zero indicates a positive spatial correlation, while the Moran’s I close to 1 shows an obvious spatial clustering of cells with higher attribute values. The Moran’s I value significantly below zero indicates a negative spatial correlation. If Moran’s I is close to \(-1\), it indicates a large global spatial difference in attribute values between cells and their neighbors. However, the global Moran’s I index close to 0 indicates that the attribute values are randomly distributed throughout the region without neighboring spatial autocorrelation [59].

Finally, conduct a local spatial autocorrelation analysis. The local Moran’s I index reveals the spatial correlation and difference in the rural industrial integrated development between the sample counties and their neighbors.

\[
I_i = S_i \sum_{j=1,j \neq i}^{n} T_{ij} S_j
\]

where \( I_i \) is the local Moran’s I index; \( S_i \) and \( S_j \) are the standardized values of the observed industry integration index for regions \( i \) and \( j \), respectively; and \( T_{ij} \) is the normalized spatial weights.

### 3.2.3. Dagum Regional Gini Coefficient Measure and Decomposition

The Dagum Gini coefficient serves as a crucial metric to assess regional wealth disparities, effectively measuring spatial variability and mitigating distributional imbalances.
arising from overlapping data [60]. It reveals regional disparities in terms of intra-regional and inter-regional variations, as well as the contribution of hypervariable density. The precise calculation formula for this coefficient is as follows:

\[ Gini = Gini_w + Gini_{nb} + Gini_t \]  

(12)

\[ Gini = \frac{1}{2n^2\mu} \sum_{h=1}^{k} \sum_{j=1}^{n_j} \sum_{r=1}^{n_h} |y_{jr} - y_{hr}|, \quad (\mu_h \leq \mu_j \leq \cdots \leq \mu_k) \]  

(13)

\[ Gini_{nb} = \sum_{j=1}^{k} \sum_{h=1}^{j-1} G_{jh}(p_j s_h + p_h s_j) D_{jh} \]  

(14)

\[ Gini_{w} = \sum_{j=1}^{k} Gini_{j} p_j s_j \]  

(15)

\[ Gini_{t} = \sum_{j=2}^{k} \sum_{h=1}^{j-1} G_{jh}(p_j s_h + p_h s_j)(1 - D_{jh}) \]  

(16)

\[ Gini_{jh} = \sum_{i=1}^{n_j} |y_{jr} - y_{hr}| / \left[ n_j n_h (\mu_j + \mu_h) \right] \]  

(17)

\[ Gini_{j} = \frac{1}{2p_j} \sum_{h=1}^{n_h} w_h \sum_{r=1}^{n_j} |y_{jr} - y_{hr}| \]  

(18)

\[ D_{jh} = \frac{d_{jh} - p_j h}{p_j h} \]  

(19)

\[ d_{jh} = \int_{0}^{\infty} dF_{j}(y) \int_{0}^{y} (y - x)dF_{h}(x); \quad p_{jh} = \int_{0}^{\infty} dF_{h}(y) \int_{0}^{y} (y - x)dF_{j}(y) \]  

(20)

In Equation (12), Gini is the overall Gini coefficient and is broken down into three components: Gini\(_w\) is the contribution of intra-regional differences; Gini\(_{nb}\) is the contribution of inter-regional differences; and Gini\(_t\) is the contribution of super-variable density. In Equations (17) and (18), Gini\(_{jh}\) and Gini\(_{j}\) denote intra-regional and inter-regional Gini coefficients, respectively; \(y_{jh}(y_{hr})\) denotes the composite index value of the integration development of the \(jth(h)\) rural industry in region \(i(r)\); \(u\) is the average of the rural industrial integration development scores in the region; \(n\) is the number of districts; and \(k\) is the number of different types of rural industrial integration in each region. \(n_j(n_h)\) is the overall number of industrial integration developments in the \(j(h)th\) region, in which \(p_j = \frac{n_j}{n}, s_j = \frac{n_j}{n_h}\).

In Equation (19), \(D_{jh}\) denotes the relative impact of RIID between regions \(j\) and \(h\). \(d_{jh}\) as the difference in composite scores between regions, is the mathematical expectation of the sum of the sample values between the \(jth\) and \(hth\) regions; \(p_{jh}\), a super-transformed first-order moment, is the mathematical expectation of the sum of all sample values in the \(jth\) and \(hth\) regional cluster. \(F_j(F_h)\) is the cumulative density distribution function for the \(j(h)th\) region.

### 3.2.4. Establishment of an Appraisal Indicator System

When examining RIID at the county level, it is essential to consider both the outward and inward integration of the rural industries. It can be conceptualized as a process of integration within the primary sector, leveraging agricultural resources and often spearheaded by circular agriculture. As this integration gradually extends into secondary and tertiary
industries, the agricultural industry chain undergoes expansion and cross-pollination, primarily through the integration of agricultural production, processing, and marketing, thus fostering the emergence of new business models. Concurrently, it has promoted deeper integration of industries, achieving synergistic development among the primary, secondary, and tertiary sectors. This approach not only enhances agricultural productivity and increases farmers’ incomes but also stimulates rural vitality and fosters integrated urban and rural development. We need to comprehensively analyze the breadth and depth of integration to measure the “quantity” and “quality” of RIID. Drawing on the research findings of previous scholars [61,62], we constructed an evaluation index system for the integrated development of rural industries. Specifically, breadth of integration involves the interaction and cooperation among various industries and links within the rural sector. It encompasses the diverse forms of rural industry integration. We have selected indicators across four dimensions: intra-agricultural integration, agricultural extension integration, agricultural cross-integration, and agricultural penetration integration. On the other hand, the depth of integration refers to the impact and effectiveness of the integration process. To capture these dimensions, we have constructed an indicator system with seventeen tertiary indicators for breadth and ten for depth. We have focused on four dimensions: farmers’ income and employment, efficient output, urban–rural integration, and ecological greenness. Table 1 outlines this indicator system, providing a comprehensive framework to evaluate and analyze the integration of rural industries at the county level.

<table>
<thead>
<tr>
<th>First-Order Index</th>
<th>Secondary Index</th>
<th>Tertiary Indicators</th>
<th>Method of Measurement</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-agricultural integration</td>
<td>Total value of the output of sub-sector industries</td>
<td>Plantation + livestock + fishery output</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fixed investment in the primary sector</td>
<td>——</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arable land in common use</td>
<td>——</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agriculture, forestry, animal husbandry, and fishing total production value</td>
<td>——</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Extended integration</td>
<td>Processing industry output per capita</td>
<td>Production value of processing industries (grain + oilseeds + vegetables + meat)/Number of rural population</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retail sales in rural markets</td>
<td>——</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of professional farmers’ cooperatives per 10,000 people in rural areas</td>
<td>Number of professional farmers’ cooperatives/Number of the village population</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total tourism receipts</td>
<td>——</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tourist arrivals</td>
<td>——</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Cross-integration</td>
<td>Agriculture, forestry, animal husbandry, and fishing total output value</td>
<td>Agriculture, forestry, animal husbandry, and fishing total output value—Primary industry total output value</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Value added of tertiary sector as a proportion of total agricultural output</td>
<td>Tertiary sector value added/Agriculture value added</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tertiary sector employment</td>
<td>——</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rural medical basic facilities per 10,000 persons</td>
<td>Number of hospital beds/Number of the rural population</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of general primary and secondary schools per 10,000 persons in rural areas</td>
<td>Number of general primary and secondary schools/Number of the rural population</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. Cont.

<table>
<thead>
<tr>
<th>First-Order Index</th>
<th>Secondary Index</th>
<th>Tertiary Indicators</th>
<th>Method of Measurement</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial integration’s scope</td>
<td>Penetration integration</td>
<td>Land area for facility agriculture</td>
<td>Number of mobile phone subscribers/Number of the rural population</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Informatization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total agricultural mechanization power</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Employment and income generation</td>
<td>Rural disposable income per capita</td>
<td>Number of people employed in villages</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average labor value added in the primary sector</td>
<td>Value added in the primary sector/Number of people employed in villages</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of Three Products and One Label Agricultural Products</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Value added per unit of arable land in the primary sector</td>
<td>Value added of primary sector/Arable land area</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Integration of urban and rural areas</td>
<td>Per capita disposable income ratio of urban to rural</td>
<td>Per capita disposable income of city dwellers/Farmer disposable income</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Urbanization rate</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Eco green</td>
<td>Intensity of fertilizer application</td>
<td>Crop fertilizer use/Crop acreage</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rural electricity consumption</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Forest coverage</td>
<td></td>
<td>+</td>
</tr>
</tbody>
</table>

Note: The “+” and “-” in the table represent positive and negative impacts.

(1) The breadth of rural industrial integration.

In this study, three indicators are chosen to assess the integration level within the agricultural sector: the aggregate output of sub-sector industries, fixed capital investments in the primary sector, and the commonly utilized arable land area. These indicators are selected because they provide insights into the productive capacity of each sub-sector and the role of capital and land in facilitating industrial integration. Specifically, the total output of sub-sectors reflects their individual productive strengths, while fixed capital formation and arable land area highlight the essential resources supporting this integration process.

For extended integration, which involves the seamless linkage of agricultural production materials’ production, processing, and marketing through farmers’ specialized cooperatives, four key indicators are employed. These include the gross output value of agriculture, forestry, husbandry, fishing, and service industries; the processing industry’s output per capita; retail sales in rural markets; and the number of farmers’ professional cooperatives per 10,000 rural inhabitants. These indicators collectively capture the comprehensive extent of agricultural integration, considering both production outputs and the supporting infrastructure.

Agricultural cross-integration involves the blending of agriculture with industries such as tourism, education, and recreation, enhanced by the infrastructure of the service sector. This integration fosters a diverse array of agricultural multifunctionality, spawning numerous innovative business models. Consequently, relevant indicators pertaining to tourism, education, and healthcare infrastructure have been selected as proxies to measure this integration. Agricultural penetration integration leverages modern information technologies, including high-tech and digital information, to enhance the added value of agricultural products. This value is amply reflected in the footprint of facility agriculture, the advancement of information technology construction, and the aggregate power of agricultural mechanization.

(2) The depth of rural industrial integration.
The ultimate goal of various RIID models is to foster employment and income generation among farmers, as emphasized by Ma et al. [63]. Consequently, rural disposable income per capita and rural employment have been chosen as proxies to assess the qualitative impacts of RIID. Ensuring efficiency growth is fundamental to the integration of the three rural industries [64], which primarily reflects its impact on local agricultural production. To measure this growth, the value added per laborer in the primary sector and the value added per unit of arable land in primary industries are employed.

Moreover, rural industry integration stimulates the seamless flow and reorganization of talent, capital, technology, and other elements between urban and rural areas. This integration enhances the complementary advantages of both urban and rural regions, optimizing resource utilization. Therefore, indicators such as the ratio of urban to rural disposable income per capita and the urbanization rate are selected to gauge the level of integrated urban–rural development. Green production is the cornerstone of RIID, as any production activity must align with sustainable development principles. Consequently, rural electricity consumption, fertilizer application intensity, and forest cover are commonly utilized metrics to assess agroecological greenness.

4. Assessment and Spatial Analysis of RIID in Counties

Utilizing the entropy-weighted TOPSIS method, we calculated the composite index scores for each district and county subsystem within the CCEC spanning from 2011 to 2020. The average of these composite indices serves as the level index and comprehensive index for each subsystem of RIID across the entire CCEC. Figure 1 illustrates a gradual upward trend in the overall composite index of RIID in the CCEC over the past decade. Notably, the index rose from 0.3 in 2011 to 0.41 in 2020, indicating a heightened level of RIID integration during the study period.

![Figure 1. Comparison of rural industrial integration development index scores.](image)

Since 2017, RIID has undergone rapid development, marked by a consistent upward trajectory in the composite index, integration breadth, and depth index. Furthermore, the depth system exhibits a higher overall index than the fusion width system, indicating that RIID has effectively enhanced farmers’ employment opportunities and income, agricultural efficiency, urban–rural integration, and green development. These positive trends underscore the successful implementation of RIID strategies in the CCEC.

Figure 2 reveals a significant disparity in the integration development levels among the subsystem indices. Within the breadth of RIID, the extended integration model leads the way, followed closely by the internal integration model. On the other hand, the depth of RIID shows a strong performance in ecological greenness and urban–rural integration.
The sustained growth of the RIID index is primarily attributed to the overall advancement of internal, extended, and deep system integrations.

When considering the intra-county integration of rural industries, the various agricultural sub-sectors play a pivotal role in concentrating resources and factor flows through functional extensions and expansions. This process ensures optimal utilization of resources. In terms of extended integration, the establishment of rural industrial integration demonstration parks in the county has a beneficial impact on building a modern agricultural system, strengthening the agricultural base, and fostering innovative business models.

Regarding the depth of RIID, the ultimate objective is to facilitate the comprehensive integration of rural primary, secondary, and tertiary industries. This integration not only enhances the agricultural value chain but also provides robust support for improving agricultural quality and efficiency, augmenting farmers’ employment and income, driving agricultural modernization, and fostering rural prosperity and stability. In essence, RIID serves as a catalyst for comprehensive rural development, encompassing all facets of the agricultural economy. Furthermore, the depth index of rural industrial integration within the counties experienced a remarkable surge, particularly following the implementation of the Rural Revitalization Strategy. This surge marked a significant increase in the vitality of rural industrial integration across all districts and counties, extending both the rural industrial chain and the value chain. Concurrently, the process of RIID accelerated farmers’ income growth, agricultural efficiency, urban–rural integration, and green development.

Additionally, this study presents the Rural Industries Integrated Development Index scores for selected districts and counties in 2011, 2016, and 2020. Based on the comprehensive index results, it is evident that the overall level of rural industrial integration in the county is relatively low. These findings highlight the need for targeted strategies to enhance rural industrial integration and bring about comprehensive rural development. Figure 3 reveals that the counties with the highest overall RIID index are situated within the Chengdu metropolitan area. Counties with persistently lower levels of RIID are primarily located in the southern and western regions of the CCEC due to their relative remoteness from the core areas of Chengdu and Chongqing, thus experiencing limited influence from the radiation-driven integration effect. This is evident in the construction of a high-quality demonstration area that seamlessly integrates urban and rural development, the establishment of a renowned airport agriculture brand, and the creation of a novel “agriculture + consumption” scenario. Thanks to its proactive exploration of rural business systems, unique transportation infrastructure advantages, and the integration of advanced technology into agriculture.
Figure 3. Ranking of RIID index in different counties.

Figure 3 reveals a gradual escalation in the integration of rural industries from the downstream tier to the top 20 counties over the past decade. The transformation of these counties into urban districts has facilitated unified urban–rural planning and spatial organization. This administrative shift has been instrumental in intensifying rural industries, optimizing the layout of industrial parks, and ensuring the optimal allocation of resources within agricultural industries and parks exhibiting distinct characteristics. Furthermore, the districts have been diligent in enhancing infrastructure and public service facilities, laying the groundwork for productive services in industrial integration. These improvements have not only provided material prerequisites but also fostered innovative vitality for the integration of rural industries, thereby expediting its overall development.

The average value of each subsystem pertaining to rural industrial integration in selected districts and counties within the CCEC is presented in Table 2, spanning the years 2011 to 2020. Table 2 illustrates the disparities in performance among the top 10 districts and counties in terms of the overall Rural Industries Integration Development Index score. The district’s proactive support for the development of “Three Types of Quality Products and One Geographical Label” and the promotion of land reclamation reserves have spurred research and development of high-quality agricultural products, significantly expanding the arable land area and thereby enhancing agricultural production conditions, market competitiveness, and both the quantity and quality of output. The district’s three industrial structures still lack coherence, and the cultivation of new growth points remains inadequate. This is due to the region’s limited economic foundation and absence of comprehensive development planning, which hinders the full utilization of its abundant ecological resources. Consequently, industrial integration and growth remain inadequate, necessitating targeted strategies and initiatives to address these challenges.

Table 2. Effects of RIID on spatial clustering in the county.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Moran’s I index</td>
<td>0.262</td>
<td>0.264</td>
<td>0.301</td>
<td>0.342</td>
<td>0.36</td>
<td>0.355</td>
<td>0.294</td>
<td>0.22</td>
<td>0.294</td>
<td>0.267</td>
</tr>
<tr>
<td>p-value</td>
<td>0.001</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Note: The data are derived from the RIID index that has been adjusted for each district and county and measured spatially using Geoda 095i software.
5. Spatial and Temporal Divergence, along with Evolutionary Characteristics of RIID in Counties

5.1. Analysis of Spatial Agglomeration Characteristics

In Figure 4, the CCEC exhibited distinct patterns of rural industry integration in 2011. By contrast, primary and intermediate levels of integration were more concentrated in the northeast and central regions of the economic circle, stretching from southwest to northeast. By 2020, the distribution of deeper rural industry integration had become more focused than in 2011. The integration extended in a northwest–southeast direction, radiating outward from Chongqing and Chengdu. Notably, Chongqing exhibited a more prominent agglomeration of deep integration areas. Over the past decade, spatial analysis revealed that deep integration areas were primarily centered in Chongqing and Chengdu, along with their neighboring districts and counties. This concentration can be attributed to the region’s flat terrain, multiple large rivers, and relatively abundant water resources, all of which provide inherent advantages for agricultural growth.

Figure 4. (a) depicts the spatial distribution of the level of RIID in the county (2011). (b) depicts the spatial distribution of the level of RIID in the county (2020).
As the capital of Sichuan Province, Chengdu’s advanced socioeconomic status, early embrace of agricultural intensification and scale, diverse industrial structure, robust factor aggregation capacity, and strong radiation effect have been pivotal in driving the intensification of rural industrial integration in neighboring counties. Chongqing, uniquely positioned as the sole municipality in western China under the direct jurisdiction of the central government, boasts a robust economic foundation, convenient transportation network, substantial policy support, and cutting-edge science and technology. These combined factors have fueled rapid efficiency growth in the integration of rural industries. Over the past decade, from 2011 to 2020, there has been a consistent spatial clustering of integrated rural industry development, along with a decreasing trend in regional disparities (Figure 5). Generally, the level of RIID within the county exhibits a spatial agglomeration effect, yet it also demonstrates spatial and temporal differentiation characteristics, indicating an unbalanced development trend.

![Figure 5. Moran’s I scatterplot of the spatial clustering of the level of RIID in the county.](image)

There is a potential for spatial correlation in RIID among various counties, with significant regional disparities in RIID levels. According to the findings presented in Table 3, the Moran’s I indices for the degree of RIID in the counties of the CCEC between 2011 and 2020 are consistently positive, indicating a notable positive spatial correlation rather than independence in RIID. The overall trend exhibits fluctuations, alternating between increases and decreases, before rising again in the final two years. Specifically, the upward trajectory of Moran’s I index from 2011 to 2014 in the CCEC suggests a spatial clustering trend in RIID levels. National policy support and sustained economic growth have contributed to this upward trend. However, from 2014 to 2018, there was a decrease in Moran’s I index.

**Table 3. Spatial clustering distribution of RIID in different counties from 2011 to 2020.**

<table>
<thead>
<tr>
<th>Years</th>
<th>H-H Aggregation Area</th>
<th>H-L Aggregation Area</th>
<th>L-H Aggregation Area</th>
<th>L-L Aggregation Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Tongnan, Hechuan, Beibei, Yubei, Shapingba, Bishan, Tongliang, Dazu, Yongchuan, Jiulongpo, Jiangbei, Nanan, Banan, Anyue, Longquanyi, Wenjiang</td>
<td>Yucheng, Dongpo</td>
<td>Da’an, Fushun, Meishan, Hongya, Hanyuan</td>
<td>Da’an, Fushun, Meishan, Hongya, Hanyuan</td>
</tr>
<tr>
<td>2016</td>
<td>Tongnan, Beibei, Dazu, Yubei, Shapingba, Bishan, Tongliang, Yongchuan, Jiulongpo, Jiangbei, Banan, Qijiang, Wenjiang, Chongzhou</td>
<td>Jiangyou, Santai, Dongpo</td>
<td>Meishan, Yucheng, Hongya, Hanyuan, Qionglai, Da’an, Fushun</td>
<td>Meishan, Yucheng, Hongya, Hanyuan, Qionglai, Da’an, Fushun</td>
</tr>
<tr>
<td>2020</td>
<td>Tongnan, Hechuan, Beibei, Dazu, Yubei, Shapingba, Bishan, Tongliang, Yongchuan, Jiulongpo, Jiangbei, Banan, Qijiang, Wenjiang, Chongzhou</td>
<td>Jiangyou</td>
<td>Yucheng, Hongya, Daan, Fushun</td>
<td>Yucheng, Hongya, Daan, Fushun</td>
</tr>
</tbody>
</table>

The spatial agglomeration effect of RIID within the CCEC has gradually diminished, leading to a widening spatial heterogeneity. This may be attributed to disparities in the
effectiveness of industrial integration development across regions, resulting in a “Matthew effect” in RIID. Furthermore, the implementation of the National New Urbanization Plan in 2014 has facilitated the migration of rural populations to cities and towns, indirectly leading to spatial shifts in industrial integration. This has caused significant regional heterogeneity in industrial structure transformation and integration quality. Simultaneously, the pole-core role of Chengdu and Chongqing has furthered urban–rural integration, promoting deeper industrial integration. However, spatial spillover effects among Chongqing’s districts and counties, Chengdu, and neighboring cities and counties have also emerged.

Given the potential spatial correlation among RIID in various counties and substantial regional disparities in RIID levels, this study employs Moran’s I index to conduct spatial autocorrelation analysis. This analysis aims to investigate the spatial correlation characteristics of RIID within the CCEC, providing insights into the distribution and patterns of RIID across the region.

The analysis of Table 3 indicates a noteworthy positive spatial correlation among RIID levels in the CCEC from 2011 to 2020, indicating that they are not independent. The overall trend exhibits fluctuations, with alternating increases and decreases, culminating in an upward trend in the last two years. The upward trend observed in the Moran’s I index from 2011 to 2014 within the CCEC suggests a spatial clustering trend in RIID levels. This can be attributed to the region’s status as a major economic center in China’s western region since the approval of the “Regional Planning of CCEC” in 2010. This has been furthered by the support of national policies and the region’s continuous economic growth, leading to a consistent rise in the index.

However, from 2014 to 2018, the Moran’s I index exhibited a decreasing trend. This indicates a gradual weakening of the spatial agglomeration effect of RIID in the CCEC, accompanied by increasing spatial heterogeneity. This may be due to disparities in the effectiveness of industrial integration development across regions after improving the breadth of RIID, leading to the emergence of a “Matthew effect” among regions. Additionally, the implementation of the National New Urbanization Plan in 2014 has facilitated the migration of rural populations to cities and towns, indirectly leading to spatial shifts in industrial integration. This has resulted in significant regional heterogeneity in industrial structure transformation and integration quality. Despite these changes, the pole-core role of Chengdu and Chongqing has furthered urban–rural integration and promoted deeper industrial integration. Overall, the analysis suggests that RIID levels in the CCEC exhibit a positive spatial correlation but with fluctuations and increasing spatial heterogeneity over time.

The spatial spillover effects within Chongqing’s districts and counties, Chengdu, and its neighboring cities and counties have been on an upward trajectory. A positive upward agglomeration trend is evident, indicating a certain siphoning effect on the neighboring regions within the CCEC. This is indicative of a strengthening interconnectedness and clustering of economic activities in the region.

From 2018 to 2020, the Moran’s I index once again began to increase, indicating a narrowing of regional differences. This reversal can be attributed to the government’s “Opinions on Establishing a More Effective Regional Coordinated Development Mechanism” issued in 2018. This policy emphasized the role of Chengdu and Chongqing as central hubs, guiding the development of urban agglomerations and fostering a more synchronized approach to development between the central city and surrounding towns. This approach has likely led to greater attention being paid to fostering competitive advantages among cities and counties within the CCEC.

Overall, from 2011 to 2020, the spatial agglomeration of county-level RIIDs within the CCEC. The Moran’s I index rose from 0.262 in 2011 to 0.267 in 2020, indicating an expansion of the overall spatial agglomeration effect and a decrease in regional disparities. The fluctuations observed in the Moran’s index over the past decade highlight the spatio-temporal differentiation characteristics and the unbalanced development trends within the CCEC.
This evolving pattern underscores the need for continued coordination and integration efforts to ensure balanced and sustainable economic growth throughout the region.

Figure 6 illustrates the Moran’s I scatterplot for the RIID levels within the CCEC region across 2011, 2016, and 2020. The horizontal axis represents the breadth index of RIID, while the vertical axis depicts the depth index. The scatterplot’s quadrants offer insights into spatial patterns. Quadrants one and three exhibit positive correlations, labeled as “H-H” and “L-L”, respectively, indicating spatial homogeneity. Conversely, quadrants two and four reveal negative correlations, labeled as “L-H” and “H-L”, indicating spatial heterogeneity. Given the consistently positive values of the global Moran’s I indices, our discussion will primarily center on the implications of the first and third quadrants.

Figure 6. Cont.
Figure 6. (a) Spatial and temporal evolution of the level of integrated development of rural industries in the county (2011). (b) Spatial and temporal evolution of the level of integrated development of rural industries in the county (2016). (c) Spatial and temporal evolution of the level of integrated development of rural industries in the county (2020).

Figure 6 depicts the evolving concentration trend of districts and counties within the CCEC. Starting from initial dispersion, the trend has progressed toward agglomeration by 2020, further concentrating on the origin. This pattern indicates a robust positive spatial correlation in RIID levels across the decade, manifesting as a consistent shift from fragmentation toward concentration. Notably, numerous counties have embarked on developing field complexes and established “one county, one industry” and “one village, one product” industrial clustering demonstration areas. These demonstration areas have demonstrated continuous convergence and concentration, highlighting the synergetic clustering of integration breadth and depth.

However, contrastingly, remote and mountainous regions, particularly “hollow villages” and aging villages, exhibit limited RIID characteristics. This leads to a negative synergy between the breadth and depth of rural industry integration. Specifically, as rural industry development weakens and its characteristics become less pronounced, the integration of rural industries externally and internally becomes more challenging. This challenge is exacerbated by the difficulty in highlighting the effects of integrated development, further compounding the negative synergy. To address these disparities and foster more balanced development, targeted policies, and strategies are needed to promote RIID and enhance rural industry integration, especially in remote and disadvantaged areas.

5.2. Analysis of Spatio-Temporal Divergence Characteristics

From 2011 to 2020, the spatial distribution pattern of RIID levels in the counties of the CCEC remained remarkably stable, exhibiting a distinct path dependency. The uneven integration of rural industries across counties was evident, resulting in a clear spatial clustering of high–high and low–low areas. Regions classified as “high-high” agglomeration, primarily situated in the central areas of Chengdu and Chongqing, remained relatively stable throughout the decade. These regions rank highly in rural industrial integration indices, indicating their strong position in leading rural industry integration efforts in surrounding areas and their potential to exert a diffusion effect. Overall, the spatial distribution of RIID levels within the CCEC has remained stable, with clear clustering patterns that reflect
the uneven integration of rural industries across counties. The leading role played by the high–high agglomeration areas in driving rural industry integration in surrounding regions is noteworthy and suggests that targeted policies and strategies could further enhance integration efforts, particularly in lower-performing areas.

High–Low Agglomeration Area: Significant variations were observed in this category between 2011 and 2020. Specifically, Yucheng District in Ya’an City transitioned from H-L agglomeration in 2011 to L-L agglomeration in 2016, indicating a stagnation or degradation in RIID levels. This region, surrounded by districts and counties with relatively low RIID, exhibits a polarization effect. This trend may be attributed to a lack of momentum in industrial integration resulting from declining factor integration within the region and the absence of timely follow-up on relevant incentive systems. Consequently, the breadth and depth of rural industrial integration have decreased.

Low–High Agglomeration Area: Only a limited number of districts emerged as transitional areas during the intermediate period. These districts and counties, driven by neighboring high-level areas, are transitioning toward H-H agglomerations. Although these counties lag in agricultural development, they exhibit a relatively high degree of integration with secondary and tertiary industries. This suggests that the depth of rural industry integration is greater than its breadth. For instance, some counties are leading the way in rural tourism, creative agriculture, and digital agriculture, thereby driving deeper integration of rural industries and indirectly accelerating urban–rural integration.

Low–Low Agglomeration Area: Most low–low-concentration districts and counties in Zigong and Ya’an City have persisted from 2011 to 2020, indicating a need for improvement in the region’s RIID levels. This area falls victim to a trap of limited integration among factors, industries, and policies, resulting in a low-level hovering agglomeration and backwardness in the spatial evolution of RIID.

To further analyze spatial patterns, the local Moran’s index was employed to measure the association between regions and their adjacent areas. Figure 5 illustrates the districts and counties that passed the significance test for the local Moran index from 2011 to 2020.

The agglomeration areas exhibiting synergistic high values in both the breadth and depth of RIID (indicating high efficiency) are gradually converging toward the east. In 2011, these areas were horizontally striped, spanning from Ziyang County to Chongqing County, with the Chengdu–Chongqing axis dominating the distribution. However, by 2020, this pattern had transformed into a block distribution, primarily concentrated in Chongqing. Chongqing has emerged as a crucial region for deep rural industry integration, leveraging its established industrial base and resource advantages to form a cohesive synergy. Due to the spatial proximity effect and radiation-driven impact of central counties, regions proximal to this core region are experiencing rapid development. The counties passing the significance test are primarily located in Chongqing, indicating that these districts and counties maintain high RIID levels and exert a significant positive radiating effect on surrounding areas.

The agglomeration areas characterized by synergistically low values for both breadth and depth of integration (inefficient types) have remained relatively stable. These regions are situated primarily in the southern and western portions of the CCEC, situated away from the core region, constituting a primary “depression area”. These areas exhibit limited radiating effects and have consistently trailed behind Chongqing’s counties in terms of RIID levels. Notably, the level of rural industry integration in these regions is significantly lower than in surrounding areas, creating a “hollowed out” situation characterized by a high periphery and a low center.

Regions exhibiting high–low concentrations of integration breadth and depth (polarized) are intermittent and transient, occurring sporadically over the years. The implementation of a modern national agricultural industrial park, utilizing a “tourism + agriculture” model, has significantly enhanced the integrated growth of urban and rural industries in terms of quality. Nevertheless, due to the region’s geographically constrained location, situated toward the western periphery of the CCEC and adjacent to Ya’an County, eco-
nomic development remains relatively underdeveloped. The significant gap in economic development between Dongpo District and its neighbors has hindered effective growth, resulting in the persistence of the high–low agglomeration phenomenon. Overall, from 2011 to 2020, the fundamental pattern of high–high and low–low RIID concentrations remained unchanged, with a clear polarization trend.

5.3. Analysis of Regional Variations and Their Sources

This study delves into the regional disparities in RIID across counties and their underlying sources by measuring and decomposing the Gini coefficient of RIID. As depicted in Figure 6, the upward trajectory of the Gini coefficient for the overall RIID index at the county level indicates a widening spatial gap in RIID within the county. In terms of contribution rates, the intra-regional variation has generally exhibited a decreasing trend in evolution, while the inter-regional variation has generally exhibited the opposite trend. Together, these two contributions account for over 90 percent, with the contribution of hypervariable density remaining relatively stable. Additionally, a combined analysis of Figure 7 and Table 4 reveals significant disparities in the breadth and depth of RIID among counties, particularly among the three rural industries within each county. Currently, the integration of rural industries is still in its early stages of outward expansion and integration.

Figure 7. Measurement and decomposition of the Gini coefficient of RIID in the county.

Table 4. Intra- and inter-county decomposition of integrated development of rural industries.

<table>
<thead>
<tr>
<th>Year</th>
<th>Overall Gini Coefficient</th>
<th>Intra-County Variation</th>
<th>Inter-County Variation</th>
<th>Super-Variable Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intra-County Gini Coefficient</td>
<td>Gini Coefficient of Integration Breadth</td>
<td>Gini Coefficient of Integration Depth</td>
<td>Intra-County Gini Coefficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>0.3482</td>
<td>0.1836</td>
<td>0.1302</td>
<td>0.0534</td>
</tr>
<tr>
<td>2012</td>
<td>0.3161</td>
<td>0.1773</td>
<td>0.1316</td>
<td>0.0457</td>
</tr>
<tr>
<td>2013</td>
<td>0.3343</td>
<td>0.1748</td>
<td>0.1316</td>
<td>0.0432</td>
</tr>
<tr>
<td>2014</td>
<td>0.3291</td>
<td>0.1753</td>
<td>0.1276</td>
<td>0.0477</td>
</tr>
<tr>
<td>2015</td>
<td>0.3351</td>
<td>0.1743</td>
<td>0.1116</td>
<td>0.0627</td>
</tr>
<tr>
<td>2016</td>
<td>0.3414</td>
<td>0.1711</td>
<td>0.0992</td>
<td>0.0719</td>
</tr>
<tr>
<td>2017</td>
<td>0.3666</td>
<td>0.1641</td>
<td>0.1012</td>
<td>0.0629</td>
</tr>
<tr>
<td>2018</td>
<td>0.3698</td>
<td>0.1608</td>
<td>0.1206</td>
<td>0.0402</td>
</tr>
<tr>
<td>2019</td>
<td>0.3801</td>
<td>0.1591</td>
<td>0.1212</td>
<td>0.0379</td>
</tr>
<tr>
<td>2020</td>
<td>0.3918</td>
<td>0.1542</td>
<td>0.1224</td>
<td>0.0318</td>
</tr>
</tbody>
</table>

Note: Authors own source analyzed by Matlab R2018a software.

There is a general trend toward decreasing disparities in RIID among counties over the years, as evident from Table 4. Specifically, the differences in the breadth and depth of RIID among counties have generally followed a year-on-year decline. However, between 2013 and 2017, the gap in RIID depth increased, indicating that the internal integration of rural
Agriculture business within counties also played a significant role. Due to the varying integration paths of the three rural industries and the greater heterogeneity in the outreach of the integration models, the variability in the breadth of RIID among counties is notably higher than that in the depth of integration. Nevertheless, spurred by the policy of urban–rural integration and driven by high-quality development, the integration of the three rural industries in counties has continuously strengthened in terms of outreach and expansion, gradually transitioning into a phase of internal quality improvement. Nevertheless, the construction quality of the three industrial integrations remains relatively poor, resulting in a steady decline in the difference between the breadth and depth of the county’s RIID. Despite this, there has been a gradual, year-on-year increase in the depth of RIID across counties, emphasizing the internal development of the integration of the three industries. This has given rise to slight differences between counties. Additionally, inter-county variation typically exhibits a V-shaped trend, decreasing from 2011 to 2014 and then gradually increasing from 2015 to 2020. Following the 18th Party Congress, the accelerated promotion of integrated urban–rural development in counties, coupled with poverty alleviation efforts, has led to strengthened growth in rural industries among counties. Initially, there was little difference in outward integration among rural industries; however, over time, a trend of perpetual competition emerged, resulting in increasing disparities in the breadth of industrial integration among counties.

6. Conclusions, Limitations, and Future Work

Since the establishment of the CCEC as a national strategy, the acceleration of integrated urban–rural development and the construction of a new development pattern have become evident. This process is marked by significant manifestations, such as the development of the fourth pole of China’s economic growth and the promotion of integrated rural industries. Utilizing county panel data from 2011 to 2020 within the CCEC, this study employs the entropy-weighted TOPSIS method to measure the level of rural industrial integration and analyzes its basic characteristics in terms of both breadth and depth. Furthermore, through the measured and decomposed Moran’s I index and Dagum’s Gini coefficient, this study examines the spatial and temporal evolution of RIID among counties, exploring the sources of their differences. The objective is to reveal the spatial evolution trend and distribution pattern of RIID levels within the CCEC, providing insights into the region’s economic development.

This study reveals several significant findings regarding the RIID in the CCEC. Firstly, the RIID level within the region has demonstrated a consistent upward trajectory, rising from 0.3 in 2011 to 0.41 in 2020. Notably, since the introduction of the rural revitalization strategy in 2017, RIID in the counties has experienced accelerated growth.

Secondly, the RIID level in the CCEC exhibits a strong positive spatial correlation. However, there exist substantial disparities in RIID levels among regions, indicating uneven development patterns. This finding is consistent with the findings of existing studies [65,66], showing that the level of county development in Chengdu and Chongqing is higher than that of other regions.

Thirdly, the study observes the emergence of regions with both high and low synergy in terms of RIID breadth and depth. This polarization is likely to intensify [67], with demonstration areas for integrated special industry development coexisting with regions characterized by disadvantaged special industries. The spatial distribution of these patterns is evolving from a belt-like to a block-like structure.

Lastly, the significant variation in RIID levels among counties is the primary driver of the overall RIID disparity. While both intra-county differences and super-variable density show a downward trend, they nevertheless exhibit a “Matthew effect” in the short term, suggesting that initial advantages tend to accumulate and lead to further disparities. Zhang et al. (2022) also explain this in terms of the mode of factor mobility, highlighting that administrative zoning is a key barrier to the flow of capital, technology, and labor in
the Chengdu–Chongqing urban agglomeration [68]. The government should continue to reduce administrative barriers to enhance factor mobility [69].

This study centers on the spatio-temporal evolution and underlying driving forces of rural industrial integration within the CCEC, particularly its relevance to China’s rural revitalization efforts. In this context, the CCEC offers a unique case study for comparisons with other significant economic hubs in China, such as the Yangtze River Delta and the Pearl River Delta. Such comparisons, coupled with a geographical, economic equidifference analysis, can yield more tailored recommendations for rural revitalization strategies.

To enhance the study’s findings, expanding the sample size would allow for a more precise portrayal of rural industrial integration’s temporal and spatial dynamics in the CCEC. This is particularly relevant given that the current study faced limitations in data availability, resulting in the exclusion of certain districts and counties.

Moreover, delving deeper into the breadth and depth of rural industrial integration remains a crucial area for further exploration. Future research could compare rural industry integration across multiple economic circles, emphasizing the interplay and synergies between diverse industries and their respective supply chains. By doing so, new integration models and pathways can be identified, tailored to specific regional contexts, and ultimately contribute to the high-quality development of rural industries in China.

7. Policy Implications

Based on the above conclusion. To this end, the following policy insights are drawn:

To ensure a balanced and high-quality development of rural industrial integration within the Chengdu–Chongqing dual-city economic circle, we must prioritize the enhancement of the central region’s secondary growth pole. This approach, led by the dual cores of Chengdu and Chongqing, aims to reverse the current central region’s collapse. Additionally, we must promote modern agriculture tailored to local conditions in the western and southern regions, where rural industry integration remains limited. Optimizing the industrial integration structure within the economic circle is crucial, especially in promoting “agriculture+”.

First, joint efforts are being made to promote the integrated development of the “agriculture plus” industry, fostering deeper integration of agriculture with commerce, culture, tourism, and sports. By guiding the integration of agriculture with animal husbandry, forestry, fishery, and cyclic development, a composite agricultural production model of close collaboration and cyclic development should be formed, promoting cross-fertilization of industries within agriculture to expand value-added opportunities. Regions relatively far from the core centers of Chengdu and Chongqing should leverage their unique rural cultures, drawing inspiration from their natural beauty, distinctive agricultural practices, and ethnic settlement resources. Additionally, it is important to explore the diversified functions of agriculture and rural areas, including leisure tourism, cultural enrichment, and eco-retirement. These areas should focus on developing three-dimensional and tourist agriculture to enhance their economic potential.

Secondly, efforts should be made to reduce regional disparities in the integrated development of rural industries. The government should continue promoting the integration of primary, secondary, and tertiary industries in rural areas and support the construction of advantageous specialty industry clusters. Special supportive policies should be implemented for areas with lower levels of rural industry integration to prevent the siphoning effect in the districts and counties of Chongqing Municipality, Chengdu Municipality, and their neighboring regions. Additionally, the radiation and spillover effects of the central cities of Chengdu and Chongqing should be strengthened to bridge the polarization trend in the degree of coupling and synergy within the region. This will help ensure more balanced and equitable rural industrial development across the entire CCEC.

Lastly, efforts have been made to create a favorable external environment and public services for the integration of rural industries, laying the foundation for their integrated development. We are accelerating the establishment of modern agricultural business...
systems in counties and promoting the seamless connection between small farmers and modern agricultural development. Collaboration with well-known enterprises and farmers’ professional cooperatives is crucial to implementing targeted strategies tailored to local conditions, promoting the adoption of advanced agricultural technologies, and improving agricultural labor productivity and modernization. Additionally, local governments must promote a free flow of resources to achieve comprehensive development of urban and rural industries. This is achieved through market diffusion and agglomeration, creating a favorable market environment for the deep integration of urban and rural industries, policies, and resources, thereby promoting sustainable and inclusive rural economic growth.

Author Contributions: Conceptualization, Y.S.; Data curation, Y.S., R.W. and Y.J.; Formal analysis, G.R.S., R.W. and Y.J.; Funding acquisition, Y.S.; Investigation, Y.S., G.R.S., R.W. and Y.J.; Methodology, Y.S., G.R.S., R.W. and Y.J.; Project administration, Y.S.; Resources, Y.S. and G.R.S.; Software, Y.S., G.R.S. and Y.J.; Supervision, Y.S.; Validation, Y.S. and G.R.S.; Visualization, Y.S. and G.R.S.; Writing—original draft, Y.S., G.R.S. and R.W.; Writing—review and editing, Y.S., G.R.S. and Y.J. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the National Social Science Fund of China (grant no. 23BJL103), Funder: yun shen; the Postdoctoral Research Foundation of China (grant no. 2023M732502), Funder: yun shen; and the Natural Science Foundation of Sichuan Province (grant no. 2023NSFSC0522), Funder: yun shen.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author, Shen Yun. The data are not publicly available due to privacy and ethical considerations.

Conflicts of Interest: The authors declare no conflicts of interest.

Notes
1 The Chengdu-Chongqing Economic Circle includes the central urban area of Chongqing and 27 districts (counties) including Wanzhou, Fuling, Qiqiang, Dazu, Qianjiang, Changshou, Jiangjin, Hechuan, Yongchuan, Nanchuan, Bishan, Tongliang, Tongnan, Rongchong, Liangping, Fengdu, Dianjiang, and Zhongxian, as well as some areas of Kaizhou and Yunyang. In addition, Chengdu, Zigong, Luzhou, Deyang, Mianyang, Suiing, Neijiang, Leshan, Nanchong, Meishan, Yibin, Guang’an, Dazhou (excluding Wanyuan City), and Ya’an (excluding Tianquan County and Baoxing County) in Sichuan Province are also included. 15 cities including counties and Zityang.

References
2. Aiyar, A.; Rahman, A.; Pingali, P. India’s rural transformation and rising obesity burden. World Dev. 2021, 138, 105258. [CrossRef]
3. Abrhám, J. Rural development and regional disparities of the new EU Member States. Agric. Econ. 2011, 57, 288–296. [CrossRef]
4. Chen, D.; Wang, Y.; Ren, F.; Du, Q. Spatio-temporal differentiation of urban-rural equalized development at the county level in Chengdu. Sustainability 2016, 8, 422. [CrossRef]
23. Huang, L.; Cao, Y. Review of the integrated development of ecological and cultural forestry. *Sustainability* **2022**, *14*, 6818. [CrossRef]
41. Bao, H.; Xu, Y.; Zhang, W.; Zhang, S. Has the monetary resettlement compensation policy hindered the two-way flow of resources between urban and rural areas? *Land Use Policy* **2020**, *99*, 104953. [CrossRef]
43. Song, W.; Pijanowski, B.C. The effects of China’s cultivated land balance program on potential land productivity at a national scale. Appl. Geogr. 2014, 46, 158–170. [CrossRef]


47. Li, Y.; Fan, P.; Liu, Y. What makes better village development in traditional agricultural areas of China? Evidence from long-term observation of typical villages. Habitat Int. 2019, 83, 111–124. [CrossRef]


49. Yin, X.; Chen, J.; Li, J. Rural innovation system: Revitalize the countryside for a sustainable development. J. Rural. Stud. 2022, 93, 471–478. [CrossRef]


51. Zhan, L.; Wang, S.; Xie, S.; Zhang, Q.; Qu, Y. Spatial path to achieve urban-rural integration development— analytical framework for coupling the linkage and coordination of urban-rural system functions. Habitat Int. 2023, 142, 102953. [CrossRef]

52. Niu, B.; Ge, D.; Sun, J.; Sun, D.; Ma, Y.; Ni, Y.; Lu, Y. Multi-scales urban-rural integrated development and land-use transition: The story of China. Habitat Int. 2023, 132, 102744. [CrossRef]

53. Rao, C.; Gao, Y. Evaluation mechanism design for the development level of urban-rural integration based on an improved TOPSIS method. Mathematics 2022, 10, 380. [CrossRef]


55. Yao, W.; Zhang, W.; Li, W.; Li, P. Measurement and Evaluation of Convergence of Japan’s Marine Fisheries and Marine Tourism. Sustainability 2022, 14, 9108. [CrossRef]


59. Lu, Y. The measurement of high-quality development level of tourism: Based on the perspective of industrial integration. Sustainability 2022, 14, 3355. [CrossRef]

60. Dagum, C. A new approach to the decomposition of the Gini income inequality ratio. In Income Inequality, Poverty, and Economic Welfare; Physica-Verlag HD: Heidelberg, Germany, 1998; pp. 47–63. [CrossRef]

61. Lai, Y.; Yang, H.; Qiu, F.; Dang, Z.; Luo, Y. Can Rural Industrial Integration Alleviate Agricultural Non-Point Source Pollution? Evidence from Rural China. Agriculture 2023, 13, 1389. [CrossRef]


64. Li, Y.; Westlund, H.; Liu, Y. Why some rural areas decline while some others not: An overview of rural evolution in the world. J. Rural. Stud. 2019, 68, 135–143. [CrossRef]


66. Yang, M.; Jiao, M.; Zhang, J. Research on urban resilience and influencing factors of Chengdu-Chongqing economic circle. Sustainability 2022, 14, 10585. [CrossRef]


Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.