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The Impact of the Regional Differentiation of Land Supply on Total Factor Productivity in China: From the Perspective of Total Factor Productivity Decomposition

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Abstract: Increasing total factor productivity is the key to promoting high-quality economic development. This paper starts with land supply as an institutional source factor and discusses the impact of the regional differentiation of land supply on total factor productivity in China. Based on the panel data of 273 cities in China from 2003 to 2017, this paper measures total factor productivity (TFP) using the DEA-Malmquist index, decomposes it into technical progress (TE), pure technical efficiency (PE) and scale efficiency (SE), and analyzes the effect of the regional differentiation of land supply on TFP using the spatial Durbin model and mediating model. This study finds the following: (1) At the national level, the tilting of land supply to the central and western regions leads to a contradiction between land supply and demand, which hinders TFP by suppressing TE, PE and SE. (2) At the regional level, the reduction in land supply in the eastern region expands the technological substitution rate, induces the substitution effect of enterprise innovation, and thus promotes TE, but inhibits PE and SE under the resource constraint and congestion effect, which hinders the improvement of TFP. The estimates for the central and western regions are generally consistent with the national results; again, as land supply increases, this hinders TFP by suppressing TE, PE and SE. (3) In terms of the mechanism of influence, the decrease in land supply in the eastern region promotes TE and TFP by promoting urban innovation and inhibiting SE through productive services agglomeration; the increase in land supply in the central and western regions hinders TE and TFP by inhibiting urban innovation, and hinders SE through manufacturing agglomeration. The conclusion of this paper has great significance for deepening the structural reform of land supply and promoting high-quality economic development.

Keywords: land supply; total factor productivity; urban innovation; industrial agglomeration

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1. Introduction

The improvement of TFP is an inherent requirement of high-quality economic development, and the optimization of factor allocation is one of the effective paths toward this requirement [1]. China's capital and labor factor markets are relatively perfect, but the land factor market is influenced by the land grant system and local government behavior, and there are problems such as excessive government intervention and the distortion of land resource allocation [2]. In 2003, in order to coordinate regional development, the central government of China tilted the spatial distribution of land supply to the central and western regions. The research found that this policy of the regional differentiation of land supply has greatly increased the proportion of land supply in the central and western regions [3]. As shown in Figure 1, from 2003 to 2017, the proportion of land supply in the central and western regions of China increased from 29.31% to 59.06%. During the same period, the proportion of land supply in the eastern region decreased from 70.69%

to 40.94%, resulting in the spatial misallocation of land, which led to a series of economic and social problems. For example, the decrease in land supply in eastern China led to a rise in housing prices, which raised the threshold for the rural migrant population to settle down in cities and pushed up the semi-urbanization rate [4–6]. At the same time, the central and western regions fell into a vicious circle of "new city development—land mortgage and refinancing—new city expansion and construction" with the advancement of the construction land index, resulting in a large number of "empty cities" and "ghost cities", and a high debt rate of local governments [7]. The above studies on housing prices, urbanization, government debt and other issues are all manifestations of obstacles to the improvement of TFP. A systematic study on the impact of the regional differentiation of land supply on TFP in China and the mechanism of its effect can help to fundamentally respond to the above problems.

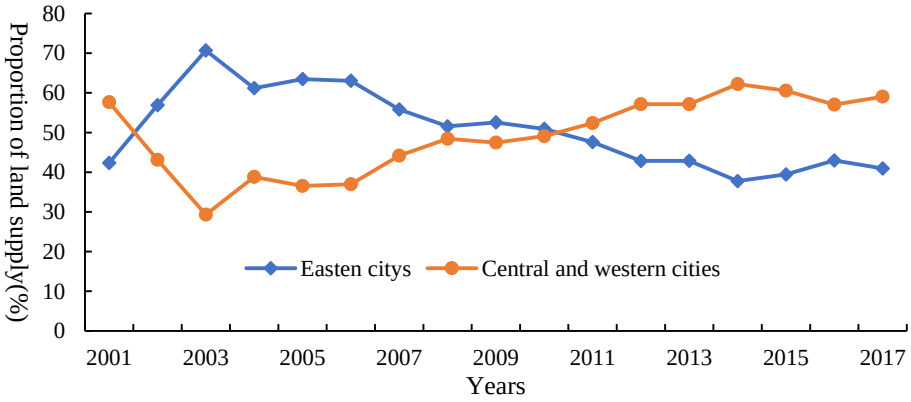

Figure 1. The trend of land supply area proportion.

Previous studies have explored the relationship between factor allocation and TFP. Among them, the research on the allocation of labor, capital and other factors is relatively mature, and it has become a consensus in the academic community that factor mismatch leads to productivity reduction. For example, Chang-Tai and Peter believe that if there is no mismatch, China's manufacturing TFP can achieve 25%~40% growth [1]; Loren and Trevor et al. found that the mismatch of resources in China's non-agricultural sector led to a loss of TFP of 20% [8]. With the maturity of the theory of factor mismatch, scholars began to pay attention to the impact of land resource mismatch, confirming that land resource mismatch inhibited urban innovation, hindered the conversion of the new and old kinetic energy of cities, and caused urban efficiency loss [7]. In 2003, the central government of China adopted a differentiated land allocation policy among regions, and academic discussions revolved around the economic performance resulting from this policy. Some scholars argue that the tilted land supply to the central and western regions is a more equitable approach, which to a certain extent, enables local governments in the central and western regions to obtain more "land finance" and creates conditions for rapid economic growth in the central and western regions to catch up with the eastern regions, and will significantly reduce the economic differences between regions in terms of land allocation. This will significantly reduce the economic differences between regions and find a good balance between "efficiency" and "equity" in land allocation [9]. Another group of scholars believes that due to regional differences in land financing capacity, this differentiated land supply has not accelerated the rate of regional economic disparity reduction but has instead led to low land concessions in central and western regions due to the blind pursuit of political achievements, resulting in a mismatch between the supply of resources and production efficiency, hindering regional economic convergence, widening the urban–rural consumption gap, contradicting the initial goal of coordinated regional development, and leading to other cascading effects such as rising housing prices in the east and pollution transfer [10–12].

The existing studies have provided an important theoretical basis for this paper, but there are several shortcomings and much room for improvement: first, the existing studies capture the phenomenon of the spatial mismatch of construction land but ignore the fact that the government's differential allocation violates the marginal output-by-optimality, which is the deep-seated cause of the mismatch. Therefore, focusing on the regional differentiation of government land supply will help enrich the theoretical system of construction land allocation. Second, these studies have attempted to analyze the influencing factors of TFP, but have not subdivided TFP, which blurs the connotation of technical progress, pure technical efficiency and scale efficiency included in TFP, and makes it difficult to accurately grasp the specific path of impact. Therefore, this paper will decompose TFP, and explore how the regional differentiation of land supply affects TFP through the decomposition item. Third, as for the mechanism of influence of land supply on TFP, existing studies have conducted exploration from the perspectives of environmental regulation, industrial land prices and wages, but have only analyzed the impact on TFP. This paper will refine the research perspective and construct a one-to-one correspondence mechanism of influence for urban innovation–TE, and industrial agglomeration–SE. The rest of this paper is organized as follows: the second part provides the mechanism of influence and theoretical hypothesis; the third details the research methods and data sources; the fourth describes the results; and the fifth presents the conclusion and discussion.

2. Mechanism of Influence and Theoretical Hypotheses

2.1. The Impact of Regional Differentiation in Land Supply on TFP

Misunderstanding "balanced" and "uniform" development, the central government of China adopted a land supply policy that favored the central and western regions and pursued balance by transferring resources, which to a certain extent, led to investment and economic growth in the central and western regions [13]. However, the government's excessive intervention in land allocation and the reverse of administrative and market power agglomeration has led to conflict between efficiency and equilibrium goals, resulting in unequal marginal benefits across regions, the mismatch of spatial resources, and the deviation of regional development from the perspective of comparative advantages, which has hindered the improvement of Pareto and the quality of economic development.

For the eastern region, the tilted land supply to the central and western regions implies that the supply of land in the eastern region is reduced. Under the guidance of the land supply policy of giving priority to key construction projects, the reduction in land supply means that the supply available for commercial housing is limited, causing housing prices to rise rapidly, which further hinders the inflow of labor, indirectly increases wages and weakens the cost advantage of the eastern region, thus hindering the improvement of TFP [14–16]. Under the market mechanism, factors such as capital and technology flow freely to the east, and "starvation land supply" forms a resource constraint. The shortage of space will aggravate the burden of urban infrastructure and public services, leading to urban congestion effects and hindering factor concentration and industrial agglomeration effects. In summary, in the eastern region, the regional differentiation of land supply will hinder the improvement of TFP.

For the central and western regions, with the increase in land supply, capital has been attracted, which to some extent has alleviated the labor migration to the eastern region, and the local governments have obtained more land transfer opportunities to make up for the fiscal gap, which is positively stimulating economic development [17,18]. However, the central government's quantitative expansionary economic development approach of interfering with factor allocation by administrative means is unsustainable, and excessive land supply will have a negative impact on economic efficiency. First, more land supply encourages local governments to subsidize inefficient enterprises with low land prices [19,20], so that inefficient enterprises can survive. Increasing investment and expanding production scale have become the "rational choice" of enterprises, resulting in redundant construction and overcapacity [21]. Second, when the central and western

regions obtained more construction land indicators, three-quarters of the land supply was used for infrastructure that had less impact on economic efficiency, such that land input had a limited effect on economic growth and hindered regional economic convergence [22]. Third, the relatively lenient land supply in central and western regions promotes local governments to attract investment by building industrial parks, but most of such parks are far away from the main urban areas and have low population densities. There is a risk that they lack the corresponding industrial activities to maintain the growth of urban space, which not only leaves a large number of industrial parks vacant, but also accumulates debts for local governments [7]. In summary, the central government's land supply differentiation policy will hinder TFP enhancement in the central and western regions.

2.2. Mechanism of Influence

In this paper, TFP is decomposed into technical progress (TE), pure technical efficiency (PE) and scale efficiency (SE). PE reflects the efficiency of factor allocation that maximizes the release of the existing technology level through a coordinated allocation among factors [23]. The central government intervenes in the allocation of construction land by administrative means, which restricts the indicators of construction land in the eastern region with high productivity and population inflow, while the indicators of construction land increase in the central and western regions with population outflow; this administrative intervention control model leads to the distorted mismatch and efficiency loss of land factors, which directly inhibits the PE. This paper focuses on the mechanism of impact of the regional differentiation of land supply on TE and SE.

2.2.1. Regional Differentiation of Land Supply, Urban Entrepreneurial Innovation and TE

Li's research shows that R&D and innovation are important ways to promote technological progress and raise the level of the production frontier, and that the supply of land resources, as an important carrier of urban production and innovation activities, is closely related to urban innovation [23]. Specifically (Figure 2), it is assumed that the initial supply and land price of construction land is IL_0 and IP_0, respectively. With the contraction of land supply in the eastern region, the supply will decrease to IL_2, and the corresponding land price will increase to IP_2 ($IP_2 > IP_0$). For the same equal cost curve, the slope C/IP2 < C/IP0 indicates that the technology substitution rate of C/IP2 is greater than C/IP0, so the reduction in land supply in the eastern region will induce other factors to replace land elements. According to the price-induced progress hypothesis and the innovation compensation effect [24,25], an increase in land price will force enterprises to reduce costs through innovation, especially in the eastern region of China, where the national high-tech zones account for 40% of the country in 2020, and the R&D expenditure accounted for 67.7% of the country, intensifying the innovation competition between enterprises and causing the technology substitution effect caused by the land price increase to be more significant. In addition, in the case of a scarcity of land indicators, local governments in the eastern region are more cautious in the use of construction land indicators and take the initiative to screen stronger high-end enterprises that are in line with industrial development trends. For example, in recent years, many places in the Yangtze River Delta and the Pearl River Delta have introduced industrial development support policies to ensure the landing of key industries and major projects, and this screening behavior of local governments will enable enterprises with stronger innovation capabilities to settle in and promote the industry in the direction of high-end development, which in turn will promote TE and TFP.

For the central and western regions, with the increase in land supply, the supply increases from IL_0 to IL_1, and the corresponding land price will drop to IP_1 ($IP_1 < IP_0$). For the same equal cost curve C, the slope C/IP1 > C/IP0, that is, the C/IP1 technology substitution rate, is smaller than C/IP0, indicating that the economic growth in the central and western regions relies more on lower-priced land inputs, which will weaken enterprises' technological innovation motivation and capacity. Moreover, the flow of population and technology to the east under the market mechanism leads to the loss of the population

base and market in the central and western regions, which results in basic judgments and psychological expectations for outside companies, reduces their willingness to move in and inhibits entrepreneurship and innovation in the central and western regions [26], thus hindering TE and TFP.

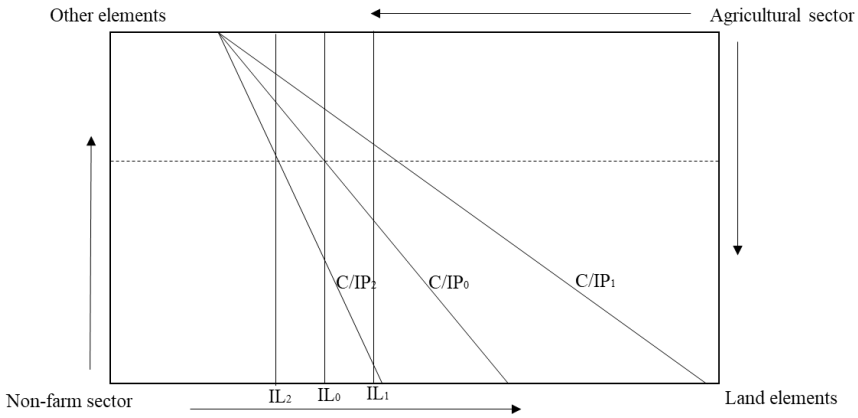

Figure 2. Schematic diagram of land supply change.

2.2.2. Regional Differentiation of Land Supply, Industrial Agglomeration and SE

The differentiated land supply policy changes the quantity of regional land supply, and when the externally given quantity of land supply changes, the local government will correspondingly change the land allocation structure, forming different types of industrial clusters in different regions according to the internal differences between the service industry and the manufacturing industry and the logic of the government in terms of allocating land [27]. Hirsch and other scholars believe that industrial agglomeration is an important factor affecting the scale effect of the urban economy. The industrial agglomeration effect can achieve scale economy and scope economy, while the crowding effect inhibits the improvement of scale efficiency [28–31].

In the context of urban industrial transformation and intensive land use assessment, the average land production value of productive service industries is higher than that of manufacturing industries. Therefore, when facing the constraint of construction land indicators, the eastern region prefers to grant commercial land to develop the service industry. In addition, the rise in house prices causes the squeeze of low-end workers, which leads to the evolution of the industrial structure to high-end producer services, promoting the concentration of intensive, efficient, and high-added-value producer services [32]. However, the agglomeration of productive service industries in the eastern region does not bring scale efficiency because the eastern region faces the problem of insufficient land supply, which leads to the reduction of land revenue and infrastructure land, constrains the ability of local governments to supply public services, causes urban diseases such as insufficient infrastructure and traffic congestion, and creates difficulty in supporting the agglomeration of productive service industries, resulting in the uneconomic agglomeration and inhibiting the improvement of scale efficiency [33,34].

The cost advantage of land is an important factor for the change in manufacturing spatial layout. On the one hand, due to the lack of consumption power in the central and western regions with a lower population concentration, it is difficult to drive the development of productive services [35]. On the other hand, the increase in land supply in central and western regions stimulates local governments to choose the manufacturing industry, with its high short-term returns, as the leading industry, forming path dependence and leading to the structural rigidity of the manufacturing industry [36–38]. Therefore, the increase in land supply in the central and western regions promotes the agglomeration of manufacturing industries. Under economies of scale, economic agglomeration development is the result of the spontaneous action of market forces [39,40], but manufacturing

agglomeration in the central and western regions is the result of government intervention in resource allocation through administrative means. Spatial expansion deviates from the actual agglomeration development speed, and the agglomeration of low-end manufacturing industries causes the agglomeration efficiency to decline with the expansion of scale, inhibiting the improvement of scale efficiency.

This paper constructs the following theoretical analysis framework diagram based on the above theoretical analysis (Figure 3) and proposes the following three hypotheses.

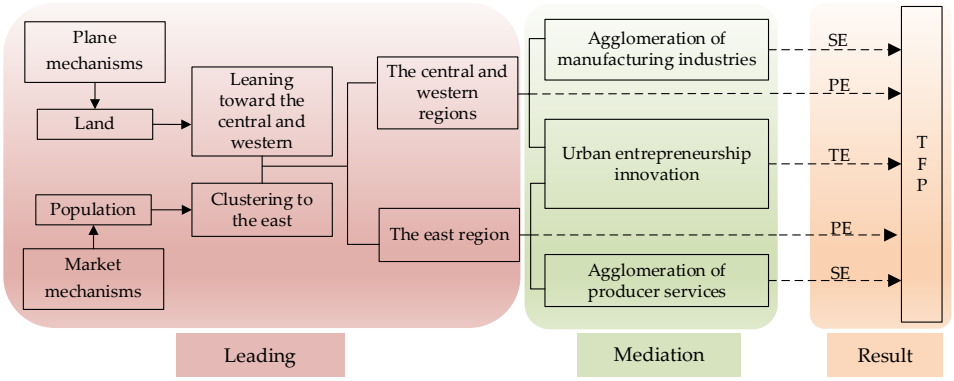

Figure 3. Analysis framework.

Hypothesis 1: *The regional differentiation of land supply will have a dampening effect on TFP.*

Hypothesis 2: *The regional differentiation of land supply in the eastern region promotes TE by promoting urban innovation, while the regional differentiation of land supply in the central and western regions hinders TE by inhibiting urban innovation.*

Hypothesis 3: *The regional differentiation of land supply in the eastern region and central and western regions inhibits SE through the agglomeration of productive service industries and manufacturing industries, respectively.*

3. Research Methods and Data Sources

3.1. Model Settings

Since ignoring the spatial characteristics will make the research conclusions biased, this paper adopts the spatial econometric analysis method. The commonly used spatial econometric models are the Spatial Autocorrelation Model (SAR), Spatial Errors Model (SEM), and Spatial Durbin Model (SDM). The general spatial econometric model used in this paper is set up as follows:

$$Y_{it} = \alpha_0 + \rho W Y_{it} + \alpha_1 X_{it} + \alpha_2 Z_{it} + \alpha_3 W X_{it} + \alpha_4 W Z_{it} + \varepsilon_{it} \quad (1)$$

where Y_{it} represents the explanatory variables, denoting TFP, TE, PE, and SE in a city, respectively; X_{it} is the quantity of land supply in a city, which is the endogenous use of lagged one-period data for mitigation. Z_{it} is the control variable, ε_{it} is the random error term, and W denotes the spatial weight matrix. This paper uses a composite spatial weight matrix of geographic and economic distances, where the geographic matrix is weighted by the inverse of the distance between the two cities, and the economic matrix is weighted by the GDP per capita. $\alpha_0 \sim \alpha_4$ are the parameters to be estimated, and the correlation between the TFP of the city and the surrounding area is tested according to the coefficient ρ.

To further test the mechanism of the effect of regional differentiation of urban land supply on TFP, this paper constructs the following mediation model based on the study of Baron and Kenny et al. [41,42].

$$M_{it} = \beta_0 + \rho W M_{it} + \beta_1 X_{it} + \beta_2 Z_{it} + \beta_3 W X_{it} + \beta_4 W Z_{it} + \varepsilon_{it} \quad (2)$$

$$Y_{it} = \gamma_0 + \rho WY_{it} + \gamma_1 X_{it} + \gamma_2 M_{it} + \gamma_3 Z_{it} + \gamma_4 WX_{it} + \gamma_5 WM_{it} + \gamma_6 WZ_{it} + \varepsilon_{it} \quad (3)$$

where M_{it} denotes the intermediate variables, which are urban innovation ($innov_{it}$), productive service agglomeration ($saggl_{it}$), and manufacturing agglomeration ($maggl_{it}$), respectively. $\beta_0 \sim \beta_4$, $\gamma_0 \sim \gamma_6$ are parameters to be estimated, and other variables have the same meaning as the model (1). α_1 and γ_1 are the total effect and direct effect, respectively, of independent variables on the dependent variable, β_1 is the effect of the independent variable on the intermediate variable, γ_2 is the effect of the intermediate variable on the dependent variable, and the indirect effect is the product of the influence coefficients $\beta_1 \cdot \gamma_2$.

3.2. Variable Selection

This study uses the panel data of 273 cities from 2003 to 2017, mainly sourced from the China Statistical Yearbook of Urban Construction, China Statistical Yearbook of Cities, and China Statistical Yearbook of Land and Resources from 2003 to 2017. The data on urban innovation are sourced from the China Regional Innovation and Entrepreneurship Index 2018, published by the Enterprise Big Data Research Center of Peking University, and the relevant indicators are measured as follows.

(1) Dependent variables: Total factor productivity (TFP). In this paper, the DEA Malmquist index is used to measure the TFP. In this paper, drawing on existing studies [43], the labor input is the number of employees in secondary and tertiary industries, the land input is the area of urban construction land, and the capital input is the fixed capital stock obtained by the perpetual inventory method [44]. The sum of the output value of secondary and tertiary industries is used as a measure of the desired output, while the non-desired output is measured by urban industrial wastewater, soot, and sulfur dioxide emissions.

Many studies currently use the FGNZ approach to decompose TFP, and the technical progress of the FGNZ decomposition is the reference technical progress rather than the real technical progress, so this paper uses the RD decomposition to decompose the TFP growth rate into technical progress (TE), pure technical efficiency (PE), and scale efficiency (SE) [45], with the following equation.

$$\begin{aligned} TFP &= M(x^{t+1}, y^{t+1}, x^t, y^t) = \left\{ \frac{D_c^{t+1}(x^{t+1}, y^{t+1})}{D_c^{t+1}(x^t, y^t)} \times \frac{D_c^t(x^{t+1}, y^{t+1})}{D_c^t(x^t, y^t)} \right\}^{\frac{1}{2}} \\ &= \frac{D_v^{t+1}(x^{t+1}, y^{t+1})}{D_v^t(x^t, y^t)} \times \left[\frac{D_v^t(x^{t+1}, y^{t+1})}{D_v^{t+1}(x^{t+1}, y^{t+1})} \frac{D_v^t(x^t, y^t)}{D_v^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \times \left[\frac{\frac{D_c^t(x^{t+1}, y^{t+1})}{D_v^t(x^{t+1}, y^{t+1})}}{\frac{D_c^t(x^t, y^t)}{D_v^t(x^t, y^t)}} \times \frac{\frac{D_c^{t+1}(x^{t+1}, y^{t+1})}{D_v^{t+1}(x^{t+1}, y^{t+1})}}{\frac{D_c^{t+1}(x^t, y^t)}{D_v^{t+1}(x^t, y^t)}} \right]^{\frac{1}{2}} \\ &= \Delta TE \cdot \Delta PE \cdot \Delta SE \end{aligned} \quad (4)$$

Since TFP and its decomposition form represent the growth rate, according to Han's research, this paper transforms the TFP growth rate and decomposition form into cumulative forms [46].

(2) Independent variables: Land supply (land). The regional differentiation of land supply is directly manifested in differences in the quantity of land supply, and this paper adopts the logarithm of the area of state-owned land concessions to characterize the land supply level, drawing on Wen's study [3].

(3) Intermediary variable: Urban innovation (innov). At present, most studies measure the innovation level by R&D funds and the number of patents, but they cannot catch inefficient behaviors such as misrepresenting R&D funds and unilaterally pursuing the number of patents. This paper uses research Mao for reference and uses the innovation and entrepreneurship index to measure the level of urban innovation, which is based on more than 50 million data records, such as the industrial and commercial registration database, and the patent and trademark database. The index system is constructed and standardized, and the urban innovation index is obtained by weight summation. The index value is between 0 and 100; the higher the value, the higher the level of urban innovation [47]. The valuation index system of urban innovation is shown in Table 1.

Table 1. Evaluation index system of urban innovation.

General Objective	Primary Index	Secondary Index
Evaluation index system of urban innovation	Number of new enterprises (20%)	Number of newly registered enterprises (1/5)
	Attracting foreign investment (15%)	Number of new foreign legal person investments (3/20)
	Attracting venture capital (25%)	Number of new venture capital enterprises (1/8)
		Amount of new venture capital (1/8)
	Patent authorization (25%)	Number of newly added invention patents (1/8)
		Number of newly added utility model patents (3/40)
		Number of newly added design patents (1/20)
	Trademark registration (15%)	Number of new trademark registrations (3/20)

Industrial Agglomeration(agglit). In order to eliminate the factors of regional scale difference, this paper uses location entropy to measure the level of industrial agglomeration, and the specific formula is as follows:

$$agglit = \frac{labor_{ijt}/labor_{it}}{labor_{jt}/labor_{t}} \quad (5)$$

where $saggl_{it}$ denotes the agglomeration level of the productive service industry, $maggl_{it}$ denotes the agglomeration level of the manufacturing industry, $labor_{ijt}/labor_{it}$ denotes the proportion of the number of employees in industry j to the total number of employees in the region I in year t, and $labor_{jt}/labor_{t}$ denotes the proportion of the number of employees in industry j to the total number of employees nationwide in year t.

(4) Control variables: To control for the effects of other factors on TFP, the following control variables are selected in this paper in conjunction with existing studies: ① The level of economic development (lngdp) is expressed by GDP per capita, and it is generally believed that the higher the level of economic development, the higher the TFP [48]. ② Good transportation infrastructure conditions (inf) are conducive to reducing enterprise costs and have an important impact on TFP enhancement [49]. ③ The degree of openness to the outside world (fdi) is expressed by the amount of actual foreign capital utilized as a proportion of GDP. The higher the level of interaction between the city and the foreign economy, the more advanced technology and management experience it can bring to local enterprises, promoting the benign development of the industry [50]. ④ The population size (lnpop) is expressed using the logarithm of the population density. ⑤ Industrial structure (indus) is expressed as the ratio of tertiary sector output to secondary sector output [51]. The descriptive statistics of each variable are shown in Table 2.

Table 2. Descriptive statistics of variables.

Layer	Variable	Mean	Std.Dev	Minimum	Maximum
Dependent variables	TFP	1.017	0.433	0.715	1.462
	TE	1.005	0.258	0.800	1.268
	PE	0.995	0.028	0.773	1.247
	SE	1.018	0.034	0.772	1.498
Independent variables	land	6.638	1.120	1.423	10.317
Intermediary variable	innov	52.535	27.75	1.024	100
	saggl	0.824	0.293	0.217	4.943
	maggl	0.856	0.478	0.033	4.332
Control variables	lngdp	10.491	0.745	7.929	15.675
	inf	5.738	0.893	1.548	7.882
	fdi	0.568	0.610	0.043	7.865
	lnpop	0.056	0.068	0.003	0.882
	indus	0.971	0.542	0.117	5.340

4. Results

4.1. Model Test

This paper first uses Moran's I index to test whether there is a spatial correlation between TFP in different regions. The results show that Moran's I index of TFP is significantly positive from 2004 to 2017 (Table 3), indicating that regions with relatively high TFP are geographically close to each other, while regions with relatively low TFP also tend to be geographically concentrated. Secondly, in order to select a suitable spatial econometric model, this paper carries out the LM test and LR test (Table 4), and the results show that LM-lag, LM-error, and robust LM-lag and LM-error tests are significant, so the spatial Durbin model should be selected. The LR test results show that the time-fixed effect and spatial fixed effect both reject the original hypothesis at the 1% level, indicating that it is more scientific to use the double fixed effects Spatial Durbin Model (SDM) for estimation.

Table 3. Spatial correlation test.

Year	Moran's I	Z	Year	Moran's I	Z
2004	0.760 **	1.816	2011	0.034 *	1.367
2005	0.075 **	2.826	2012	0.032 *	1.300
2006	0.061 **	2.300	2013	0.010 **	1.871
2007	0.056 **	2.121	2014	0.038 *	1.506
2008	0.052 **	1.981	2015	0.071 **	2.694
2009	0.084 ***	3.128	2016	0.050 **	1.935
2010	0.035 *	1.399	2017	0.118 ***	4.326

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4. Residual spatial correlation test of OLS estimation results.

Test Model	Hybrid Estimation Model	Spatial Fixed Effects Model	Time-Fixed Effects Model	Spatial and Time-Fixed Effects Models
LM spatial lag	70.037 ***	76.728 ***	49.649 ***	52.347 ***
LM spatial error	142.438 ***	151.200 ***	99.435 ***	102.416 ***
Robust LM spatial lag	52.670 ***	55.711 ***	38.292 ***	40.351 ***
Robust LM spatial error	125.072 ***	130.183 ***	88.078 ***	90.420 ***
LR spatial fixed effects			318.652 **	
LR time fixed effects			78.986 ***	

*** $p < 0.01$, ** $p < 0.05$.

4.2. Estimated Results at the National Level

To test the robustness of the model estimation results, this paper also reports the estimation results of the SEM model, SAR model and SDM model (Table 5). Columns (1)–(3) show that the estimation results of the three models are basically the same, and the SDM model estimation results are used as the main basis for further explanation. The estimation results in columns (3)–(6) show that the coefficients of the effects of land supply on TFP, TE, PE, and SE are all significantly negative and indicate that the central government's tilted land supply to the central and western regions leads to the flow of land resources to less efficient regions, causing the contradiction of the oversupply of land in the central and western regions and the shortage of land supply in the eastern region [21], reducing the allocation efficiency of land resources, and having a negative effect on TFP, TE, PE, and SE; the strongest inhibiting effect is on SE. The spatial spillover effect of land supply is significantly negative, indicating that the central government's differentiated land supply leads to the clustering of industries and factors in the central and western regions, and the more land supply leads to a stronger siphoning effect, resulting in insufficient investment and labor shortage in neighboring regions and inhibiting the efficiency improvement of neighboring regions.

Table 5. Results of spatial econometric estimation at the national level.

Variable	SEM	SAR	SDM			
	TFP	TFP	TFP	TE	PE	SE
	(1)	(2)	(3)	(4)	(5)	(6)
ρ	0.306 ***	0.212 ***	0.183 ***	0.192 ***	0.298 ***	0.317 ***
	(10.586)	(7.311)	(5.647)	(5.908)	(9.924)	(11.109)
land	−0.012 ***	−0.010 ***	−0.004 ***	−0.002 **	−0.001 **	−0.007 ***
	(−9.045)	(−7.703)	(−4.235)	(−3.073)	(−1.780)	(−9.317)
lngdp	0.014 ***	0.014 ***	0.014 ***	0.002 **	0.003 ***	0.013 ***
	(10.132)	(9.186)	(9.197)	(2.089)	(2.842)	(9.416)
inf	0.001	0.001	0.002 ***	0.001	0.003 ***	0.005 ***
	(0.894)	(0.818)	(1.430)	(0.595)	(4.217)	(5.063)
fdi	0.017 ***	0.016 **	0.021 ***	0.002 *	0.018 ***	0.001
	(11.681)	(9.494)	(12.082)	(1.786)	(8.014)	(0.078)
lnpop	0.019	0.024 ***	0.012	0.017 **	0.039	−0.008
	(1.563)	(2.167)	(0.619)	(2.059)	(0.285)	(−0.921)
indus	0.023 ***	0.022 **	0.023 ***	0.018**	0.031 ***	0.015 ***
	(7.452)	(6.411)	(6.672)	(5.382)	(5.398)	(4.117)
W × land			−0.003 ***	−0.002 **	−0.007 **	−0.002 **
			(−2.171)	(−1.692)	(−4.979)	(−1.217)
W × lngdp			0.008 ***	−0.002	0.005 **	0.004 **
			(2.700)	(−0.931)	(3.215)	(2.103)
W × inf			−0.002	−0.001	−0.001	0.003 **
			(−0.741)	(−0.586)	(−0.619)	(2.093)
W × fdi			−0.018 ***	0.002	−0.007 **	−0.008 **
			(−6.406)	(1.258)	(−4.401)	(−3.979)
W × lnpop			0.002	−0.026 *	−0.052 **	0.026
			(0.105)	(−1.667)	(−3.685)	(1.552)
W × imdus			0.008 *	0.021 **	0.017 **	0.014 **
			(4.224)	(3.811)	(5.872)	(2.981)
σ^2	0.001	0.001	0.001	0.001	0.001	0.001
r^2	0.922	0.936	0.962	0.998	0.943	0.975
sample	273	273	273	273	273	273
log like	7101.646	7080.049	6774.212	8215.060	8998.206	8421.975

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.T values are shown in parentheses.

The estimation results of the control variables are found to be in line with expectations that a higher level of economic development, infrastructure, openness to the outside world, and industrial structure will promote the improvement of TFP. Due to the coexistence of the contradiction between the over-concentration of the population in the eastern region and the under-concentration of the population in the central and western regions, there is an insignificant effect of population size at the national level.

4.3. Estimated Results for Different Regions

Although the above has confirmed that regional differentiation of land supply inhibits TFP, the differentiated land supply forms a spatial pattern of more people and less land in the eastern region, and less people and more land in the central and western regions, and its impact has spatial heterogeneity. This paper will identify this spatial heterogeneity, and the estimation results are shown in Table 6.

(1) Analysis of the results in the eastern region. The estimation results in columns (1)–(4) show that the impact of land supply on TFP, PE and SE are linearly positively correlated, and the effects on TE are linearly negatively correlated, which indicates that as the supply of land decreases in the eastern region, resource constraints are formed, hindering the agglomeration effect of population, capital, technology, and other factors, and hindering TFP by inhibiting PE and SE. However, the decrease in land supply and increase in land price in the eastern region cause the technology substitution rate to increase, which is consistent with the price-induced progress hypothesis and the innovation compensation

effect, where firms replace scarce land by increasing R&D investment and eventually promoting TE. The estimated results of the spatial spillover effect show that the decrease in land supply and the rise of land price in the eastern region causes local enterprises to transfer to the surrounding areas. On the one hand, under the effect of technology spillover and output spillover, the TE, PE and TFP in the surrounding areas are promoted; on the other hand, the industrial transfer intensifies the crowding effect in the surrounding areas and restrains SE.

Table 6. Spatial econometric regression results for different regions.

Variable	The Eastern Region				The Central and Western Regions			
	TFP	**TE**	**PE**	**SE**	**TFP**	**TE**	**PE**	**SE**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
ρ	0.301 ***	0.278 ***	0.207 ***	0.209 ***	0.249 ***	0.152 ***	0.401 ***	0.381 ***
	(7.460)	(4.233)	(4.253)	(4.253)	(7.772)	(4.467)	(9.145)	(8.718)
land	0.003 **	−0.004 ***	0.005 ***	0.002 *	−0.012 ***	−0.003 **	−0.001 ***	−0.008 ***
	(1.895)	(−2.282)	(3.553)	(1.935)	(−9.228)	(−3.634)	(−2.469)	(−9.118)
W × land	−0.009 **	−0.006 *	−0.009 **	0.006 **	−0.010 ***	−0.003 ***	−0.002 ***	−0.004 **
	(−2.330)	(−1.811)	(−3.044)	(2.481)	(−4.913)	(−2.724)	(−2.358)	(−2.628)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
σ^2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
r^2	0.955	0.996	0.911	0.945	0.960	0.929	0.908	0.959
sample	101	101	101	101	172	172	172	172
log like	2926.381	3099.192	3370.662	3740.445	4003.118	5288.7651	5474.21	4635.896

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.T values are shown in parentheses.

(2) Analysis of the results in the central and western regions. The estimation results from (5)–(8) show that the estimation results for the central and western regions are generally consistent with those at the national level. The coefficients of the effects of land supply on TFP, TE, PE, and SE are all significantly negative, indicating that the increase in land supply has not contributed to the improvement of TFP in the central and western regions, which is due to the fact that the central and western regions subsidize inefficient enterprises with the advantage of land supply, allowing the survival of backward production capacity that should have been eliminated in the region. In addition, the massive construction of new cities in the central and western regions in recent years, but the lack of sufficient industries and population to move in, has left a large number of industrial parks vacant, resulting in a large amount of low-utility land, which hinders the increase in TFP by suppressing TE, PE and SE. The spatial spillover effect of land supply in the central and western regions is consistent with that in the whole country, which also shows that the increase of land supply restrains TFP in the surrounding regions.

In summary, regional differentiation in land supply significantly inhibits TFP, thus proving hypothesis 1.

4.4. Results of the Estimation of the Mechanism of Impact

According to the previous theoretical analysis, the regional differentiation of land supply may affect TE and SE through urban innovation and industrial agglomeration, and then affect TFP. Therefore, based on the mediation model, this paper further tests the mechanism of impact of the regional differentiation of land supply on TFP.

(1) Analysis of the mechanism of impact in the eastern region (Table 7). Columns (1)–(3) report the path of impact in the order land supply–urban innovation–TE (TFP). The results show that the estimated coefficient of land supply on urban innovation is −3.541, and is significant at the level of 1%, indicating that the reduction in land supply in the eastern region forces enterprises to increase R&D investment and save relatively scarce land elements, which promotes the improvement of urban innovation. The inclusion of intermediate variables in columns (2) and (3), both of which are significantly positive, indicates that the reduction in land supply in the eastern region has improved TE and

TFP by promoting urban innovation. Columns (4)–(6) report the path of impact of land supply–productive service industry agglomeration–SE (TFP), and the results show that the coefficient of the impact of land supply on productive service industry agglomeration is significantly negative, indicating that the reduction in land supply promotes productive service industry agglomeration in the eastern region, but the industrial agglomeration caused by non-market instruments such as restricting land supply amplifies the negative externalities of urban economic agglomeration, potentially leading to the crowding effect and the damaging of efficiency at the city scale. As productive service industry agglomeration promotes enterprise resource integration and structural optimization, it plays a partially positive role in terms of knowledge spillover and diffusion effects [32,52,53], and therefore has an insignificant impact on TFP.

Table 7. Test of influence mechanism in the east region.

Variable	innov	TFP	TE	saggl	TFP	SE
	(1)	(2)	(3)	(4)	(5)	(6)
ρ	0.638 ***	0.225 ***	0.207 ***	0.236 ***	0.207 ***	0.208 ***
	(4.402)	(4.252)	(4.223)	(4.835)	(4.253)	(4.265)
land	−3.541 ***	0.017 *	−0.002 ***	−0.012 **	0.002 **	0.001 **
	(−5.623)	(1.999)	(−4.414)	(−2.641)	(2.624)	(2.776)
innov		0.001 *	0.001 **			
		(1.598)	(2.041)			
saggl					0.001	−0.003 *
					(0.323)	(−2.115)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
σ^2	0.001	0.001	0.001	0.001	0.001	0.001
r^2	0.902	0.945	0.995	0.919	0.957	0.942
sample	101	101	101	101	101	101
log like	5601.676	2868.006	3104.029	153.593	2862.849	3750.721

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.T values are shown in parentheses.

(2) Analysis of the mechanism of impact in the central and western regions (Table 8). Columns (1)–(3) report the impact path of land supply–urban innovation–TE (TFP). In column (1), the estimated coefficient of the dependent variable is −6.0829%, which is significant at the 1% level, indicating that, when land supply is abundant in the central and western regions, local governments supply land at low prices to reduce business operating costs, which weakens firms' willingness to innovate and thus inhibits urban innovation. The absolute value of the estimated coefficients of the independent variables decreases with the inclusion of intermediate variables in columns (2) and (3), and the estimated coefficients of the intermediate variables are both significantly positive, indicating that the increase in land supply in the central and western regions hinders TE and TFP by inhibiting urban innovation. Columns (4)–(6) report the path of the impact of land supply–manufacturing agglomeration–TE (TFP), and in column (4), the estimated coefficient is 0.026, which is significant at the 1% level, indicating that the central and western regions promote manufacturing agglomeration as land supply increases. After adding the intermediate variables in column (6), the estimated coefficient of the intermediate variables is significantly negative, indicating that local governments blindly introduce low-end industries for "political achievements", which causes agglomeration efficiency to decrease with the expansion of scale and inhibits scale efficiency [54]. In addition, manufacturing agglomeration contributes to the increase in economic output and mitigates the negative impact of land surplus, so the estimated coefficient of manufacturing agglomeration on total factor productivity is not significant, as shown in column (5).

In summary, the regional differentiation of land supply in the eastern region drives TE and TFP by promoting urban innovation and hinders SE through productive services agglomeration; the regional differentiation of land supply in central and western

regions hinders TE and TFP by inhibiting urban innovation, and hinders SE through manufacturing agglomeration.

Table 8. Test of influence mechanism in the central and western regions.

Variable	innov	TFP	TE	maggl	TFP	SE
	(1)	(2)	(3)	(4)	(5)	(6)
ρ	0.653 ***	0.254 ***	0.149 ***	0.589 ***	0.259 ***	0.008 ***
	(9.818)	(7.942)	(4.371)	(7.218)	(8.139)	(9.233)
land	−6.083 ***	−0.011 ***	−0.002 ***	0.026 ***	−0.012 ***	−0.005 ***
	(−10.723)	(−8.981)	(−5.127)	(8.551)	(−10.226)	(−9.233)
innov		0.001 ***	0.001 **			
		(3.810)	(2.301)			
maggl					0.001	−0.008 ***
					(0.342)	(−3.481)
					(−0.646)	(0.817)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
σ^2	0.001	0.001	0.001	0.001	0.001	0.001
r^2	0.983	0.964	0.930	0.920	0.917	0.966
sample	172	172	172	172	172	172
log like	10,087.560	4013.406	5292.626	592.427	4003.379	4643.441

*** $p < 0.01$, ** $p < 0.05$.T values are shown in parentheses.

5. Discussion

Based on the latest research results of various disciplines, this explores the impact of the regional differentiation of land supply on TFP from the perspective of land spatial allocation and establishes a one-to-one corresponding influence mechanism between regional differentiation of land supply and TFP decomposition terms in terms of research content. Our results confirm the heterogeneity of the direct and indirect effects of the regional differentiation of land supply on TFP.

(1) Nichols was the first to propose the important role of land factors in economic growth [55]. However, the research results of this paper show that the Chinese government's support for the economic development of backward areas by increasing land supply has not played a role in but caused the loss of TFP and damaged the internal impetus of economic growth. This is due to the regional differentiation policy of land supply implemented by the government that leads to the distortion of the land factor market and breaks the balance of land supply and demand, which damages economic growth.

(2) Previous studies have confirmed that industrial agglomeration is an effective way to improve urban scale efficiency and labor productivity [56]. The results of this paper show that the agglomeration of productive service industries in the eastern region and the agglomeration of manufacturing industries in the central and western regions are not conducive to the improvement of scale efficiency. This is because industrial agglomeration is not the result of the spontaneous action of market forces, but the result of government administrative intervention in resource allocation, which makes industrial agglomeration unable to produce economic effects and ultimately hinders scale efficiency.

(3) This paper enriches the theory of the spatial allocation of construction land and provides a reference for improving the efficiency of the spatial allocation of land resources in China and promoting the internal driving force of economic growth. However, this paper has some limitations. First of all, the resource endowment difference is also one of the reasons for regional differences in land supply; bas a result of the lack of relevant data, this paper explains the reasons for regional differences in land supply only from the perspective of government regulation and control policies. The following can be based on urban planning documents, the urban sprawl border, and the red line to protect cultivated lands from verifying the cause of the regional differentiation of land supply. Second, there are many mechanisms by which land supply influences TFP, such as the institutional environment and marketization level, which are all potential impact paths. Considering the limitation of

space, this paper only argues from the two main perspectives of urban innovation and industrial agglomeration, and other influencing mechanisms can be explored and empirically tested in the future. Finally, this paper proposes that when the central government regulates the quantity of land supply, local governments will adjust the land supply structure, so as to form a pattern of different types of industrial agglomerations. Considering that this paper focuses on the influence mechanism of industrial agglomeration and does not provide empirical tests for the intermediate aspects of land use structure, it is expected that it can be supplemented by different types of land supply data in future studies.

6. Conclusions

Based on the panel data of 273 prefecture-level cities from 2003 to 2017, this paper uses the spatial econometric model and mediation model to include urban innovation and industrial agglomeration in the analysis framework to analyze the path of impact and mechanism of influence of the regional differentiation of land supply on TFP. The results show the following: (1) The regional differentiation of land supply adopted by the central government to coordinate regional development increased the proportion of land supply area in the central and western regions from 29.31% to 59.06% from 2003 to 2017, while the proportion of land supply in the eastern region decreased from 70.69% to 40.94%, forming a spatial pattern of misalignment between land supply and demand. (2) At the national level, as the degree of differentiated supply deepens, the disconnect between land supply and demand leads to a serious spatial mismatch that undermines Pareto efficiency and hinders TFP by inhibiting TE, PE, and SE. (3) In the eastern region, the decrease in land supply leads to higher land prices, expanding the factor substitution rate and stimulating enterprises to increase R&D investment to replace the scarce land factor, thus promoting technological progress. However, the decrease in land supply creates resource constraints and congestion effects, hindering the agglomeration effect of capital, technology, population and other factors and impeding TFP by suppressing PE and SE. (4) The results for the central and western regions are largely consistent with those estimated at the national level; that is, excessive land supply leads to an inefficient growth dilemma of being trapped in land inputs for economic development; causes technological innovation to contribute inadequately to economic growth; and stimulates overinvestment by firms, which leads to overcapacity and hinders TFP by suppressing TE, PE, and SE. (5) In terms of the mechanism of impact, the reduction in land supply in the eastern region promotes TE and TFP by promoting urban innovation, and hinders SE by promoting productive service sector agglomeration. The increase in land supply in the central and western regions discourages TE and TFP by inhibiting urban innovation, and the increase in land supply stimulates local governments to choose low-end manufacturing with higher short-term gains as the leading industry. The agglomeration efficiency decreases as the scale increases, thus inhibiting SE.

The findings of this paper suggest that the central government's attempt to coordinate regional development with differentiated land supply has resulted in a misalignment between land supply and demand, which hinders the improvement of TFP. The findings of this paper provide a new perspective to solve the practical problem of the decline in TFP growth in China and point the way to deepening the structural reform of land supply. Finally, this paper proposes the following countermeasures: (1) when the central government regulates and controls the macroeconomy with land policies, it should adapt land supply to the level of economic development and population size. In the eastern region, the scale of land use needs to be moderately increased, especially the supply of land for the construction of public goods, such as affordable housing and education, to ease urban congestion and rising costs. In the central and western regions, on the one hand, the central government needs to increase fiscal subsidies to ease the pressure of fiscal expenditure, and on the other hand, it needs to reduce land supply to prevent economic development from relying too extensively on land. (2) Improving the market-based land allocation mechanism. The cross-region trading of construction land should

be permitted, so that the central and western regions can obtain the funds needed for urban development through indicator trading, and the eastern region can obtain the construction land needed for urban development, so as to achieve the flexible land effective reallocation of construction land. (3) Strengthen the supervision of local government's land transfer behavior and restrain the vicious competition of local governments' reliance on land to attract investment. In addition, the government should take the level of R&D investment and internal R&D amount as important reference indexes for enterprise tax reduction, and guide the land resources to flow to efficient enterprises by improving the quality of investment attraction, achieving the purpose of improving TFP.(4) Land users should consciously increase investment in research and development, adjust the structure of factor input, defuse the upward pressure of land prices by developing new technologies, and ensure the investment of research and development funds by using land mortgage loans. (5) The eastern region should provide full play to the advantages of local production and service agglomeration, foster specialized industrial clusters, strengthen the connections among enterprises, establish a modern industrial system with a high added value and strong employment capacity, and exert the effect of economic agglomeration further. In the central and western regions, industrial access thresholds and environmental regulations should be set to select enterprises. Enterprises need to cooperate with scientific research institutions, improve the incentive system to attract high-tech talents, strengthen the competitiveness in the product market and improve the productivity of enterprises.

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