

Article

How Does Quota-Oriented Land Use Planning Affect Urban Expansion? A Spatial Analysis of 280 Chinese Cities

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Abstract: As the key tool for land use management in China, land use planning (LUP) is characterized by the advantage of being state-led, quota-oriented, and easily monitored. Nevertheless, increasing research has doubted its effectiveness, particularly in controlling urban expansion, while few studies have empirically confirmed it. To this end, we construct a planning constraint index (PCI), supported by land use quota, for evaluating the pressure from LUP on urban expansion, and then analyze the spatial equilibrium of PCI. We also explore the spatial effects of PCI on urban expansion via the geographically weighted regression model (GWR) by collecting the spatial data of 280 prefecture-level cities in China from 2009 to 2016. The results show that: (1) most cities present a shortage of urban land quotas, and spatial disequilibrium exist among regions; (2) PCI has significant negative effects on urban expansion for all of the 280 cities, and spatial disparity of these effects occurs as well; (3) PCI has a stronger influence in southwest China where the economy is relatively backward. This study aims to provide a reference for land use planners and policymakers to help improve the effectiveness of LUP.



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Keywords: land use planning; urban expansion; geographically weighted regression; spatial effects; China

1. Introduction

Urban expansion has been a worldwide phenomenon in the last few decades, especially in developing countries [1–3]. Owing to the rapid urbanization and industrialization, the continuous growth in urban residents generates increasing demands for living and working space. This results in considerable farmland and ecological land being converted into urban land [4,5]. The biodiversity reduction [6,7], farmland reduction [8], and urban heat island effect [9,10] caused by urban expansion seriously threaten the ecological security [11]. The urban expansion also leads to social impacts, such as traffic congestion [12], residential segregation [5], and food shortages [13].

To cope with these negative impacts in pace with urban expansion, many countries have adopted various measures, including planning tools, such as land use planning (LUP) [14], green belt planning [15], and urban growth boundaries [16]; and political and fiscal tools, such as smart growth strategy [17,18] and regional tax resource sharing [19,20]. As one of the countries with the fastest urban expansion in the world, China has exploited quota-oriented LUP for more than 30 years to limit urban expansion, and the last planning is from 2006 to 2020. However, according to statistics, nearly two-thirds of the cities had exceeded the planning target of urban land for 2020 as early as 2016. Therefore, the question remains: is it effective? If it is effective, how effective is the quota-oriented planning tool for limiting urban expansion?

Planning implementation performance is an international burning issue that attracts considerable attention from either policymakers or researchers [21–23]. Considerable research has evaluated the implementation of urban/land plans from two perspectives: a conformance and a performance perspective [21,24,25]. For the conformance principle, scholars compare the actual land use with the planning goals to assess whether the planning goals are achieved and regard it as a criterion for judging the success or failure of the planning [8,26]. However, researchers who appreciate the performance principle argue that success is not an absolute concept and the plan is still effective if it is conducive to the improvement of subsequent decision making [27–29]. Based on the performance principle, quantitative methods, such as econometric models, including the difference-in-difference model [22,30], and regression models [23,31,32], have been used in recent years to evaluate the contribution of planning to the realization of planning targets.

Previous publications have made many meaningful explorations and laid a solid theoretical foundation for this study. Nevertheless, the following two aspects are rarely concerned. On the one hand, previous studies have paid much attention to explaining the external reasons for the failure of planning implementation [33], but discussion on the rationality of the planning itself remains deficient. In China, the fairness of land quota allocation among cities in LUP is often questioned [30]. Due to the top-down LUP system, the expected quota of specific land use types in local planning is allocated by superior planning, and the cities in the same jurisdiction share a total amount of land use quota. That is, cities in the same jurisdiction will have a competitive relationship in land use quota allocation. Hence, the rationality of land quota allocation among cities has become a vital factor affecting the success of planning and is worthy of discussion. On the other hand, whether spatial differences in the impact of LUP on urban expansion exist has been ignored by past research. Such differences may be caused by the strategic interactions between local governments, which has been found by previous research to occur during planning implementation. For instance, Wang et al. (2020) [34] determined that the land supply decisions for a given local government will be affected by the land supply decisions of adjacent local governments. Therefore, in the context of China's top-down LUP system and the coexistence of competition and cooperation between local governments, the reasons for the success or failure of LUP implementation should be explored in conjunction with administrative hierarchies and spatial relationships.

To fill these gaps, we quantify the pressure of LUP on urban expansion by constructing PCI, and conduct a case study of 280 Chinese cities using the GWR model to probe into the spatial effect of PCI on urban expansion. There are two major contributions of this paper. First, PCI is an indicator that combines the planning targets and the actual land use. It is more advantageous than indicators that only consider planning targets. The distribution analysis of PCI in space and urban hierarchy illustrates the equilibrium of urban land quotas in different cities, which will help to understand the governments' preferences in quota allocation. Second, the GWR model applied in the case study can well recognize the spatial effect of PCI on urban expansion. This is very important for evaluating the performance of local governments in LUP implementation of different regions. This study attempts to give a reference for the scientific formulation of LUP and promote its effective implementation.

The rest of this paper is organized as follows. Section 2 introduces the background of this study. Section 3 describes the data and methods. Section 4 presents the results and correlation analysis. Section 5 discusses the key findings of this study. Section 6 provides the conclusions.

2. Background

Urban expansion has played a crucial role in China's economic development in the past 30 years. In China, the urban land is monopolized by the government, and urban expansion relies on land supply of the government [30]. Through land supplying, on the one hand, the local governments could generate an amount of financial revenue, which

supports the local economic development [35,36]. On the other hand, compared with the inner-city land, the low-cost expropriated land is conducive to the investment growth and the industrial development, which provides many development opportunities for the city [34,37]. Therefore, under the GDP-oriented performance achievement assessment, the local governments always tend to supply more land for urban expansion to stimulate local economic growth and achieve political promotion [38]. According to the statistical yearbooks, the urban built-up area in mainland China has increased to 60,721.32 km² in 2020 (Figure 1). This is 2.7 times that of in 2000 (21,379.56 km²) and 4.7 times that of in 1990 (12,856 km²) [39]. Meanwhile, China's urbanization rate is predicted to continue to grow at a speed of approximately 1% per year and reach 70% by 2030. By then, approximately 1 billion people will be living in cities [40], and a massive demand for urban land will be generated in the future.

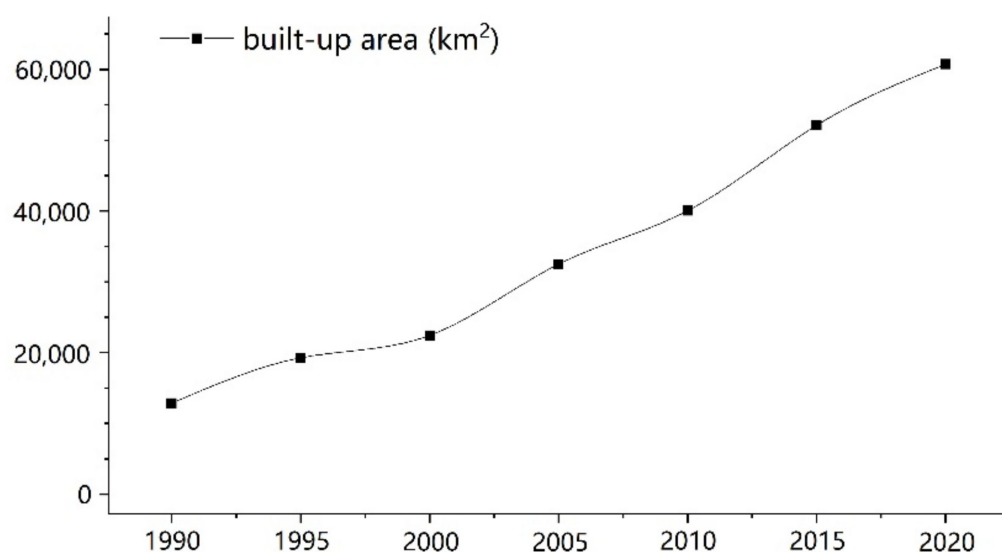


Figure 1. Change in urban built-up area in Chinese mainland from 1990 to 2020.

To deal with the disordered urban expansion, especially the large loss of farmland, China has implemented a strict farmland conservation system, with a quota-oriented LUP as the core measure [31,34]. ‘Quota’ is a mandatory indicator, which refers to the upper or lower limits for a given land type during the planning period (usually 15 years) within a jurisdiction. For urban land, upper quota limits are set as a restriction on urban expansion. As noted by Fang and Tian (2020) [30], it is similar to the concept of urban growth boundaries and green belt planning, but they do not delineate the location of the future development.

As a key indicator elaborately designed in LUP, land use quota has not been well implemented. For the third round of LUP (2006–2020), the national urban land quota designed for 2020 was broken in 2013. By 2016, more than three-quarters of provincial-level planned urban land quotas had been breached. Meanwhile, nearly two-thirds of prefecture-level cities had run out of their urban land quota. Moreover, LUP has strict top-down enforcement regulations in the context of the unique five-level administrative system in China. The land use quota is first formulated in the National General Land Use Plan, which is the highest-level land use plan. Then, it is allocated to provinces, prefecture-level cities, counties, and townships step by step. Faced with such a situation, local governments complained about not only the shortage of construction land quota but also the fairness of quota allocation [30]. However, this has not attracted sufficient attention from planners and policymakers. Therefore, in this study, we make an attempt to explore the equilibrium of urban land quota allocation and its spatial effect on the impact of urban expansion.

3. Materials and Methods

3.1. Study Area and Data Sources

In consideration of the availability and accuracy of data, 280 Chinese cities are selected as the research object in this study, including 4 municipalities directly under the central government (zhi xia shi), 25 provincial capital cities (sheng hui), and 251 general prefecture-level cities (di ji shi). Figure 2 shows the spatial distribution of the research units and economic zoning in China. That will help us understand the differences of research results in response to space and urban hierarchy.

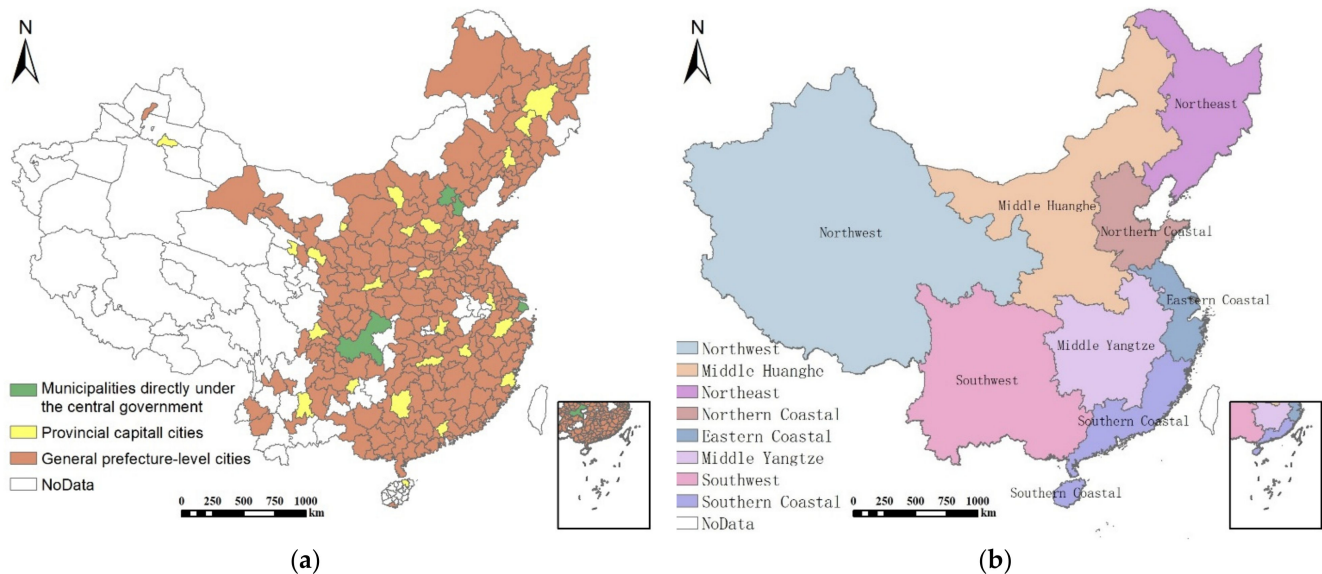


Figure 2. The spatial distribution of research units (a) and economic zoning in China (b).

The data used in this study include three types. First, the expected quota of urban land for the 280 cities in 2020 is collected from China's third round of land use plans, which regards 2005 as the base year and extends from 2006 to 2020. It reflects the intervention degree of LUP to urban expansion. Second, the real scale of urban land comes from the land use survey record and is gathered from the Ministry of Natural Resources of China. These annual data are available from 2009 to 2016. Third, the economic and social data from 2009 to 2016 are acquired from China's Regional Economic Statistics Yearbook, China's Urban Statistical Yearbook, and provincial statistical yearbooks. They include the annual per capita disposable income of urban households, total fixed asset investment, the secondary industry output value accounts for the proportion of GDP, and urban population.

3.2. The Flow Chart of the Methods

The flow chart of the methods in this study is presented in Figure 3. It mainly includes two parts: the spatial analysis of PCI and a case study of the GWR model. The detailed procedure is introduced as follows:

- Step 1. We design a planning constraint index (PCI) based on the data of urban land quota in 2020 and the actual urban land area in 2009. PCI is taken as the main independent variable of the case study.
- Step 2. We perform an analysis of PCI in space and urban hierarchy to expound the equilibrium of urban land quota allocation in LUP.
- Step 3. We calculate urban expansion speed (ULES) as the dependent variable to assess the urban expansion pattern.
- Step 4. Data preparation for control variables.
- Step 5. We conduct an empirical study of 280 Chinese cities using the GWR model to explore the spatial effect of LUP on limiting urban expansion.

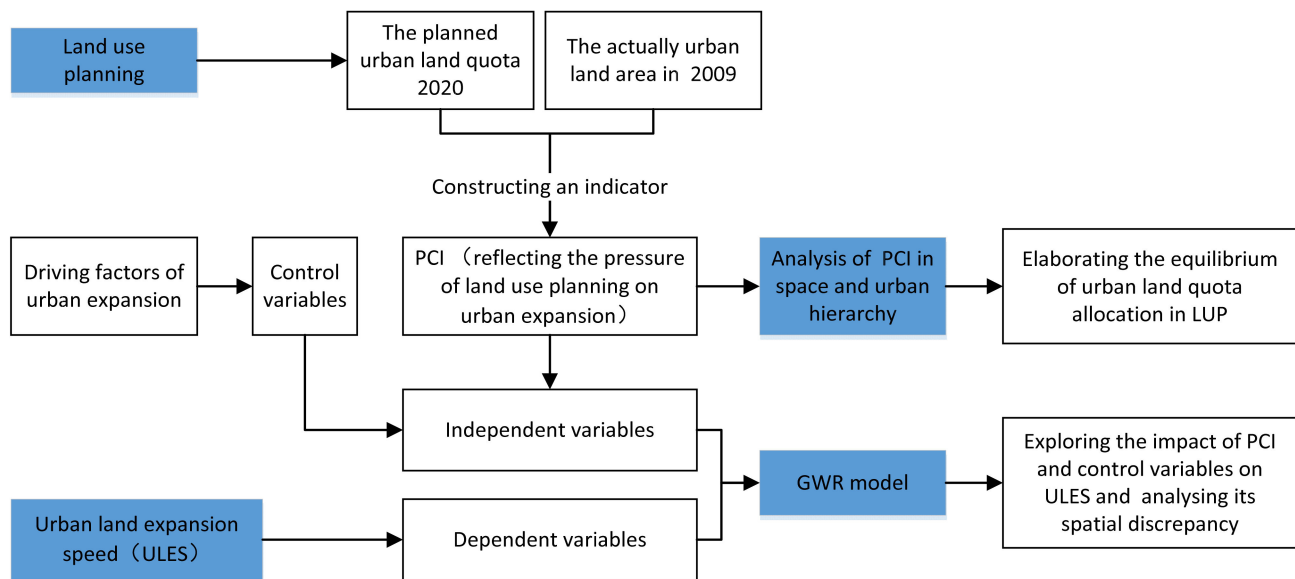


Figure 3. The flow chart of the methods for understanding the impact of quota-oriented LUP on urban expansion.

3.3. GWR Model

The GWR model is a commonly used spatial analysis method that explores the unstable relation between dependent and independent variables in space [41,42]. Compared with the ordinary least squares (OLS) regression, GWR cannot only greatly reduce the spatial autocorrelation of residuals when modeling geographic data [43] but also identify local patterns that cannot be recognized in the OLS model by calculating the local coefficients of the variables [44]. Regional differences can be reflected in land resource endowment, urban development, and even urban management due to the vast territory of China. Furthermore, the urban land quota of cities in the same province is approved by the same superior department. Therefore, regional differences in the impact of LUP on urban expansion may exist, and the GWR model can well simulate and identify the spatial characteristics. The basic expression of the GWR model is as follows:

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^p \beta_k(u_i, v_i)x_{ki} + \varepsilon_i \quad (1)$$

where y_i and x_{ki} are the dependent and independent variables, respectively; β_0 and β_k present the intercept and regression coefficient, respectively; u_i, v_i is the coordinate that represents the location of observation i ; p is the number of independent variables; and ε_i represents error.

We have tried to use adaptive Gaussian, adaptive bi-square, fixed bi-square, and fixed Gaussian kernel functions as the geographical weight. The adaptive Gaussian kernel function performs best and is thus used in this study. It can be written as:

$$w_{ij} = \exp(-d_{ij}^2/\theta_{i(k)}^2), \quad (2)$$

where w_{ij} is the weight of observation j for estimating the coefficient of observation i . d_{ij} is the Euclidean distance between i and j , and $\theta_{i(k)}$ is an adaptive bandwidth size defined as the k nearest neighbor distance of observation i .

3.4. Variables

In previous literature, scholars have analyzed the driving factors of urban expansion from various perspectives. Most of them focused more on urban expansion intensity,

regarding urban expansion area as the dependent variable [38,45,46], but less on urban expansion speed. However, considering the sensitivity of urban expansion area to urban size, it is significant to understand the expansion speed of cities under different development stages. Although ULES is seldom used as the main research object, several researchers have mentioned it in the study of urban expansion [47–49]. In this study, ULES is used as the dependent variable, and it is calculated as follows:

$$\text{ULES} = (S_t - S_0) / (t * S_0) * 100\%, \quad (3)$$

where S_0 and S_t are the urban land areas in 2009 and 2016, respectively; and t is 7 in this paper.

The underlying driving forces of urban expansion have been extensively discussed over the past few decades in both developed and developing countries from the neoclassical, sociological, and institutional perspectives [5]. In China, the government plays an important role in urban expansion by controlling land supply. Government officials always tend to sell more land to achieve financial and economic growth for political promotion [35,36]. As a key tool for land management in China, LUP stipulates the maximum area of urban land that is allowed to increase during the planning period. This will inevitably have an impact on urban expansion. Thus, this study proposes PCI to explore the impact of LUP on urban expansion. It is defined as:

$$\text{PCI} = \text{UL} / \text{ULQ}_{2020} * 100\%, \quad (4)$$

where UL is the actual urban land area in a given year, and ULQ_{2020} is the planned urban land quota in 2020 approved in the LUP. Thus, PCI reflects the pressure that LUP has imposed on urban expansion. If the PCI value is greater than 100%, then the city has used up the land quota for planning permission.

In addition to the impact of LUP, the necessary control variables must also be considered. Indicators about economic level, investment, industrial structure, and demographic were generally considered indispensable for explaining urban expansion in previous literature [3,38,50]. Firstly, eight determinants are selected as potential control variables on the basis of data availability in this paper. They are gross domestic product (GDP) per capita, urbanization rate (UR), disposable income of urban households (INCOME), log of total fixed asset investment (FAI), log of foreign direct investment (FDI), changes in the share of secondary industry in GDP (SIC), population density (PD), and log of urban population (UPOP). Secondly, we screen the variables by the Stepwise Regression model, which ensures that all independent variable is significant and no collinearity. In the end, the main variable PCI and four control variables INCOME, FAI, SIC, UPOP are left, and the other four variables are removed. In addition, the variance inflation factor (VIF) for the five independent variables varies between 1.08 and 4.83, and the maximum value is much less than 10. Therefore, there is no collinearity problem among the variables. Detailed definitions of the final variables are shown in Table 1.

Table 1. Variables.

Type	Category	Abbreviation	Description
Dependent variable	Urban land expansion speed	ULES	Average annual urban land growth rate from 2009 to 2016
Independent variables	Land use planning	PCI	The proportion of urban land area in 2009 to the planned urban land area approved in the LUP in 2020
	Economic level	INCOME	Log of disposable income of urban households in 2010
	Investment	FAI	Log of total fixed assets investment (annual average 2009–2016)
	Industrial restructuring	SIC	Changes in the share of secondary industry in GDP from 2009 to 2016
	Demography	UPOP	Log of urban population in 2010

Note: Log is the natural logarithm.

4. Results and Analysis

4.1. Spatial Pattern of ULES from 2009 to 2016

Figure 4a,b describes the expansion intensity (the average annual change in urban land area) and expansion speed of urban land in different regions of China from 2009 to 2016, respectively. From the perspective of urban land expansion intensity (ULEI) (Figure 4a), no significant clustering feature in space is observed, and high and low values occur uniformly in different areas. Chongqing is the city with the highest ULEI, and its annual expansion area has reached 10,447.6 ha. However, when we focus on the ULES (Figure 4b), different spatial patterns are observed, with an evident characteristic of spatial agglomeration. Despite presenting the highest ULEI, Chongqing has only a medium ULES. Thus, no necessary link is found between ULEI and ULES of each city. The former may depend more on the city size, while the latter may be more sensitive to the location of the city.

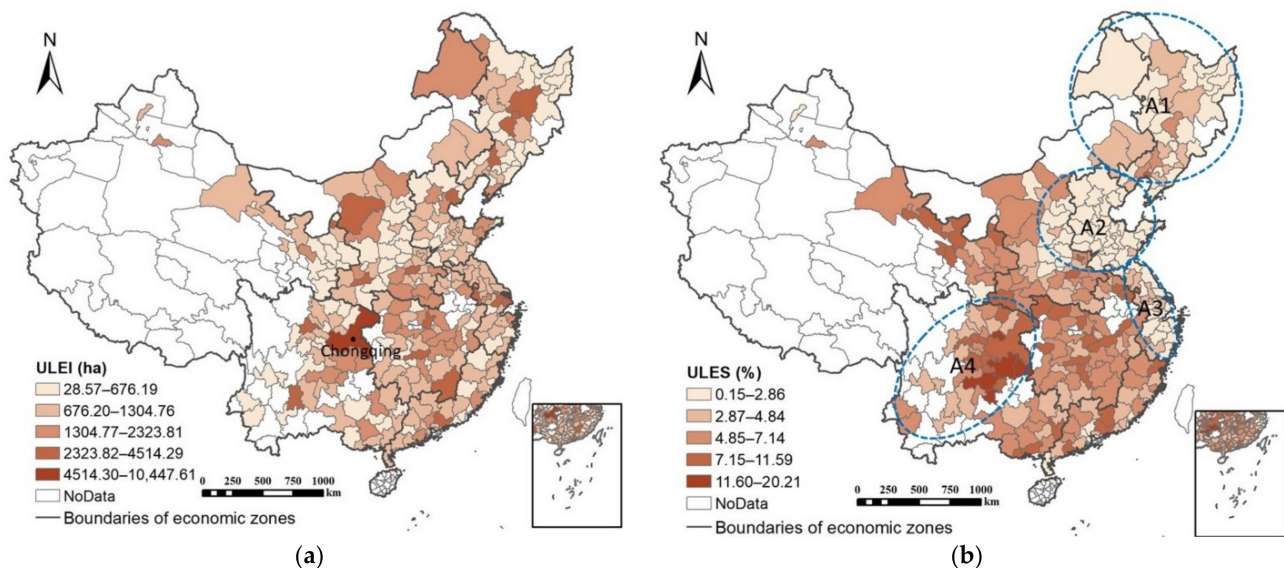


Figure 4. Change in urban land from 2009 to 2016. (a) ULEI; (b) ULES.

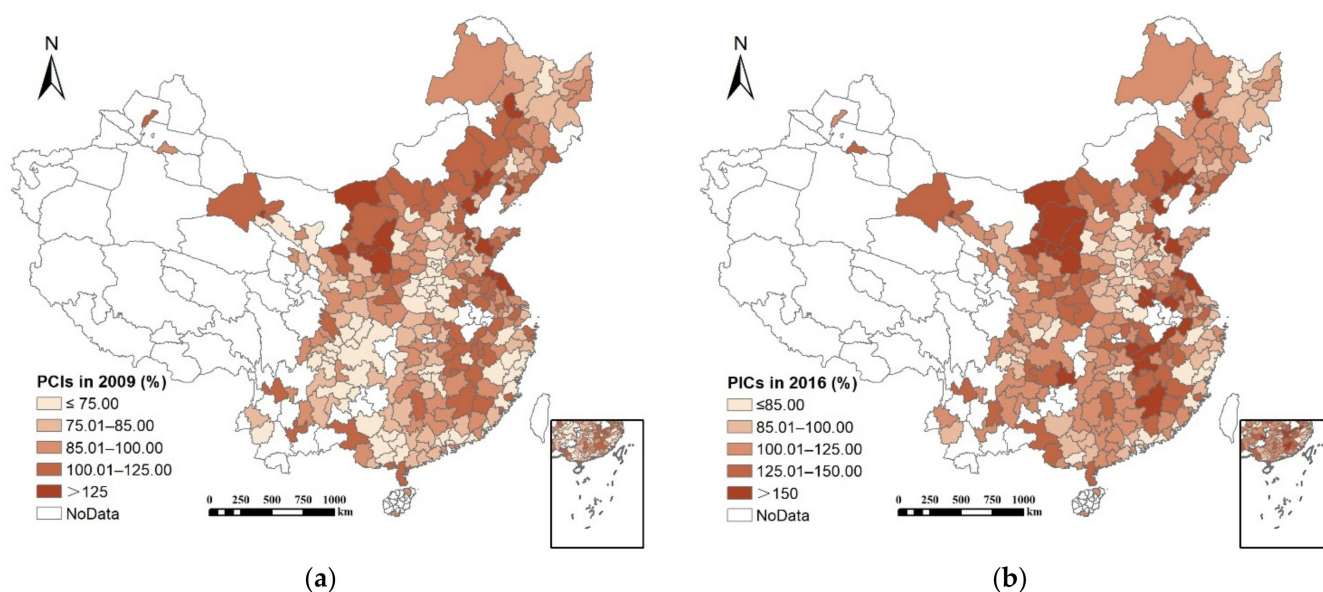
Figure 4b shows that the ULES of cities in the Northeast (circle A1 in the figure), Northern Coastal (circle A2), and Eastern Coastal China (circle A3) is relatively low, whereas that in other regions, especially in Southwest China (circle A4), is relatively high. For different regions, the main affecting factors of ULES vary. Table 2 describes the ULES and its regional characteristics.

Table 2. ULES and its regional characteristics.

Regions	ULES	Regional Characteristics
Northeast China	Low	Labor outflow, aging population, and slow economic development.
Eastern Coastal China	Low	High level of urbanization and economic development, advanced industrial structure, and population inflow.
Northern Coastal China	Low	Medium level of urbanization and economic development.
Middle Huanghe Region	Nonstationary	Covering a large area, with a medium or low level of urbanization and economic development
Middle Yangtze Region	High	Medium level of urbanization and economic development.
Southern Coastal China	High	High level of urbanization and economic development, as well as population inflow.
Southwest China	High	Low level of urbanization and economic development.
Northwest China	High	Low level of urbanization and economic development.

4.2. Spatial Patterns of PCI in 2009 and 2016

As shown in Figure 5, the PCI value in 2009 (Figure 5a) varies evidently with each city and presented a certain spatial agglomeration feature. The PCI value is relatively lower in central and southwest China, yet relatively higher in other regions. Figure 5b shows that from 2009 to 2016, most cities experienced an increase in PCI, particularly those in Southwest China. Table 3 presents detailed statistical information about the PCI values in these cities. From 2009 to 2016, the number of cities with a PCI value below 75% decreased from 71 to 8. On the other hand, the number of cities with a PCI value over 125% increased from 16 to 78. Therefore, most of the cities faced great pressure on land shortage for urban expansion in 2016.

**Figure 5.** PCI values of 280 prefecture-level cities in China in 2009 (a) and 2016 (b).**Table 3.** Number of cities with PCI values in different range.

Range	0–75	75–85	85–100	100–125	>125	Sum
2009	71	57	78	58	16	280
2016	8	30	56	108	78	280

According to further statistics shown in Table 4, in 2009, cities with the smallest mean value of PCI are characterized by an urban population of 5–10 million. Nine of the fifteen cities are provincial capitals and the six other cities are located in more developed areas

along the eastern coast. Cities with the second-smallest mean value of PCI were Beijing, Shanghai, Tianjin, Chongqing, Guangzhou, and Shenzhen, which had a population of more than 10 million. They are all of the growth poles of regional development, and the first four are municipalities directly under the central government. This finding suggests that the higher administrative-level or larger cities have relative privileges over the other cities during the urban land quota allocation. Similar findings were reported by Li et al. (2015) [38], who argued that urban expansion and its driving factors are sensitive to administrative hierarchy.

Table 4. Statistics of PCI values in cities with different urban population.

Urban Population (Million)	Obs.	Mean Value of PCI in 2009 (%)	Mean Value of PCI in 2016 (%)	Changes in PCI from 2009 to 2016 (%)
0.2–1	57	90.38	119.39	29.01
1–3	158	90.78	114.87	24.09
3–5	28	90.93	107.69	16.76
5–10	15	77.55	94.93	17.38
>10	6	83.57	97.65	14.08
Sum	280	89.83	113.89	24.06

Table 4 also presents the 2009–2016 changes in mean PCI for cities with different sizes. For cities with a population of less than 5 million, the mean value of PCI did not differ significantly in 2009, but a certain difference was observed in 2016. The average PCI for cities with a population of 0.2–1 million increased by 29.01%. The comparison of the mean value of PCI in 2009 and 2016 indicates that urban land quotas in smaller cities were used up earlier than those in larger cities.

A problem worthy of our attention is that the PCI values in some cities were greater than 100%, especially in some northern cities. Thus, the amount of urban land in these cities in 2009 had exceeded the planned value for 2020. This situation might be attributed to two reasons. On the one hand, the prediction of urban land in 2020 in LUP was based on the data in 2005, which might have some errors that could be ignored because of the relatively poor technical conditions of the First National Land Survey. On the other hand, some urban land areas had expanded before they had been approved by the local government, and these areas had not been considered in the LUP. For the cities with PCI values more than 100%, they had minimal land available for urban expansion and could only rely on the policy of “increasing vs. decreasing balance of urban–rural built land” and “urban village reconstruction” to obtain some land for urban development. For most cities, the superior government successively approved the adjustment plan of the urban land quota around 2016.

4.3. Comparison of Model Performance

Before the GWR model is applied, its applicability was tested using Moran’s index of the residuals of the OLS model. The results show that Moran’s index is 0.2035, and it is significant at 1%. That is, the residuals in the OLS model are spatially autocorrelated. Therefore, the GWR model is suitable for explaining the relationships between LUP constraint and urban expansion. The reason is that many studies have shown that the GWR model can effectively eliminate the spatial autocorrelation of OLS model residuals. A comparison of coefficients between the GWR model and the OLS model is presented in Table 5. The adjustment R^2 of the GWR model is larger than that of the OLS model, and the AICc value is smaller than that of the OLS model. This result verifies the superiority of the GWR model. More information about the results of the OLS model and the GWR model can be seen in Table 6.

Table 5. Comparison of coefficients between the OLS model and the GWR model.

Models	R ²	Adjusted R ²	AICc	Residual Sum of Squares	Moran's I of the Residual
OLS	0.3480	0.3337	1265.2985	1436.4360	0.2035
GWR	0.6155	0.5187	1203.4690	847.1720	0.0355

Table 6. Parameters of OLS model and the summary statistics for varying (local) coefficients of variables in GWR model.

OLS						GWR				
Variable	Estimate	Standard Error	t(Est/SE)	P > t	VIF	Mean	Min	Max	STD	Range
Intercept	41.692	5.915	7.050	0.000	/	39.418	−0.871	87.958	17.574	88.828
PCI	−0.038	0.006	−6.400	0.000	1.080	−0.041	−0.121	−0.014	0.026	0.107
INCOME	−3.223	0.752	−4.290	0.000	1.630	−3.388	−8.882	1.186	1.929	10.068
UPOP	−1.910	0.379	−5.050	0.000	4.410	−2.111	−4.264	−0.747	0.737	3.516
CIR	0.098	0.019	5.230	0.000	1.080	0.086	−0.066	0.249	0.085	0.314
FAI	1.590	0.377	4.210	0.000	4.830	2.018	0.619	4.648	0.778	4.030

The coefficient of PCI reflects the influence degree of PCI on ULES. It varies from −0.041 to −0.121, suggesting that PCI has a sustained negative impact on ULES and the LUP has indeed moderated the speed of urban expansion. This finding is similar to that of Zhou et al. (2017) [31]. That is, although the actual situation of urban land expansion is not completely consistent with the LUP goals, LUP still plays a certain role.

UPOP has a sustained negative impact on ULES, whereas FAI has a consistently positive impact on ULES. However, the impact of INCOME and SIC on ULES varies from positive to negative. The variations in the regression coefficients imply that the influence of variables on urban expansion speed is inconsistent among different cities. Therefore, exploring the spatial differences concerning the impact of various variables on ULES is necessary.

4.4. Spatial Effects of PCI and the Control Variables

Figure 6b shows significant differences in regression coefficients among cities in different regions. This reflects the obvious spatial correlation of the impact of PCI on ULES. This finding is supported by the local R² (Figure 6a), which varies from 0.3418 to 0.7133. The regression coefficients of PCI increase gradually from southwest to northeast, with the northeast region as an exception. Yunnan, Sichuan, Guizhou, Chongqing, and Guangxi have the largest negative impact on ULES. Therefore, the southwest area is more affected by PCI, whereas other regions, such as the northern coastal and the southeast coastal areas, are less affected. On the one hand, the spatial distribution of regression coefficients of PCI is similar to that of ULES in Figure 4b. This finding indicates that LUP will exert a great inhibitory effect when urban land grows at a fast rate. On the other hand, in consideration of the level of economic development, PCI plays a weaker role in controlling urban land expansion in more developed areas but a stronger role in less developed areas.

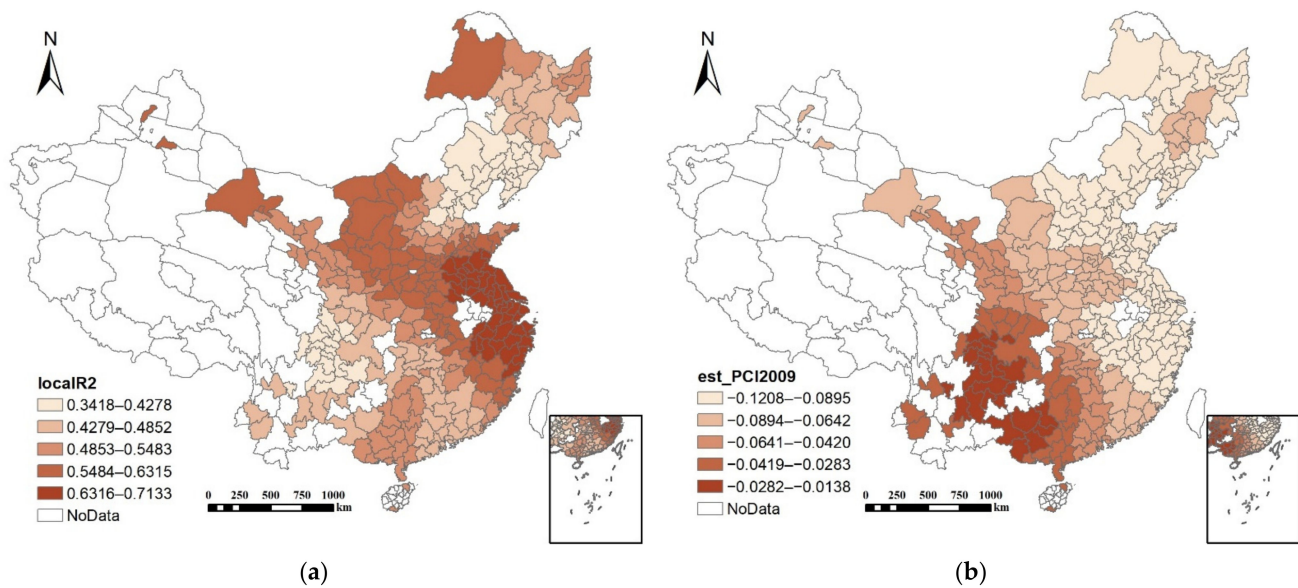


Figure 6. Spatial patterns of local R^2 and coefficients for PCI in the GWR model. (a) Local R^2 , (b) local coefficients of PCI.

The spatial distribution of local regression coefficients of the four control variables is shown in Figure 7. In terms of the investment factor, FAI has a significant positive impact on ULES, and the impact of FAI on ULES is relatively greater in underdeveloped areas such as southwest and central China (Figure 7a). With regard to income (Figure 7b), it has an overall negative impact on ULES except for several exceptions (the major disaster-stricken areas due to Sichuan M_S 8.0 Earthquake in 2008) in Sichuan and Gansu. This finding suggests that the growth rate of urban land will slow down under the condition of increased income level. Urban population has a sustained negative effect on ULES (Figure 7c). The spatial distribution of regression coefficients shows that the central and southwestern regions of China are more sensitive to the change in urban population. The growth of the secondary industry is considered one of the main reasons for the growth of urban land [28,50], and this study finds a similar result. The impact of secondary industry changes on ULES is positive on the whole, especially in the Middle Yangtze Region and the Middle Huanghe Region (Figure 7d).

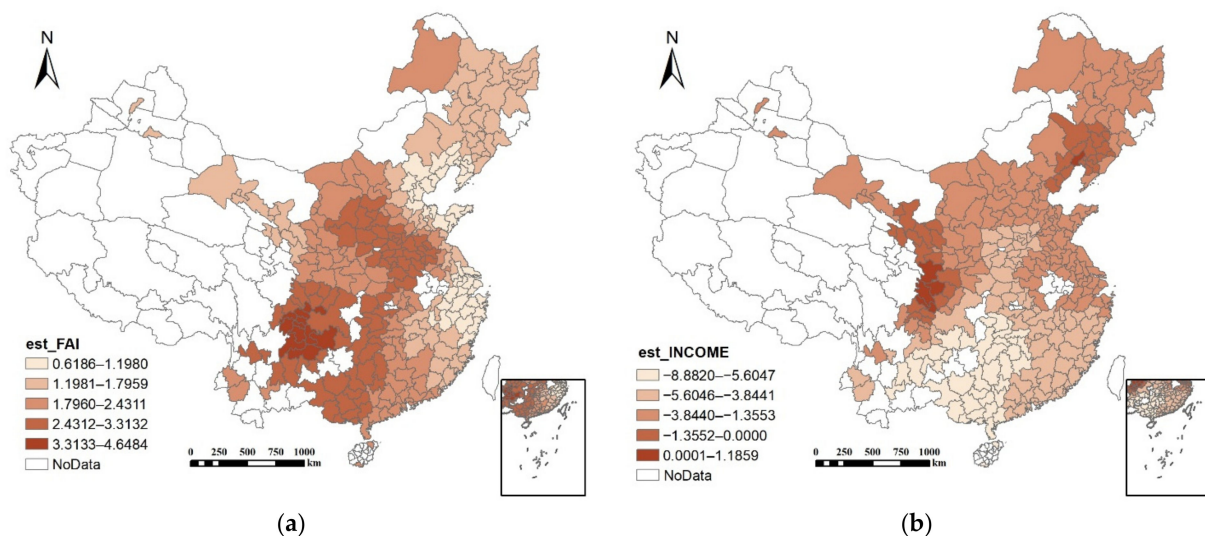


Figure 7. Cont.

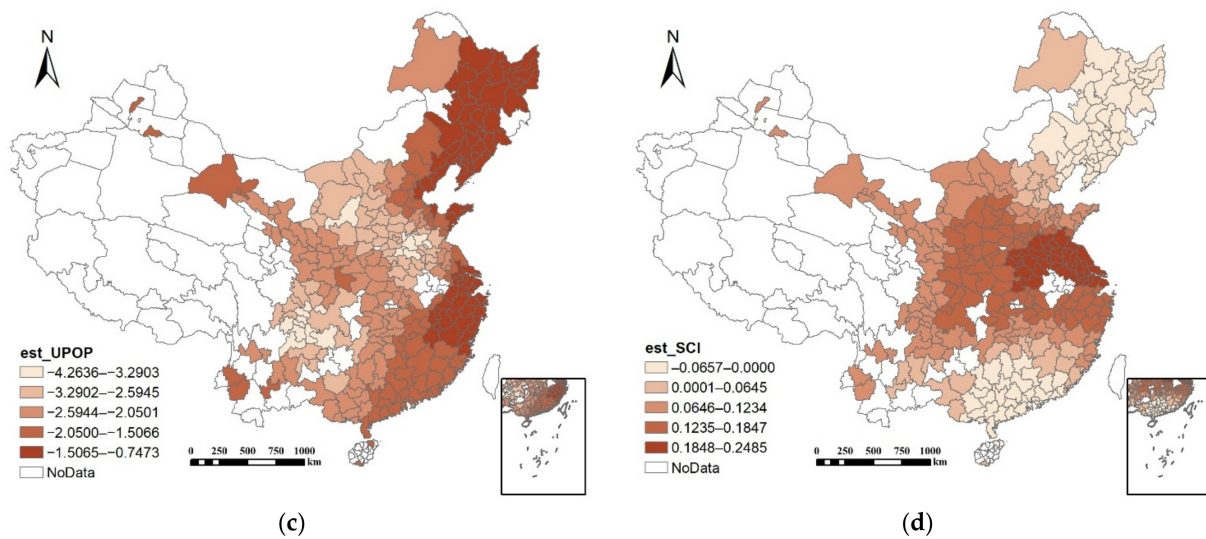


Figure 7. Local regression coefficient of control variables. (a) Local coefficients of FAI, (b) local coefficients of INCOME, (c) local coefficients of UPOP, (d) local coefficients of SIC.

5. Discussion

5.1. Urban Land Quota in LUP

The PCI results show that in 2009, just 3 years after the LUP implementation, 74 of the 280 cities had a PCI value of more than 100. This condition suggests that a certain gap exists between the planned new urban land (i.e., the urban land quota) and the actual demand for urban land. This may not simply be regarded as inadequate implementation of the plan, but the plan itself deviates from the actual needs of local urban land development. As Tian and Ma (2009) [36] pointed out, land supply policy is a double-edged sword. Accordingly, the urban land quota that does not match the actual demand will lead to two results. (1) If the expected urban land quota exceeds the actual demand in terms of urban expansion, then the control of LUP on urban expansion will be relatively weak, resulting in land waste. The reason is that if sufficient land quotas for urban expansion exist, the government always tends to sell more land to obtain fiscal and economic growth, which is beneficial to the promotion of officials. (2) If the expected urban land quota is less than the actual demand for urban expansion, then it may lead to insufficient supply of urban land, causing a rise in land prices and further hindering the rational development of the city. Therefore, finding a scientific method to forecast the future urban land demand is of great significance for determining a reasonable urban land quota and improving the effectiveness of LUP.

5.2. Equilibrium of Urban Land Quota among Cities in Different Regions

According to our research, PCI vary greatly among cities of different regions and levels, which indicates the disequilibrium distribution of urban land quota. Highly developed cities have advantages in urban land quota allocation. This may lead to the siphon effect and increase the development gap between cities. The reason is that urban land quota is a key factor affecting urban land supply and urban expansion, which are the important potential impetuses of economic growth. Thus, regional equity should be considered in land use quota allocation in LUP. Given that LUP is top-down in China, the allocation of land quota is currently determined by its immediate upper-level planning in accordance with its natural environment condition, economic development demand, land supply capacity, population growth, and other socioeconomic indicators. However, no unified estimation method to allocate these quotas is available, and the allocation process may be affected by planners' preferences, resulting in unequal land use quotas in these cities. Some scholars have paid attention to the distribution of land quota among cities and conducted some researches [51,52]. Nonetheless, they usually regarded the realization of planning

goals as the research orientation while ignoring regional equity. As a result, in-depth, consistent, and popular allocation methods for land quota should be further studied.

5.3. Performance of LUP in Controlling Urban Expansion

The impact of LUP on urban expansion can be reflected from two aspects. (1) Most cities present a shortage of urban land quotas. From the results of PCI, the PCI values of 74 cities had exceeded 100% in 2009, and those of the 112 other cities had gradually reached 100% by 2016. Accordingly, out of 280 cities, only 94 cities have urban land quotas. Although the PCI value has exceeded 100%, the governments usually would not stop supplying land for urban development to pursue fiscal revenue. They may adopt policies, such as “increasing vs. decreasing balance of urban–rural built land,” to increase the available quota for urban land [53]. Therefore, the role of LUP in controlling the rapid expansion of urban land is limited and has been confirmed by several literatures [30,31]. The authority of LUP is also questionable in the implementation process when the rationality of LUP is ignored at the beginning of its formulation. (2) The significant difference in the local regression coefficient of PCI in the GWR model indicates a spatial discrepancy in the impact of PCI on ULES. This result provides another explanation for the findings of Wang et al. (2017) [34]. That is, the implementation effect of LUP is similar in neighboring cities, but very different in regions farther apart. In pursuit of economic development, the government often increases the land supply without authorization, regardless of the restrictions of urban land quota. The reason is that the assessment mechanism of the government and officials is imperfect, and the punishment provisions for illegal acts are unclear. Therefore, it is necessary to establish an early warning mechanism and a punishment mechanism for illegal acts. At the same time, LUP should be adjustable on the basis of rigid constraints due to uncertainty in the future.

6. Conclusions

LUP has played an important role in controlling the rapid growth of urban land in China over the past decades. However, local governments often break the land use quota for economic development, leading researchers to doubt the effectiveness of LUP. Previous literature often focused on the overall implementation effect of LUP on controlling urban expansion but ignored its spatial differences. This study uses the GWR model to explore the spatial pattern of the implementation effect of LUP on controlling the speed of urban expansion.

The ULEI and ULES of 280 cities are calculated as the basic work. The results show that ULEI is randomly distributed in space, but ULES is characterized by spatial agglomeration. We conclude that the former may be sensitive to city size, while the latter is sensitive to city location.

The pressure that LUP has imposed on urban expansion is evaluated using PCI, which is calculated on the basis of the urban land quota allocated by the superior LUP. The spatial analysis of PCI suggests that some cities faced the pressure of insufficient urban land quota in 2009, and more cities faced this pressure in 2016. From the perspective of the entire country, the central and southwest regions with low levels of urbanization are facing relatively minimal pressure. This is beneficial to the economic and urbanization development of these regions but may also cause land waste. From a local perspective, economically developed cities are facing minimal pressure on urban land shortage. This finding indicates that the highly developed cities (especially provincial capitals) are prioritized when the total urban land quota of the entire province is allocated to the cities under its jurisdiction.

The spatial effect of LUP on ULES is estimated using the GWR model. LUP exerts significant negative effects on ULES for all of the 280 cities, and the effects show evident spatial differences among various regions. The impact of PCI on ULES is strong in areas with a relatively backward economy but high ULES, such as southwest China. On the contrary, it is relatively weak in areas with a relatively developed economy but low ULES, such as Eastern Coastal China.

This study is instructive for enhanced understanding of the impact of LUP on controlling urban expansion. The results imply that the coordinated development of cities among regions should be emphasized to determine a reasonable scale of urban land quota in LUP. In the future, the impact mechanism of LUP on urban expansion can be further explored by combining other spatial analysis models, such as geographical detector and multi-level regression. We will also explore the allocation principle of urban land quota on the basis of information entropy principles, Gini coefficient theory, or other methods. This study facilitates a scientific LUP and its effective implementation.

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