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Spatial–Temporal Evolution and Driving Factors of Industrial Land Marketization in Chengdu–Chongqing Economic Circle

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Abstract: Industrial land is essential for supply-side structural reforms, particularly in the Chengdu–Chongqing area, Western China's most densely populated and industrially robust region. This area, a pivotal hub linking Southwest China with South Asia and Southeast Asia, is critical for the national strategic layout and regional economic restructuring. Despite its substantial industrial foundation as an old industrial base, internal developmental stagnation has led to an irrational industrial land use structure. This paper analyzed land transaction data from the China Land Market Network (2010–2021) using methods such as kernel density estimation, the standard deviation ellipse method, and Global Moran's I index. The analysis focuses on the spatiotemporal evolution of industrial land marketization and its driving factors in 44 cities within the Chengdu–Chongqing economic circle. The findings aim to enhance the strategic implementation of national policies and regional economic optimization, suggesting intensified development efforts in key cities and promoting integrated growth in potential areas like Suining and Ziyang to foster a conducive environment for high-quality regional development.

Keywords: industrial land premium rate; spatiotemporal evolution; driving factors; Chengdu–Chongqing economic circle

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1. Introduction

The process of land marketization reform represents the country's shift from planned to market-based land resource allocation. The degree of land marketization reflects the outcomes of these reforms, indicating the extent to which land resources are allocated through the market at a particular stage. It serves as a crucial measure of the state of land market transactions [1,2]. Since the late 1980s, China has implemented reforms to establish a market-oriented urban land allocation system. These reforms have significantly improved the optimal allocation of land resources and effectively promoted urbanization and socioeconomic development.

Industrial land is a key production factor for industrial development. Its optimal allocation significantly impacts industrial restructuring and upgrading, as well as the construction of new urbanization. In the context of economic transformation, the industrial economy holds a dominant position in the socioeconomic landscape. In 2006, the former Ministry of Land and Resources issued the "Notice on Implementing the National Minimum Price Standards for Industrial Land Transfer", which stipulated that the transfer of industrial land must be conducted through a "bidding, auction, and listing" process while adhering to minimum price standards [3]. To promote the market-oriented allocation of industrial land, the state once again emphasized the need to deepen the reform of factor market allocation and advance the unified development of urban and rural construction land markets in the 14th Five-Year Plan and the Vision for 2035. In 2022, the General Office of the State Council released the "Overall Plan for Comprehensive Reform Pilots

of Market-Oriented Allocation of Factors", calling for the optimization of industrial land supply methods and the activation of existing land through market-oriented approaches [4]. The market is an effective pathway and a crucial means for resource allocation. In a market economy, resource allocation is achieved through changes in price signals. Price not only guides the flow of resources [5] but also serves as the core driving factor for industrial upgrading driven by land marketization [6].

Unlike the liberal market transactions of industrial land under private land ownership systems in Western countries, the primary objectives of local governments in China's current political system are to maximize output and fiscal revenue [7]. Land, as a critical resource under the control of local governments, naturally becomes a powerful policy tool for achieving these dual objectives. This has led to widespread government intervention and regulation in land resource allocation during the marketization reform of land. In their pursuit of economic growth and urbanization targets, local governments often engage in competitive investment attraction, resulting in large-scale, low-priced industrial land transfers and high-priced commercial and residential land transfers [8]. Such practices have caused problems such as disorderly expansion, inefficient land use, and industrial homogeneity [9]. These issues contradict the marketization reform of land factors and severely hinder the rational flow of factor resources and the optimization of national spatial layout. Therefore, enhancing the marketization level of industrial land is crucial for addressing these current issues, as it facilitates rational resource allocation and regional industrial upgrading.

Industrial land is an essential element in industrial economic development, extensively studied by scholars both domestically and internationally. In countries with private land ownership, research has focused on industrial land pricing due to decentralized land transaction data and high marketization. These studies primarily examine the impact of physical characteristics [10] (e.g., land area, available office space) and locational attributes [11] (e.g., transportation accessibility, market proximity, street frontage) on industrial land prices. Additionally, research has explored the effects of environmental pollution [12] and land zoning regulations [13] on prices. As land systems and urbanization mature in developed countries, land transaction volumes have decreased, leading to a reduction in related studies. In contrast, China's ongoing land market reforms have spurred extensive research in this area. Scholars' research on industrial land mainly focuses on industrial land efficiency [14], industrial land price [15], industrial land policy [16], and the intensive use of industrial land [17]. Research related to the marketization of industrial land remains relatively limited. Studies related to land marketization mainly include the following two aspects: (1) Assessment of the current status of land marketization levels. Research on the assessment of the current status of land marketization levels predominantly focuses on macro- and meso-level cities. Most studies choose either the entire country or specific urban agglomerations as the research area to measure the level of marketization [18–21]. There are also scholars who have conducted studies on the level of land marketization from a mrcro-scale perspective, focusing on a single city [22,23]. From the spatial division of China's regions, the research concluded that the industrial land marketization level in China's eastern region is higher than in the central and western regions [3,15]. Additionally, the level of industrial land marketization in the region with better economic development is declining, and the level of industrial land marketization is obviously differentiated between prefectural-level cities, etc. Regarding measurement methods, early assessments of industrial land marketization primarily relied on the proportion of the quantity or area of land transferred through "bidding, auctioning, and listing" to the total quantity or area supplied. This ratio was used to gauge the level of industrial land marketization [24,25]. Some scholars use the "weighted correction method" to correct the quantity or area of land supply according to the level of the land, with the unit price of the auction as the benchmark [26,27], and by analyzing the premium rate of the industrial land transaction price in different regions of the country relative to the national minimum price of industrial land transfer [28]. Based on the inter-regional differences in the level of land marketization,

scholars have studied the influencing factors and found that the level of regional economic development [29], the size of the industrial sector [30], investment promotion behavior [31], the conditions of the regional land resource endowment, the degree of demand for industrial land [32,33], and other factors have a positive impact on the level of land marketization. (2) Local government land policy. From the perspective of local government fiscal competition, scholars analyze the degree of influence of government behavior on regional land marketization and find that intergovernmental fiscal competition has a positive effect on the level of urban land marketization, while competition for attracting capital has a negative effect [34,35]. From the perspective of resource mismatch, fiscal competition between governments leads to a mismatch of land resources and the adoption of differential pricing of industrial land, which inhibits industrial structure upgrading and land marketization development. In order to alleviate the resource mismatch phenomenon, some scholars have proposed exploring the flexible terms and scope of industrial land grants [36], establishing a system of periodic evaluation and updating of the minimum price standard for industrial land, setting assessment indicators for industrial land grant and withdrawal [37] (e.g., the minimum output per mu in the remaining years of the land-use right), implementing the graded ratings of industrial enterprises and differentiated tax policies, and advancing to the mode of selecting business and capital [38] and other policy recommendations.

Currently, academic research on the marketization of industrial land primarily focuses on nationwide dimensions and economically developed regions, such as the eastern coastal urban clusters of China. However, there is a lack of attention given to emerging regions within the country. Although research findings from economically advanced areas can provide certain experiences, their applicability is relatively limited. There are many cities in China that are still in urgent need of development and require more pertinent theoretical and practical experiences for reference. Moreover, the fundamental objective of China's industrial land marketization reform is to maximize the explicit value of land resources. Most current studies determine the level of marketization based on the area or price proportion of land transfers, with varying degrees of marketization. However, this method often focuses on the "marketization" of land transaction forms and cannot identify the formalistic "bidding, auctioning, and listing" by local governments. Therefore, reflecting the degree of marketization from the perspective of land transfer methods lacks persuasive power. In summary, the marginal contribution of this paper lies in selecting emerging regions and quantifying the marketization level of industrial land in the Chengdu–Chongqing region from the perspective of the primary land market. The aim is to deepen and expand the research on the evolution of the marketization level of industrial land and to provide references for developing cities in formulating scientifically sound regional industrial land policies.

The Chengdu–Chongqing Twin City Economic Circle, recognized as the "fourth pole" of national economic growth, is the focus of this study due to its representative and unique characteristics in the new spatial economic development pattern of the Western region of China. Therefore, this paper selects 44 prefecture-level cities within the Chengdu–Chongqing Twin City Economic Circle as the research subjects. The aim of this study is to quantify the degree of industrial land marketization in these 44 prefecture-level cities from 2010 to 2021 using land market transaction data. This study employs kernel density estimation, the centroid migration method, and the global Moran's I spatial statistical model to explore the temporal and spatial evolution characteristics of industrial land marketization in the Chengdu–Chongqing area and reveal its changing patterns. Furthermore, the gray relational analysis model is used to identify the key driving factors. The findings are intended to provide valuable references for the implementation of national macroeconomic strategies and the optimization of regional economic structure. Additionally, this research seeks to offer development strategies and policy insights for the Chengdu–Chongqing region to better play its role as the "Twin Cities" in the new era of Western development, thereby promoting efficient and coordinated economic development nationwide.

The structure of this paper is as follows: The second part introduces the study area, the selection of variables, the research methods employed, and the data sources. The third part presents the research results, including the evolution characteristics and regional differences in the marketization level of industrial land in the Chengdu–Chongqing region over time and space, along with an exploration of its driving factors. The fourth and fifth parts summarize the research conclusions based on the findings and propose corresponding policy implications.

2. Research Design

2.1. Research Area

The Chengdu–Chongqing Economic Circle is located in the upper reaches of the Yangtze River within the Sichuan Basin. It is bordered by Hunan and Hubei to the east, connects with the Qinghai–Tibet Plateau to the west, adjoins Yunnan and Guizhou to the south, and is adjacent to Shaanxi and Gansu to the north. This region is the most densely populated, industrially robust, innovation-capable, market-extensive, and open area in Western China. In 2020, the Chinese government officially incorporated it into the national strategy, positioning it at the intersection of the "Belt and Road Initiative" and the Yangtze River Economic Belt. The region plays a crucial role in promoting regional development and the national strategic layout. Furthermore, as a bridge linking Southwest China with South Asia and Southeast Asia, the region's external development and regional expansion have not only invigorated the internal market but also provided new momentum for international cooperation. However, despite its strong industrial foundation, the Chengdu–Chongqing region faces challenges such as insufficient new growth drivers and an irrational structure of industrial land use. These issues have become major obstacles to its sustainable development and the achievement of higher levels of market-oriented resource allocation. This not only hinders the optimization and upgrading of the local economy but also limits its strategic execution capabilities in the national and global economic landscape.

This paper is based on the "Chongqing Municipal Master Plan for National Land and Space (2020–2035)", focusing on the Chengdu–Chongqing Economic Circle within the designated area (Figure 1). The Chengdu–Chongqing Economic Circle includes the central urban area of Chongqing and 29 other districts and counties, namely Wanzhou, Fuling, Qijiang, Dazu, Qianjiang, Changshou, Jiangjin, Hechuan, Yongchuan, Nanchuan, Bishan, Tongliang, Tongnan, Rongchang, Liangping, Fengdu, Dianjiang, Zhong County, Kaizhou, and Yunyang. Additionally, the circle encompasses 15 cities in Sichuan Province, which are Chengdu, Zigong, Luzhou, Deyang, Mianyang, Suining, Neijiang, Leshan, Nanchong, Meishan, Yibin, Guang'an, Dazhou, Ya'an, and Ziyang. The study area considers prefecture-level cities, totaling 44 cities.

2.2. Variable Setting

In order to explore the driving factors of the marketization level of the twin city economic circle in the Chengdu–Chongqing region, this paper selects the following five indicators as control variables by drawing on the relevant literature [20,29,39].

Economic development level. The level of economic development reflects the effects of geographic advantages, industrial endowments, investment climates, and policy biases, revealing a region's economic status and potential. Regions with higher levels of economic development typically offer more favorable investment environments and policy incentives, which tend to attract a significant influx of businesses. This increase in economic activity not only promotes employment and technological innovation but also intensifies the demand for limited land resources, consequently leading to heightened competition in the land market and rising land prices. As a result, GDP per capita is the measure used in this study to describe the degree of regional economic development.

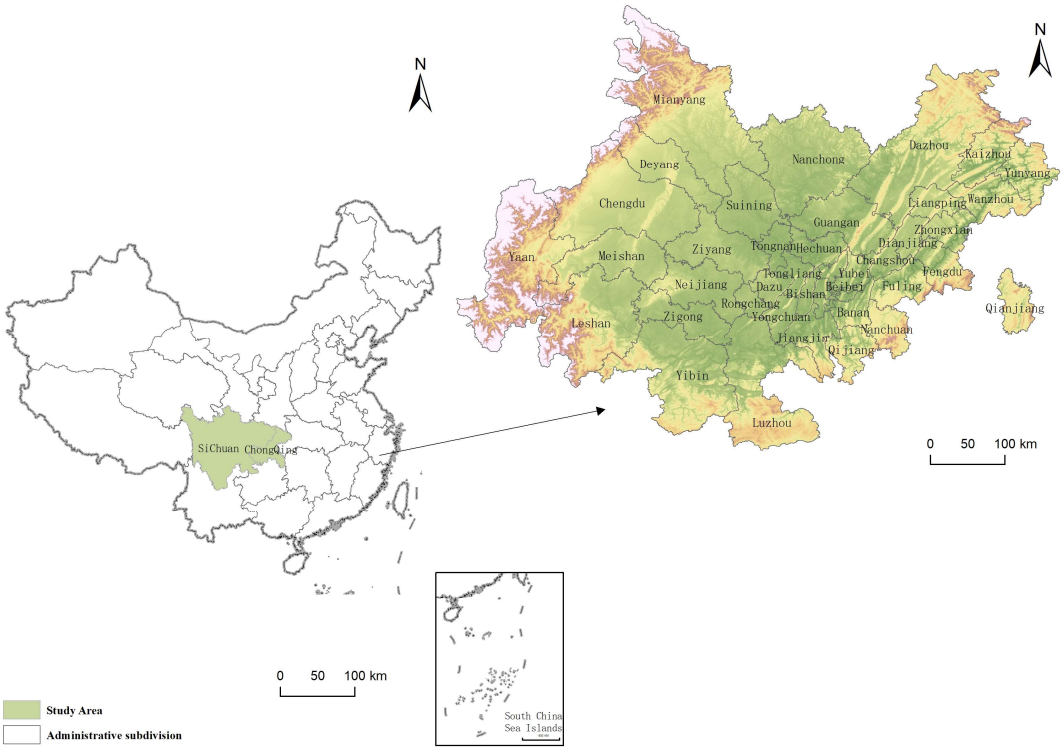

Figure 1. Study Area.

Fixed asset investment. In recent years, merely reducing industrial land prices has proven insufficient to effectively attract industrial enterprises. This shift necessitates that local governments increasingly rely on boosting fixed asset investments, improving regional infrastructure, enhancing public services, and optimizing the investment environment to attract and retain businesses. By adopting this approach, local governments can also reduce their dependence on land finance, fostering economic development in a healthier and more sustainable manner while indirectly normalizing and increasing industrial land prices.

Foreign direct investment. As regional economies develop and industries mature, the industrial structure optimizes, and market competition conditions diversify. In this process, the interaction between local governments and industrial enterprises evolves into a bilateral selection relationship, where local governments consider the long-term benefits of industrial development needs and foreign investment. In this interactive dynamic, foreign direct investment becomes a key force in driving regional economic restructuring and industrial upgrading. Furthermore, the aggregation of foreign enterprises and industrial expansion increase the demand for industrial land, indirectly causing land prices to rise. This increase in land prices, in turn, affects the region's attractiveness for investment, creating a dynamic interaction cycle.

The ratio of government revenue and expenditure. Under the condition of meeting the minimum bid price, the actual transaction price of industrial land is largely influenced by local fiscal demands. Local governments adjust the transaction prices of different plots through differentiated land supply policies to secure off-budget revenues. Consequently, this paper selects fiscal autonomy as a measure of local governments' ability to rely on autonomous income to finance their expenditures.

Industrial structure upgrading. The transformation and upgrading of industrial structures directly influence the distribution of land resources among different sectors, particularly affecting the fluctuations and adjustments in industrial land prices. The growth rate of the tertiary sector relative to the secondary sector reflects the trends and maturity of these structural changes as the economy evolves. Such shifts often result in the redistribution of land demand, impacting the pricing and efficiency of industrial land use.

Therefore, the ratio of the output value of the tertiary to the secondary industry is used as a measure of industrial structure, illustrating the effects of industrial development on industrial land prices.

2.3. Data Resource

To comprehensively explore the evolution of the spatial and temporal patterns of industrial land marketization in the Chengdu–Chongqing area over a decade, data completeness, timeliness, and accessibility were considered. The basic data included the transaction area, land grades, and transaction prices of industrial land parcels in 44 prefectural-level cities within the Chengdu–Chongqing Twin Cities Economic Circle, as well as socioeconomic data from 2010 to 2021, such as per capita GDP, secondary and tertiary industry output, and the total amount of investment in fixed assets for the period of 2010–2021, government revenue, and foreign direct investment. Industrial land transaction data were obtained by web scraping from the China Land Market Network. After excluding data with missing prices or areas and removing "unassessed" land grades, potential outliers or extreme values were addressed using a two-sided trimming method, resulting in 19,995 valid data entries. Other relevant socioeconomic data were obtained from the Sichuan Statistical Yearbook, the Chongqing Statistical Yearbook, the China Urban Statistical Yearbook, and the Regional Economic Statistical Yearbook.

2.4. Research Method

2.4.1. Measurement of Industrial Land Marketization

In order to maximize the value of industrial land resources and improve the accuracy of the measurement of the marketization level, this paper adopts the premium rate of industrial land to express the marketization level of industrial land, with reference to the previous research [40], which is calculated as follows:

The premium rate for nth-class industrial land in City i is as follows:

$$\mathrm{R}_{in} = \frac{\mathrm{P}_{in}}{A_{in}} / P_{in}^{b} \tag{1}$$

The premium rate for industrial land in City i is as follows:

$$\mathrm{R}_{i} = \sum_{\mathrm{n}=1}^{15} \frac{A_{in}}{A_{i}} * \mathrm{R}_{in} \tag{2}$$

where P_{in} and P_{in}^{b} denote the total price of industrial land offered in the nth class of industrial land in prefecture i and the minimum price of land offered in that class, respectively; A_{in} denotes the area of industrial land offered in the nth class of industrial land in prefecture i; and A_i denotes the total area of industrial land offered in prefecture i.

2.4.2. The Standard Deviation Ellipse

The standard deviation ellipse (SDE) method uses the marketization level of industrial land in each prefecture-level city as a weight to study the spatial distribution directionality of industrial land marketization through standard parameters such as the regional distribution center, azimuth, and standard distance. This model effectively reflects the development direction and dynamic balance issues of industrial land marketization allocation within the region. The distribution center of gravity (SDE_X, SDE_Y), also known as the center of mass, is an extension of the mean value of the studied factor in two-dimensional space, indicating the point where the moments of industrial land marketization in the spatial plane reach equilibrium at a specific moment. The formula for calculating the coordinates of its center of gravity is given below:

$$SDE_X = \frac{\sum_{i=1}^{n} W_i X_i}{\sum_{i=1}^{n} W_i};\ SDE_Y = \frac{\sum_{i=1}^{n} W_i Y_i}{\sum_{i=1}^{n} W_i} \tag{3}$$

where (X_i, Y_i) are the geographical coordinates of prefecture i; n is the number of prefectures in the study area; and W_i is the weight measured in terms of the level of industrial land marketization in prefecture i.

2.4.3. Global Spatial Autocorrelation Estimation

The essence of the global Moran's I index is to illustrate the strength of the association between neighboring entities, which can characterize the spatial clustering of industrial land marketization levels on a whole spatial scale [1]. Given the neighboring effects on the land supply behavior of local governments, this study intends to use this spatial statistical analysis method to conduct an exploratory spatial analysis of the industrial land marketization level in the Chengdu–Chongqing area. The value of the index range is [−1, 1]. Under a given significant level, Moran's I value is greater than 0, which indicates that the overall pattern of land marketization level shows significant spatial agglomeration; Moran's I value is less than 0, which indicates that the overall pattern shows significant spatial differentiation; and Moran's I value is equal to 0, which indicates that the overall pattern is randomly distributed and does not have spatial autocorrelation. The calculation formula is as follows:

$$\text{Moran's I} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij(X_i - X)(X_j - \overline{X})}}{\left(\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}\right)\sum_{i=1}^{n}\left(X_i - \overline{X}\right)} \quad (4)$$

where X_i and X_j are the attribute values of regions i and j, respectively; n is the total number of research objects in the study region; the spatial weighting matrix X_{ij} represents the linking relationship of the research objects between the ith and j th points, with spatial proximity being 1 and non-proximity being 0; and $\overline{X}$ is the average value of the attribute values.

2.4.4. Gray Correlation Analysis Model

Gray correlation analysis is a method for quantitatively describing the development and change dynamics of a system based on gray system theory. It is characterized by its convenience in calculation and wide applicability [41], making it suitable for systems with partially incomplete information. This method is used to measure the relative strength of the influence of various factors on a particular indicator. Given the complexity of industrial land marketization levels, which are influenced by various socioeconomic factors, this study employs gray relational analysis to reveal the relationship between marketization levels and their influencing factors. The calculation method is as follows:

(1) Determine the comparison and reference series, denoted X_{ij} and X_{0j}, respectively (i = 1, 2, 3, . . ., m; j = 1, 2, 3, . . .,n);

(2) The series were normalized with the following formula:

$$X'_{ij} = \mathrm{X_{ij}} \div \mathrm{X_{i1}} \quad (5)$$

(3) Calculation of gray correlation:

$$\delta = \frac{1}{\mathrm{n}}\sum_{\mathrm{j}=1}^{\mathrm{n}} \frac{\min\limits_{\mathrm{i}}\min\limits_{\mathrm{j}}\left|\mathrm{X'_{0j}} - \mathrm{X'_{ij}}\right| + \mu\max\limits_{\mathrm{i}}\max\limits_{\mathrm{j}}\left|\mathrm{X'_{0j}} - \mathrm{X'_{ij}}\right|}{\left|\mathrm{X'_{0j}} - \mathrm{X'_{ij}}\right| + \mu\max\limits_{\mathrm{i}}\max\limits_{\mathrm{j}}\left|\mathrm{X'_{0j}} - \mathrm{X'_{ij}}\right|} (\mu = 0.5) \quad (6)$$

where δ is the gray correlation; $\min\limits_{i}\min\limits_{j}\left|X'_{0j} - X'_{ij}\right|$ and $\max\limits_{i}\max\limits_{j}\left|X'_{0j} - X'_{ij}\right|$ are the minimum value of the extreme difference and the maximum value of the extreme difference, respectively. μ is the resolution, taking the value of 0.5.

3. Results

This paper covers the period from 2010 to 2021, selecting the years 2010, 2013, 2016, and 2020 as benchmark years. It should be noted that 2010 marks the end of the 11th Five-Year Plan, while 2016 and 2020 span the entire 12th Five-Year Plan period, with 2020 being significant as the year the Chengdu–Chongqing Twin City Economic Circle strategy was established. Analysis of the dynamic changes from 2010 to 2016 revealed that the data from 2013 represented the peak level of industrial land marketization within the study period, displaying more typicality and representativeness in spatial dimensions compared to other years. This provides crucial temporal markers for examining the progress of industrial land marketization in the Chengdu–Chongqing area and its impact on regional economic development. Therefore, this paper selects the aforementioned years as typical to explore the dynamic evolution patterns of industrial land marketization in the Chengdu–Chongqing Twin City Economic Circle, revealing key turning points and development trends in the marketization process.

3.1. Characteristics of Temporal Fluctuations

The trend of the marketization level of industrial land in the Chengdu–Chongqing region is determined by measuring the premium rate (Figure 2). During the study period, the marketization of industrial land in the Chengdu–Chongqing area paralleled that of Chongqing, showing initial growth, a mid-term decline, and a subsequent rise. This pattern illustrates the phased successes of China's land market reforms, with Chongqing exhibiting a notably higher marketization level than Sichuan, reflecting its market vibrancy and competitive intensity. The analysis reveals that from 2010 to 2013, the marketization process was primarily driven by the Chinese government's mandatory "bidding, auctioning, and listing" policies and the proactive response of local governments. Since 2012, initiatives like the Western Development Strategy and the "One Belt and One Road" Initiative have optimized regional industrial structures, further accelerating marketization. However, a significant decline occurred in 2016–2017, largely due to growth challenges in Chongqing's key automotive and electronics industries, which stifled land market liquidity. From 2020 to 2021, the marketization levels stabilized and rose, showing a convergence across the Chengdu–Chongqing area, particularly as Chongqing's industrial activities significantly boosted Sichuan's sector, underscoring the efficacy of the Twin City Economic Circle strategy.

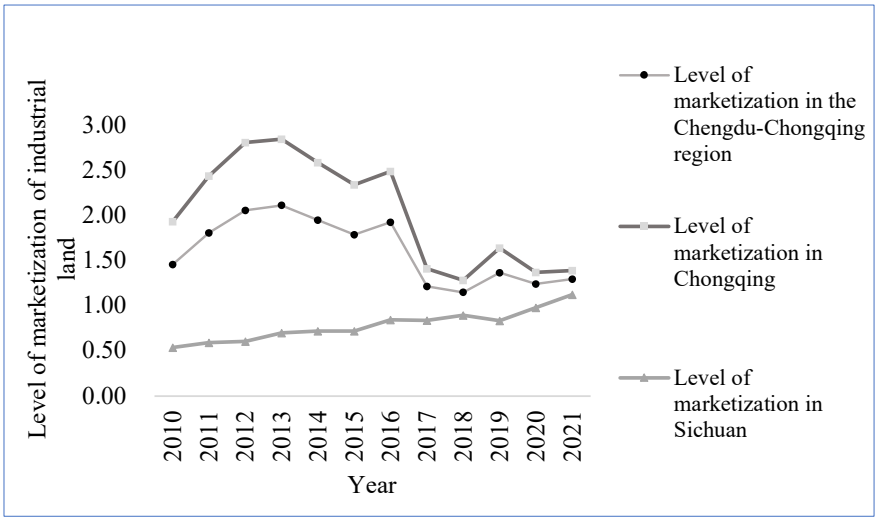

Figure 2. Change trend of marketization level of industrial land in the Chengdu–Chongqing area from 2010 to 2021.

The analysis presented above is based on static time series changes within the Chengdu–Chongqing region. However, due to the randomness and variability of the distribution

of the industrial land marketization level in the region [21], a static approach alone can not accurately reflect the dynamic evolution of industrial land marketization. As a result, the non-parametric kernel density estimation method is used to more clearly illustrate the dynamic evolution characteristics of the industrial land marketization level in the region. Figure 3 displays the time-series dynamic evolution characteristics of the level of industrial land marketization in the Chengdu–Chongqing region in typical years.

The kernel density curve's wave peak from 2010 to 2020 shows a first decline before rising again, with the wave peak in 2020 being the highest. It indicates that more prefecture-level cities in the Chengdu–Chongqing region are concentrated in the low-value zone of the industrial land marketization level, and the right side of the curve in that year shows a small multi-peak trend, demonstrating that the intra-regional differentiation phenome is increasing. The marketization level of industrial land in the Chengdu–Chongqing region's kernel density curve illustrates a change in shortening and then lengthening over the course of the study, indicating that intra-regional differences are also increasing. Additionally, the length of the trailing tail has been lengthening year over year since 2016, with a certain degree of broadening of the distribution extension, indicating that the spatial gap in the marketization level of industrial land in the Chengdu–Chongqing region is increasing.

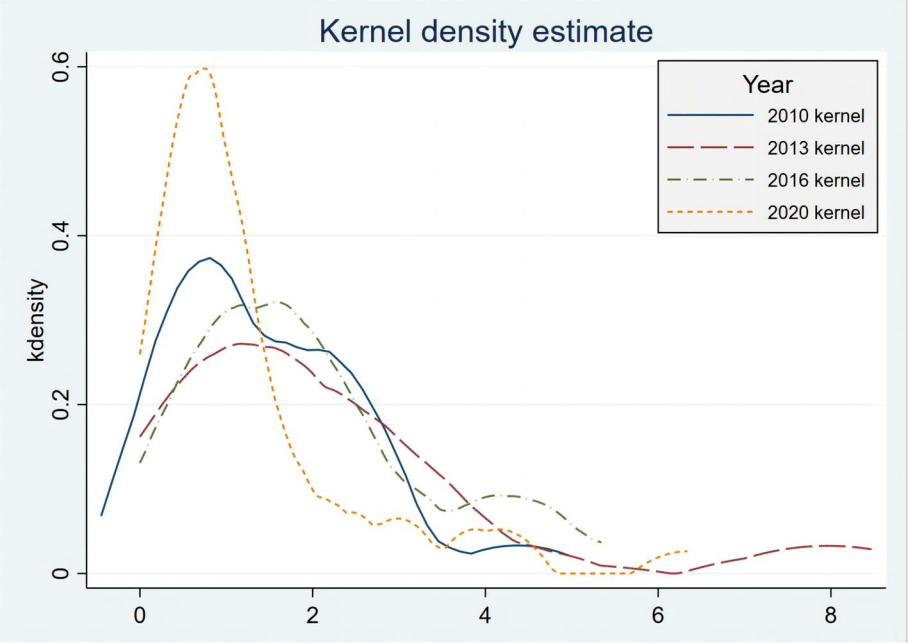

Figure 3. K-density distribution of industrial land marketization level in the Chengdu–Chongqing area.

In conclusion, the vertical height of the wave peaks of the kernel density curve of the marketization level of industrial land in the Chengdu–Chongqing region in 2020 increases, the horizontal breadth reduces, and the number of wave peaks decreases when compared to other typical research periods. In other words, the marketization gap between the Chengdu and Chongqing regions is closing, and there is a characteristic of dynamic convergence. This suggests, at least in part, that the prefectural-level cities within the Chengdu–Chongqing Twin Cities Economic Circle have improved the marketization level of industrial land and that there is a certain clustering effect, with the high-value areas also receiving a bigger boost while the low-value areas are driven significantly.

3.2. Characteristics of Spatial Fluctuations

3.2.1. Cenetr of Gravity Migration Trajectory

In 44 prefecture-level cities in the Chengdu–Chongqing Twin Cities Economic Circle, this study chose five typical years and plotted the trajectory of the center of gravity shift

based on the degree of industrial land marketization in each year (Figure 4). The parameters of the center of gravity shift are displayed in Table 1.

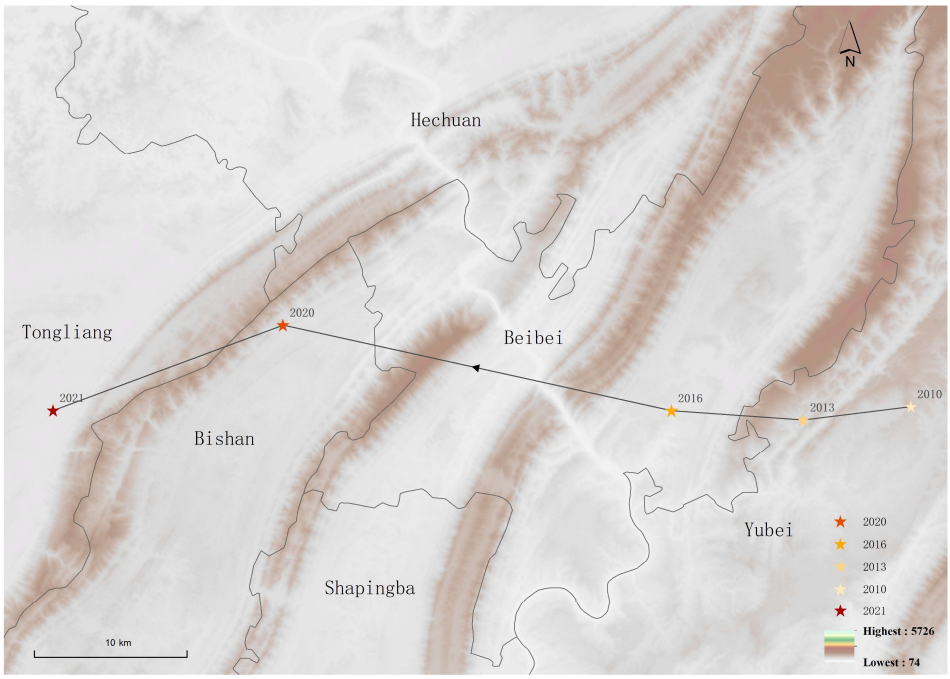

Figure 4. Gravity center migration map of industrial land marketization level in the Chengdu–Chongqing area.

From 2010 to 2013, the centroid of industrial land marketization was located in Yubei District and shifted to Bishan by 2016–2020, eventually moving to Tongliang District in 2021. The movement of the centroid, initially gradual, accelerated significantly, reaching its fastest at 16.08 km/year between 2020 and 2021. Throughout this period, the centroid remained within Chongqing, progressively moving southwest, reflecting a higher marketization in Chongqing compared to Sichuan, with a gradual shift towards their mutual border. This shift was influenced by two main factors: the relocation of old industrial areas due to urban center repositioning in Chongqing since 2012 and the strategic launch of the Chengdu–Chongqing Twin City Economic Circle in 2020, which aimed to foster a major growth pole in Western China. This strategy enhanced regional collaboration and industrial agglomeration, leading to the centroid's relocation to Tongliang District, a strategic site in the economic circle.

Table 1. Gravity center migration parameters of industrial land marketization level.

Year	2010–2013	2013–2016	2016–2020	2020–2021
Centre coordinates	106.7 E 29.82 N	106.63 E 29.81 N	106.54 E 29.81 N	106.13 E 29.77 N
Migration distance	7.11 km	8.67 km	26.08 km	16.08 km
Migration speed	2.37 km/year	2.89 km/year	6.52 km/year	16.08 km/year
Migration direction	West by south	West by north	Northwest	Southwest

3.2.2. Change in Spatial Dimensions

In order to more intuitively reflect the spatial distribution pattern of the industrial land marketization level in the Chengdu–Chongqing region, this paper takes the industrial land marketization data in 2010, 2013, 2016, and 2020 as the benchmark and uses the equal-interval breakpoint method of ArcGIS10.8 software to divide the value of the industrial land marketization level of each research cross-section into six grades (Figure 5).

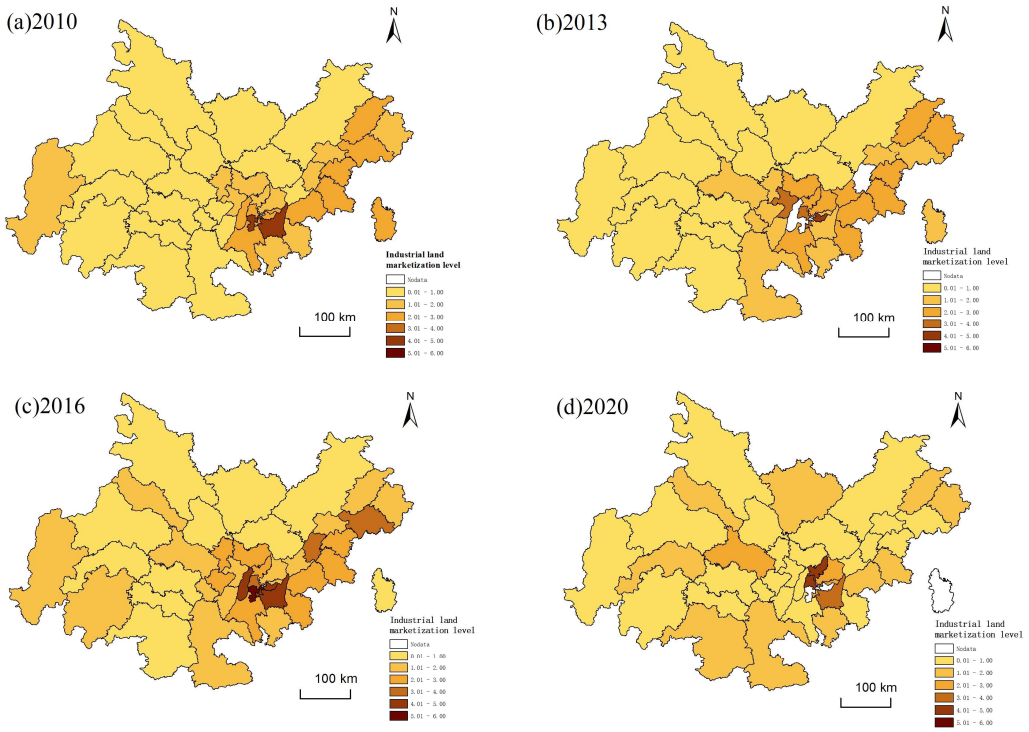

Figure 5. Spatial marketization level and pattern distribution of industrial land in the Chengdu–Chongqing area.

Overall, the value of industrial land marketization has been gradually increasing annually. The average value of industrial land marketization level in the four selected years is 1.46, 2.11, 1.93, and 1.24. Specifically, in 2010, the highest premium rates were mainly distributed in the central urban areas of Chongqing and its northeastern region. The highest values were found in Banan and Jiulongpo Districts, both exceeding 4.0, while the lowest value was 0.17 in Suining. In most other regions, the premium rates fluctuated between 0 and 1. In 2016, the overall premium rates indicated that only the Yuzhong District lacked data on industrial land sales. The highest value remained concentrated in the central urban areas and the northeastern region of Chongqing, though Luzhou and Ziyang in the Sichuan region showed a noticeable deepening of the color band. In 2020, the spatial variation in premium rates was minimal, with high values radiating distinctly not only from Chongqing's central urban areas but also towards the Sichuan region, notably in Ziyang, Luzhou, Nanchong, Deyang, and Meishan.

Broadly speaking, during the study period, the darker bands representing higher levels of industrial land marketization gradually converged from Chongqing's central urban area and northeastern region toward the western region. Since 2016, the bordering regions of southern Sichuan, such as Ziyang, Suining, and Nanchong, have shown a clear growth trend. The level of industrial land marketization in the Chengdu–Chongqing region presents a distribution pattern of "high in Chongqing and low in Sichuan." In the Chongqing region, there is a clustering pattern in the western region, while in Sichuan, the distribution is more dispersed. Cities such as Ziyang, Suining, and Nanchong demonstrate good development potential.

3.2.3. Spatial Autocorrelation Test

The marketization level of industrial land in the Chengdu–Chongqing region spatially exhibits the distribution features of concentrated and contiguous color blocks, and there may be spatial correlation between regions, as can be seen from the above spatial pattern distribution map (Figure 5). Therefore, the global Moran's I index of industrial land marketization level in the Chengdu–Chongqing region is calculated in this article using ArcGIS10.8

and GeoDa software. Through Table 2, it can be seen that the spatial autocorrelation test Moran's I index of industrial land marketization level in the Chengdu–Chongqing region is all significantly positive at the 1% level and that the worldwide Moran's I index typically keeps oscillating within the range of 0.28–0.34 before 2020.

Table 2. Spatial autocorrelation test.

Year	2010	2013	2016	2020	2021
Moran's I	0.325	0.316	0.334	0.135	0.265
p-value	0.001	0.003	0.002	0.033	0.005
Z-value	3.956	3.928	4.079	1.964	3.370

After 2020, the global Moran's I index gradually declines. This study adds the geographical relationship data on the level of industrial land marketization in the Chengdu–Chongqing region in 2021 to this part for comparative analysis in order to test the hypothesis that there is a substantial correlation between the level of industrial land marketization in the Chengdu–Chongqing region. In comparison, it was discovered that the level of marketization of Chengdu–Chongqing's industrial land rose quickly from 2020 to 2021. This finding suggests that the region's high market value tends to concentrate the low value of the region over time in the region's spatial degree of agglomeration, but it also suggests that the region's twin cities' economic policy actively encourages the level of marketization of the region.

3.3. Analysis of the Drivers of the Level of Marketization of Industrial Land

The level of economic development, industrial structure modernization, fixed asset investment, the government's fiscal revenue and expenditure ratio, the amount of foreign direct investment, etc., are all assumed to have an effect on the level of industrial land marketization in this paper in order to further clarify the main driving factors affecting the evolution of the spatial–temporal pattern of the level of industrial land marketization in the Chengdu–Chongqing region. In Table 3, each distinct sign is displayed.

Table 3. The description and explanation of driving factors of land marketization.

Explanatory Variables	Variable Name	Variable Symbol	Definition	Variable Type
Implicit variable	the level of industrial land marketization	Y	Value of industrial land marketization level by prefecture-level city	continuous variable
Independent variable	Level of economic development	X_1	GDP per capita by prefecture/Yuan	continuous variable
	Investment in fixed assets	X_2	Total social investment in fixed assets for the year/billions	continuous variable
	Foreign direct investment	X_3	Foreign direct investment for the year/USD 10,000	continuous variable
	Ratio of government revenues to expenditures	X_4	Government revenue/government expenditure /%	continuous variable
	Upgrading of industrial structure	X_5	Tertiary industry output/secondary sector output/%	continuous variable

The marketization levels in 2010, 2013, 2016, and 2020 are used as the reference series, and each driving factor is used as the comparison series to compute the correlation degree between each factor and the marketization level based on the gray correlation analysis approach and the aforementioned analytical framework. The gray correlation analysis

method, which is based on the earlier study [1], is split into three categories according to its strength: strong correlation (0.75, 1.00], medium correlation (0.35, 0.75), and weak correlation [0, 0.35). Table 4 displays the measurement results. Except for 2020, all years in the study period have a gray correlation value between the level of industrial land marketization and each driver that is greater than 0.5, indicating that all of the drivers considered have a significant impact on the level of industrial land marketization [41].

3.3.1. Level of Economic Development

Throughout the year, there is a consistent medium link between the degree of regional industrial land marketization and economic progress. In the course of the study, it dropped from 0.5534 to 0.4128. The foundational resources for local economic development are land resources, particularly industrial land, which is vital to the growth of the local economy and one of the key industries supporting it. As a result, local governments will modify the type and extent of industrial land use in the area in accordance with their actual degree of economic development, and shifts in the way that regional economic development is developing, among other factors, will have a bigger influence on how industrial land marketization develops.

3.3.2. Investment in Fixed Assets

There was a correlation seen during the study period between the level of industrial land marketization and the amount of fixed asset investment. In particular, the correlation demonstrates a tendency to initially gradually increase, peaking at 0.9772 in 2016 and then sharply dropping. The scale and direction of fixed asset investment determine the evolutionary trajectory of urban infrastructure, industrial layout, and economic structure. In the process of urban development, the government's adjustment of fixed asset investment will have a direct impact on the rise and fall of industrial industries. This influences industrial businesses' competitiveness and capacity for innovation, in addition to their production environment and market conditions. Thus, the degree of industrial land marketization is highly dependent on fixed-asset investment.

3.3.3. Foreign Direct Investment

The link between the level of industrial land marketization and the amount of foreign direct investment remains consistent throughout the study period until 2020, when it starts to show a downward trend. Since the reform and opening up, China's land management practices have seen a trend toward diverse development. Even so, the trend of globalization has resulted in an annual increase in foreign direct investment (FDI), which has helped to some extent in the promotion of regional land marketization. However, the study area's long history, robust industrial base, and generally autonomous self-sufficiency have led to a moderate association between the degree of industrial land marketization and foreign direct investment. The comparatively small increase in foreign investment also raises the need for industrial land, which gives the growth of industrial businesses some momentum.

3.3.4. Ratio of Government Revenues to Expenditures

The government's fiscal revenue and expenditure situation reflects its fiscal balance status over a specific period. For local governments, fiscal imbalances can prompt an increase in land sale activities to bolster government revenue, thereby, to some extent, facilitating a higher level of land marketization within the region. During the study period, the correlation between the fiscal revenue–expenditure ratio and the level of industrial land marketization fluctuated but remained consistently strong, ranging from 0.846 in 2010 to a peak of 0.6871 in 2020.

3.3.5. Upgrading of Industrial Structure

Since industrial restructuring and upgrading directly influence the distribution ratio of land among different industries and are closely related to industrial land prices, the

results of the gray relational analysis show that the correlation of this indicator dropped sharply in 2020. To analyze the impact of industrial upgrading on the marketization level of industrial land more objectively and considering data availability, relevant 2019 data were included for comprehensive analysis. During the study period, the correlation coefficient declined from 1 in 2010 to 0.7292 in 2019 and 0.4128 in 2020, maintaining a moderate to high degree of correlation throughout.

The upgrading of industrial structure will encourage the exodus of industrial land and the reorganization of land use within the city, and land resources, as the spatial facilitator of urban industrial development, will highlight the market demand for land components while promoting the evolution of industrial structure [42]. As a result, there is a significant relationship between regional industrial development, land marketization, and industrial structure upgrading.

Table 4. Gray relational degree of each influencing factor and marketization from 2010 to 2020.

Factors	2010		2013		2016		2019		2020	
	Gray Correlation	Level	Gray Correlation	Level	Gray Correlation	Level	Gray Correlation	Level	Gray Correlation	Level
Level of economic development	0.5534	medium	0.4535	medium	0.6815	medium	0.4806	medium	0.4128	medium
Investment in fixed assets	0.5326	medium	0.4627	medium	0.9772	high	0.8646	high	0.3414	low
Foreign direct investment	0.9827	high	0.4194	medium	0.4890	medium	0.5817	medium	0.3634	low
Ratio of government revenues to expenditures	1	high	0.4870	medium	0.6518	medium	0.7292	medium	0.4465	medium

4. Discussion

Early related studies have demonstrated that foreign direct investment (FDI) has a significant impact on the development of China's industrial sectors [1,43,44], which is consistent with the findings of this study. In 2010, the correlation between FDI and industrial land marketization reached as high as 0.9827. Notably, our research reveals that this correlation has decreased annually in the subsequent years, with the correlation dropping to 0.3634 in 2020, even as the level of industrial land marketization increased during the same period. A possible explanation is that the improvement in the level of industrial land marketization has a general promoting effect on the optimization and upgrading of the industrial structure [5], thereby allowing China to gradually reduce its reliance on foreign investment. Additionally, related studies indicate that the nationwide trend of industrial land marketization has shown a general annual increase since 2010 [7]. However, in the Chengdu–Chongqing region, this trend exhibits an "increase-decrease-increase" fluctuation pattern, indicating a clear difference between the two. A possible explanation is that the national trend is driven by the high marketization levels in the economically developed eastern coastal regions, resulting in an overall upward trend. In contrast, in the Chengdu–Chongqing region, market volatility and policy reforms during this period have had a significant impact on the level of industrial land marketization in the area.

In this study, we have demonstrated the temporal and spatial evolution of the industrial land marketization level in the Chengdu–Chongqing region from 2010 to 2021. While these results carry significant policy implications, a limitation of this research is that it does not provide predictions for the future trends of industrial land marketization. Therefore, future research could build upon this foundation to conduct a more in-depth exploration of these trends.

5. Conclusions and Policy Implications

This paper measures the level of industrial land marketization in 44 prefecture-level cities in the Chengdu–Chongqing economic circle from 2010 to 2021 based on the premium

rate of industrial land. A combination of Global Moran's I, kernel density estimation, centroid migration, and gray relational analysis models are used to study and explore the spatiotemporal patterns and driving factors of industrial land marketization in the region. The main conclusions are as follows:

(1) The process of industrial land marketization in the Chengdu–Chongqing region aligns closely with that of Chongqing, both exhibiting an initial period of steady growth followed by a mid-term decline and subsequent resurgence. The marketization level of industrial land in the Chengdu–Chongqing region is mainly influenced by market dynamics in Chongqing, where the degree of marketization is significantly higher than in Sichuan. Following the establishment of the Chengdu–Chongqing Twin City Economic Circle strategy, the gap in industrial land marketization levels within the region has gradually narrowed, revealing a certain degree of agglomeration.

(2) The level of industrial land marketization in the Chengdu–Chongqing region exhibits a "high in Chongqing, low in Sichuan" pattern, with a spatial distribution trend toward concentration in western Chongqing and southeastern Sichuan. From a spatial pattern perspective, it is evident that the level of industrial land marketization in the Chengdu–Chongqing region exhibits significant regional disparities. In Chongqing, industrial land marketization tends to concentrate in the western part of the city, whereas in Sichuan, it is relatively dispersed. Cities like Ziyang, Suining, and Nanchong display promising development potential. During the study period, the focal point of industrial land marketization in the Chengdu–Chongqing region gradually shifted from Yubei District to Tongliang District, a strategic city at the forefront of the central axis of the Chengdu–Chongqing Economic Circle.

(3) Multiple factors interact to produce the spatial and temporal structure of the regional industrial land marketization level. The level of economic development, modernization of the industrial structure, fixed asset investment, government fiscal revenue and expenditure ratio, foreign direct investment, and other factors primarily drive the spatiotemporal pattern of industrial land marketization in the Chengdu–Chongqing region, and there is a significant difference in the degree of influence of each driving factor in different years.

6. Suggestions

Based on the above conclusions, this paper proposes the following policy insights:

(1) In the Chengdu–Chongqing Twin City Economic Circle, land policy formulation must be grounded in a nuanced understanding of spatial variations in industrial land marketization levels. Considerations should include regional development, resource distribution, and strategic positioning to establish consistent industrial land policies [42]. Specifically, in Chongqing, as a traditional industrial hub, priority should be given to bolstering industrial growth in pivotal cities along the central axis, such as Tongliang and Yongchuan. This strategy aims to facilitate regional economic restructuring and elevate industrial development, positioning Chongqing as a primary battleground for new industrialization. Furthermore, building upon existing cooperation alliances, efforts should focus on integrating and developing regions with significant growth potential, like Suining and Ziyang. This approach not only accelerates the growth of these cities but also fosters new economic hubs, thereby propelling high-quality development across the entire Chengdu–Chongqing region.

(2) The Chengdu–Chongqing area should continue to advance the integration of planning, infrastructure, industry, and public services, exploring the integrated development of regional industries and avoiding industrial homogenization, thereby fostering a virtuous cycle of regional economic development. Furthermore, enhancing the interaction between the Chengdu–Chongqing area and the global market can effectively elevate the marketization level of industrial land [45], achieving high-quality and synchronized regional economic development. This strategy will not only help position the Chengdu–Chongqing area within the global industrial chain but also facilitate the formation of a new develop-

ment paradigm in the context of the new era of Western China's development, leading to an efficient and innovative economic growth model.

(3) To further accelerate the process of land marketization, more precise measures should be adopted. For instance, setting entry thresholds for industrial enterprises and implementing flexible land policies to meet the needs of different types of enterprises. Additionally, a differentiated land transfer term mechanism should be established based on the life cycle of enterprises to ensure the alignment of enterprise life cycles with land use durations. This approach can reduce operational costs for enterprises and promote the rational allocation and efficient utilization of industrial land, thereby enhancing the overall efficiency of land resource use. Moreover, considering that the root cause of the current fiscal competition among local governments is performance evaluation, it is essential to optimize the performance evaluation system for local governments from the source. Instead of relying solely on GDP as the assessment criterion, the evaluation should expand to include various economic development indicators. A comprehensive examination of the dimensions of regional economic development, tailored to local conditions, is necessary. Such optimization is a long-term measure to effectively regulate the land transfer behavior of local governments.

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