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Research Article

Utilisation Efficiency of Construction Land in China's Coastal Cities Based on Debt Level

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Optimising the allocation of population, land, and capital production resources is crucial for promoting an efficient urbanisation and solving the urban land financial problem. This study uses a panel threshold model to identify the response boundary of urban construction land use efficiency to government debt level for 51 postfinancial crisis Chinese coastal cities. The results indicate that the threshold of economic development level and provincial gross domestic product (per capita gross domestic product: pgdp) are 2.67 and 5.17, respectively. In cities with relatively backward economic development, an expansion of the government debt scale hinders the improvement of the utilisation efficiency of construction land. Also, the threshold value of the government's accumulated debt level threshold (sd) is 15.83%. When cities fall below the government accumulated debt level threshold (sd < 15.83%), the new debt level has a positive effect on the utilisation efficiency of construction land. When sd > 15.83%, the new debt level impedes the improvement of the utilisation efficiency of construction land. Local governments should reduce their dependence on land finance in cities with high cumulative debt ratios, especially those with negative responses to both thresholds (pgdp and sd thresholds). This study's findings can provide a reference for a sustainable promotion of new urbanisation in both China and in other countries to avoid the risk of land urbanisation.

1. Introduction

Land use determines urban density and spatial efficiency, which are both related to environmental sustainability and human liveability [1]. Land use is an important factor involved in characterising the human response to global change. The description and simulation of the spatiotemporal process and the identification and analysis of land use's dynamic mechanism have always occupied the forefront of science. Global change research has focused on land use since the International Geosphere-Biosphere Programmer (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP) formulated the "scientific research plan of land use/cover change" in 1995 and the Global Land Project (GLP) was released in 2005 [2–6]. In 2012, the International Council for Science and the International Social Science Council launched the "Future Earth" research plan, which also incorporated land use-related content into the dynamic planet

and sustainable goal realisation research systems [7]. Given this background, the study of urban land use is particularly important.

As the most active and representative development mode of land use, construction land represents the core and hot spot areas in which the interactions between human production/life activities and natural space occur [8, 9]. After China's 1994 tax-sharing reform was implemented, "land finance" (which included core land transfer fees) gradually became widespread as a technique used to promote both urban economic growth and the expansion of construction land scales. For instance, the total revenue from land transfers accounts for approximately 5.5% of China's GDP (2014) [10]. To attract workers and investments, local governments heavily invest in infrastructure construction with land as the main bearing body to ensure that the urban public services and housing supply are maintained. However, due to local governments' limited revenue and expenditure capacities, to ensure that infrastructure

construction investments and other financial subsidies are stably maintained, local governments have resorted to urban development and infrastructure companies (UDIGs), local government financing vehicles, and other platforms for debt financing. As common collateral and a financing tool, governments transfer and trade land (which, then, increases local government debt). The increase in local government debt results in these governments having to sell more land to repay debts. Therefore, the local financial situation is closely related to land use [11].

It is undeniable that local government debts are now important for social and economic development. Under the balance of supply and demand, a rational use of local debt can effectively promote urbanisation development. However, as an integral part of financial risk, the risk of non-standard debt and the uncertainty of financing instruments as generated by excessive debt are likely to lead to excessive development and frequent land transactions. This would not only increase economic sensitivity but would also cause overdrafts and obscure governmental behaviours. Accordingly, it can produce many practical problems, such as land price fluctuations, fragmented construction land development, and partial land income fund transfers, which all lead to the dilution of urban construction concentration. Due to the high credit risks generated by excessive debt, some cities would even fall into a vicious circle of "debt risk rising-new capital decreasing-infrastructure investment shrinking-economic growth decreasing-debt risk rising" [12].

At this stage, it is generally believed that there is a significant and complex relationship between land finance and local government debt [13–15]. The risk involved in controlling government debt and the intensive use of urban land are key issues related to the healthy development of cities. Academics and government decision-makers constantly focus on improving the efficiency of urban land use [16], optimising the land circulation system [17], and reducing the dependence of government debt on land finance [18].

Land urbanisation is an important step in the process of urbanisation. Land transfers can be directly used for urban construction and can also be used as a guarantee and debt repayment tool to expand financing; this mutual mechanism is particularly significant in areas that are characterised by rapid urbanisation [15]. Compared with the way that urbanisation has evolved in other developed countries, as the strategic core area of China's economic development and the country's main new urbanisation area, the eastern coastal area's urbanisation pace is faster, its effects are more obvious, and the human/land collision in the area is more intense. Coastal urban agglomerations have always been in the utilisation state of high-intensity development, high-density agglomeration, high-speed expansion, and high-risk stress [19]. Moreover, due to their proximity to large cities (which have large markets, access to international markets, convenient transportation conditions, complete infrastructures, and vast economic hinterlands), an increasing number of land-intensive manufacturing industry clusters are attracted to coastal cities. These agglomeration and specialisation benefits lead to the shrinking of urban construction land

stock; the tightening of the "red line" of land resources has started to restrict the eastern coastal cities' sound economic growth [20]. Simultaneously, as coastal cities are rapidly urbanising, debt financing and land transfers have become powerful tools for these cities in regard to promoting the urbanisation process.

In 2017, the National Audit Office of China announced that the local governments' total debt stock was 16470.6 billion yuan and that the debt stock of 11 coastal provinces (the municipalities directly under the central government) had reached 7255.8 billion yuan, accounting for 45.674% of the total debt. As the main collateral and repayment method used in government debt financing, the land transfer market in coastal cities reached $13734 \, km^2$ in 2016. In the coastal cities, the current debt situations and urban land use have been closely linked. In addition to the construction land use efficiency and government debt problems, the coastal areas are also faced with land finance problems (with specific Chinese characteristics) in the urbanisation process. The exploration of related problems can provide suggestions for the central and western cities that are currently lagging in their urban development.

Numerous studies have focused on the relationship between local government debt risk and "land finance" [21]. Scholars generally agree that a large amount of government debt is not conducive to capital accumulation, productivity improvement, or long-term economic growth [22]. However, there are relatively few quantitative studies on the interaction between local government debt and land use (especially urban construction land efficiency). Also, the impact of the different types of urban governments' debt level risks on the diversification of urban land use efficiency has not been considered. This study considers 51 post-financial crisis coastal cities in China and uses a threshold model to quantitatively evaluate the significant and non-significant local debt threshold levels that affect urban construction land efficiency. Then, it identifies the coastal cities' construction land efficiencies by identifying the significant and nonsignificant thresholds.

2. Method

2.1. Variable Selection and Processing. The efficiency of urban construction land use is the result of the interaction between human and natural factors in urban multisystem, multilevel, and multifield models. The mechanisms that influence such efficiency are complex and diverse [20]. A number of studies have shown that fiscal expenditure, urban population density [23], transportation infrastructure [9, 24, 25], and urban industrial composition, and layout [26] have an impact on urban construction land efficiency [27]. However, researchers are yet to reach a consensus in regard to the quantitative measurements and mechanisms of urban construction land use efficiency.

This study mainly discusses whether there is a threshold effect between local government debt level and urban construction land efficiency, and it identifies the response boundary between the two factors under different threshold levels. The selection of relevant mechanisms is mainly based

on the interactive mode of "land guarantee-debt increase-land repayment-land use." Among them, the explained variable is urban construction land use efficiency, the core explained variable is local government debt level, and the control variables include the economic development level and various population factors (Figure 1). Given that local government debt in China has rapidly expanded since the 2008 global financial crisis, this study focuses on the 51 coastal cities that were more significantly impacted by the financial crisis. This study also conducts a threshold regression analysis of debt level and urban construction land use efficiency for the period 2007–2016.

2.1.1. Interpreted Variable. At present, the definition and connotation of urban construction land use efficiency have not been effectively unified, and researchers pay more attention to land use efficiency than to urban construction land use efficiency. As for the connotation of land use efficiency, land use is an activity launched by human beings under the overall socio-ecological system [28–30]. Therefore, land use efficiency should include economic benefits, social benefits, and ecological benefits [31, 32]. One or more benefits should be considered based on the research needs and the availability and reliability of data [33]. The efficiency of urban construction land use (nl) is a comprehensive reflection of the development and utilisation intensity of regional construction land and its bearing intensity on the regional population and economic society, which is generally manifested in the population density of land unit use and the output intensity of land unit use [34]. As the land expression of human will, the ultimate service object of construction land always revolves around human groups. The population density per land unit can reflect the intensive degree and utilisation efficiency of urban construction land. The larger the population that each land unit can support, the higher the utilisation efficiency of urban construction land. Therefore, this study chooses the population density per land unit to represent the explained variable, that is, nl = urban population/urban construction land area.

2.1.2. Core Explanatory Variable. The core explanatory variable is local government debt level (*d*). The data on prefecture and city level debt cannot be obtained directly, and local government debt levels are mainly characterised by the funding gap that occurs when the financial expenditure is greater than the financial revenue. Therefore, this study uses the government funding gap to total local national income ratio to measure the local government debt level: *d* = (expenditure within the general local finance budget − income within the general budget)/GDP.

2.1.3. Control Variables. Urban construction land is a reflection of the vitality of regional economic development and is closely related to the state of the urban economic development. Scholars generally agree that land is one of the most important resources in urban economic development. There is a significant positive correlation between land use

efficiency and economic development level; that is, land use efficiency is higher at higher levels of economic development [35]. Based on the selection of economic development level variables in typical regional case studies, this study includes the following economic development level control variables: "urban per capita GDP" (pgdp) and "urban GDP growth rate" (*p*). Simultaneously, considering that China's urban construction land type is mainly characterised as "agricultural to nonagricultural" (i.e., its urban land type mainly extends from the first industry exclusive land to the second industry and the third industry collaborative use), the "proportion of secondary and tertiary industry output to GDP" (*b*) is selected as the control index of urban construction land use efficiency.

Previous studies have shown that population factors have significantly different effects on the land use efficiency of different levels and types of cities. When the urban population scale is small, the expansion of the population scale might improve the urban scale economy and demand level and, thus, improve the urban land use efficiency. However, when the urban population scale is too high, a continuous increase in the population scale will amplify the city's congestion and environmental costs, thus hindering the sound operation and sustainable development of the urban economy and reducing the urban land use efficiency. To accurately identify the multiple fluctuation effects of different population sizes on the efficiency of urban construction land, this study adds the following population factor control variables: "year-end urban population" (*n*) and "urban population growth" (an). Also, considering the reverse causality between population factors and urban construction land (i.e., a continuous increase in the population scale will lead to a rapid expansion of the urban construction land scale, but an expansion of the urban construction land area and an improvement of infrastructure services will also attract the population to gather in the city), the "urban built-up area growth" (al) is also introduced as a population factor control variable. Fruit indicators and response mechanisms were helpful in interpreting the population factors' control effects.

2.1.4. Threshold Variable. The impact of local government debt on urban construction land use efficiency differs among cities with different levels of economic development and debt. In terms of land use efficiency, the construction land use efficiency of cities with high economic development level is generally high, and the impact of the economic development level on construction land use efficiency may counteract the impact of the urban debt level on land use efficiency. On the other hand, in terms of local debt, some cities with high economic development levels no longer rely on the input of land elements. To promote urbanisation development, more structural optimisation and technological innovation are needed. Urban development may not require debt financing itself, and the debt level's impact on urban construction land is not significant. However, some cities with high economic development levels often carry enormous debts to invest into urban construction due to
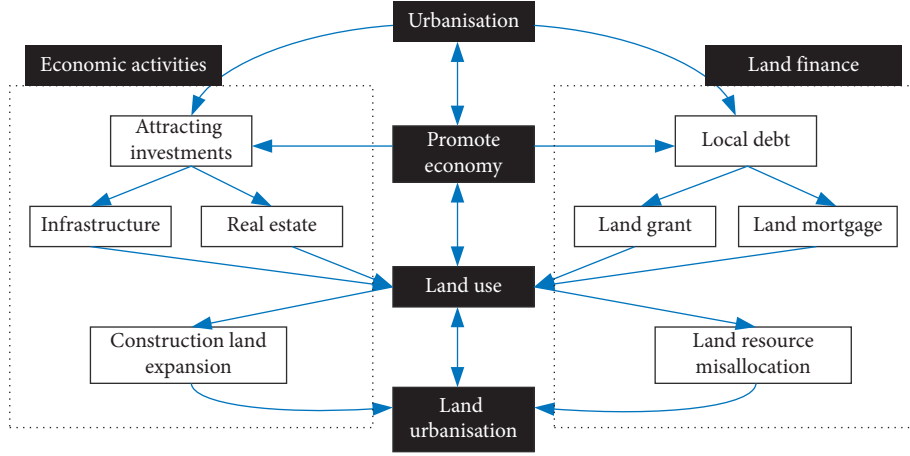
Figure 1: Logical relationship between local debt and land use.

their strong debt repayment abilities and high government credit ratings. The impact of city debt levels on urban construction land use efficiency is extremely significant and remarkable. Therefore, this study includes urban per capita GDP (pgdp), which represents the level of urban economic development and the accumulated debt level (sd) of local governments (which represents the level of urban debt) as threshold variables, and it conducts a multiple threshold analysis to understand the potential impact of the above problems. Therefore, in this study, sd = (general budget cumulative expenditure-general budget cumulative income)/GDP.

2.2. Model Construction.
To avoid a false regression of the selected variables, a unit root test should be conducted with the relevant indicators to determine whether the data is stable. Table 1 displays the stationary test results, which indicate that the parameters nl, b, p, an, and al all reject the original hypothesis. This indicates that the five indicators are a stationary series; however, the parameters d, pgdp, and n cannot reject the original hypothesis, indicating that these three indicators are a nonstationary series. A unit root test was conducted for the first- and second-order difference items of the three nonstationary indexes. The results for the first-order differential data indicate that pgdp and n reject the original assumption as a stationary sequence, and they represent the growth of pgdp and the growth of urban population, respectively. The results for the second-order differential data indicate that d rejects the original assumption as a stationary sequence, and it represents an increase in government debt level. As the above indexes are not of the same order and are not single integers, this study uses the difference stationary index to construct the threshold regression model for the multiple threshold regression analysis.

Through the threshold variables for pgdp and local government cumulative debt level, this study conducts a stage threshold regression analysis of the impact of local government debt on urban construction land use efficiency. The corresponding panel threshold model is as follows:

$$Y_{it} = \beta_1 X_{1it} + \sum_{j=2}^{n} \beta_j X_{jit} + \mu_{it},$$

$$Y_{it} = \beta_1 X_{1it} I(q_{it} \leq \gamma) + \beta_2 X_{1it}(q > \gamma) + \sum_{j=3}^{n} \beta_j X_{jit} + \mu_{it},$$

(1)

where Y_{it} represents the interpreted variable, X_{1it} represents the interpreted variable, X_{jit} represents the relevant control variable, β represents the parameter to be evaluated, q_{it} represents the threshold variable, γ represents the threshold value, and μ_{it} represents the random disturbance term.

Combined with the economic problems studied and Hansen's proposed panel threshold model [36], the following empirical model is established:

$$\begin{aligned} nl_{it} &= \beta_1 dn_{it} + \beta_2 dpgdp_{it} + \beta_3 b_{it} + \beta_4 p_{it} + \beta_5 an_{it} + \beta_6 al_{it} \\ &\quad + \beta_7 d_{it} I(pgdp_{it} \leq \gamma) + \\ \beta_8 d_{it} I(pgdp_{it} &> \gamma) + \mu_{it} nl_{it} = \beta_1 dn_{it} + \beta_2 dpgdp_{it} + \beta_3 b_{it} \\ &\quad + \beta_4 p_{it} + \beta_5 an_{it} + \beta_6 al_{it} + \beta_7 d_{it} I(sd_{it} \leq \gamma) + \\ \beta_8 d_{it} I(sd_{it} &> \gamma) + \mu_{it}. \end{aligned}$$

(2)

The threshold variables are pgdp and sd, and I is the indicator function. If the conditions listed in brackets are met, $I = 1$ and $I = 0$ otherwise.

3. A Case Study in China and the Results

3.1. Threshold Regression Results.
In this study, the level of urban economic development (pgdp) and the level of local government debt (d) are used as threshold variables; three threshold assumptions are used to estimate the model, and the corresponding F and Pvalues are obtained. In the model that includes pgdp as the threshold variable, the single and double threshold models passed the significance test with two different threshold variables. Therefore, it is necessary to focus on the double threshold analysis. Table 2 illustrates that when pgdp < 2.668, the local debt level growth has no significant

TABLE 1: Unit root test results.

Variable	Variable	Levin, Lin & Chu t^*	Im, Pesaran, and Shin W-stat	ADF-fisher chi-square	PP-fisher chi-square
Utilisation efficiency of construction land	Nl	−34.47 (0.0001)	−9.34 (0.0001)	170.61 (0.0001)	210.55 (0.0001)
	Sd	9.07 (1.000)	17.30 (1.000)	19.20 (1.000)	23.52 (1.000)
Local debt level	D	−3.77 (0.0001)	−0.08 (0.5318)	122.77 (0.0790)	112.28 (0.2288)
	D (d)	−19.48 (0.0001)	−7.55 (0.0001)	260.25 (0.0001)	320.58 (0.0001)
	pgdp	0.60 (0.7662)	7.05 (1.000)	34.66 (1.000)	45.06 (1.000)
Economic development level	D (pgdp)	−15.88 (0.0001)	−5.29 (0.0001)	215.20 (0.0001)	284.45 (0.0001)
	b	−9.68 (0.0001)	0.37 (0.6436)	122.59 (0.0807)	176.60 (0.0001)
	p	−6.07 (0.0001)	−2.63 (0.0042)	121.02 (0.0229)	118.23 (0.0341)
	n	2.36 (0.9909)	1.80 (0.9637)	130.33 (0.0307)	129.12 (0.0361)
	D (n)	−354.80 (0.0001)	−50.89 (0.0001)	321.61 (0.0001)	360.93 (0.0001)
Population	an	−52.60 (0.0001)	−17.93 (0.0001)	305.28 (0.0001)	330.39 (0.0001)
	al	−69.42 (0.0001)	−14.86 (0.0001)	247.05 (0.0001)	263.23 (0.0001)

TABLE 2: Simulation results with urban economic development level as the threshold variable.

Variable	Coefficient	Robust standard deviation	T Statistic	P
D (n)	0.0014	0.0002	9.4172	0.0001
D (pgdp)	0.0076	0.0095	0.7982	0.0425
B	0.0139	0.0058	2.3766	0.0179
P	0.0011	0.0006	1.9369	0.0535
An	0.0004	0.0002	1.7486	0.0811
Al	−0.0023	0.0003	−6.9148	0.0001
Inimser (pgdp < 2.6681)	0.3262	0.4594	0.7101	0.4781
Inimser (2.6681 < pgdp < 5.1700)	−2.5232	1.3127	−1.9222	0.0553
Inimser (pgdp > 5.1700)	1.3175	0.5908	2.2300	0.0263

impact on the land use efficiency of urban built-up areas. Also, when 2.668 < pgdp < 5.170, the local debt level growth has a significant and negative impact on the land use efficiency of urban built-up areas. Finally, when pgdp > 5.170, the local debt level growth has a significant and positive impact on the land use efficiency of urban built-up areas.

In cities with relatively backward economic development levels, local governments have to engage in land finance to obtain funds to promote urban economic development. Although they have to strengthen the urban infrastructure construction, they have enough space to reduce the price of industrial land to obtain more enterprises with short cycles and quick effects. Simultaneously, local governments' debt levels will also increase significantly. To address the governments' debt gaps, land finance has become a "life-saving straw" in which more land is used for selling and mortgaging to repay the government debt. The urban built-up areas have increased rapidly, even though the urban population has not significantly improved, which results in low efficiency construction land use. However, in the high economic development level areas, the urban infrastructure construction is relatively good, and the government does not need to finance so much land. In such areas, the "land guarantee-government debt-land repayment" mechanism is controllable.

Concerning the model that included local government debt level as the threshold variable, the results indicate that it passed the significance test with a single threshold variable. Table 3 shows that when the cumulative level of local government debt is lower than 15.38%, the local government debt growth has a

significant and positive impact on the land use efficiency of urban built-up areas. Also, when the cumulative level of local government debt is higher than 15.38%, the local government debt growth has a significant and negative impact on the land use efficiency of urban built-up areas.

3.2. City Type Identification. As for the response boundary simulated by the threshold regression results, it is possible to interpret the response degree of construction land use efficiency for the coastal 51 cities with multiple thresholds for the period 2007–2016 (Table 4). In the regression results that include the pgdp threshold, Zhangzhou has pgdp < 2.668 and its local debt has no effect on the utilisation efficiency of urban construction land. Fifteen cities, such as Qinhuangdao, Jiaxing, and Rizhao, have pgdp < 2.668 < pgdp < 5.170, and their government debts will hinder the improvement of urban construction land efficiency. As the "rising stars" of new urbanisation in China's coastal areas, most of these cities have good economic momentum and remarkable development effects. The urbanisation process in these cities has been significantly compressed. The increasingly faster land use rhythm makes it difficult for low local governments to accurately control the urban debt levels and effectively promote an efficient use of construction land. There are 35 cities with 5.170 < pgdp, such as Tianjin, Yantai, and Qinzhou; in these cities, any increase in local debt will significantly improve the utilisation efficiency of urban construction land (Table 4).

TABLE 3: Estimation results for urban governments' cumulative debt ratio threshold.

Variable	Coefficient	Robust standard deviation	T Statistic	P
D (n)	0.0014	0.0001	9.3207	0.0001
D (pgdp)	0.0091	0.0114	0.9710	0.0428
B	0.0158	0.0044	3.5853	0.0004
P	0.0013	0.0009	2.4107	0.0164
An	0.0004	0.0001	1.7298	0.0844
Al	−0.0024	0.0002	−7.4214	0.0001
Inimser (sd < 15.38%)	2.3848	0.9618	2.4795	0.0136
Inimser (sd > 15.38%)	−0.6546	0.3870	−1.6913	0.0916

TABLE 4: Identification of city type by the first threshold regression results.

Response boundary	City	Response type
pgdp < 2.67	Zhangzhou	No response
2.67 < pgdp < 5.17	Qinhuangdao Cangzhou Dandong Lianyungang Ningbo Wenzhou Jiaxing Shaoxing Zhoushan Weihai Rizhao Quanzhou Huizhou Dongguan Chaozhou	Negative response
5.170 < pgdp	Tianjin Tangshan Dalian Jinzhou Yingkou Panjin Hulu Island Shanghai Nantong Yancheng Hangzhou Taizhou Qingdao Dongying Yantai Weifang Binzhou Fuzhou Xiamen Putian Ningde Guangzhou Shenzhen Shantou Jiangmen Zhanjiang Maoming Shanwei Yangjiang Zhongshan Jieyang Beihai Fangchenggang Qinzhou	Positive response

TABLE 5: Identification of city type by the second threshold regression results.

Response boundary	City	Response type
sd < 15.83%	Shanghai Nantong Hangzhou Ningbo Jiaxing Shaoxing Qingdao Dongying Yantai Fuzhou Xiamen Quanzhou Guangzhou Shenzhen Dongguan Zhongshan	Positive response
sd > 15.83%	Tianjin Tangshan Qinhuangdao Cangzhou Dalian Dandong Jinzhou Yingkou Panjin Hulu Island Lianyungang Yancheng Wenzhou Zhoushan Taizhou Weifang Weihai Rizhao Binzhou Putian Zhangzhou Ningde Zhuhai Shantou Jiangmen Zhanjiang Maoming Huizhou Shanwei Yangjiang Chaozhou Jieyang Beihai Fangcheng Port Qinzhou	Negative response

Table 5 displays the regression results for local governments' cumulative debt levels (sd) as the threshold variables. As shown in Table 5, 16 cities have sd < 15.83% (such as Shanghai, Nantong, and Hangzhou). These cities' sustainable debt behaviours will significantly promote the efficiency of urban construction land use. There are 35 cities with sd > 15.83%, such as Tianjin, Weihai, and Beihai. These cities' cumulative debt levels have reached the upper limit. A continuous expansion of their debt scales will damage the efficiency of urban construction land use.

Figure 2 illustrates the quadrant division that was created to illustrate the above urban identification results. The red dots indicate the cities that have positive responses to the double threshold, which includes 11 cities (Shanghai[11], Nantong[12], Hangzhou[15], Qingdao[22], Dongying[23], Yantai[24], Fuzhou[29], Xiamen[30], Guangzhou[35], Shenzhen[36], and Zhongshan[46]). The blue dots indicate the 24 cities that have only positive responses to the urban economic development level threshold (pgdp) (Tianjin[1], Tangshan[2], Dalian[5], Jinzhou[7], Yingkou[8], Panjin[9], Huludao[10], Yancheng[14], Taizhou[21], Weifang[25], Binzhou[28], Putian[31], Ningde[34], Zhuhai[37], Shantou[38], Jiangmen[39], Zhanjiang[40], Maoming[41], Shanwei[43], Yangjiang[44], Jieyang[48], Beihai[49], Fangchenggang[50], and Qinzhou[5]). The pink dots represent the cities that have positive responses to the local government accumulated debt level threshold (sd) (Ningbo[16], Jiaxing[18], Shaoxing[19], Quanzhou[32], and Dongguan[45]). The grey dots represent the 11 cities that have negative responses to both thresholds (Qinhuangdao[3], Cangzhou[4], Dandong[6], Lianyungang[13], Wenzhou[17], Zhoushan[20], Weihai[26], Rizhao[27], Huizhou[42], Chaozhou[47], and Zhangzhou[33]). The arrows represent the urban distribution's degree of deviation, in which the government debt and construction land use efficiency problems become more prominent as the sample points extend farther away from the origin.

The cities with positive responses to both thresholds can serve as reference templates for other cities in China in regard to handling the government debt level and urban construction land use efficiency problems. These cities not only give full play to the government debt enthusiasm but also effectively avoid the reverse impact of debt risk. They have entered the sustainable mode of land urbanisation. Such cities not only manage their government debt well but also effectively avoid the reverse impact of debt risk and have sustainable urbanisation processes. For the cities that only respond positively to a single threshold, it is possible that cities close to the origin can become transition cities. As shown in Figure 2, Tianjin, Zhuhai, Weifang, and Tangshan (blue dots) can realise the double positive response transformation by reducing their accumulated debt
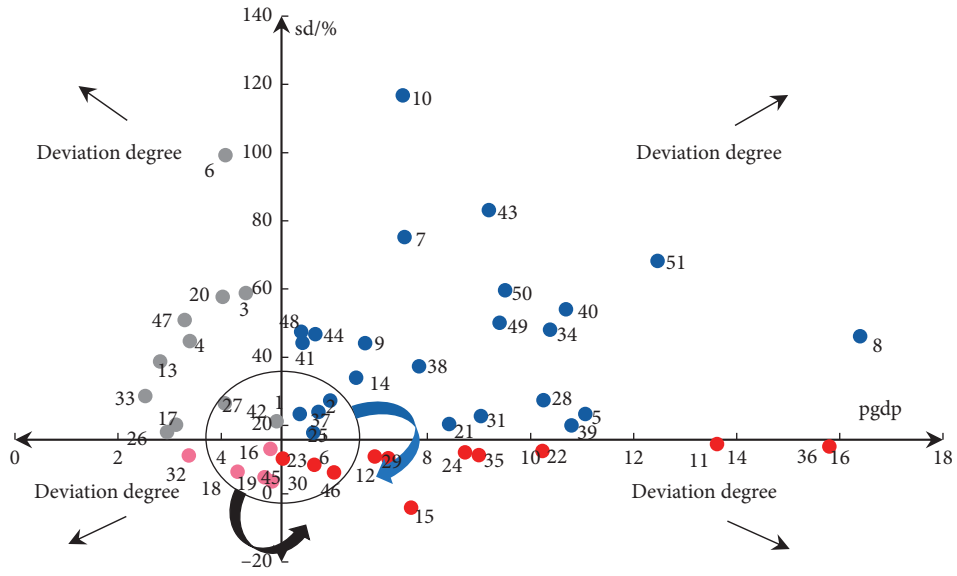
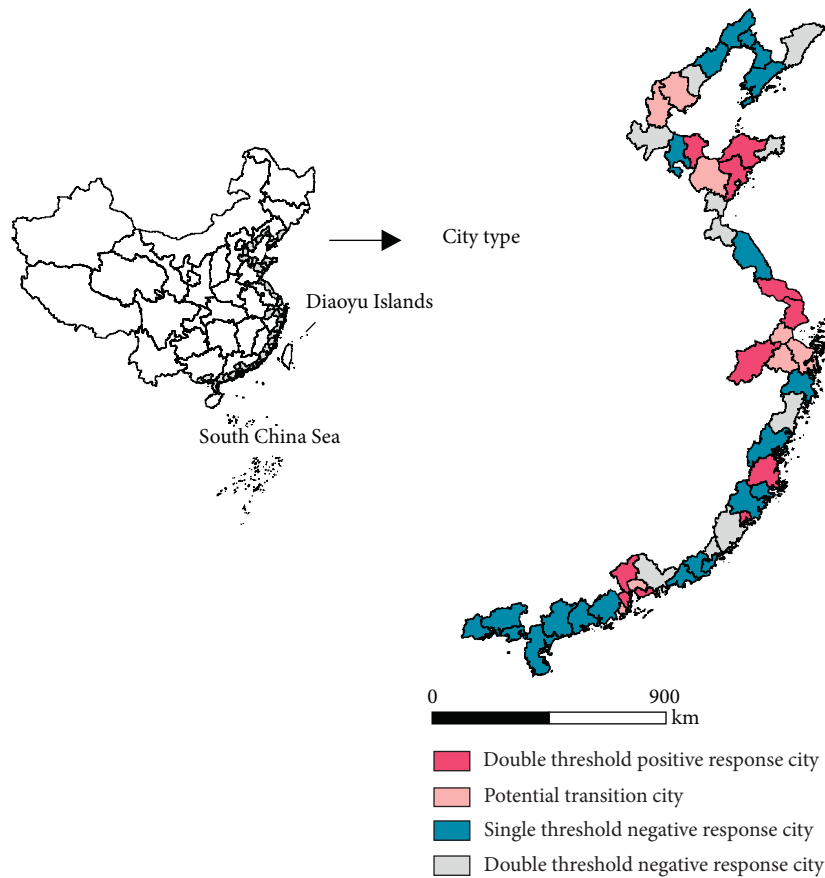FIGURE 2: Quadrant distribution of different city types.

FIGURE 3: City type identification results.

ratios. Also, Ningbo, Dongguan, Shaoxing, and Jiaxing (pink dots) can realise the double positive response transformation by steadily improving their economic levels. Further, Huizhou and Rizhao (grey dots) can reduce

their accumulated negative responses by steadily improving their economic levels.

The debt level can realise the transformation of a double positive response, thus allowing the positive feedback effect of

government debt on urban construction land use efficiency to reach its full potential. However, in the future, China should focus on the ten cities that have negative responses at both thresholds. From the perspective of urban construction land use efficiency, at this stage, these cities have become typical government debt risk cities. The local governments' debt levels are separated from the urban economic development, and the accumulated debt levels are also beyond the region's economic repayment range. The governments' public trust and credit ratings have been subject to potential declines. The economic development and financial modes, which rely on land elements, have hindered the effective improvement of urban construction land efficiency; also, the normal urbanisation process in some regions will be exceeded. In addition, the negative impact of debt risk leads to a mismatch in the population, capital, and land resources, and it causes additional and uncontrollable economic problems, risks people's livelihoods, and leads to government public trust crises. There might be hidden dangers if China continues to promote new urbanisation.

The spatial expression of the above urban threshold response results can compensate for the overgeneralised quadrant division of the urban category spatial information. Figure 3 illustrates the urban spatial distribution for the quadrant division results. The cities with positive responses to the double threshold are distributed mainly in the South of the Bohai Sea and the Yangtze River Delta, whereas the cities with negative responses to the double threshold fall in a spatial cross distribution pattern that is relatively concentrated in the surrounding areas of the Bohai Sea. The cities that could potentially transition are concentrated in the South of the Bohai rim, in the Yangtze River Delta, and in parts of the Pearl River Delta. In general, the relationship between construction land use efficiency and government debt in China's coastal cities is mainly characterised by a single threshold positive response, and such cities have occupied the mainstream status.

4. Discussion

China's urban debt and land use problems are mostly affected by the local competition that is produced by the horizontal GDP's rigid assessment mechanism and the vertical central government's implicit connivance. The fuzzy boundary between the administrative intervention, which is represented by the governmental credit guarantee and traditional macro policy tools, such as land fiscal and monetary policies, is largely responsible for aggravating the urban debt and construction land problems. In the future, researchers should focus on the impacts of urban topography, water and other resources, and environmental conditions on the development potential of urban construction land [37, 38]. Future research should also consider the possible "unexpected" damage to the urban environment, biodiversity, and ecological service function caused by the expansion of construction land.

5. Conclusions

This study empirically analysed the relationship between increases in local government debt levels and the land use efficiency of urban built-up areas, exploring cities that have different economic development levels and local governments that have different accumulated debt levels. In addition to offering concrete advice for China, the implications of our results will be useful for any countries that are currently urbanising. The study contributes to the literature by providing evidence in regard to how local debt levels can affect the utilisation efficiency of urban construction land.

The panel threshold regression results indicate that there are threshold constraints on local debt levels in the economic development stage and that the utilisation efficiency of urban construction land either relatively lags behind in economic development (pgdp < 2.67) or is significantly compressed in the urbanisation process (2.67 < pgdp < 5.17). Thus, a "disordered" and "excessive" expansion of the government debt model can easily hinder an improvement of urban construction land's utilisation efficiency. However, the lagged utilisation efficiency of urban construction land restricts the government's solvency and credit rating. At the same time, the economic enthusiasm in favour of local debt will be weakened by the impact of debt accumulation risk, and the cumulative government debt level should be maintained below 15.83%. In cities with low cumulative debt ratios, local governments with sustainable debt behaviours can significantly promote an efficient urban construction land use. In the cities where the local governments have high accumulated debt levels, the governments should reduce their dependence on land finance and avoid the negative feedback loop trap of "the more land is used, the more land is needed." Based on this, this study identifies 51 coastal cities' debt levels and proposes that, in the future, China should focus on the 10 cities that have negative threshold responses (Qinhuangdao, Cangzhou, Dandong, Lianyungang, Wenzhou, Zhoushan, Weihai, Rizhao, Huizhou, and Chaozhou) to avoid the potential negative debt feedback cycle trap and uncontrollable debt risk. Simultaneously, the transfer of potential cities to the double threshold's positive response quadrant should be promoted to realise a sustainable transformation of land urbanisation.

Data Availability

The data used to the paper were taken from the government statistical yearbook.

Conflicts of Interest

The authors have no conflicts of interest to declare.

Acknowledgments

References

[1] C. Schmid, O. Karaman, N. C. Hanakata et al., "Towards a new vocabulary of urbanisation processes: a comparative approach," *Urban Studies*, vol. 55, no. 1, pp. 19–52, 2018.

[2] Scientific Steering Committee and International Project Office of LUCC, C. Nunes, and J. I. Augé, "Land-use and land-cover change (LUCC): implementation strategy," *Environmental Policy Collection*, 1999.

[3] B. L. I. Turner, D. L. Skole, S. Sanderson, G. Fischer, L. Fresco, and R. Leemans, "Land-use and land-cover change," *Science/research Plan. Global Change Report (Sweden)*, vol. 43, pp. 669–679, 1995.

[4] GLP, "Science plan and implementation strategy," GBP Report No. 53/IHDP Report No.19, IGBP Secretariat, Stockholm, Sweden, vol. 64, 2005.

[5] M. Howells, S. Hermann, M. Welsch et al., "Integrated analysis of climate change, land-use, energy and water strategies," *Nature Climate Change*, vol. 3, no. 7, pp. 621–626, 2013.

[6] C. K. Wright and M. C. Wimberly, "Recent land use change in the Western corn belt threatens grasslands and wetlands," *Proceedings of the National Academy of Sciences*, vol. 110, no. 10, pp. 4134–4139, 2013.

[7] *Future Earth Initial Design: Report of the Transition Team*, International Council for Science (ICSU), Paris, France, 2013.

[8] J. Yang, A. Guo, Y. Li, Y. Zhang, and X. Li, "Simulation of landscape spatial layout evolution in rural-urban fringe areas: a case study of Ganjingzi district," *GIScience & Remote Sensing*, vol. 56, no. 3, pp. 388–405, 2019.

[9] R. Ding, "The complex network theory-based urban land-use and transport interaction studies," *Complexity*, vol. 2019, Article ID 4180890, 14 pages, 2019.

[10] Joint Research Group of the Development Research Centre of the State Council and the World Bank, "China: promote efficient, inclusive and sustainable urbanization," *Management World*, vol. 4, pp. 5–41, 2014.

[11] P. Galiński, "Determinants of debt limits in local governments: case of Poland," *Procedia - Social and Behavioral Sciences*, vol. 213, 2015.

[12] C. Ding and E. Lichtenberg, "Land and urban economic growth in China," *Journal of Regional Science*, vol. 51, no. 2, pp. 299–317, 2011.

[13] H. Whiteside and Heather, "Foreign in a domestic sense: Puerto Rico's debt crisis and paradoxes in critical urban studies," *Urban Studies*, vol. 56, no. 1, pp. 147–166, 2019.

[14] W. Chen, R. He, and Q. Wu, "A novel efficiency measure model for industrial land use based on subvector data envelope analysis and spatial analysis method," *Complexity*, vol. 2017, Article ID 9516267, 11 pages, 2017.

[15] Y. Bin and L. Quan, "Construction financing problem of local government in China," *Physics Procedia*, vol. 24, pp. 1773–1780, 2012.

[16] L. Zhang, L. Zhang, Y. Xu, P. Zhou, and C.-H. Yeh, "Evaluating urban land use efficiency with interacting criteria: an empirical study of cities in Jiangsu China," *Land Use Policy*, vol. 90, 2020.

[17] C. Shi and B. S. Tang, "Institutional change and diversity in the transfer of land development rights in China: the case of Chengdu," *Urban Studies*, vol. 57, no. 3, 2020.

[18] F. L. Wu, "Land financialisation and the financing of urban development in china," *Land Use Policy*, 2019.

[19] C. L. Fang, C. H. Zhou, C. L. Gu, L. D. Chen, and S. C. Li, "Theoretical analysis of interactive coupled effects between urbanization and eco-environment in mega-urban agglomerations," *Acta Geographica Sinica*, vol. 71, no. 4, pp. 531–550, 2016.

[20] I. Marovic, I. Androjic, N. Jajac, and T. Hanak, "Urban road infrastructure maintenance planning with application of neura networks," *Complexity*, vol. 2018, Article ID 5160417, 10 pages, 2018.

[21] J. X. Miao, D. C. Huang, and Z. Q. He, "Social risk assessment and management for major construction projects in China based on fuzzy integrated analysis," *Complexity*, vol. 2019, Article ID 2452895, 17 pages, 2019.

[22] J. Woo and M. S. Kumar, "Public debt and growth," *Economica*, vol. 82, no. 328, pp. 705–739, 2015.

[23] L. Zhang, J. Lu, B. B. Fu, and S. B. Li, "A review and prospect for the complexity and resilience of urban public transit network based on complex network theory," *Complexity*, vol. 2018, Article ID 2156309, 36 pages, 2018.

[24] I. Hardie, P. Parks, P. Gottleib, and D. Wear, "Responsiveness of rural and urban land uses to land rent determinants in the U.S. South," *Land Economics*, vol. 76, no. 4, pp. 659–673, 2000.

[25] J. Yang, W. Liu, Y. H. Li, X. M. Li, and Q. S. Ge, "Simulating intraurban land use dynamics under multiple scenarios based on fuzzy cellular automata: a case study of Jinzhou district, Dalian," *Complexity*, vol. 2018, Article ID 7202985, 17 pages, 2018.

[26] C. Wei, S. Yue, W. Yanan, and W. Qun, "The effect of industrial relocation on industrial land use efficiency in China: a spatial econometrics approach," *Journal of Cleaner Production*, vol. 205, pp. 525–535, 2018.

[27] Y. Wang, X. M. Li, J. F. Li, Z. D. Huang, and R. B. Xiao, "Impact of rapid urbanization on vulnerability of land system from complex networks view: a methodological approach," *Complexity*, vol. 2018, Article ID 8561675, 18 pages, 2018.

[28] J. Yang, P. Xie, J. C. Xi, Q. S. Ge, X. M. Li, and Z. D. Ma, "LUCC simulation based on the cellular automata simulation: a case study of Dalian economic and techological development zone," *Acta Geographica Sinica*, vol. 70, no. 3, pp. 461–475, 2015.

[29] X. Gao, A. L. Zhang, and Z. L. Sun, "How regional economic integration influence on urban land use efficiency?A case study of Wuhan metropolitan area, China," *Land Use Policy*, vol. 90, 2020.

[30] J. Liu, X. B. Jin, W. Y. Xu et al., "A new framework of land use efficiency for the coordination among food, economy and ecology in regional development," *Science of the Total Environment*, vol. 710, 2020.

[31] R. Costanza, R. d'Arge, R. de Groot et al., "The value of the world's ecosystem services and natural capital," *Nature*, vol. 387, no. 6630, pp. 253–260, 1997.

[32] L. van den Belt, Z. X. Guo, and C. Peng, "Construction land utilization efficiency based on SBM-Undesirable and Metafrontier model," *Resources Science*, vol. 39, no. 5, pp. 836–845, 2017.

[33] Q. T. Do and L. Iyer, "Land titling and rural transition in vietnam," *Economic Development and Cultural Change*, vol. 56, no. 3, pp. 531–579, 2008.

[34] K. Hill, "County's hiring of land-use attorney concerns urban growth expansion opponents," *The Spokesman-Review*, 2015.

[35] T. Kuemmerle, K. Erb, P. Meyfroidt et al., "Challenges and opportunities in mapping land use intensity globally," *Current Opinion in Environmental Sustainability*, vol. 5, no. 5, pp. 484–493, 2013.

[36] B. Hansen and M. Caner, "Instrumental variable estimation of a threshold model," *Econometric Theory*, vol. 20, pp. 813–843, 2004.

[37] H. Wang, H. Schandl, G. Wang, L. Ma, and Y. Wang, "Regional material flow accounts for China: examining China's natural resource use at the provincial and national level," *Journal of Industrial Ecology*, vol. 23, no. 6, pp. 1425–1438, 2019.

[38] H. M. Wang, G. Q. Wang, J. C. Qi et al., "Scarcity-weighted fossil fuel footprint of China at the provincial level," *Applied Energy*, vol. 258, 2020.