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Spatio-Temporal Evolution and Drivers of High-Quality Utilization of Urban Land in Chinese Cities

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Abstract: High-quality utilization of urban land (HUUL) is essential for optimizing urban land use and promoting high-quality development. Previous research has mainly focused on examining urban land use efficiency, neglecting the connection between urban land use and high-quality development. This study reveals the intrinsic association mechanism between high-quality development and urban land use, which can provide comprehensive theoretical and empirical support for high-quality land use and high-quality urban development. This study constructed an evaluation system for HUUL that comprehensively adopted the entropy method, kernel density estimation, and the geodetector model to analyze the spatio-temporal evolution and driving factors of the HUUL levels of 284 Chinese cities from 2006 to 2020. The measurement results showed that during 2006–2020, the HUUL level showed an apparent upward trend, and the eastern region > the central region > the overall region > the western region > the northeast region. From the kernel density map, there was a noticeable trend of varying degrees of increase in the difference of the main peak position of the HUUL level among cities in all regions except the west. Furthermore, some cities in the eastern and western regions had significantly higher HUUL levels than the others. According to the results of the factor analysis, it is evident that innovative use and open use are the internal primary factors that drive the enhancement of the HUUL level. Moreover, the level of economic development is the external primary factor that facilitates the improvement in HUUL level.

Keywords: urban land use; high-quality development; spatio-temporal evolution; driving factors

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1. Introduction

The report of the 19th National Congress of the Communist Party of China indicates that the main conflict in Chinese society has shifted, and the national economy has transitioned from rapid growth to high-quality development. General Secretary Xi Jinping further emphasized in the report of the 20th Party Congress that "high-quality development is the primary task of building a modern socialist country in an all-round way". This indicates that achieving high-quality development has become a new proposition for China's future economic and social development [1]. Urban land is an essential carrier for economic development, and improving the quality of urban land use is crucial to promoting economic transformation and realizing high-quality development. Accompanied by the increasing tightening of environmental resources, urban land is facing the fourfold pressure of low land use efficiency [2], slow land resource flow [3], the mismatch between land use and industrial structure [4], and uncoordinated land use and ecological environmental protection [5]. Therefore, solving urban land use problems to improve the quality and structure of urban land use and enhance the ability to coordinate land development has become an important direction for future urban and regional development.

Urban land use shows different connotations at different stages of development, and land intensive and economic use [6,7], sustainable use [8], and green use [9] are the products of a land system adapted to various stages of socio-economic construction [10,11]. With China's economy shifting from high-speed growth to high-quality development, traditional land use has gradually lagged behind social production [12,13]. In recent scholarly research, scholars have initiated an exploration into the impacts of regional integration [14,15], innovative use [16,17], and land policy [18,19] on urban land use. The research has transitioned its focus from the traditional intensive and economical use of urban land to guiding urban land use through high-quality development, progressively unveiling the relationship between urban land use and high-quality development. Zhang et al. [20] analyzed the effects of globalization, marketization, and decentralization on urban land use from the standpoint of economic transformation. They indicated that urban land use in the Yangtze River Delta showed significant stage and time scale dependence. Ding et al. [21] pointed out that the coupling degree of "land use—economic quality development" was relatively higher in economically developed areas by constructing a coupling coordination evaluation index system. Wu et al. [22] explicitly emphasized that the proper meaning of high-quality development lay in the efficient use of land resources. Achieving the maximum economic, social, and ecological benefits with minimal land investment is crucial for regional high-quality development. While extensive research in the existing literature has focused on the correlation between high-quality development and urban land use, most studies have primarily aimed to explain this relationship [23,24]. However, they have not yet established and assessed the high-quality utilization of urban land (HUUL) based on the concept of high-quality development.

Under the guidance of high-quality development, this paper constructed a HUUL measurement index system based on the new development concept. It then analyzed the spatio-temporal evolution characteristics and driving factors of the HUUL levels of 284 Chinese cities. This provides a vital theoretical foundation and methodological support for promoting the healthy, coordinated, and sustainable development of Chinese cities. First, this paper used the entropy method to calculate the HUUL levels in China from 2006 to 2020, and then the average HUUL levels were calculated to display the spatio-temporal pattern. Second, we employed a kernel density map to portray the dynamic evolutionary trends of the overall and sub-regional HUUL levels, revealing the evolution and differentiation of HUUL levels across the whole and in the four regions. Finally, we utilized the geodetector model to investigate the explanatory power of each driver on the HUUL level at both the internal and external levels. Additionally, we documented the variations in the explanatory power of each driver in the four regions from 2006 to 2020.

2. Indicator Construction and Research Methods

2.1. Indicator Construction and Variable Selection

Since the reform and opening up, Chinese cities have encountered a significant wastage of land resources, degradation of the ecological environment, and three-way conflicts between the population, economic growth, and resource supply [19,25,26]. Concepts such as conservation and intensive use, sustainable development, and green use have been gradually adopted to steer urban land use, yielding positive outcomes during the rapid urbanization stage of the population. However, with the change in the principal contradiction in society [27], problems such as the prominent contradiction between the supply and demand of urban land, uncoordinated spatial structure of land allocation, differentiated quality of land use, and imbalance of intensity and benefits of land use have gradually begun to appear [19,25,26]. In this context, promoting the quality of urban land use and the coordinated use of various land types is crucial for promoting high-quality development. Guided by the principles of high-quality development and new development concepts, this article posits that HUUL is attained through optimizing the land use structure, fostering technological innovation, enhancing international cooperation, bolstering ecological and environmental protection, facilitating fair distribution, improving the policy system, and addressing the deep-seated problems in urban land use processes to achieve high-quality, efficient, and sustainable land resource utilization.

In selecting indicators for this study, we considered the characteristics of urban land use in China at the current stage, focusing on the balanced development of the economy, society, and environment as well as the sustainability, inclusiveness, and innovation of land use [28–30]. Compared with previous land use evaluation indicator systems, this is more in line with the requirements of high-quality economic development in the new period. Table 1 shows the indicator system and the weights of each indicator calculated by the entropy method.

Table 1. HUUL level evaluation index system.

Guideline Layer	Index Layer	Index Meaning	Weight
Innovation utilization	Innovation input	Education expenditure per square kilometer	0.1023
		R&D internal expenditure per square kilometer	0.1299
	Innovation output	Patent authorization per square kilometer	0.1354
	Innovation environment	Number of college students per 10,000 people	0.0586
Coordinated utilization	Industry coordination	Rationalization of industrial structure	0.0005
		Upgrading of industrial structure	0.0044
	Employment coordination	The number of registered urban unemployed per ten thousand people at the end of the year	0.0214
Green utilization	Green life	Per capita green area	0.0565
		Green coverage rate of built-up area	0.0036
	Green governance	Industrial wastewater discharge per square kilometer	0.0004
		Industrial waste gas emissions per square kilometer	0.0009
		Harmless treatment rate of domestic waste	0.0080
Open utilization	Open network	Number of Internet users per ten thousand people	0.0230
	Market opening	The import and export volume of goods per square kilometer	0.2141
	Open financing	The actual amount of foreign capital used per square kilometer in the year	0.0733
Shared utilization	Medical sharing	Number of beds in hospitals and health centers per ten thousand people	0.0395
	Transport sharing	Road area per capita	0.0272
	Cultural sharing	Public library collections per ten thousand people	0.1007

Note: The upgrading of industrial structure is the ratio of the value added by the tertiary industry to that of the secondary industry; the rationalization of industrial structure is measured based on the data of the three industrial structures using the Thiel index.

In addition to the data used in the above index system, this paper also chose five external driving factors related to the urban development carrying capacity, population agglomeration, economic development, financial investment, and energy consumption. Among them, the urban development carrying capacity level uses the ratio of construction land to urban area. The population agglomeration level uses the population per unit of urban land. The economic development level uses the GDP output per unit of urban land as a proxy variable. The government support level uses government expenditure per unit of urban land as a proxy variable, and the energy consumption level uses electricity consumed per unit of urban land as a proxy variable.

2.2. Research Methods

2.2.1. Entropy Method

As a method for objective assignment, the entropy method is better suited for handling multi-indicator data and uncertain information than subjective evaluation methods. It is extensively utilized in quantitative analysis [31,32]. This paper employed the discrete degree of data to objectively determine the weights of indicators to obtain more accurate and rational evaluation results of high-quality urban land utilization. The specific process of the entropy method refers to the research of Zhao et al. [32].

2.2.2. Kernel Density Estimation

As a nonparametric method, kernel density estimation is mainly used to study the spatio-temporal dynamic evolution [33–35]. Frequently employed kernel density functions include the triangular kernel, quadrangular kernel, Gaussian kernel, and Epanechnikov kernel. This research paper concentrated on analyzing the distributional dynamics of the HUUL level in China by employing the widely recognized and commonly used Gaussian kernel function in the theoretical community [36]. The formulas are as follows:

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{\overline{X} - X_i}{h}\right) \quad (1)$$

$$K(x) = \frac{1}{\sqrt{2\pi}} e\left(-\frac{x^2}{2}\right) \quad (2)$$

In the formulas, $K(x)$ denotes the Gaussian kernel density function, $X_1, X_2, \ldots, X_n$ is the HUUL level of each city, $\overline{X}$ is the mean value, n is the number of sample cities, and h is the window width [37].

2.2.3. Geodetector

Wang et al. pointed out that a geodetector is a spatial analysis model used to study the relationship between a certain geographic attribute and its explanatory factors, detect the spatial differentiation of the research object, and reveal its driving force [38,39]. Researchers frequently employ this method to investigate the driving mechanisms of natural economic and social phenomena [40,41]. Compared to other methods, geodetectors have a clear advantage in dealing with mixed types of data and can still be useful when constrained by fewer prerequisites. In this paper, we employed the factor detection probe module of the geodetector to investigate the magnitude of the degree of explanation of each driving factor and the changes in the evolution of the HUUL level. The q statistic is calculated as shown in Equation (3):

$$q = 1 - \frac{SSW}{SST} \quad (3)$$

$$SSW = \sum_{i=1}^{m} n_i \sigma_i^2, SST = n\sigma^2 \quad (4)$$

where $i = 1, 2, \cdots, m$ denotes the classification, partitioning, or stratification of factor Y or variable X, and m denotes the number of classifications. n_i and n represent the number of cells in the i-th stratum and the whole region, respectively, and σ^2 is the variance of the X values in the i-th stratum and the entire region, respectively. SSW denotes the sum of the variances within all strata, and SST is the total variance of the whole area. The q value indicates the factor explanatory power of factor X for the HUUL, and the q value is between [0, 1]. The larger the q value, the greater the explanatory power of the factor [42]. In extreme cases, when the q value of factor X is 1, factor X can fully explain the HUUL, while 0 means that factor X is irrelevant to the HUUL.

2.3. Data Sources

The data were sourced from the China City Statistical Yearbook, the China Urban and Rural Construction Statistical Yearbook, the China Environmental Statistical Yearbook, provincial and municipal statistical yearbooks, and national economic and social development plans from 2007 to 2021. When the statistical caliber of the data was not uniform, the data released by the statistical agency at the higher level prevailed. The study used interpolation to fill in the missing data of individual years and cities. To avoid the problem of multicollinearity, this study tested the covariance of the indicators with the help of variance inflation factor (VIF) analysis. The results showed that the VIF values of all variables were less than 10, and the results obtained met the requirements. Meanwhile, some cities with more missing data were excluded to ensure the chi-square of the variable data and the validity of the empirical results. Finally, we identified 284 cities as the research unit (excluding data from Tibet, Hong Kong, Macao, and Taiwan).

3. Spatio-Temporal Patterns and Dynamic Evolution of the High-Quality Utilization of Urban Land Level in China

3.1. Spatio-Temporal Patterns of High-Quality Urban Land Utilization in China

This study calculated the average HUUL levels of the four regions and the overall HUUL levels from 2006 to 2020 based on the measured HUUL levels. Figure 1 displays the measurements.

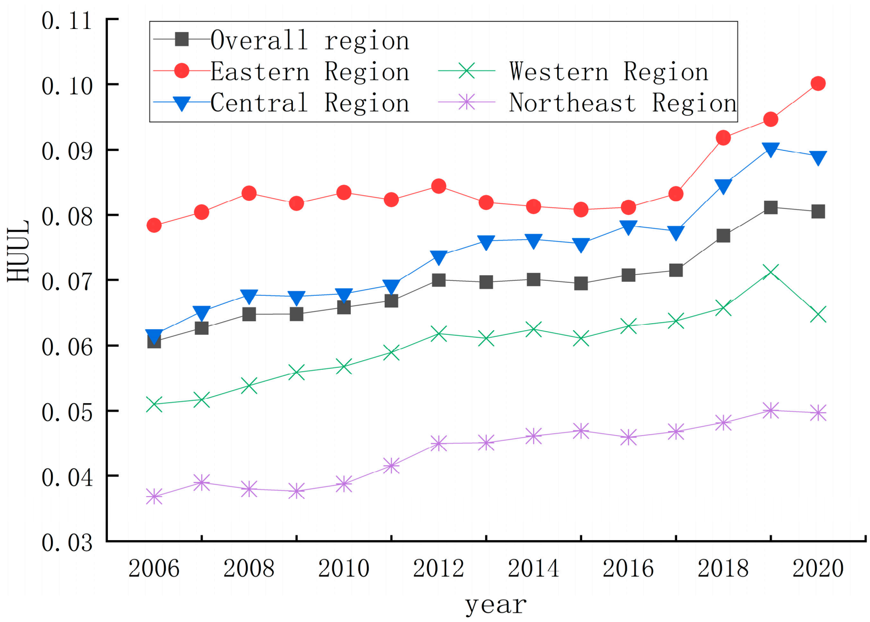


Figure 1. Calculation of the HUUL for the whole country and four regions of China.

During the sample period, the average HUUL level showed a relatively consistent trend of fluctuating growth in both the country and four regions. The overall HUUL level continued to climb, with an average annual growth rate of 2.19%. Regarding subregions, the HUUL level in the eastern region has always been higher than the overall HUUL level. Between 2006 and 2020, the eastern region, benefiting from its geographic location, resource endowment, and policy background, demonstrated a leading HUUL level. The eastern region sustained an average annual growth rate of 1.85%. From 2006 to 2020, the average yearly growth rate of the central region exceeded that of the other three regions, standing at 2.96%, indicating that the central region experienced rapid growth in its HUUL level. During the sample period, there was a clear trend toward smaller differences between the HUUL levels of the eastern and central regions. This suggests that the central region is actively pursuing a high-quality development path within the policy framework for the rise of central China. As shown in Figure 1, the average annual growth rates of the HUUL levels in the western and northeast regions between 2006 and 2020 were 1.80% and 2.32%, respectively, showing a long-term upward trend. However, the western and northeast regions had lower HUUL levels than the overall average due to their remote geographic location, brain drain, and lack of adequate planning and governance of existing land.

3.2. Dynamic Evolution of the High-Quality Utilization of Urban Land Level in China

To illustrate the distribution status, ductility, and polarization trend of the HUUL level, this paper utilized MATLAB2021b software to create a three-dimensional map depicting the kernel density of HUUL levels for the entire country and its four regions. mboxcreffig:land-3023033-f002,fig:land-3023033-f003 illustrate the findings.

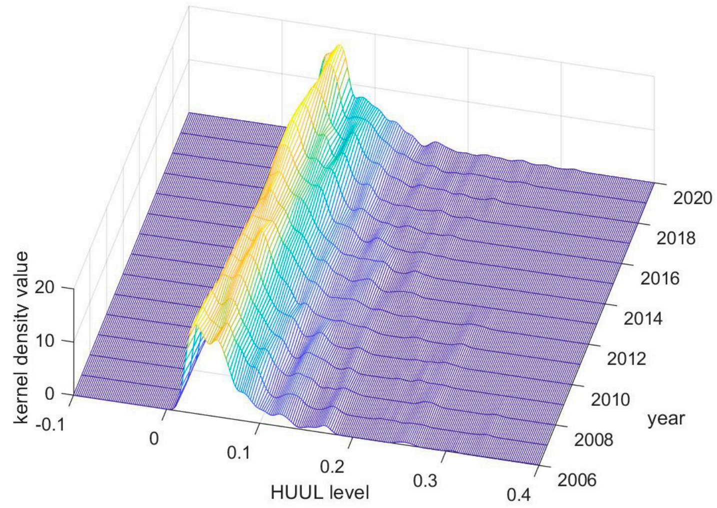
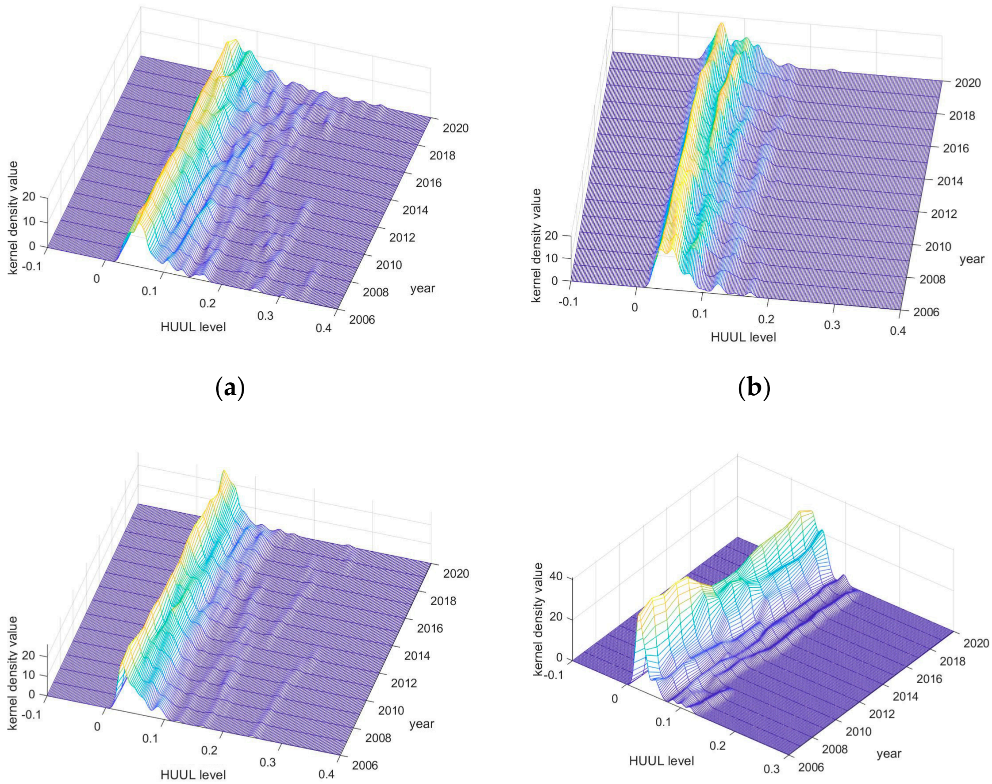


Figure 2. Three−dimensional kernel density estimation of HUUL in Chinese cities.



(**a**) (**b**)

(**c**) (**d**)

Figure 3. Three−dimensional kernel density estimation map of HUUL in the four regions. (**a**) Eastern region; (**b**) Central region; (**c**) Western region; (**d**) Northeast region.

Figure 2 shows that the center of gravity distribution of the overall HUUL level moved steadily to the right from 2006 to 2020. This was accompanied by a steady rise in ductility and a gradual widening of the wave peak span, which showed a clear right trailing characteristic. The measurement results indicated a general upward trend in the country's HUUL levels of the 284 cities, with individual cities exhibiting higher HUUL levels.

From a subregional standpoint, China's HUUL levels exhibited the following notable characteristics:

First, the analysis of the distribution position revealed that the center of gravity distribution of the HUUL level in the four regions exhibited a rightward movement and an expansion trend in ductility. This indicates that the HUUL levels of the four regions showed an increasing trend from 2006 to 2020, consistent with the results of the spatio-temporal pattern measurements in the previous section.

Second, based on the distribution pattern, the HUUL kernel density map trend in the eastern and northeast regions was more consistent. Since 2006, the distribution of HUUL levels in the eastern and northeast regions has shown a trend from a single peak to a double peak, and the span of the peaks has gradually widened. This indicates that the HUUL levels in the eastern and northeast regions showed a trend of bipolarity and that the gap between the two regions is widening. The distribution of HUUL levels in the central region showed a transformation trend from single to multiple peaks, and the span of the wave peaks gradually widened. This demonstrated a trend of multi-polarization in the HUUL levels in the central region, and that the gap in the HUUL level between cities widened. The trend toward multi-level differentiation began to emerge, and the "Matthew effect" of the HUUL level between cities was significant. The variations in HUUL levels among cities in the central region at the primary peak location were notably pronounced compared to those in the eastern and northeast regions. In the western region, the HUUL level consistently exhibited a single-peak pattern, with no discernible differentiation among the primary peak regions.

Finally, regarding distributional extensibility, the kernel density images of the eastern and western regions demonstrated a right-trailing feature. This indicates that individual cities in these regions had significantly higher levels of high-quality land utilization than others. This phenomenon was presumed to occur because individual coastal cities or cities with mineral resources can more readily elevate the HUUL level by developing advantageous resources. The kernel density images of the central and northeast regions did not exhibit prominent trailing features, demonstrating a higher concentration in the HUUL levels in cities within these regions and an absence of exceptionally high HUUL levels.

4. Drivers of High-Quality Utilization of Urban Land Level in China

The HUUL level in the context of high-quality development comprises five essential components: innovative, coordinated, green, open, and shared urban land use. These five components comprise the HUUL level and represent the five facets that contribute to maximizing the economic, social, and ecological benefits of urban land [22]. Therefore, we selected five components as endogenous drivers to examine the drivers of HUUL levels. Moreover, the urban development carrying capacity level, population agglomeration level, economic development level, governmental support level, and energy consumption level are five critical aspects that affect the HUUL from the outside. Given this, this paper employed a geodetector to detect the vital drivers of HUUL from both the endogenous and exogenous perspectives.

4.1. Endogenous Drivers of High-Quality Utilization of Urban Land Level

The research utilized the factor detector method to investigate the endogenous driving factors of high-quality urban land development from a structural perspective and measured the q value and significance level of the five components of innovative, coordinated, green, open, and shared utilization, as shown in Table 2. All endogenous driving factors, except for green utilization in the western region, passed the 1% significance level test. This indicates that these factors possess significant determining power for HUUL.

Figure 4a shows that innovative and open utilization significantly impacted Chinese cities and the four regions more than the other factors. These two factors were the primary internal driving forces of HUUL. First, innovative utilization has a direct impact on the HUUL level. It encompasses both technological innovation and institutional innovation. Technological innovation can effectively improve the quality of urban land use. Using new construction technology and materials can result in more space-efficient buildings, and implementing new agricultural technology can boost land productivity. Institutional innovation can enhance the efficiency of land allocation, increase the dynamism of land utilization, and optimize land utilization. Second, open utilization reflects the degree of influence of external resources on land use. Open utilization refers to the incorporation of external capital and the integration of external technology. Introducing external capital can enhance investment in land development and optimize land utilization. Introducing external technology can bring advanced land use technology and management expertise to improve the HUUL and management levels. Furthermore, shared utilization is the third most significant inherent factor that impacted HUUL, while coordinated and green utilization also played a significant role in driving it.

Table 2. The explanatory power of endogenous driving factors on HUUL.

Area	IU	CU	GU	OU	SU
Overall Region	0.79 ***	0.02 ***	0.04 ***	0.67 ***	0.13 ***
Eastern Region	0.86 ***	0.03 ***	0.07 ***	0.74 ***	0.09 ***
Central Region	0.90 ***	0.05 ***	0.02 ***	0.59 ***	0.16 ***
Western Region	0.58 ***	0.01 **	0.01	0.65 ***	0.09 ***
Northeast Region	0.88 ***	0.24 ***	0.09 ***	0.58 ***	0.40 ***

Note: IU, CU, GU, OU, and SU represent the concepts of innovative utilization, coordinated utilization, environmentally friendly utilization, open utilization, and shared utilization, respectively. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

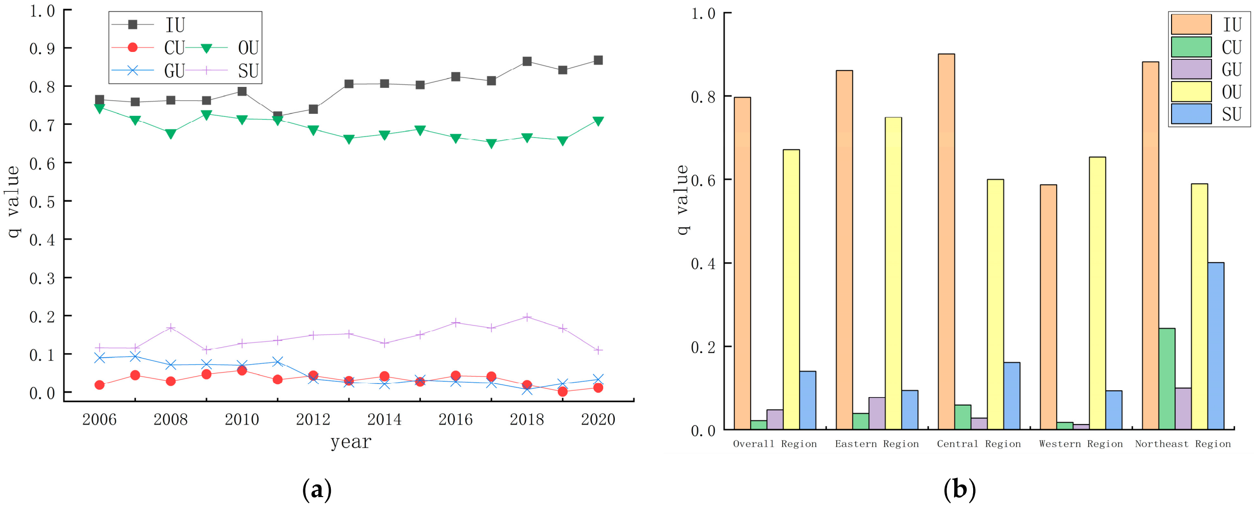


Figure 4. Results of the endogenous driving factor exploration. (**a**) China's overall urban areas and the four regions; (**b**) Year−by−year evolution.

In the eastern region, the primary drivers of HUUL were innovative and open utilization, with explanatory powers of 0.86 and 0.74, respectively. Among these factors, innovative utilization was the primary driving force behind HUUL in the eastern region. The eastern region's location gave it an advantage in absorbing overseas investment, leading to significantly higher open utilization than the other three regions. However, the explanatory power of coordinated, green, and shared utilization in the eastern region was minimal. The explanatory power of the factors for the five dimensions in the central region was higher than that of the eastern region, except for green and open utilization. The primary reason for the higher HUUL level in the eastern region compared to the central region was the contrast in the utilization of open and green resources, with open resource utilization as the dominant factor in this contrast. Open utilization played a significant role in the western region, leading to higher levels of HUUL in individual cities than in others. Due to the high proportion of mountainous areas in the western region and the aridity and low rainfall in most parts of the region, the impact of green utilization on HUUL was in-significant. In the northeast region, the utilization of innovation surpassed the explanatory power of the other four endogenous explanatory factors for the HUUL level. This suggests that innovative utilization is crucial in promoting technological innovation, upgrading industrial structure, and enhancing the HUUL level. Additionally, coordinated and shared utilization had a higher explanatory power on HUUL than the other three regions, playing a vital role in enhancing the high-quality development of cities in the northeast region.

Figure 4b portrays the dynamic evolution of the endogenous drivers' degree of influence on the HUUL level in China. During the sample period, the influence of innovative utilization on HUUL was notably stronger than that of other factors. Open utilization significantly impacted China's HUUL following innovative utilization. Shared, coordinated, and green utilization had a relatively minimal impact on China's HUUL: the impact of coordination and green utilization was smaller than that of shared utilization, but their impact was relatively similar. Regarding the evolution process, the impact of innovation utilization has been rising, with an average annual growth rate of 0.90%, suggesting that both innovation utilization and the HUUL level continued to exhibit a dynamic evolution trend of continuous growth. Except for innovation utilization, the impact of the other four internal drivers on HUUL showed a tendency to decrease from 2006 to 2020. The average annual decay rates were 2.66%, 4.19%, 0.29%, and 0.41%, respectively. Coordinated utilization and green utilization consistently exhibited the lowest explanatory power of HUUL.

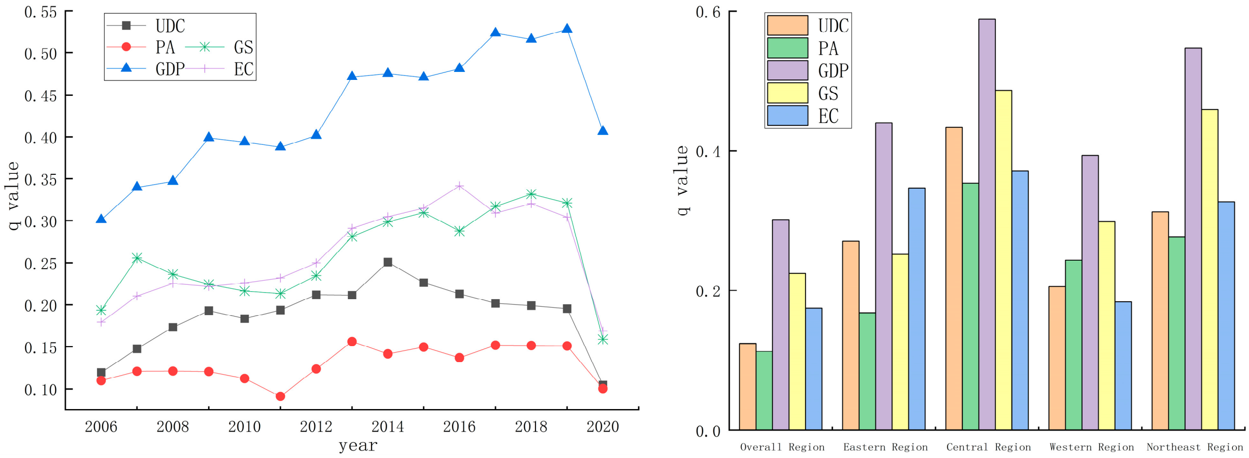
4.2. Exogenous Drivers of High-Quality Utilization of Urban Land Level

Table 3 reports the magnitude of the explanatory power of exogenous drivers on HUUL and their significance levels. All exogenous drivers passed the 1% significance level test, indicating that these factors significantly impact the spatio-temporal evolution of HUUL. The primary drivers of HUUL were the level of economic development and government support. Specifically, the level of economic development was identified as the primary driver of increasing HUUL. First, it attracts more capital and technology to the city, which can be used to invest in and develop the land. Second, the influx of technology can lead to innovative approaches to urban land utilization, resulting in improved efficiency and quality. Finally, increased economic development will enhance the city's scientific, technological, and managerial capabilities, facilitating the efficient and high-quality utilization of urban land. Furthermore, government support also contributes to boosting the HUUL level enhancement process. The government can implement land policies to regulate and control land use, optimize resource distribution on urban land, and improve land use efficiency. Moreover, governmental support can be extended for land development and utilization, advancement of land use technology and management techniques, encouragement of market participation, and increased investment of production factors in urban land. As depicted in Figure 5a, there was variability in the external factors' explanatory power for the four regions:

Table 3. The explanatory power of exogenous driving factors on HUUL.

Area	UDC	PA	GDP	GS	EC
Overall region	0.12 ***	0.11 ***	0.30 ***	0.22 ***	0.17 ***
Eastern region	0.27 ***	0.16 ***	0.44 ***	0.25 ***	0.34 ***
Central region	0.43 ***	0.35 ***	0.58 ***	0.48 ***	0.37 ***
Western region	0.20 ***	0.24 ***	0.39 ***	0.29 ***	0.18 ***
Northeast region	0.31 ***	0.27 ***	0.54 ***	0.45 ***	0.32 ***

Note: UDC, PA, GDP, GS, and EC denote the levels of urban development carrying capacity, population agglomeration, economic development, government support, and energy consumption, respectively. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.



(**a**) (**b**)

Figure 5. Results of the exogenous driving factor exploration. (**a**) China's overall urban areas and the four regions; (**b**) Year−by−year evolution.

Based on the research findings, the explanatory power of exogenous drivers in the eastern region followed this ranking order: economic development level > energy consumption level > urban development carrying capacity level > government support level > population agglomeration level. Furthermore, it suggests that the explanatory power of all of these driving factors surpasses the explanatory power of the factors at the national level. Among them, the explanatory power of the economic development and energy consumption levels were 0.44 and 0.34, respectively, indicating that economic development and energy consumption effectively promote urban land use. The explanatory power of exogenous drivers in the central region was ranked as follows: economic development level > government support level > urban development carrying capacity level > energy consumption level > population agglomeration level. The influence of the five exogenous factors on HUUL was more significant in the central region than in the other regions, suggesting that these factors substantially impacted the HUUL in the central region. In the field of urban construction, the explanatory power of the urban development carrying capacity for HUUL in the central region was substantial, reaching 0.43. This suggests that increasing the urban construction land area in the central region could enhance the high-quality utilization of urban land. The ranking of the explanatory power of exogenous drivers in the western region was as follows: economic development level > government support level > population agglomeration level > urban development carrying capacity level > energy consumption level. Among these, economic development and government support were the most critical factors influencing the HUUL level in the western region. These findings underscore the significance of economic prosperity and governmental backing in shaping urban land quality in the western region. The concentration of the urban population resulting from economic advancement can also contribute to the increase in the HUUL level. The research findings revealed that the explanatory power of exogenous drivers in the northeast region followed the ranking: economic development level > government support level > energy consumption level > urban development carrying capacity level > population agglomeration level. Among these, economic development and government support levels emerged as the primary factors propelling the HUUL level in the northeast region during the research period. The explanatory power of the population agglomeration level in the northeast region was lower than that of other factors due to serious population loss and the lack of urban development impetus in recent years.

This paper further examined the evolution of the intensity of exogenous drivers on the spatio-temporal evolution of HUUL levels from a dynamic perspective. As shown in Figure 5b, the explanatory power of the five factors was roughly distributed in an inverted "U" shape. Among these factors, the level of economic development consistently exhibited a higher explanatory power compared to other factors, positioning it as the primary external influential factor with an average annual growth rate of 2.33%. Following this, the explanatory power of government support and energy consumption levels about HUUL ranked second and third, demonstrating average yearly decay rates of 1.20% and 0.40%, respectively. The influence of urban development carrying capacity and population agglomeration levels on HUUL exhibited a declining trend, with annual average decay rates of 0.84% and 0.57%, respectively. Notably, the population agglomeration level consistently had the least significant impact on HUUL.

5. Discussion, Implications, and Limitations

5.1. Discussion

The high-quality utilization of urban land is an important direction to achieve high-quality urban development. Understanding the current situation and development trend of HUUL is a prerequisite for improving the HUUL level. Therefore, the primary purpose of this study was to analyze the spatial and temporal evolution and driving factors of HUUL by measuring the HUUL levels from 2006 to 2020 to provide a basis for high-quality urban development.

The paper commenced with high-quality development, founded on the new development concept, and comprehensively built an indicator system encompassing five aspects: innovation, coordination, green, openness, and sharing. Compared with the indicator system constructed under the guidance of intensive utilization [43,44] and green utilization [45,46], this paper considered the aspects of coordination, openness, and sharing. This provides a reference for the construction of an indicator system for urban land use in the future.

The results of the entropy and kernel density estimation methods showed that the HUUL levels of each region increased during the sample period. As time passed, "high and high aggregation" and "low and low aggregation" became more obvious in the eastern, central, and northeast regions. This means that, in most cases, areas with high HUUL levels tend to be adjacent to other areas with high HUUL levels. Therefore, we should focus on the "spatial linkage" of urban land use, deepen the spatial diffusion effect, and reduce the spatial polarization effect. It is necessary to firmly establish the idea of "one chess" across the whole country, set up inter-regional coordination and linkage mechanisms, and synergize to improve the HUUL level. We should also strengthen the role of cities with high-quality land use in driving the development of other cities. Cities with low-quality land use should actively seek a new balance between environmental protection and economic growth that suits their development. To achieve the expected improvement in economic, social, and environmental benefits and develop coordinated development in the four regions, it is essential to promote the fair distribution of resources in the area. Furthermore, this study explored the drivers of HUUL from both endogenous and exogenous sources. This research process of examining the endogenous and exogenous drivers of HUUL based on the structural perspective also provides new ideas for subsequent studies. According to the magnitude of the explanatory power of the impact factor, endogenous factors demonstrated higher performance in driving HUUL. Specifically, innovative utilization, open utilization, and economic development exhibited higher explanatory power. This indicates that innovative technology and management concepts, attracting foreign investment and talent, and increasing economic development inputs are powerful ways to achieve high-quality urban development and land use.

5.2. Implications

After thoroughly analyzing the spatio-temporal dynamics of the HUUL level and its influencing factors in each region, this paper presents suggestions and strategies to enhance the HUUL level.

First, the eastern region shows more excellent economic development and higher land utilization, with limited land resource availability. In promoting urban land use, it is essential to prioritize transforming old urban areas and shanty towns, unleashing the internal potential of urban land, advancing green building and smart city construction, and enhancing land use quality. Second, the central region displays moderate economic development and HUUL levels, and possesses relatively abundant land resources. When promoting urban land use, it is crucial to advocate for the integrated use of land and spatial sharing, optimize the land-use structure, prioritize developing new urban areas and industrial parks, and facilitate the efficient allocation of land resources to enhance market efficiency. Third, the level of economic development and HUUL in the western region is relatively low. This region has abundant land resources but a fragile ecological environment. In promoting the high-quality use of urban land, attention should be paid to ecological protection and environmental management to protect the ecological environment and biodiversity. Simultaneously, it is essential to enhance infrastructure construction, upgrade fundamental facilities such as transportation, water, and energy supply, and facilitate industrial transfers and population movements to drive the urbanization process actively. Fourth, the northeast region in China is described as an old industrial base with delayed economic development, abundant land resources, poor land use quality, and numerous old industrial zones and urban villages. Promoting the HUUL level in the northeast should focus on transforming old industrial land, releasing land resources within the city, optimizing the industrial structure, and promoting economic and social transformation development.

5.3. Limitations

Despite our efforts to improve the analysis in this paper, there were still some limitations. First, this paper analyzed the sample mainly from the perspective of the four regions and as a whole, and not from the perspective of the cities. This may make this study unable to apply to each city within this region when analyzing the development direction of each region. Second, the influencing factors and driving mechanisms of HUUL are complex and result from a combination of multiple factors. This paper focused on the impact of a single factor on HUUL when discussing the driving factors without addressing the interactions between the various factors.

6. Conclusions

Based on the above analysis, the main conclusions of this study were as follows:

(1) Further measurements based on HUUL levels showed that between 2006 and 2020, the HUUL levels in the country and its four regions experienced yearly increases. Throughout the measurement period, the HUUL levels in each region and the entire country exhibited the following: eastern region > central region > overall region > western region > northeast region.

(2) The kernel density map illustrated an upward trend in HUUL levels across the overall country and four regions from 2006 to 2020, indicating a progression toward higher levels. From the evolutionary trend of the four regions, it is evident that, except for the western region, the level span of the main peak position of the HUUL level among the cities in the other three regions showed a tendency to expand to varying degrees. Most cities have "high and high aggregation" and "low and low aggregation" HUUL levels. The HUUL levels of individual cities exhibited higher values than others in the eastern and western regions. However, this distributional extension trend was not observed in the central and northeast regions.

(3) The factor detector results revealed that in terms of endogenous factors, innovative utilization and open utilization had notably stronger effects than other endogenous factors in explaining the HUUL in the overall region and four regions. These were the endogenous dominant factors in the spatio-temporal evolution of HUUL levels. Regarding exogenous factors, the primary driving force for the HUUL level as a

whole and the four regions was the level of economic development. Government support and energy consumption levels closely followed, while urban development and population agglomeration levels were at the bottom. The explanatory power of all drivers, except for the level of economic development, decreased to varying degrees over the sample period. With changes in all drivers, only innovative utilization and economic development levels exhibited a consistent upward trend.

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