

Article

Does the Land Market Have an Impact on Green Total Factor Productivity? A Case Study on China

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Abstract: The influence process of the land market on urban green total factor productivity (GTFP) is characterized by complexity and region. Based on the panel data of 271 cities in China from 2004 to 2016, this paper analyzes the impact of the land market on urban GTFP and explores the regulatory effect of the innovation investment level and the infrastructure investment level on the land market. The following conclusions are drawn: First, the land market restrains the improvement of urban GTFP, whether analyzed from the dimension of land transfer price or land transfer scale, and the influence degree varies in different dimensions. Second, there is regional heterogeneity in the inhibition effect of the land market on urban GTFP. Third, the level of innovation investment and the level of infrastructure investment have significantly different regulatory effects on the impact of the land market on urban GTFP; the level of innovation investment aggravates the inhibition effect of urban GTFP by the land market, while the infrastructure investment level weakens this inhibition effect.



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Keywords: land market; green total factor productivity; innovation investment; infrastructure investment

1. Introduction

1.1. Motivation

The special characteristics of the land market and the long-term nature of urban green development make the relationship between them very complicated. This complex relationship makes it necessary to study the impact of the land market on urban green total factor productivity. Since the land position is fixed, the land market transaction has strong regional characteristics, which make the land market unable to form a unified price, and there is no strong interaction between different land markets, as well as between real estate appreciation and depreciation. For the same reason, the land market is less efficient than other commodity markets. From the goal of land market allocation of resources, because of the diversity of human production and life activities, the realization of differentiated land demand through the market mechanism has become the main means of all countries in the world. However, the “invisible hand” is more about value maximization; green development has not been paid enough attention. The purpose of urban sustainable development is to establish a green garden city based on living capacity, which requires rational use of its own resources and attention to the efficiency of its use. The input indicators, such as human resources and capital, the expected output indicators, such as GDP, and the unexpected output indicators, such as environmental pollution, can be used to measure green total factor productivity to monitor urban sustainable development.

The relationship between China's land market and urban sustainable development has very typical characteristics. From the perspective of the land market, since the establishment of China's socialist market economy system in 1992, land, as an important component of the factor market, has been closely related to the sustainable development of Chinese cities. From the perspective of the urban development process, after China's reform and

opening up in 1978, in order to break the dual economic structure of urban–rural division, urbanization and sustainable development of cities have been continuously promoted. Since 1992, the land market has been gradually established; in the land market transactions, aspects such as land transfer scale and land transfer income have a complex correlation with urban green total factor productivity to a large extent. Green total factor productivity is a concept with green background, proposed on the basis of total factor productivity by considering the output of pollutants. It emphasizes the coordinated development of economic growth and ecological environment, which can reflect the quality of economic growth, so it can be used as one of the core indicators to measure urban sustainable development. Therefore, this paper explores the complex relationship between the land market and green total factor productivity by taking China as an example.

1.2. Literature Review and Contribution

The existing literature pays more attention to the relationship between land markets and urban economic growth, while the correlation between land markets and green total factor productivity is relatively less focused on. Scholars explore the relationship between land markets and urban development mainly from the following three aspects.

One is the study of the relationship between land market allocation and economic growth, to which scholars hold different opinions. Some scholars believe that the development of the land market promotes economic growth. Loupias and Wiogniolle [1] emphasized the role of land in economic development and concluded that both the development of land marketization and human resources growth led to economic growth. Development of land markets can have a positive impact on urban economic growth through the construction of public infrastructure [2]. Chen and Kung [3] found that the relationship between the land market and political turnover will make the local GDP rise rapidly by studying the political mistakes of Chinese county leaders between 1999 and 2008. Mo [4] found that the development of the land market will promote local economic growth by analyzing Chinese county-level data from 2009 to 2014. Huang and Chan [5], by studying the land market financing arrangements for urban development, drew the conclusion that new models of land market cooperation can stimulate the market, reduce local debt and promote urban economic development. Wang et al. [6] analyzed the impact of the land reserve system on the quality of urbanization by using Chinese city-level panel data from 2008 to 2014, and they concluded that the land reserve system in the land market improved the quality of urbanization in China to a certain extent, which is beneficial to cities' sustainable development. FAN et al. [2] found that different types of urban land marketization level play different roles in urban economic development by the spatial lag model with the data of land transfer in China from 2007 to 2016. Song et al. [7] studied 331 cities in China and found that the economic benefits caused by different degrees of land market development are biased, and these effects are significant for promoting sustainable urban growth. Other scholars believe that the development of the land market has a negative impact on urban economy. Davoodi and Zou [8] used panel data from 46 countries between 1970 and 1989 to study the relationship between fiscal decentralization and economic growth, and they found that there was a negative correlation between land fiscal decentralization and economic growth in developing countries but not in developed countries. Prato et al. [9] found that different land market policies limited the economic growth rate to varying degrees. Zheng et al. [10] studied China's urbanization and found that the tax system, which uses land market development to compensate for budget imbalances, is out of control, causing social problems and even endangering China's environmental and socio-economic development. Gilles et al. [11] quantified the mismatch of manufacturing output and factors of production in various regions of India from 1989 to 2010 and discovered that the improper land distribution caused by the land market inhibits the local economic development. By studying the influence of the land market on urban construction land in Liaoning Province China, Li et al. [12] found that the uncoordinated development of the land market and population urbanization caused

a correlation between urban construction land expansion and economic growth change, from weak, positive correlation to strong, negative correlation. Fu et al. [13] found that there is an unreasonable distribution of land conversion quota in the land market of each city, resulting in economic losses.

Second, the relationship between land marketization and environmental effects was studied. Zhang et al. [14] used the STIRPAT model to study the impact of land urbanization and land marketization on carbon emissions in China from 2004 to 2013, and found that land urbanization helped to reduce carbon emissions, but the land marketization behavior aggravated the carbon emission significantly. Dong et al. [15] adopted the GMM and IRF methods to empirically test the land-use efficiency impact of 108 cities in the Yangtze River Economic Belt of China on carbon emissions, concluding that as land use efficiency improves, urban carbon intensity continues to decline, which contributes to the sustainable development of the city. Wang et al. [16] used the DID and stochastic frontier analysis methods to study the impact of land marketization on sustainable economic development, indicating that the reduction of construction land will significantly reduce the emission intensity of pollutants in the short term while inhibiting construction land efficiency; in the long run, it can significantly promote the sustainable development of the economy. Wu et al. [17] employed provincial panel data from 1998 to 2016 to explore the impact of land marketization on carbon emissions, indicating that the land market has a nonlinear effect on carbon emissions, which depends on the per capita GDP level. Based on panel data from 31 provinces in China from 2000 to 2015, Yan et al. [18] found that the impact of land marketization on pollution presents an inverted U-shaped structure.

Third, the relationship between land market and total factor productivity has aroused intense discussion. Sun et al. [19] analyzed the impact of different land-use forms on industrial TFP in the land market and found that high-tech industrial development zones are conducive to promoting the TFP development of enterprises in the industrial zones. Lu et al. [20] explored the relationship between land marketization, industrial structure and green total factor productivity based on panel data from 30 provincial administrative regions in China from 2004 to 2016, and they found that the marketization of land transfer has significantly improved China's green total factor productivity and China generally used land market policy to regulate regional economic development. Jin et al. [21] used the panel data of 278 prefecture-level cities in China from 2004 to 2013 to find that in the political promotion competition caused by land market development, excessive interregional competition has a negative impact on urban green total factor productivity.

Throughout the abovementioned studies, scholars mainly focused on the impact of land market development on urban economic growth and urban environmental effects [22], providing many important ideas and research methods but giving less attention to the impact of land marketization on urban green total factor productivity. Some scholars have carried out related research and analyses from the provincial level or individual city level. However, due to the great differences in the level of economic development and the degree of land market development in various regions of China, it is difficult for local governments to improve the city's development strategy through conclusions at the provincial or individual city levels. Therefore, on the basis of existing studies, this paper used the panel data of 271 cities at the prefecture level or above in China from 2004 to 2016 to study the impact and mechanism of land marketization on urban GTFP. Compared with previous studies, the marginal contribution of this paper is mainly reflected in the following three aspects: First, from the perspectives of land market transfer price and quantity, this paper explores the impact of land marketization on urban GTFP at the city level and enriches and expands the research dimension in this field by combining with sustainable development and global carbon neutrality. This paper employs the SBM-DEA model to measure the level of urban GTFP. By controlling time and individual effects, the OLS method is adopted to explore whether the dependence of land transfer fee and land transfer scale inhibit the promotion of urban GTFP. Second, in view of the differences of economic development levels and regional factors in various regions of China, this

paper uses sub-sample regression to analyze the influence of land marketization on urban GTFP. Third, by adding innovation investment level and infrastructure investment level as moderating variables, the paper further analyzes whether there is heterogeneity in the degree to which different mediating variables affect the impact of land marketization on urban GTFP.

2. Materials and Methods

2.1. Theoretical Analysis and Research Hypothesis

Before exploring the impact path and mechanism of urban land marketization on GTFP, two core concepts are defined. The first is the marketization of land transfer, which means that local governments use more market-oriented methods, such as bidding, auction and listing, to sell land at high prices instead of with the agreement way. Generally speaking, in the process of competing for economic growth, local governments often transfer land at a low price as a condition for introducing foreign industrial enterprises to promote economic growth, so the agreement mode has become an ideal choice for local governments to transfer industrial land. The second concept is the GTFP, which emphasizes the coordinated development of economic growth and ecological environment, essentially requiring the allocation of resource elements to be adjusted from relatively unreasonable to relatively reasonable so as to promote sustainable economic growth. By adjusting the allocation of factor resources and transferring industries to environment-friendly industries, the environmental pressure in the process of economic growth can be reduced.

With the development of the land market, there is a mismatch of resources in all regions in China. For example, land prices across China have soared in recent years, which is closely related to the development of the land market. As land markets develop, land prices rise [23] so that many entity enterprises allocate capital to the land market in pursuit of high profits, causing a serious mismatch of resources and, thus, inhibiting the development of total factor productivity in cities [24]. This paper is not only concerned with how the land market affects the economic development of a city, but more concerned with whether the land marketization will affect the city's green and sustainable development [25], that is, the analysis is made from the perspective of the transfer of production factors of urban industries to environmentally friendly industries. In order to get a head-start in the "promotion tournament", local governments will rely on the rapid development of the land market to improve the level of urban economic development in the short term, but this behavior may inhibit the GTFP of the city. First of all, in order to make up for the low price of industrial land, local governments will raise the commercial and residential land price for horizontal subsidies [26]. Along with the increase in the commercial and residential land price, the housing price will also rise. However, people with middle and low income or below in cities can hardly cope with the problem of high housing prices, so they can only look for accommodation in other cities with lower housing prices, which will lead to the loss of labor force, that is, the input factors of GTFP will be affected. The problem of high housing prices will also lead to idle land resources. Each local family can only buy one new commercial apartment since the government introduced a "purchase restriction order". In the face of such high housing prices, it is difficult for families of low or middle income to buy commercial houses [27], and high-income people are also prohibited by law from speculation in real estate, which will lead to a large number of vacant commercial houses, thus resulting in a waste of land resources. From the perspective of opportunity cost, if the land resource is used as a green belt, its green economic benefit will be higher than that of idle commercial housing, so it can be concluded that the land marketization will inhibit the development of urban GTFP. Land marketization will inhibit urban GTFP growth whether it is from the perspective of resource mismatch, industrial structure or financial development [7]. Therefore, the first hypothesis of this paper is proposed.

Hypothesis 1 (H1). *In the process of land marketization, with the increase in land transfer fee dependence and land transfer scale, the increase in urban GTFP will be inhibited.*

Due to the imbalanced and inadequate regional economic development in China, the different levels of economic development in different cities lead to the uneven development of land marketization. The marketization level of urban land supply in China has reached about 35%, but there is a great difference in the marketization level between the developed coastal areas and the underdeveloped inland areas [28]. The difference in urban land development intensity is equally significant, which increases as the city grows. The difference in land development intensity in the central region is lower than that in the eastern and western regions [29]. As a result, resource efficiency, ecological efficiency and scale efficiency vary greatly among regions [30], leading to the heterogeneity of GTFP in different regions. China's land transfer is mainly concentrated in the eastern region, but the dependence of land transfer fees in the central and western regions is larger than that in the eastern region. Taking 2015 as an example, the dependence of land transfer fees in the eastern region is 0.8, while that in the central region is 1.09 and that in the western region is 1.25. Due to regional heterogeneity of land demand, the development of land marketization is also heterogeneous to the capital accumulation of different cities, exerting a different impact on the GTFP of each region. Therefore, this paper puts forward the second hypothesis.

Hypothesis 2 (H2). *In the process of land marketization, the impact of land marketization on urban GTFP has regional heterogeneity.*

At present, China adheres to the road of innovation-driven development, taking the transformation and upgrading of industrial structure as the core and innovation-driven economic growth as the key. In innovation-driven development, it is necessary to achieve the reasonable allocation of factors to enhance innovation capacity and improve green total factor productivity. From the conclusion of the existing research, we can see that the level of innovation investment has a significant impact on total factor productivity, and scholars have different opinions on this. Wang et al. [31] concluded that green technology innovation promotes the improvement of green total factor productivity based on the spatial Durbin model. However, Howell's research [32] shows that innovation investment reduces the enterprise performance of related technology industries, and then affects innovation efficiency and total factor productivity. Based on the panel data of 11 provinces and cities in coastal areas of China, Ren and Ji [33] found that the effects of different technological innovation levels on GTFP can be positive and negative. Zhang and Vigne [34] found that innovation efficiency will reduce GTFP, and enterprise decision makers need to consider the relationship among innovation efficiency, green enterprise development and GTFP. Along with the development of land market, the scale of R&D investment increases year by year, but it does not improve the GTFP rapidly [35]. Because of the uncertainty and high-risk characteristics of innovation investment, even if local governments and enterprises consciously increase innovation investment, these innovation inputs are still in the inefficient stage and may even show negative efficiency. Thus, with the further development of land market, the expansion of local government revenue and expenditure as well as the increase of innovation investment may not improve the city's GTFP; instead, the inefficient innovation investment may cause the improper allocation of resources, thus reducing the city's green total factor productivity. Therefore, this paper puts forward the third hypothesis.

Hypothesis 3 (H3). *The level of innovation investment intensifies the inhibitory effect of the land market on urban GTFP.*

Scholars generally believe that the level of infrastructure investment can effectively promote the increase in TFP. Duggal [36] discovered that infrastructure can lead to long-term economic growth by promoting TFP. Huang et al. [37] found that urban infrastructure construction can promote the economy and the GTFP development of the city. Due to the existence of political competition, local governments will bias their fiscal expenditure into

infrastructure projects, such as high-speed rail, subway and airport construction, in the process of land market development. With the increase in infrastructure investment, the transportation capacity of cities has been significantly improved, shortening the time cost and transaction cost between cities, improving the utilization efficiency of elements, and attracting high quality foreign investment more easily; thus, they improve local technological progress, promote local industrial transformation and upgrading, and ultimately, enhance the city's green total factor productivity. Therefore, this paper puts forward the fourth hypothesis.

Hypothesis 4 (H4). *The level of infrastructure investment weakens the inhibitory effect of the land market on urban GTFP.*

2.2. Variable Description and Data Sources

2.2.1. Variable Description

Explained variable: Urban green total factor productivity (GTFP), which is calculated by the SBM-DEA model, and the specific calculation process is in the Chapter 2.4 [38].

Explanatory variables: Referring to the research of the Zhang and Xu [39], this paper uses the dependence of the land transfer fee (LAN) and land transfer scale (LAS) to measure the behavior of land marketization. LAN is expressed by the ratio of the land transfer fee to GDP of local government in that year, and LAS is expressed by the land transfer scale of local government in that year. This paper uses two different dimensions to describe the land marketization behavior, both of which can well reflect the land market situation of the local government in that year.

Regulatory variables: Referring to Chen and Hu [40], actually paved road areas can reflect the real situation of the urban infrastructure construction level, so this paper uses the city's actually paved road area at the end of the year to represent its infrastructure investment level (ISL) [41]. The innovation investment cannot be separated from the cultivation of talents, and there is a positive correlation between the expenditure of education and the cultivation of talents [42]. In this paper, the proportion of education expenditure in the whole city to the local budget expenditure is used to measure the level of innovation investment (IIL).

Other control variables: Referring to the research and availability of data of other scholars [9,19,43], this paper chooses industrial structure (IS2), information level (INFO), population size (POP), financial support for science and technology (TFS) to control the influence of external factors on GTFP. Specifically, the city's population at the end of that year is chosen to represent POP; the proportion of the total output value of foreign-invested industrial enterprises above the designated size in the total output value of industrial enterprises above the designated size in the whole city is used to represent the scale of foreign direct investment FDI; the proportion of the city's science and technology expenditure to the city's local budget expenditure is used to measure the TFS; the proportion of the output value of the tertiary industry in the output value of the secondary industry in the whole city is used to represent the industrial structure IS2; and the number of the city's internet-access households is used to represent the INFO. In the regression models, the above variables are treated with a natural logarithm.

2.2.2. Data Source

The samples of this study are 271 prefectural or above cities in 30 provinces of China from 2004 to 2016 (due to the lack of variable data in some cities and the change of names of some urban administrative districts, the data is not consistent and were eventually deleted, such as Shuang Ya shan, Chao hu, Lhasa, etc.). Among them, the data of land transfer fee and land transfer scale are from "China Land and Resources Statistics Yearbook" from 2004 to 2017; other variables data are mainly from "China Urban Statistics Yearbook" and "China Urban Construction Statistics Yearbook" from 2004 to 2017. For the missing data of a few cities, this paper uses the arithmetic average of two years before and after the data as

well as the interpolation method to make up for the balance panel data. The variable data source is in Table 1.

Table 1. Variable data source.

Variable	Abbreviation	Source
Urban green total factor productivity	GTFP	SBM-GML
Dependence of land transfer fee	LAN	China Land and Resources Statistics Yearbook
Land transfer scale	LAS	China Land and Resources Statistics Yearbook
Innovation investment level	IIL	China Urban Statistics Yearbook
Infrastructure investment level	ISL	China Urban Construction Statistics Yearbook
Population size	POP	China Urban Statistics Yearbook
Foreign direct investment	FDI	China Urban Statistics Yearbook
Financial support for science and technology	TFS	China Urban Statistics Yearbook
Industrial structure	IS2	China Urban Statistics Yearbook
Information level	INFO	China Urban Statistics Yearbook

After that, all the variables in the empirical analysis come from Table 1. The data of variables used in the analysis are consistent.

2.2.3. Descriptive Statistics

Descriptive statistics of variables at the Chinese and regional levels (after logarithmic processing) are shown in Tables 2–5.

Table 2. Descriptive statistics of main variables (urban level in China).

Variable	Obs	Mean	Std	Min	Max
Urban green total factor productivity (GTFP)	3523	0.4150	0.3280	−0.0790	2.0840
Dependence of land transfer fee (LAN)	3523	−3.5830	0.9060	−9.3270	1.9440
Land transfer scale (LAS)	3523	6.2790	1.0270	−0.2480	12.3420
Innovation investment level (IIL)	3523	−4.8540	0.9800	−14.990	−1.5800
Infrastructure investment level (ISL)	3523	6.8770	0.9860	2.6390	9.9750
Population size (POP)	3523	5.880	0.6750	3.3920	9.3150
Foreign Direct Investment (FDI)	3523	−3.091	1.3100	−8.6800	14.5090
Financial support for science and technology (TFS)	3523	−1.7100	0.2620	−0.4260	−0.7050
Industrial structure (IS2)	3523	0.2880	0.4260	−1.4270	2.3620
Information level (INFO)	3523	3.5130	1.1450	−3.7440	8.5510

Data source: Calculated with software stata.16, the same below.

Table 3. Descriptive statistics of main variables (eastern region level).

Variable	Obs	Mean	Std	Min	Max
Urban green total factor productivity (GTFP)	1482	0.4160	0.2950	−0.0580	1.6890
Dependence of land transfer fee (LAN)	1482	−3.4140	0.8790	−7.9520	1.7940
Land transfer scale (LAS)	1482	6.5980	1.0200	1.9420	12.3420
Innovation investment level (IIL)	1481	−4.8450	0.9360	−7.9470	−2.6310
Infrastructure investment level (ISL)	1482	7.2090	1.0390	4.0600	9.9750
Population size (POP)	1482	5.9980	0.6170	3.9270	8.8340
Foreign Direct Investment (FDI)	1482	−2.3910	1.1270	−8.6800	14.5090
Financial support for science and technology (TFS)	1482	−1.7150	0.2680	−2.9640	−0.7050
Industrial structure (IS2)	1482	0.2730	0.4530	−1.4140	1.8010
Information level (INFO)	1482	3.9350	1.1370	−3.7440	8.5510

It is worth noting that the minimum negative value of all considered variables in Tables 2–5 is due to the logarithm of the data. For example, some variables are measured by proportional relationship, and after data logarithm processing, the original data between 0–1 become negative.

Table 4. Descriptive statistics of main variables (central region level).

Variable	Obs	Mean	Std	Min	Max
Urban green total factor productivity (GTFP)	1378	0.4430	0.3740	−0.0640	2.0840
Dependence of land transfer fee (LAN)	1378	−3.7230	0.9120	−9.3270	1.2690
Land transfer scale (LAS)	1377	6.1380	0.8790	1.4230	8.4890
Innovation investment level (IIL)	1378	−4.7960	1.0130	−8.2360	−1.5760
Infrastructure investment level (ISL)	1378	6.7160	0.7790	3.9510	9.2690
Population size (POP)	1378	5.8390	0.672	3.7430	9.3150
Foreign Direct Investment (FDI)	1378	−3.4220	1.1200	−8.6560	−0.5610
Financial support for science and technology (TFS)	1378	−1.7280	0.2630	−4.2580	−0.9740
Industrial structure (IS2)	1377	0.2600	0.3770	−1.4270	1.6710
Information level (INFO)	1378	3.2750	0.9610	−0.4470	6.3140

Table 5. Descriptive statistics of main variables (western region level).

Variable	Obs	Mean	Std	Min	Max
Urban green total factor productivity (GTFP)	663	0.3550	0.2850	−0.0790	1.8290
Dependence of land transfer fee (LAN)	663	−3.670	0.8930	−8.2820	1.9440
Land transfer scale (LAS)	663	5.8580	1.1100	−0.2480	9.0210
Innovation investment level (IIL)	662	−4.9970	0.9910	−14.9900	−2.9370
Infrastructure investment level (ISL)	663	6.4710	1.0140	2.6390	9.8530
Population size (POP)	663	5.6990	0.7530	3.3920	8.1290
Foreign Direct Investment (FDI)	663	−3.9690	1.2570	−8.2820	−1.4100
Financial support for science and technology (TFS)	663	−1.6800	0.2410	−4.0320	−1.0320
Industrial structure (IS2)	663	0.3790	0.4470	−0.6300	2.3610
Information level (INFO)	663	3.0610	1.2030	−0.1300	7.3360

2.3. Methods

The emphasis of this paper is on the impact of local government's land market development on GTFP; specifically, it is to test the impact of land transfer fee dependence and land transfer scale on urban GTFP, as well as the regulation effect to the land market by taking innovation investment level (IIL) and infrastructure investment level (ISL) as the mediating variables. In order to control the problem of missing variables caused by individual changes, 271 sample cities in China are divided into 30 individual dummy variables according to the administrative district code. Considering the time trend caused by the change of city GTFP over time, 13 individual time dummy variables are added to the model to control the time trend effect. Based on the panel data of 271 cities in China and the Hausman test, this paper uses the fixed effect model of Panel OLS by controlling the individual effect and time trend effect through dummy variables of individual and time. Models (1) and (2) are used as benchmark models to test whether the impact of land marketization on urban GTFP is consistent with Hypothesis 1.

$$\ln GTFP_{it} = \alpha_0 + \alpha_1 \ln LAN_{it} + \sum_j^N \beta_j \ln CV_{ijt} + \beta_i + \gamma_t + \mu_{it} \quad (1)$$

$$\ln GTFP_{it} = \alpha_0 + \alpha_2 \ln LAS_{it} + \sum_j^N \beta_j \ln CV_{ijt} + \beta_i + \gamma_t + \mu_{it} \quad (2)$$

By further analyzing the regulatory effect of innovation investment level and infrastructure investment level on land marketization, the mediating model with regulatory effect is adopted, as shown in Models (3)–(6), so as to verify Hypothesis 2 and Hypothesis 3.

$$\ln GTFP_{it} = \alpha_0 + \alpha_3 \ln LAN_{it} + \alpha_4 \ln LAN_{it} * \ln IIL_{it} + \sum_j^N \beta_j \ln CV_{ijt} + \beta_i + \gamma_t + \mu_{it} \quad (3)$$

$$\ln GTFP_{it} = \alpha_0 + \alpha_5 \ln LAS_{it} + \alpha_6 \ln LAS_{it} * \ln IIL_{it} + \sum_j^N \beta_j \ln CV_{ijt} + \beta_i + \gamma_t + \mu_{it} \quad (4)$$

$$\ln GTFP_{it} = \alpha_0 + \alpha_7 \ln LAN_{it} + \alpha_8 \ln LAN_{it} * \ln ISL_{it} + \sum_j^N \beta_j \ln CV_{ijt} + \beta_i + \gamma_t + \mu_{it} \quad (5)$$

$$\ln GTFP_{it} = \alpha_0 + \alpha_9 \ln LAS_{it} + \alpha_{10} \ln LAS_{it} * \ln ISL_{it} + \sum_j^N \beta_j \ln CV_{ijt} + \beta_i + \gamma_t + \mu_{it} \quad (6)$$

where $GTFP_{it}$ represents the green total factor productivity of city i in year t ; LAN_{it} is the dependence of land transfer fees of city i in year t ; LAS_{it} represents the land transfer scales of city i in year t ; $LAN_{it} * IIL_{it}$ is the interaction item of the dependence of land transfer fees and the innovative investment level; $LAS_{it} * IIL_{it}$ is the interaction item of land transfer scales and innovative investment level; $LAN_{it} * ISL_{it}$ and $LAS_{it} * ISL_{it}$ represent the interaction items of land transfer fees and land transfer scales with the infrastructure investment level; CV_{ijt} is the number j control variable of city i in year t . Coefficient α_i ($i = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10$) is the key parameter in this paper. β_i is the individual fixed effect; γ_t is the time effect; α_0 is the constant term and μ_{it} is the random interference term.

2.4. Measure of GTFP

SBM-DEA measure model: On the basis of the traditional total factor productivity index, GTFP integrates the environmental pollution index into the index system of economic growth so as to judge whether the economic development of the region conforms to the long-term sustainable concept, rather than taking the old road of pollution first and treatment later. In this paper, the SBM-DEA method is used to calculate urban GTFP.

According to Fukuyama and Weber [44], the GML index can be obtained in the form of Formula (7):

$$GML^{t,t+1}(X^t, Y^t, Z^t, X^{t+1}, Y^{t+1}, Z^{t+1}) = \frac{1 + \overset{\rightarrow G}{S}(X^t, Y^t, Z^t, g^X, g^Y, g^Z)}{1 + \overset{\rightarrow G}{S}(X^{t+1}, Y^{t+1}, Z^{t+1}, g^X, g^Y, g^Z)} \quad (7)$$

where $\overset{\rightarrow G}{S}(X^t, Y^t, Z^t, g^X, g^Y, g^Z)$ represent the global SBM-DDF based on the non-radial and non-directional measurement. The GML index represents the periodic change from period t to period $t+1$. If the GML index is greater than 1, this indicates that GTFP is increasing year by year; if the GML index equals 1, it means that it is in a stationary state; if the GML index is less than 1, GTFP is decreasing year by year. It is necessary to point out that in fact the GML index is not entirely GTFP, and it is just the growth rate of GTFP. Therefore, regression assumptions are needed. Referring to the practice of Liu and Li [45], this paper assumes that the GTFP of each city in 2004 is 1, and then the GTFP formula of 2005 can be deduced, as shown in Formula (8). By analogy, the city GTFP of other years can also be calculated accordingly.

$$GTFP_{2005} = GTFP_{2004} * GML_{2004-2005} \quad (8)$$

The description of input and output elements for calculating GTFP: Input variables include capital stock K and labor input. Output variables include expected outputs, such as regional GDP and non-expected outputs, such as industrial wastewater. The specific variables are described in Table 6 below.

Table 6. Description of input and output indicators.

Type	Indicator Name	Calculation Method
Input indicators	Capital	Perpetual inventory method
Output indicators	Labor	The final number of employees in urban units
Expected output	Regional GDP	Regional GDP of the year
Non-expected output	Industrial wastewater discharge	Industrial wastewater discharge of the city
	Industrial smoke emissions	The city's industrial smoke and dust emissions
	Industrial SO ₂ emissions	SO ₂ emissions of the city

Capital stock K is measured by the perpetual inventory method, as shown in Formula (9).

$$K_{i,t} = \frac{I_{i,t}}{P_{i,t}} + (1 - \delta)K_{i,t-1} \quad (9)$$

where K_t the current capital stock; K_{t-1} the capital stock of the previous period; δ is the depreciation rate of fixed assets, set to 9.6% referring to Zhang [14]; $P_{i,t}$ is the current asset price index based on 2004, adjusted according to the fixed assets investment price index of the provinces where the cities are located.; I_t is the initial capital stock, calculated by dividing the total investment of urban fixed assets by 10%. The relevant data mainly come from China Environment Statistics Yearbook, China Urban Statistics Yearbook, China Statistical Yearbook and so on. Descriptive statistics of GTFP with GML index is in Table 7 below.

Table 7. Descriptive statistics of GTFP with GML index.

Variable	Sample Number	Mean	Standard Deviation	Minimum Value	Maximum Value
Urban green total factor productivity (GTFP)	3523	1.613	0.71	0.924	8.04

3. Results and Empirical Analysis

3.1. Measurement of Land Marketization and Urban GTFP

Due to the differences of China's economic development strategy, there are great differences in the economic development and industrial structure between different regions. Therefore, according to the division of economic zones in China, this paper classifies the sample cities into the eastern coastal region, the central inland region and the western remote region. According to regression Models (1) and (2), the regression analysis of the whole sample and the sub-regional samples is carried out by the Panel OLS estimation method. The basic regression results are shown in Table 8.

Table 8. Impact of land marketization on urban GTFP (overall and sub-regional).

	China (1)	Eastern (2)	Central (3)	Western (4)	China (5)	Eastern (6)	Central (7)	Western (8)
	lnGTFP	lnGTFP	lnGTFP	lnGTFP	lnGTFP	lnGTFP	lnGTFP	lnGTFP
lnLAN	−0.0176 *** (−3.40)	−0.0181 * (−2.46)	−0.0115 (−1.19)	−0.0084 (−0.80)				
lnLAS					−0.0211 *** (−3.79)	−0.0043 (−0.60)	−0.0153 (−1.25)	−0.0545 *** (−5.32)
lnFDI	0.0213 *** (4.74)	0.0410 *** (3.68)	0.0191 ** (2.82)	−0.0078 (−0.91)	0.0216 *** (4.80)	0.0403 *** (3.71)	0.0195 ** (2.85)	−0.0066 (−0.78)
lnIIL	−0.0213 *** (−4.68)	−0.0454 *** (−6.65)	−0.0131 * (−1.74)	0.0196 ** (2.27)	−0.0211 *** (−4.63)	−0.0458 *** (−6.73)	−0.0122 (−1.60)	0.0173 ** (2.03)
lnIS2	−0.0174 ** (−2.18)	−0.0194 * (−1.78)	−0.0008 (−0.05)	−0.0584 ** (−2.98)	−0.0161 ** (−2.02)	−0.0181 * (−1.66)	0.0001 (0.01)	−0.0489 ** (−2.62)
lnISL	−0.0232 *** (−3.44)	−0.0116 (−1.22)	−0.0150 (−1.10)	−0.0791 *** (−5.61)	−0.0207 *** (−3.05)	−0.0134 (−1.41)	−0.0125 (−0.92)	−0.0633 *** (−4.69)
lnPOP	0.0386 *** (5.24)	0.0460 *** (3.67)	0.0620 *** (4.92)	0.0443 ** (2.42)	0.0434 *** (5.83)	0.0492 *** (3.82)	0.0668 *** (5.50)	0.0547 *** (3.11)
lnTFS	0.0214 (1.44)	−0.0502 ** (−2.49)	0.1220 *** (4.63)	−0.0941 ** (−2.37)	0.0187 (1.26)	−0.0524 ** (−2.60)	0.1230 *** (4.72)	−0.0866 ** (−2.25)
lnINFO	−0.0166 ** (−2.51)	−0.0093 (−1.32)	−0.0453 *** (−3.02)	−0.0012 (−0.09)	−0.0117 * (−1.69)	−0.0095 (−1.34)	−0.0427 ** (−2.71)	0.0190 (1.39)
_cons	−0.3240 *** (−4.04)	−0.6870 *** (−5.51)	−0.1370 (−1.10)	0.2900 (1.56)	−0.1930 ** (−2.54)	−0.6070 *** (−4.99)	−0.0716 (−0.53)	0.4240 *** (2.85)
Time effects	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Individual effects	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
N	3520	1481	1377	662	3520	1481	1377	662

Note: *, ** and *** represent passing the significance test of 10%, 5% and 1%, respectively, the same below.

Table 8 reports the regression results of the impact of land transfer fee dependence (LAN) and land transfer scale (LAS) in the land marketization behavior on urban GTFP of the overall sample and the sub-regional samples. On the whole sample level, the estimated coefficients of land transfer fee dependence lnLAN and land transfer scale lnLAS are significantly negative, and all pass the significance test at the 1% level. This indicates that whether LAN or LAS is used as a measure of land marketization, they all show

obvious negative correlation to urban GTFP, meaning that the land marketization inhibits the promotion of urban GTFP. In column (1) and (5) of Table 6, most of the explanatory and control variables pass the 5% significance test, and key explanatory variables $\ln LAN$ and $\ln LAS$ are significant at the 1% level. The coefficients and significance of $\ln LAN$ and $\ln LAS$ are in line with expectations. According to the estimated coefficients, the urban GTFP will decrease by 0.0176% if the dependence degree of land transfer fee increases by 1%, while the urban GTFP will decrease by 0.0211% if the land transfer scale increases by 1%, indicating that further development of the land market will inhibit the improvement of urban GTFP, and the inhibitory effect of the land transfer scale is stronger than that of land transfer fee dependence. Hypothesis 1 is confirmed. The regression results of the control variables indicate that the scale of FDI and population POP have a significant role in promoting urban GTFP, while other control variables, such as the level of innovation investment IIL can inhibit the GTFP development of cities. This is also in line with the conclusions of the existing literature. The development of the land market will lead to the occurrence of high housing prices and mismatched resources [46]. With the development of the land market, the massive transfer of industrial land has squeezed urban land resources, which further exacerbates the mismatch of land resources, thus inhibiting the development of green total factor productivity. Existing studies show that, resource mismatch is an important factor affecting urban total factor productivity. With the development of land marketization, local governments carry out a lot of construction of development zones. In order to attract foreign capital, they do not hesitate to use zero land price or even negative land prices to attract investment. This excessively distorted rough development mode of factors aggravates the mismatch of land resources, which is not conducive to the improvement of production efficiency [26]. In the process of land marketization, local governments “compensate” the mode of the low-price transfer of industrial land by raising the price of commercial and residential land, leading to the distortion of land prices and the allocation of land resources, further inhibiting the increase in total factor productivity [24]. Meanwhile, local companies not only face rising factor prices due to the distortion, but also face intense competition with the entry of foreign enterprises. Therefore, companies will allocate resources as much as possible to more profitable industries, such as real estate, causing a loss in labor. Environmentally friendly enterprises will also face the problem of insufficient resources, which will further inhibit the development of urban GTFP [19]. To sum up, no matter whether it is from the perspective of local government’s land-transfer decision making, or from the perspective of the problems faced by local enterprises, the development of the land market will inhibit the promotion of the urban GTFP.

Further analysis is carried out on the eastern, central and western regions. From the perspective of the land price, by comparing columns (1)–(4) of Table 8, we can see that the estimated coefficients of $\ln LAN$ are negative in eastern, central and western China, but only the estimated coefficient of $\ln LAN$ in eastern China passes the significance test at the 5% level. According to the $\ln LAN$ estimation coefficient of the eastern region, the urban GTFP will decrease by 0.0181% when the land transfer fee dependence increases by 1%, which indicates that the inhibition effect of the land transfer fee dependence on the urban GTFP in the eastern coastal region is higher than that of the whole of China as well as the central and western regions. One possible explanation is the high land price in eastern coastal China. Driven by land marketization, housing prices in the eastern coastal areas far exceed those in the central and western regions. A series of problems caused by excessive housing prices will make the dependence of land transfer fees in the eastern coastal area have a higher inhibitory effect on urban GTFP than other regions. From the quantitative perspective of the land market, columns (5)–(8) in Table 8 display that the estimated coefficients of the land transfer scale $\ln LAS$ in each region are negative. Unlike estimations in columns (1)–(4) of Table 8, only the $\ln LAS$ estimated coefficient in the western remote region pass the 1% significance test. Every 1% increase in the land transfer scale of the western remote region reduces the urban GTFP by 0.0545%, and the inhibition effect of the land transfer scale of the western remote region on the urban GTFP is much higher than that of other areas.

This may be due to the fact that the level of land marketization and industrial structure in western China are quite different from those in other regions [47]. The urbanization of the western region is relatively backward, and its economic development is still in the initial stage of industrialization, which is dwarfed by the industrialization level of other regions. It is easy to rely too much on the mismatch of resources caused by the expansion of the land transfer scale, thus falling into the “low efficiency trap”. The area of land available for transfer in the western remote areas is far more than that in the central and eastern areas, and the economic development level of the western remote areas is lagging behind other areas, so the dependence of the western remote areas on land transfer is also higher than other areas. Therefore, combined with the above analysis, in the process of land market development, the inhibitory effect of the western region on GTFP is higher than that of other regions through the form of “quantity”. Therefore, no matter in terms of “price” or “quantity”, there is regional heterogeneity in the impact of land marketization on urban GTFP, which verifies Hypothesis 2.

3.2. Mechanism Analysis

3.2.1. Analysis of the Role of Innovation Investment Level in the Process of the Impact of Land Market on Urban GTFP

According to regression Models (3) and (4), this paper makes a regression analysis on the whole sample by the Panel OLS estimation method. The parameter estimation results of Models (3) and (4) are shown in Table 9. Columns (1) and (3) in Table 9 are the Panel OLS estimation results without introducing interactive terms, while columns (2) and (4) are the Panel OLS estimation results after introducing interactive terms.

Table 9. Effect of innovation investment level on land market: regulatory effect results.

	(1)	(2)	(3)	(4)
	lnGTFP	lnGTFP	lnGTFP	lnGTFP
lnLAN	−0.0176 *** (−3.40)	−0.0997 *** (−4.55)		
lnLAS			−0.0211 *** (−3.79)	−0.1370 *** (−7.53)
lnIIL	−0.0213 *** (−4.68)	−0.0790 *** (−5.12)	−0.0211 *** (−4.63)	0.1240 *** (5.79)
lnLAN*lnIIL		−0.0166 *** (−4.08)		
lnLAS*lnIIL				−0.0227 *** (−6.87)
_cons	−0.3240 *** (−4.04)	−0.5870 *** (−5.23)	−0.1930 * (−2.54)	0.5410 *** (4.10)
Control variables	Controlled	Controlled	Controlled	Controlled
Time effects	Controlled	Controlled	Controlled	Controlled
Individual effects	Controlled	Controlled	Controlled	Controlled
N	3520	3520	3520	3520

Note: *, ** and *** represent passing the significance test of 10%, 5% and 1%, respectively, the same below.

In columns (1) to (4), key explanatory variables LAN, LAS and the interaction LANIIL, LASIIL are significant at the 1% level, all having a negative impact on urban GTFP. This indicates that the regulatory effect of the innovation investment level is significant, and the increase in the innovation investment level will strengthen the inhibition effect of the land market on urban GTFP. This verifies Hypothesis 3. China’s supply-side reforms in recent years have clearly set the goal of increasing total factor productivity and providing a continuous impetus for sustainable economic development. In response to the call, local governments have increased investment in innovation funds. However, due to the local innovation level and innovation efficiency constraints, it is difficult to fully transform into actual productivity to promote GTFP improvement. During the process of land marketization, local enterprises will strengthen the level of innovation investment under the pressure of survival so as to improve the green economic benefits and achieve the goal of sustainable development [24]. The current innovation investment intensity is

insufficient, and the enterprise innovation behavior is too dependent on the external technology, so the innovation efficiency is low, and this kind of inefficient R&D investment restrain TFP promotion [48]. Thus, in the process of land marketization, limited by the current innovation environment and level, increasing the level of innovation input by local governments does not necessarily increase the level of urban GTFP [49]. On the contrary, inefficient and ineffective innovation investment will cause the waste of resources, increase the degree of mismatch of resources, and then significantly inhibit the GTFP of the city.

3.2.2. The Role of Infrastructure Investment Level in the Impact of Land Market on Urban GTFP

According to regression Models (5) and (6), the regression analysis of the whole sample in China by the Panel OLS estimation method is made. The parameter estimation results of Models (5) and (6) are shown in Table 8, where columns (1) and (3) are the Panel OLS estimation results without introducing interactive terms, while columns (2) and (4) are the Panel OLS estimation results after introducing interactive terms.

In columns (1) to (4), key explanatory variables LAN and LAS are significant at the level of 1%, and the coefficients of interaction LANISL and LASISL are significantly positive, indicating that there is a regulatory effect of the level of infrastructure investment, and the increase in the infrastructure investment level will weaken the inhibition of land marketization on urban GTFP, which verifies Hypothesis 4. On the one hand, with the development of land marketization, local governments have more money to invest in the city's public infrastructure [4]. The development of the land market will also lead to the upgrading of the local public infrastructure, and the improvement in infrastructure can effectively reduce the logistics transportation costs of local enterprises and the living costs of residents [50], affecting the production cost and factor input structure of the enterprise and improving enterprise productivity, thus promoting the city's GTFP. On the other hand, infrastructure investment also has a certain crowding-out effect on the introduction of foreign technology, effectively enhancing the contribution of FDI technology spillover to total factor productivity [51]. In conclusion, the level of infrastructure investment promoted by land marketization is conducive to the improvement of urban GTFP, and then weakens the inhibiting effect of land marketization on urban GTFP.

Through the comparison between Tables 9 and 10, it can be seen that there is a significant difference between the level of innovation investment and the level of infrastructure investment on the regulatory effect of the land market [52]. With the improvement of the innovation investment level, the inhibition effect of land market on urban GTFP will be enhanced [53], while with the improvement of infrastructure investment level, the inhibition effect of land market on urban GTFP will be weakened. From the estimated parameter coefficients in Tables 9 and 10, we can see that the interactive coefficients of innovation investment level and land market are -0.0166 and -0.0227 , respectively, and the interactive coefficients of the infrastructure investment level and land market are 0.0147 and 0.0133 , respectively, indicating that the negative regulatory effect of the innovation investment level is stronger than the positive regulatory effect of the infrastructure investment level [54].

3.3. Robustness Test

3.3.1. SLS Model Estimation

No matter whether it is from the perspective of logic or economics, there are endogenous problems between land marketization and urban green total factor productivity. Therefore, this paper uses the two-stage least square method [55] to select the first-order lag term of land transfer fee dependence and land transfer scale as the instrumental variable to further analyze the impact of land marketization on urban GTFP. This not only helps to avoid the endogenous problem in the model, but also can be compared with the Panel OLS estimation of Models (1) and (2). Table 11 shows that the estimation coefficient of the first order lag term of LAN and the first order lag term of LAS pass the significance test at

the 1% level and have a significant inhibitory effect on the urban GTFP. The conclusion is consistent with the previous Panel OLS estimation results [56].

Table 10. Impact of infrastructure investment levels on land market: results of regulatory effects.

	(1)	(2)	(3)	(4)
	lnGTFP	lnGTFP	lnGTFP	lnGTFP
lnLAN	−0.0176 *** (−3.40)	−0.116 *** (−3.85)		
lnLAS			−0.0211 *** (−3.79)	−0.1070 *** (−4.65)
lnISL	−0.0232 *** (−3.44)	0.0308 (1.82)	−0.0207 ** (−3.05)	−0.1030 *** (−4.55)
lnLAN*lnISL		0.0147 *** (3.31)		
lnLAS*lnISL				0.0133 *** (3.82)
_cons	−0.3240 *** (−4.04)	−0.6800 *** (−5.14)	−0.1930 * (−2.54)	0.2740 (1.81)
Control variables	Controlled	Controlled	Controlled	Controlled
Time effects	Controlled	Controlled	Controlled	Controlled
Individual effects	Controlled	Controlled	Controlled	Controlled
N	3520	3520	3520	3520

Note: *, ** and *** represent passing the significance test of 10%, 5% and 1%, respectively, the same below.

Table 11. Empirical results of robustness tests.

	2SLS(1)	2SLS(2)	OLS(3)
	lnGTFP	lnGTFP	lnGTFP
L.lnLAN	−0.0209 *** (−3.80)		
L.lnLAS		−0.0231 *** (−3.95)	
lnLFI			−0.0223 *** (−4.33)
lnFDI	0.0239 *** (4.81)	0.0242 *** (4.86)	0.0218 *** (4.73)
lnIIL	−0.0231 *** (−4.88)	−0.0228 *** (−4.81)	−0.0219 *** (−4.79)
lnIS2	−0.0200 ** (−2.37)	−0.0184 ** (−2.16)	−0.0174 ** (−2.17)
lnISL	−0.0267 *** (−3.74)	−0.0239 *** (−3.32)	−0.0148 ** (−2.04)
lnPOP	0.0416 *** (5.33)	0.0465 *** (5.91)	0.0449 *** (6.00)
lnTFS	0.0231 (1.43)	0.0208 (1.29)	0.0214 (1.43)
lnINFO	−0.0161 ** (−2.24)	−0.0108 (−1.43)	−0.0078 (−1.14)
_cons	0.7890 *** (9.17)	0.9580 *** (11.69)	−0.1230 (−1.51)
Time effects	Controlled	Controlled	Controlled
Individual effects	Controlled	Controlled	Controlled
N	3250	3249	3493

Note: *, ** and *** represent passing the significance test of 10%, 5% and 1%, respectively, the same below.

Meanwhile, referring to the research of Fan et al. [2] and other scholars, this paper replaces the core explanatory variables with the land transfer income LFI to measure the degree of land marketization as a robustness test. The results are shown in Table 11. The LFI estimation coefficient passes the significance test at the 1% level, and the conclusion of LFI inhibition GTFP promotion can be obtained [57], which is consistent with the previous Panel OLS estimation results, indicating that the conclusion of this paper is robust.

3.3.2. Model Comparison

A large amount of literature shows that when using DEA data as the explained variable, the Tobit model is mostly used for estimation [58,59]. Therefore, based on the existing model, the Tobit model is added to compare and analyze to see whether the conclusions of this paper are robust. The variables used in the panel Tobit model are consistent with the Panel OLS model. According to the range of $\ln GTFP$, the lower limit is set to 0, and the upper limit is set to $+\infty$. The comparison results of the two models are shown in Table 12. In Table 12, columns (1)–(4) are the regression results of the Panel Tobit model, and columns (5)–(6) are the regression results of the panel OLS. The sources of variables in Table 12 are consistent with those in Table 1.

Table 12. The comparison of the Panel Tobit model and Panel OLS model.

	(1)	(2)	(3)	(4)	(5)	(6)
	$\ln GTFP$	$\ln GTFP$	$\ln GTFP$	$\ln GTFP$	$\ln GTFP$	$\ln GTFP$
$\ln LAN$	−0.0094 (−1.52)	−0.0189 *** (−3.34)			−0.0176 *** (−3.40)	
$\ln LAS$			−0.0415 *** (−5.95)	−0.0228 *** (−3.74)		−0.0211 *** (−3.79)
$\ln FDI$	−0.0214 *** (−4.83)	0.0243 *** (6.41)	−0.0189 *** (−4.30)	0.0246 *** (6.49)	0.0213 *** (4.74)	0.0216 *** (4.80)
$\ln IIL$	0.0878 *** (15.36)	−0.0231 *** (−4.69)	0.0885 *** (15.60)	−0.0229 *** (−4.65)	−0.0213 *** (−4.68)	−0.0211 *** (−4.63)
$\ln IS2$	−0.0298 ** (−2.46)	−0.0204 ** (−2.23)	−0.0286 ** (−2.38)	−0.0190 ** (−2.08)	−0.0174 ** (−2.18)	−0.0161 ** (−2.02)
$\ln ISL$	−0.0649 *** (−7.72)	−0.0280 *** (−4.06)	−0.0498 *** (−5.68)	−0.0255 *** (−3.66)	−0.0232 *** (−3.44)	−0.0207 *** (−3.05)
$\ln POP$	−0.103 *** (−11.31)	0.0444 *** (5.58)	−0.0921 *** (−9.97)	0.0494 *** (6.12)	0.0386 *** (5.24)	0.0434 *** (5.83)
$\ln TFS$	−0.0237 (−1.20)	0.0246 (1.64)	−0.0279 (−1.42)	0.0220 (1.47)	0.0214 (1.44)	0.0187 (1.26)
$\ln INFO$	0.185 *** (23.57)	−0.0178 ** (−2.20)	0.191 *** (24.32)	−0.0125 (−1.50)	−0.0166 ** (−2.51)	−0.0117 * (−1.69)
Time effects	No	Controlled	No	Controlled	Controlled	Controlled
Individual effects	No	Controlled	No	Controlled	Controlled	Controlled
_cons	1.094 *** (13.17)	−1.453 (−0.04)	1.203 *** (15.31)	−1.317 (−0.04)	−0.3240 *** (−4.04)	−0.1930 ** (−2.54)
N	3523	3523	3523	3523	3523	3523

Note: *, ** and *** represent passing the significance test of 10%, 5% and 1%, respectively.

It can be seen from the regression results in Table 12 that in columns (1)–(4), the important explanatory variables $\ln LAN$ and $\ln LAS$ are basically significantly negative, passing the 1% significance level test. After controlling for time effect and individual effect, the estimated coefficients of the two variables are close to the coefficients of the Panel OLS models, columns (5) and (6), indicating that whether it is the Panel OLS model or the Panel Tobit model, the conclusion of this paper is robust; the development of the land market inhibits the impact of green total factor productivity.

4. Discussion

Empirical Analysis and Discussion

After regression of the benchmark model of China's whole sample and sub sample, it can be found that the strategy of the land market in China on the land transfer price and land transfer area often affects the development of regional green total factor productivity. Some local governments will adopt a low-price agreement to transfer industrial land, and then restrict the combination of residential commercial land to expand financial income, which will lead to the distortion of the land factor price and the occurrence of resource mismatch. This development mode also affects the investment choice of local enterprises, and will make the local industry develop rapidly, while hindering the development of other industries, making the local industrial structure unitary. This phenomenon is especially obvious in the remote areas of the west. Unreasonable industrial structure and the

development mode relying on land transfer will inhibit sustainable development of the remote areas in the west [60].

In the mechanism analysis, we can see that the adjustment effect of the innovation input level and infrastructure investment level on the land market is heterogeneous [61]. On the one hand, with the continuous development of the land market, the financial revenue of the local government is also increasing year by year, which is leading to the continuous increase in scientific research investment and innovation investment, and the number of patents is also growing rapidly. However, some inefficient and ineffective innovation projects are also included, which will also lead to the waste of resources. The low efficiency of innovation will also inhibit the development of green total factor productivity. On the other hand, China is a big country in infrastructure construction, and its infrastructure construction has achieved remarkable results. With the financial support of local government, infrastructures, such as traffic roads, have been further improved, reducing the cost of commodity transportation in various industries. At the same time, foreign advanced technologies will be introduced, which will intensify the technology and commodity exchange among regions, and coordinate development and progress among different industries, thus rationalizing the allocation of social resources and improving the utilization rate of elements; thus, the green total factor productivity will be promoted [62].

According to the empirical results of this paper, we put forward the following policy suggestions: First, we need to strengthen the supervision of local government's land transfer behavior, strengthen the land market planning reform, control the rationalization of land price, optimize the land supply structure, realize the full development and utilization of land, and solve the unreasonable allocation of land resources. In particular, some areas that rely on land transfer mode need to change their development mode to diversified development and sustainable development. Secondly, while increasing the investment in innovation, the local government should also improve the supervision on the effectiveness of enterprise innovation [62], avoid the problems of inefficient and ineffective innovation, and promote the sustainable development of the region through green technology innovation [63]. At the same time, the local government should strengthen infrastructure construction, improve traffic road facilities, reduce the transportation cost of enterprises, attract a lot of excellent foreign investment, and introduce more advanced equipment and technology. Finally, the local government should combine the local economic development level and the characteristics of the industrial structure, adjust measures to local conditions, reasonably control the development of the land market, optimize the industrial structure, and achieve high-quality economic development.

5. Conclusions

Based on the data of 271 Chinese cities, except Hong Kong, Macao, Taiwan and Tibet from 2004 to 2016, this paper analyzed the impact of the land market on urban green total factor productivity, as well as the regulatory effect of the innovation investment level and infrastructure investment level on urban green total factor productivity. The following conclusions are drawn:

- (1) It is found that the development of the land market inhibits the increase of urban green total factor productivity from the perspective of land market price and scale, and the inhibition effect of land transfer scale is stronger than that of land transfer fee dependence.
- (2) The inhibition effect of the land market on urban green total factor productivity is heterogeneous among different regions in which the inhibition effect of eastern coastal cities is especially obvious from the perspective of the land market price, while the inhibition effect of western remote areas is stronger than that of other regions from the perspective of the land market scale, indicating that the impact of the land market on urban green total factor productivity has regional heterogeneity.
- (3) The level of innovation investment and the level of infrastructure investment have significant regulatory effects on the land market. With the development of the land

market, the improvement of innovation investment level will strengthen the restraining effect of land market on urban green total factor productivity. However, the improvement of the infrastructure investment level will weaken the restraining effect of land market on urban green total factor productivity, improve the construction of urban infrastructure, effectively reduce the local logistics transportation cost, promote the development of local green building industry, and provide hardware facilities and suitable environments to attract foreign investment. For the land market, the regulatory effect of the innovation investment level is stronger than that of the infrastructure investment level.

In view of the conclusions, this paper puts forward the following relevant suggestions: First, local governments should control the development of land market, adapt measures to local conditions, optimize local industrial structure, rationally allocate different resources, curb the rapid increase of housing prices and absorb more relatively excellent and efficient foreign enterprises. Second, local governments should increase the investment of local infrastructure projects, and focus on the construction of infrastructure to avoid the phenomenon of inefficient input and uneconomical output scale. Third, local governments should respond to the global trend of carbon neutralization, introduce policies to encourage local enterprises to transform and upgrade into environmental protection and energy-saving enterprises, increase green R&D investment in enterprises, and improve the level of environmental protection supervision of enterprises so as to reduce local pollutant emissions and carbon emissions, thereby increasing the green total factor productivity of cities. In addition, if a city wants to achieve sustainable development and improve its green total factor productivity, it should not rely too much on the development of the land market but should improve its own level of public facilities and resource allocation efficiency and attract more excellent talents and enterprises.

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