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The Impact of Green Finance on Industrial Land Use Efficiency: Evidence from 279 Cities in China

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Abstract: Improving the efficiency of industrial land use is of great significance to the sustainable development of cities. Based on a financial perspective, this paper studies the relationship between green finance and urban industrial land use efficiency (UILUE). First, the epsilon-based measure model was used to calculate the UILUE of 279 cities in China from 2011 to 2020, and then an empirical model is constructed to test the impact and path mechanism of green finance on UILUE. The research results show that green finance can improve the UILUE. The mediation effect test shows that the optimization of industrial structure and technological innovation are the key paths for green finance to affect UILUE. In addition, land finance inhibits the positive effect of green finance on the UILUE. This study provides new evidence for the role green finance plays in improving the efficiency of industrial land use and promoting the sustainable development of cities.

Keywords: green finance; urban industrial land use efficiency; influence mechanism; epsilon-based measure; mediation effect

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1. Introduction

With the improvement of urban industrialization levels, the lack of land resources has become an obstacle to industrial development [1]. The expansion of the land use scale in the early stages of industrialization promoted urban economic growth [2]. However, the development model of industrial land with highly extensive, high pollution and low efficiency also compresses the urban development space and affects the urban ecological environment and residents' lives [3,4]. Under the constraints of resources and the environment, improving the urban industrial land use efficiency (UILUE) is a problem that needs attention.

Industrial land use efficiency refers to the economic benefits obtained from the existing land use scale [5]. Scholars' research on the UILUE focuses on influencing factors, efficiency evaluation, spatial differences, and economic impacts. In terms of influencing factors, government policy is the basic factor affecting industrial land use. Land resources are public assets, and the government determines the allocation, approval, lease and sale of industrial land. The cost and scale of industrial land purchases by companies are limited by government land policies [6,7]. The level of regional economic development, industrial agglomeration and land prices are important factors for UILUE. Industrial structure and industry agglomeration affect the scale of urban industrial land [8,9]. Land prices affect the cost of industrial land [10,11]. In addition, population size, natural resources and transportation facilities also affect the UILUE [12,13]. In terms of efficiency evaluation, comprehensive index evaluation and data envelopment analysis (DEA) are the main methods to measure the UILUE [3,5,14]. On this basis, Super-DEA, Super-SBM, CCR, and Malmquist index are extensions of traditional DEA models [3,5]. These methods take into account the impact of undesired outputs on industrial land use. In terms of spatial differences, intensive management and extensive management have caused the difference in the dependence of urban industries on land [15–17]. At the same time, the industrial

transfer in developed regions has an impact on the regional land use structure, and the regional convergence development of UILUE is also the focus of scholars' research [18]. In terms of economic impact, the effect of land scale is the key to urban economic growth. The inefficient urban land development aggravates the contradiction between man and land, which not only compresses the living space of residents but also pollutes the urban ecological environment [19].

At present, the proportion of industrial land in developed countries is between 8% and 10%, while that percentage in Chinese cities is as high as 30%. To improve the efficiency of urban industrial land use, the Chinese government has taken a series of actions [20]. For example, they have implemented strict environmental regulations, increased investment in environmental governance, and encouraged the application of green technologies [21,22]. The Chinese government has also adapted its economy to employ a green financial system to deal with imbalances in resources, environment and economy. Green finance refers to economic activities that support environmental improvement, combat climate change and conserve resources. Its role is mainly to guide the flow of capital to resource-saving, technologically advanced, and ecologically-friendly industries [23]. The United Nations Environment Programme Financial Institution (UNEPFI) proposes that green finance not only includes green investment in environmental protection departments, but also the preparation of investment projects, such as land acquisition for projects.

Scholars have studied the connotation, influencing factors and social effects of green finance [24]. First of all, compared with traditional finance, green finance is the performance of financial activities to improve the ecological environment [21]. Green credit, green securities, green insurance, and green investment are important indicators reflecting the level of green finance [23,25]. Single-index evaluation and comprehensive index evaluation are the main methods to measure green finance. Zhou (2020) calculated green finance using the scale of green credit and green investment [26]. Lee (2022) constructed a green finance evaluation system using four dimensions: green credit, green securities, green investments, and green insurance [23]. In addition, some scholars believe that carbon finance is also a key indicator for measuring green finance [27]. Second, the government's environmental policy and financial policy are key factors affecting the development of green finance [28]. Financial structure is the main reason for the difference in the development of green finance. A lack of green finance standards and information asymmetry among participants in the green finance market will hinder the development of green finance [29,30]. Finally, green finance realizes the sustainable development of the regional economy by increasing green investment, promoting green technology innovation, and optimizing urban industrial structures [31]. In terms of ecological impact, green finance meets the investment needs of green industries and has a positive impact on environmental protection and energy conservation [32]. The use of financial instruments such as green credit and green securities can improve the efficiency of carbon market transactions, restrain the extensive investment behavior of enterprises and significantly reduce pollution emissions from industries with high pollution, high emissions and high energy consumption [33]. However, insufficient disclosure of corporate environmental protection information and energy conservation information has led to insufficient enthusiasm for commercial banks to participate in green finance [34].

Overall, the research on green finance and industrial land use is sufficient, which provides a basis for our research, but there are limitations. First, the government plays a leading role in urban land use, but with the improvement of the land market system, the role of the market in the allocation of land resources is becoming more and more significant. From the perspective of the financial market, studying UILUE is more in line with the asset attributes of the land. Second, carbon emissions and energy consumption are the focus of scholars' research on green finance. Land is a key input factor for industrial production, the market attributes of cost and resources make it closely related to finance, and the inefficient use of land also has an impact on urban ecology. However, the relationship between green finance and UILUE has been overlooked. Finally, comprehensive index evaluation and

data envelopment analysis (DEA) are the main methods to measure UILUE, but subjective indicators, the shortcomings of a single radial model and non-radial model will affect the accuracy of the results.

Therefore, this paper studies the impact of green finance on the UILUE in China and clarifies its impact paths, which can provide new evidence for improving the UILUE and promoting the sustainable development of the urban economy. The main research contributions of this paper are as follows. First, the relationship between green finance and UILUE is studied based on financial function. This is a study of the allocation of land resources based on the role of the market, which complements the government's management of land. This research on the integration of green development and sustainable use of industrial land is also more in line with the needs of China's economic development. Second, this paper constructs an empirical model to test the basic impact and mechanisms of green finance on UILUE. The mediating role of industrial structure optimization and urban technological innovation and the regulating role of government land policy are comprehensively analyzed. These studies provide new evidence for the improvement of urban industrial land use efficiency. Third, the UILUE is calculated based on the epsilon-based measure (EBM) model. The EBM has the basic function of data envelopment analysis (DEA) and eliminates the defects of the single radial and non-radial models of DEA models. It incorporates radial and non-radial variation features, making the results more accurate.

The remaining arrangements for this study are as follows. The third part is the theoretical mechanism and research hypothesis. The fourth part is the research design. The fifth part is the results analysis. Finally, the research conclusions and policy implications are presented.

2. Theoretical Mechanism and Research Hypothesis

2.1. The Impact of Green Finance on UILUE

Public property rights determine the government's position on the allocation of urban land resources. Enterprises need to purchase or lease land from local governments for production in accordance with the approval process. The land price of higher land affects firm fixed costs. Market financing and bank loans form a capital supplement for enterprises to acquire land resources, which also leads to the existence of financial attributes in land use. Green finance with the goal of sustainable development affects the ability of industrial enterprises to acquire land and has the effect of shrinking the scale and improving efficiency. First, urban industrialization is the driving force for regional economic growth. To achieve rapid industrialization in the early stage, the Chinese government implemented preferential policies for industrial enterprises, such as large-scale and low-cost land support, financial subsidies and tax incentives [35]. Traditional industries are highly dependent on land investment, and the expansion of the industrial land scale not only causes environmental pollution, but also exacerbates the contradiction between residents and land.

With the development of the green economy, local governments have begun to strengthen the management of industrial land use supply [36]. When the preferential policies disappeared, the extremely high land cost became a problem that industrial enterprises needed to solve. Green finance limits the ability of industrial enterprises to expand in scale from the capital supply. With the decline of the market competitiveness of traditional industrial enterprises, if the enterprise is a traditional industry with high energy consumption, high pollution, and high investment, then green finance cannot support its development. Second, green finance's preference for environmental protection industries affects the operation of industrial enterprises. Changing the extensive business model, reducing the input of traditional production factors, and improving the application of green technology are in line with the requirements of green finance [15,16]. In the past, traditional industrial enterprises relied on land expansion to form economies of scale. However, green finance guides the flow of resources from high-polluting, high-energy-consuming traditional industries to technologically advanced industries. The scale expansion driven by land investment is replaced by technology-driven efficiency growth. Finally, the biased

support of green finance for industrial enterprises will accelerate the elimination of traditional industrial enterprises that are highly dependent on land. From a cost perspective, land price cost is a key factor affecting urban industrial land [9]. In the land transaction market, when the business performance of the enterprise is poor and there is no external capital support, the land cost will accelerate the bankruptcy of the enterprise, which forms a good exit system and optimizes the land use structure. Based on this, we propose research hypothesis 1.

Hypothesis 1. *Green finance can improve urban industrial land use efficiency.*

2.2. The Impact Mechanism of Green Finance on UILUE

The industrial structure is affecting the land demand of enterprises [7]. Industrial cities are highly dependent on land resources. Under the influence of land shortage and market competition, enterprises must make new adjustments to their production scale and land location selection to meet production and social needs. Emerging industries have significant competitive advantages and are gradually phasing out inefficient traditional industries. Green finance restricts the land expansion of traditional industries by guiding the flow of capital, providing financial support for intensive and green industries and optimizes the regional industrial structure. At the same time, the adjustment of the industrial structure will inevitably break the balance of the allocation of land resources among the existing industrial sectors and change the land use structure [37]. Therefore, green finance affects the urban industrial land use efficiency by optimizing the regional industrial structure. Based on this, we propose research hypothesis 2.

Hypothesis 2. *Green finance improves urban industrial land use efficiency by optimizing the industrial structure.*

In market competition, in order to maximize profits, enterprises often add input of factors to achieve scale expansion. Expanding factories and building new factories are the main ways to achieve the expansion of the internal production scale, which increases the intensity of land input and leads to lower output efficiency per unit of land. Technological innovation affects the input of production factors of industrial enterprises [38]. The application of advanced production technology can effectively reduce the dependence of enterprises on production factors such as labor and land [39]. The role of green finance provides financial support for the development of green industries. Financial support provides opportunities for the development and application of green technologies [23,31]. On the one hand, it enhances the market competitiveness of technology-based enterprises and improves the efficiency of land output. On the other hand, it has accelerated the elimination of industries with a high degree of land dependence, provided land space for enterprises with high production efficiency and optimized the structure of urban industrial land use. Based on this, we propose research hypothesis 3.

Hypothesis 3. *Green finance can improve urban industrial land use efficiency by promoting technological innovation.*

Figure 1 shows the impact mechanism of green finance on UILUE.

2.3. The Influence of Local Government Land Finance

The local government's land policy is a factor that cannot be ignored for urban industrial land. In China, land finance is an important source of local government fiscal revenue, and the local government's land transactions affect the utilization of urban land [34]. On the one hand, to attract investment and expand the economic scale, local governments often sell industrial land at low prices in a non-public way, which leads to the disorderly expansion of urban industrial land. On the other hand, since the land transfer fee occupies a larger

share of the local fiscal revenue, the increase in industrial land prices and sales revenue will also stimulate local government land sales [37], which will lead to the expansion of the scale of industrial land. Therefore, the allocation of urban land resources by administrative power leads to lower utilization efficiency of urban industrial land [4]. The impact of green finance on urban industrial land is a market-oriented effect [35]. Under the influence of the incomplete land marketization system, the implementation of the local government's land fiscal policy will reduce the positive effect of green finance on the UILUE. Based on this, this paper proposes research hypothesis 4.

Hypothesis 4. *Land finance inhibits the positive effect of green finance on urban industrial land use efficiency.*

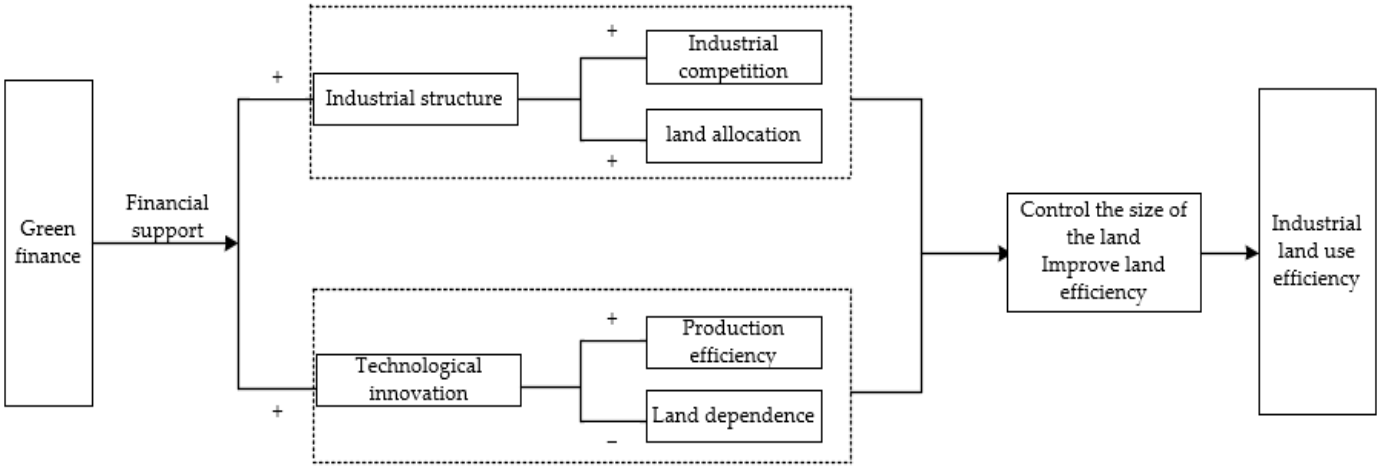

Figure 1. The impact mechanism of green finance on UILUE. "+" stands for positive effect, "−" stands for negative effect.

3. Research Design

3.1. Model

To study the relationship between green finance and UILUE, this paper refers to Lee (2022) to construct Equation (1) as the benchmark model.

$$UILUE_{i.t} = \alpha_0 + \alpha_1 gf_{i,t} + \alpha_n controls_{i,t} + \lambda_i + \theta_t + \varepsilon_{it} \quad (1)$$

In Equation (1), *UILUE* represents the urban industrial land use efficiency, *gf* represents green finance, and *controls* are the control variables. i is the city and t is the time. λ_i is the individual effect, θ_t is the time effect, and $\varepsilon_{i,t}$ is the random error term. α_1 is the coefficient of influence of green finance on UILUE. When $\alpha_1 > 0$, green finance has a positive effect on UILUE.

To study the impact mechanism of green finance on the UILUE, this paper constructs a mediation effect model. Equation (2) shows the relationship between green finance and intermediary variables, and Equation (3) shows the effects of green finance and intermediary variables on the UILUE.

$$M_{i.t} = \beta_0 + \beta_1 gf_{i,t} + \beta_2 controls_{i,t} + \lambda_i + \theta_t + \varepsilon_{it} \quad (2)$$

$$UILUE_{i.t} = \omega_0 + \omega_1 gf_{i,t} + \omega_2 M_{i,t} + +\omega_3 controls_{i,t} + \lambda_i + \theta_t + \varepsilon_{it} \quad (3)$$

M is the mediator variable. The test of the mediation effect is mainly judged by α_1 in Equation (1), β_1 in Equation (2), and ω_2 in Equation (3). Both α_1 and β_1 pass the significance test, indicating that the intermediary variable affects green finance and UILUE. At the same time, ω_2 passed the significance test, indicating that the intermediary variable can effectively explain the impact of green finance on the UILUE. $\omega_1 < \alpha_1$ and ω_1 passed

the significance test, indicating that there is a partial mediation effect. If ω_1 is not significant, there is a complete mediation effect. Otherwise, β_1 and ω_1 are not significant, the Sobel test needs to be further judged, and there may be no mediating effect of the *M*.

To test the regulatory effect of local government land policy, based on Equation (1), this paper adds the interaction variables between land policy and green finance, as shown in Equation (4). *lf* represents the local government land policy. When $\alpha_2 > 0$ and α_2 are significant, the local government land policy has a positive regulatory effect on the relationship between green finance and urban industrial land use efficiency. Otherwise, it exhibits inhibitory effects.

$$UILUE_{i.t} = \alpha_0 + \alpha_1 gf_{i,t} + \alpha_2 gf_{i,t} * lf_{i,t} + \alpha_3 controls_{i,t} + \lambda_i + \theta_t + \varepsilon_{it} \quad (4)$$

3.2. Variables

3.2.1. Explained Variable: Urban Industrial Land Use Efficiency (UILUE)

The input-output method is an important method to measure urban industrial land use efficiency. In the measurement method, the data envelopment analysis model (DEA) can be divided into a radial model and a non-radial model. The radial model mainly includes CCR and BCC models, and the non-radial model is mainly the SBM model. The main difference between them is that the radial model assumes that the input or output has the characteristics of proportional adjustment, which can achieve the most efficient production, but it ignores the existence of slack in the non-radial case. The non-radial model considers the existence of slack, but the loose assumption misses the original ratio information between input and output. To solve the problem of efficiency measurement of radial and non-radial models, it is necessary to use a comprehensive model. The epsilon-based measure (EBM) model is a hybrid model that includes radial and non-radial distance functions [40]. It is able to adjust radial or non-radial slack from element inputs, which is more comparable to a single radial or non-radial slack model. This paper adopts an EBM model with undesired output, non-orientation and variable return to scale. Specifically, it is shown in Equation (5).

$$\gamma^* = \frac{\theta - \varepsilon_x^- \frac{1}{\sum_{i=1}^{m} w_i^-} \sum_{i=1}^{m} \frac{w_i^- s_i^-}{x_i}}{\varphi + \varepsilon_y^- \frac{1}{\sum_{p=1}^{s} w_p^+} \sum_{p=1}^{s} \frac{w_p^+ s_p^+}{y_p} + \varepsilon_b^- \frac{1}{\sum_{q=1}^{z} w_q^+} \sum_{q=1}^{z} \frac{w_q^+ s_q^+}{y_q}} \quad \begin{aligned} s.t. \quad & x\lambda + s_i^- = \theta x_i \\ & y\lambda - s_p^- = \varphi y_p \\ & b\lambda + s_q^- = \varphi b_q \\ & \lambda \geq 0,\ s_i^-,\ s_p^+,\ s_q^- \geq 0,\ \theta \leq 1,\ \varphi \geq 1 \end{aligned} \quad (5)$$

In Equation (5), x, y and b are input, output and undesired output factors. ε represents the relative importance of the non-radial part in the EBM model, and the value range is [0, 1]. s_i^-, s_p^+ and s_q^- represent the slack in inputs, outputs, and undesired outputs. w_i^-, w_p^+, w_q^- represent the indicator weights of input, output and undesired output.

The EBM model in this paper contains three types of indicators: input indicators, expected output indicators and unexpected output indicators. Among them, the input indicators include land, capital and labor, and this paper converts all indicators into the quantity of unit land area [41]. The expected output index is expressed by the average industrial GDP of land, and the undesired output index is expressed by the average land pollution discharge. All data come from the National Bureau of Statistics of China, China Environmental Statistical Yearbook, China Urban Statistical Yearbook, etc. The indicators are shown in Table 1.

Figure 2 shows the average value of UILUE in different regions of China from 2011 to 2020. The results show that the level of UILUE in China overall showed an upward trend during the sample period, with an average of 0.428, which indicates that the efficiency of industrial land use is not high. In addition, there are significant regional differences in the efficiency of industrial land use, and the eastern cities are much higher than the central and western cities. This also shows that the low efficiency of urban industrial land use is a problem that needs to be paid attention to in the sustainable development of cities.

Table 1. Input-output indicators.

Elements	Indicator	Description
input	land	Industrial land area
	capital	Investment in fixed assets per unit of land
	energy	Energy consumption per unit of land
	labor	Number of industrial employees per unit of land
	environment	Investment in industrial pollution control per unit of land
expected output	economy profit	Industrial economic output value per unit of land
undesired output	environmental pollution	Amount of industrial wastewater discharged per unit of land
		Amount of SO2 emitted per unit of land
		Amount of smoke and dust emitted per unit of land

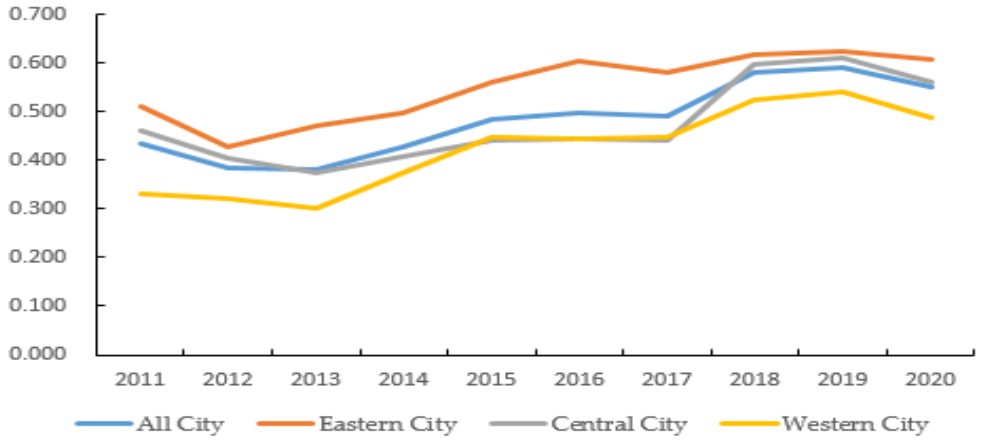

Figure 2. The average value of UILUE in different regions of China.

3.2.2. Explanatory Variables: Green Finance (*gf*)

China's green financial system has become increasingly complete with the government and the market's in-depth understanding of green finance. In order to implement the green finance policy, the People's Bank of China has formulated green credit guidelines and formed an implementation method centered on bank loans. With the development of regional financial markets, green securities, green insurance and green investment have also become the main content of green finance. At present, China's green financial system is mainly composed of green credit, green securities, green investment and green insurance. Among them, green credit is commercial banks guiding funds to flow to environmental protection industries and enterprises by adjusting interest rates. Green securities are bond instruments that use the funds raised to finance green projects that meet certain standards. Green investment is the investment made by investors with ecological and environmental concepts, such as government investors and market investors. Green insurance is environmental pollution liability insurance in which insurance companies compensate the victims of pollution. This paper refers to the method used by Lee (2022) to construct a green financial index system using four dimensions of green credit, green securities, green investment, and green insurance [23], and employs the principal component analysis (PCA) method to calculate. Among them, green credit is expressed by the ratio of the interest expenditure of high-energy-consuming enterprises in the region to the interest expenditure of industrial enterprises above the designated size. Green securities are represented by the market value ratio of environmental protection companies in the region. Green investment is expressed by the ratio of the total investment in regional environmental pollution control to GDP. Green insurance is represented by the scale of regional environmental pollution liability insurance. Green finance is calculated as follows.

First, this paper uses Equation (6) to standardize the indicators of green credit, green investment, green securities, and green insurance, which can effectively solve the incom-

patibility of data.f_n is the normalized value, f_j is the value of the j index, $\overline{f_j}$ is the average value of the j index, S_j is the standard deviation of the j indicator

$$f_n = \frac{f_j - \overline{f_j}}{S_j} \tag{6}$$

Secondly, combined with f_n, we use SPSS software (KMO value is 0.693) to calculate the principal component factor l_j and the information contribution degree c_j, and use Equation (7) to calculate the value of green finance.

$$gf = \sum_{j=1} c_j l_j \tag{7}$$

Finally, we use the data of i cities in t periods to get gf_{it}. The specific results are shown in Figure 3.

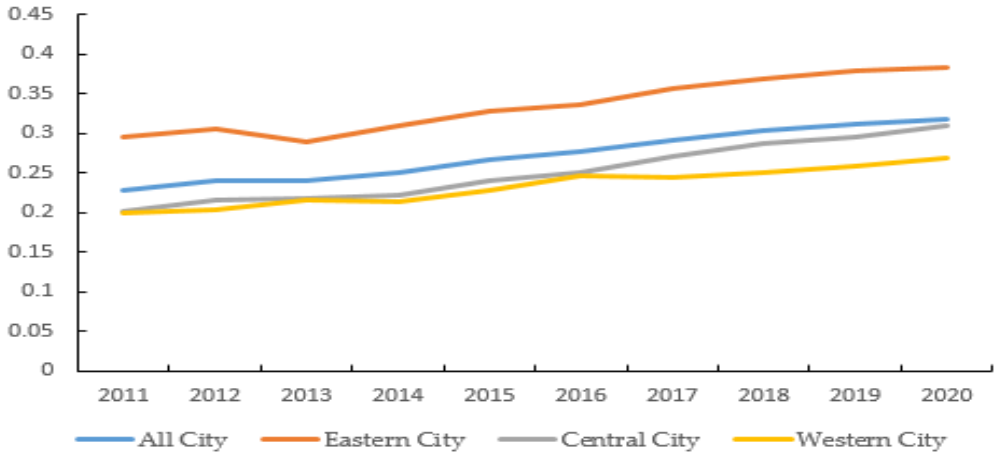

Figure 3. The value of green finance in different regions of China.

This paper presents the calculation results of green finance for eastern, central and western cities in China. The results show that there are differences in the level of green finance in China, and the green finance level of eastern cities is higher than that of central and western cities. In addition, combined with the results in Figure 2, we found that the development trends and regional characteristics of green finance and UILUE are similar, which provides a realistic basis for studying the relationship between green finance and UILUE.

3.2.3. Mediating Variables

According to the analysis of the theoretical mechanism, optimization of urban industrial structure and technological innovation are the mediating variables of this research. Among them, the industrial structure optimization index (*is*) is calculated by weighting the product of the proportional relationship between the three major industries and labor productivity. As shown in Equation (8), $Y_{i,j,t}$ and $L_{i,j,t}$ represent the industrial added value and employment of j industry in i region in t period. $Y_{i,t}$ is the gross economic output value of region i in period t. Urban technological innovation (*inv*) is mainly represented by the number of regional green patents. The government's land policy is mainly represented through the performance of land finance (*lf*), which is expressed by the ratio of the local government's land transfer revenue to the general fiscal revenue.

$$is_{i,j,t} = \sum_{j}^{3} \frac{Y_{i,j,t}}{Y_{i,t}} * \frac{Y_{i,j,t}}{L_{i,j,t}} \tag{8}$$

3.2.4. Control Variables

Considering the impact of other economic factors on the UILUE, this study also selected control variables. We refer to the methods of Koroso et al. (2021) and Chen et al. (2020), and select control variables from dimensions such as economic level, urbanization, regional opening and regional infrastructure [3,17]. The reasons for the selection of variables and the calculation methods are as follows.

Regional economic level (*regdp*). Regional economic development is closely related to the UILUE, and the use of land resources in economically developed regions is more reasonable. In this study, the urban per capita GDP is used to represent the regional economic level.

Urbanization. Urbanization is in line with the development of industrialization, and the increase in the urban population affects the utilization of urban land. In this paper, the ratio of the urban population to the total regional population is used to represent the urbanization index.

Openness. Land is an important resource for cities to accept foreign industrial transfer and for local governments to attract foreign investment. This paper uses foreign direct investment to represent the level of urban openness.

Infrastructure. Urban industrial development is highly dependent on infrastructure. In particular, traffic conditions are an important guarantee for industrial production material transactions and product sales. In this paper, the urban highway area is used to represent the infrastructure level.

3.3. Data

This paper mainly studies the impact of green finance on UILUE. Considering the completeness of the data, we selected the data of 279 prefecture-level cities in China from 2011 to 2020 as the research sample. The reason for this is that the data of prefecture-level cities is not only a direct reflection of urban economic activities, but also reflects the implementation of financial policies and land policies. All data come from the National Bureau of Statistics of China, China Urban Statistical Yearbook, China Environmental Statistical Yearbook and the EPS Economic Database. The calculation of key indicators is performed according to the equation of the variables. Table 2 shows the descriptive statistics of the variables.

Table 2. Descriptive statistics.

Variables	Unit	Obs	Mean	Std. Dev.	Min	Max
UILUE	1	2790	0.482	0.107	0.216	0.641
gf	1	2790	0.273	0.082	0.104	0.619
is	1	2790	1.253	0.635	0.163	3.742
ino	1	2790	2.438	1.832	0.012	10.159
lf	1	2790	0.479	0.275	0.093	1.783
regdp	yuan	2790	55,694	27,190.76	4994	164,889
Infrastructure	Kilometer	2790	13,226.98	10,237.22	614	174,284
Urbanization	1	2790	0.566	0.124	0.368	0.893
Openness	billion-yuan	2790	113.295	161.115	1.865	638.792

To avoid the influence of multicollinearity and heteroscedasticity on statistical results. In this study, variables were tested using the variance inflation factor (VIF). The test results show that the VIF values of all variables are less than 3.1, which indicates that there is no multicollinearity problem. At the same time, this study performed logarithmic processing on all variables in the regression analysis to reduce the effect of heteroscedasticity. The *p*-value of White's test is 0.8204, which indicates that there is no problem with heteroskedasticity.

4. Empirical Results

4.1. The Impact of Green Finance on the UILUE

To test Hypothesis 1, this study uses Equation (1) to empirically test the effect of green finance on UILUE. The sample selected in this study is panel data. We need to test fixed effects and random effects. The results of the Huasman test (Prob > chi2 = 0.0001) show that the fixed effect model is suitable. For the comparison of results, we show the regression results of Ordinary Least Squares (OLS), Fixed Effects Model (FE), and System Generalized Matrix Model (SYS-GMM). Among them, SYS-GMM has advantages in overcoming the problem of variable endogeneity. The regression results are shown in Table 3.

Table 3. Regression results.

Variables	(1) OLS	(2) FE	(3) SYS-GMM
$UILUE_{t-1}$			1.007 **
			(2.26)
gf	0.263 **	0.309 ***	0.321 ***
	(2.01)	(2.71)	(3.10)
regdp	−0.016	−0.021 *	−0.023 **
	(−1.33)	(−1.71)	(−1.98)
Urbanization	0.024 *	0.032 *	0.038 *
	(1.74)	(1.69)	(1.81)
Openness	−0.104 *	−0.008 **	−0.012 **
	(−1.83)	(−2.09)	(−2.03)
Infrastructure	0.160 *	0.240 **	0.198 **
	(1.82)	(2.35)	(2.10)
_cons	−0.038 ***	−0.042 ***	−0.043 ***
	(−2.64)	(−2.70)	(−2.71)
YEAR	YES	YES	YES
CITY	YES	YES	YES
N	2790	2790	2790
R^2/*AR(2)*	0.4571	0.6283	0.3105
Sargan-test			0.6252

Note: ***, **, and * represent significance of *p*-values at 1%, 5%, and 10%, respectively.

In Table 3, the green finance coefficients of OLS, FE and SYS-GMM models are 0.263, 0.309, and 0.321, which all passed the significance test at different levels. The variable coefficients of the FE model and the SYS-GMM model are more significant, and it is necessary to control for fixed effects and endogeneity. Since the coefficient of the green finance variable is significantly positive, green finance has a positive effect on the UILUE, which is in line with our theoretical expectations. In addition, the results of control variables show that urbanization and infrastructure have a promoting effect on UILUE, while the regional economic level and openness level have an inhibitory effect on UILUE. This is mainly because urbanization and infrastructure provide sufficient labor force and production conditions for urban industrial development, which help to improve the industrial production efficiency per unit of land. However, the regional economic level and opening have not significantly improved the efficiency of urban industrial land use, which is closely related to the urban extensive economic growth model and the transfer of foreign low-end industries. In particular, the local government's administrative intervention to use regional land resources to attract foreign investment affects the efficiency of resource allocation. It is in line with China's economic facts.

4.2. Robustness Test

To avoid a biased result caused by variable statistical methods and sample data, this paper uses methods of replacing explanatory variables and grouping tests to conduct robustness tests. First, this study replaces the calculation method of green finance variables. Since China's financial system is dominated by banks, bank loans are the main source of

financing needs of enterprises. In order to implement green finance policies, the China Banking Regulatory Commission (CBRC) has specially formulated "Green Credit Guidelines". We refer to Zhou's calculation method for green finance and directly use green loans (gf_1) to represent green finance variables [26]. Second, considering the heterogeneity caused by urban characteristics, we divide the research sample into eastern, central and western regions according to economic characteristics for group testing. The results of substitution variables and group tests are shown in Table 4.

Table 4. Robustness test.

Variables	(1) SYS-GMM	(2) East	(3) Central	(3) West
$UILUE_{t-1}$	0.996 **	1.217 ***	0.964 **	0.853 *
	(2.22)	(3.18)	(2.18)	(1.77)
gf_1	0.275 **			
	(2.00)			
gf		0.380 ***	0.290 ***	0.242 *
		(4.02)	(2.93)	(1.88)
Control variables	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
CITY	YES	YES	YES	YES
N	2790	2790	2790	2790
AR(2)	0.276	0.361	0.305	0.298
Sargan-test	0.583	0.680	0.649	0.602

Note: ***, **, and * represent significance of *p*-values at 1%, 5%, and 10%, respectively.

In Table 4, column (1) is the result of changing the calculation method of green finance. In column (1), the coefficient of the green finance is 0.275, and it has passed the 5% significance test, which indicates that green finance still has a significant effect after being replaced. Columns (2)–(4) are the group test results. The regression results show that the coefficients of green finance in the three regions are all significantly positive, which further verifies the positive effect of green finance. However, it should be noted that green finance has a greater impact in the eastern region. The reason for this is that the financial level in the eastern region is relatively high, which provides conditions for green finance to play a major role. In conclusion, the robustness test shows that our benchmark result is robust.

4.3. Mechanism Test

To test the path of green finance affecting the efficiency of urban industrial land, this study uses Equations (2) and (3) to test the mediating effect of industrial structure (*is*) and technological innovation (*inv*). Columns (1) and (2) in Table 5 are the test results with industrial structure (is) as the mediating variable. Columns (3) and (4) are the test results with inv as the mediating variable.

In Table 5, column (1) shows that the coefficient of green finance is 0.297 and significant, which indicates that green finance optimizes regional industrial structure. The variable coefficients of *gf* (0.257) and *is* (0.215) in the results in column (2) all passed the significance test, which indicated that industrial structure optimization played a partial mediating effect in the relationship between green finance and UILUE. There is an influence path for green finance to improve UILUE by optimizing the industrial structure. In columns (3) and (4), the coefficients of *gf* and *inv* are also significantly positive, which indicates that a partial mediation effect of technological innovation also exists in the relationship between green finance and UILUE. There is also an impact path for green finance to improve UILUE by promoting technological innovation. These results are consistent with our research hypothesis (2) and (3).

Table 5. The results of the mediation test.

Variables	(1) *is*	(2) *ULIUE*	(3) *ino*	(3) *UILUE*
gf	0.297 **	0.257 **	1.033 ***	0.233 ***
	(2.30)	(2.24)	(2.93)	(3.19)
is		0.215 **		
		(2.41)		
ino				0.085 **
				(2.28)
Control variables	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
CITY	YES	YES	YES	YES
N	2790	2790	2790	2790
R^2/*AR(2)*	0.597	0.261	0.503	0.270
Sargan-test		0.627		0.633

Note: ***, ** represent significance of *p*-values at 1% and 5%, respectively.

4.4. The Role of Land Finance

To test the heterogeneous effect of government land policy on the relationship between green finance and UILUE, this study uses Equation (4) to test the moderating effect of land finance. At the same time, considering the urban differences, this paper conducts a group test of the eastern, central and western cities in Table 6.

Table 6. Moderating effect test results.

Variables	(1) ALL	(2) East	(3) Central	(3) West
$ULIUE_{t-1}$	1.062 **	1.195 ***	0.924 **	0.818 *
	(2.17)	(3.11)	(2.14)	(1.75)
gf	0.299 **	0.347 **	0.268 **	0.220 *
	(2.01)	(2.47)	(2.31)	(1.80)
gf × *lf*	−0.064 **	−0.012 **	−0.080 **	−0.116 **
	(−2.13)	(−2.07)	(−2.35)	(−2.26)
Control variables	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
CITY	YES	YES	YES	YES
AR(2)	0.281	0.359	0.303	0.294
Sargan-test	0.579	0.663	0.630	0.594

Note: ***, **, and * represent significance of *p*-values at 1%, 5%, and 10%, respectively.

In Table 6, the coefficient of green finance is still significantly positive, which indicates that the positive effect of green finance on the UILUE still exists. In column (1), the coefficient of interaction between green finance and land finance is −0.064, which indicates that land finance inhibits the positive effect of green finance on the UILUE. This is mainly because the administrative intervention of local governments on land resources is not conducive to the allocation of urban land resources. In columns (2)–(4), the coefficient of the interaction variable in the eastern region is smaller, which indicates that the inhibitory effect of land finance on green finance is lower. This is mainly due to the higher level of land marketization in the eastern region, and the higher level of financial development in the eastern region, which is more conducive to the play of green finance. In conclusion, the results in Table 6 are consistent with hypothesis 4 of this study. Land finance inhibits the positive effect of green finance on the UILUE.

4.5. Discussion

Land is an important resource that limits the development of urban industries. This paper empirically studies the relationship between green finance and UILUE and analyzes its impact path and the regulatory effect of land finance. First, this paper calculates

the UILUE of 279 cities in China from 2011 to 2020 based on the EBM with variable returns to scale, which is different from single-dimensional indicators and traditional DEA models [3,41]. It avoids the defects of the DEA single radial model and non-radial model, and makes the measurement result more accurate [40]. We found that the maximum value of UILUE in the sample is 0.641, and the minimum value is 0.216, which indicates that the overall level of China's UILUE is low, and there is a large gap. It is necessary to pay attention to the problem of urban land use efficiency. Second, green finance can improve the UILUE. The optimization of industrial structure and technological innovation are the main paths for green finance to improve the UILUE. The results of the SYS-GMM model show that when green finance increases by 1 unit, it can bring an increase of 0.321 units to the UILUE. This reflects the role of green finance in the intensive use of industrial land and provides a new direction for solving the sustainable problem of urban industrial land. At the same time, green finance accelerates the green transformation of industrial enterprises by optimizing the urban industrial structure [42], thereby reducing the dependence of enterprises on traditional production factors, improving the allocation efficiency of urban industrial land resources, and finally forming an impact path of green finance → (+) industrial structure → (+) UILUE. In addition, the role of green finance in promoting green technology innovation has changed the business model of industrial enterprises relying on land expansion to obtain economies of scale. The advantages of green technology not only reduce the dependence of enterprises on land, but also effectively improve the output efficiency per unit of land [43], and finally form an impact path for green finance → (+) technological innovation→ (+) UILUE. There are many factors affecting land use efficiency, such as urbanization, traffic conditions and natural resources [44–46]. However, this paper combines green development with sustainable use of industrial land based on a financial perspective, which is more in line with the needs of China's economic development. Finally, the administrative intervention of local governments in land resources is not conducive to the optimal allocation of urban industrial land resources [37]. Land finance inhibits the positive effect of green finance on UILUE. The inhibitory effect of land finance in the eastern region is lower. This is mainly due to the higher level of land marketization in the eastern region, and the higher level of financial development in the eastern region, which is more conducive to the success of green finance [47]. In general, it is necessary to attach importance to the role of green finance, build a market-oriented system of land transactions [35] and provide guarantees for the interplay of green finance functions and the sustainable use of urban land.

5. Conclusions and Policy Implications

Improving the UILUE is of great significance to urban sustainable development. This paper uses the EBM to calculate the UILUE of 279 cities in China from 2011 to 2020, and empirically tests the impact of green finance on the UILUE in China. The research results show that green finance can improve the UILUE. The optimization of industrial structure and technological innovation are the main paths for green finance to improve the UILUE. Land finance inhibits the positive effect of green finance on UILUE. The inhibitory effect of land finance in the eastern region is lower.

Based on a financial perspective, this paper studies the relationship between green finance and UILUE, which provides new evidence for sustainable urban development. First, green finance can improve UILUE. It is necessary to attach importance to the coordination of land resources and financial resources, optimize urban land use structure by using financial resource allocation, provide land space for the development of green enterprises and improve the output efficiency of unit land. Secondly, the optimization of industrial structure and technological innovation are the main paths for green finance to improve the UILUE. It is necessary to guide the flow of funds through green finance, limit the land expansion of high-energy-consuming and high-polluting industries and provide financial support for green-intensive industries to optimize the regional industrial structure. At the same time, the innovation and application of green production technology should be

strengthened, the expected output per unit of land should be increased and the dependence of enterprises on land expansion should be reduced. Finally, it is necessary to build a market-oriented land transaction system, regulate the administrative intervention of local governments on land resources and reduce the inhibitory effect of land financial policies.

There are still some limitations to this study. For example, the development of market integration has made China's urbanization show the characteristics of urban groups. Under the influence of urban groups, the cross-regional integration of industrial land resources is not limited to cities, but also strengthens the spatial relevance of industrial land use. The relationship between green finance and urban group industrial land use efficiency is our future focus. In addition, the heterogeneity of enterprises (light industry and heavy industry) may also lead to differences in land use efficiency, and analysis using enterprise-level data also needs to be considered.

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