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Industrial Land Protection and Allocation Efficiency: Evidence from Guangdong, China

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Abstract: Industrial land allocation in China has been distorted for a long time by local governments providing land at a low price to attract manufacturing activities. This study explores whether an industrial land protection policy can reduce the distortions and, hence, improve land allocation efficiency in China. Using industrial land zoning and protection policies adopted in some cities in Guangdong province, this study finds that industrial land allocation efficiency is indeed improved after the implementation of protection policies, reflected in higher land prices and greater land use intensity. However, the improvement is smaller for industrial land provided to advanced manufacturing industries, indicating that local governments continue to rely on a strategy of offering cheap land to compete for high-end manufacturing activities. Further analysis suggests that the adoption of industrial land protection in one region generates a positive spillover effect on industrial land allocation efficiency in neighboring regions. Overall, this study provides new evidence on the effectiveness of industrial land protection.

Keywords: industrial land protection; land allocation efficiency; industrial land price; land use intensity; spillover effect

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1. Introduction

Industrial land protection is a widely recognized urban planning and land management issue globally [1]. Against the background of rapid post-industrialization, special land use provisions that support manufacturing, transportation, warehousing, and other industrial uses have been adopted in many countries around the world. In Chicago in the United States, 15 Planned Manufacturing Districts (PMDs) set up in the 1980s explicitly prohibit housing and other uses and generate an artificial supply of cheap land to attract and retain industrial employers on constrained urban sites. The PMD policy has thus been translated into a local response to gentrification [2]. In Japan, a re-examination and planning of areas with existing industrial land and with potential for industrial infrastructure expansion was conducted to formulate a land strategy plan under the Basic Land Law. The approach of designating industrial land space has also been adopted in Korean cities, where multiple stakeholders determine land prices to ensure the redevelopment of industrial land [3]. Several studies explore the effect of industrial land protection policies on industrial land preservation in developed countries in the era of post-industrialization [1,4,5].

As the world's second-largest economy, China has gradually placed greater importance on accelerating the transformation and upgrading of its manufacturing industries and developing advanced manufacturing sectors, particularly in light of the recent shift in overall economic development outlined in the Made in China 2025 policy. Manufacturing facilities, particularly those outfitted with novel technologies or innovative production processes, impose fresh demands when it comes to site selection, exerting a notable influence on urban economies [6]. Many coastal provinces in China have identified the protection of industrial land as a key focus to promote high-quality economic development. In particular, Guangdong province, as an economic leader in China, has been actively implementing industrial land protection measures in recent years, including the planning of industrial blocks and the delineation of industrial protection lines, with the aim of preserving existing industrial land and providing continuous support for the development of the real economy [7]. However, it is not clear whether an industrial land protection policy can effectively eliminate distortions in industrial land prices and improve land resource allocation efficiency in China, where local governments have long adopted a strategy of "extremely low industrial land prices" to attract manufacturing activities and boost local economic growth [8,9].

To investigate the effectiveness of these protection strategies and policies, our research developed three hypotheses for empirical analysis on whether industrial land protection policy can improve industrial land allocation efficiency (which are stated in the section of hypothesis development). Based on industrial land zoning and protection policies in 85 counties in Guangdong province, and utilizing a comprehensive industrial land conveyance dataset from 2010 to 2021, our difference-in-differences (DID) analysis reveals that industrial land protection policies significantly increase industrial land prices and improve land use intensity. However, counties implementing industrial land protection policies still offer preferential land prices to advanced manufacturing industries to varying degrees. Furthermore, the results reveal that industrial land protection policies generate positive and significant spillover effects on the land allocation efficiency of neighboring counties. In summary, this study finds that industrial land protection policies can significantly improve land allocation efficiency in China.

This study is the first to explore the effectiveness of industrial policy protection in a developing country in which industrial land prices are severely distorted to attract industrial investment [8,10]. Industrial land protection is of universal importance worldwide, and scholars have focused on analyzing industrial land preservation policies in developed countries [1,5]. However, developing countries also need to consider how to preserve industrial land after periods of rapid industrialization. The evidence from the largest developing country complements the findings of industrial land preservation in the developed countries. The study also contributes to the literature that explores whether government intervention in land market could improve or distort land allocation efficiency. Unlike the prior studies [11], our findings suggest that industrial land protection policy enforced by local governments can indeed improve land allocation efficiency, if the policy is consistent with the local governments' goal in upgrading industrial structure. However, local governments could still depress industrial land price as to attract high-end manufacturing industries. Lastly, the research also contributes to the literature that investigates the spillover effect in the land market. Prior studies show that local governments in China are engaged in "race-to-bottom" competition in industrial land conveyance with neighboring municipalities to attract investments [9] or take advantage of the housing purchase restriction policy imposed in the neighboring municipalities to gain more land revenue [12]. This study shows that local governments could coordinate in industrial land conveyance, leading to an improvement in industrial land allocation efficiency in both regions with industrial land protection policy and neighboring regions.

The study also has policy implications on other developing countries. Countries can learn from each other's policy measures and practical experiences in industrial protection, especially considering the new practices that have emerged from China's recent economic development and land use planning reforms. Guangdong province has played an active and leading role in this process and contributed significantly to industrial land protection efforts. Hence, this study has important policy implications for the implementation of industrial land protection.

2. Background, Literature Review, and Hypothesis Development

2.1. Research Background

China started to establish a land market in 1987 when Shenzhen, a city in Guangdong province, sold land use rights to private entities for the first time. Although land remains state-owned, local governments are entitled to use land resources to boost local economic performance. Typical strategies adopted by local governments are to sell residential and commercial land use rights at a higher price and industrial land use rights at a much lower price. Setting a high price for residential and commercial land use rights increases land sale revenue for local governments. Meanwhile, selling industrial land at a lower price can attract foreign investment and manufacturing activities to local regions, thus contributing to GDP, taxes, and employment through local development and helping local governments win competitions over neighboring governments. Despite helping local governments promote economic growth, the strategy of low industrial land prices can distort resource allocation as local governments compete for low-quality and even pollution-intensive industrial activities. The oversupply of industrial land at low prices has also contributed to unsustainable urban sprawl [10,13].

Apart from poor allocation efficiency and oversupply to low-productivity land users, local governments also have strong incentives to convert industrial land into commercial or even residential land. This land use conversion allows local governments to obtain more land revenue from selling land for commercial and residential uses. Indeed, industrial land conversions have occurred in cities in North America, Europe, and Australia, where land is expensive and residential/commercial developments can generate higher land values [14]. However, it reduces the scale of industrial land available for manufacturing activities.

The central government in China eventually realized that the strategy of low industrial land prices was causing inefficient industrial land allocation. Accordingly, in December 2006, the Ministry of Land and Resources issued a policy setting minimum transfer prices for industrial land[1]. The policy stipulated that neither the floor price nor the settlement price of transferred industrial land could be lower than the minimum transfer price corresponding to the land grade of the region where the land is located. Industrial land in China was classified into 15 grades, with a minimum transfer price for each grade. The policy was adjusted in 2009 to allow local governments to sell industrial land at 70% of the minimum transfer price for projects in priority development industries[2]. This policy adjustment was an attempt to balance the need to support local industrial development through low industrial land prices with the need to address the inefficiency caused by the low-price strategy. However, around 20% of industrial land was still sold below the stipulated minimum price after 2006, and some was transacted at zero price [15].

In recent years, China's national spatial planning, which is a strategic plan for the rational allocation and utilization of land resources, has gradually incorporated industrial land protection, showcasing the country's strong commitment to the rational planning and protection of industrial land. Playing a significant role in the national spatial control system, industrial land protection lines are an essential consideration in the formulation of specialized industrial protection plans and industrial spatial planning. Guangdong province has played a proactive role to delimiting industrial protection boundaries as a means to foster the development of leading and advanced manufacturing industries. In the "Notice on Measures to Lower Manufacturing Enterprise Costs and Support the Development of the Real Economy in Guangdong Province" issued in 2017, it required that "each city should delineate industrial land protection lines to safeguard land for key manufacturing projects".

Under the guidance of provincial policies, cities and counties/districts in Guangdong province have implemented numerous policy measures for industrial protection. Shenzhen has been a pioneer city in the exploration of the delineation of industrial land protection lines as early as 2016, providing valuable experience for other cities. The measure was first implemented in the Bao'an District of Shenzhen, which explicitly defined the methods for establishing primary and secondary protection lines, demarcating approximately 75 square kilometers of industrial land for protection. In 2018, Shenzhen further issued the "Shenzhen Municipal Regulations on the Management of Industrial Block Lines"[3], providing detailed guidelines on the basic principles, basis, definitions, and scope of application for industrial land protection lines, and demarcating an area of 270 square kilometers of protected industrial land across the entire city. Subsequently, other cities in Guangdong province, such as Foshan, Huizhou, Dongguan, Guangzhou, and Zhuhai, successively issued policies regarding industrial land protection lines. These policies specify the control and adjustable areas of industrial land, and combine the formulation of specialized industrial protection plans, thereby contributing to efforts to optimize the land use structure and improve land resource use efficiency. Ever since then, cities in Guangdong province implementing industrial land protection policies generally maintain the scale of protected industrial land within 15% to 35% of the city's total construction land. Table 1 summarizes the industrial land protection policies that have been implemented in different cities/counties in Guangdong province.

Table 1. Industrial zoning in the Pearl River Delta.

Counties/Cities	Released Time	Government Documents	Area and Classification of Industrial Zoning
Bao'an, Shenzhen	February 2016	Bao'an District of Shenzhen Industrial Control Line Management Regulations (Trial)	75 km^2
Shenzhen	August 2018	Shenzhen Industrial Zone Boundary Management Regulations	The overall scale of the city's zone boundaries should generally be no less than 270 km^2; the scale of the primary boundary should not be less than 90%.
Shunde, Foshan	March 2017	Shunde District of Foshan Industrial Development Protection Zone Management Regulations	352 industrial development protection zones have been identified, covering approximately 350 km^2.
Huizhou	March 2017	Huizhou Urban Area Industrial Control Line Management Regulations (Trial)	The total control line for industrial land in the central four districts is 216.65 km^2, accounting for approximately 33.31% of the urban construction land. Among them, the scope of the primary industrial control line is 211.87 km^2.
Dongguan	September 2018	Dongguan City Industrial Protection Line Management Regulations	The total land scale of the city's industrial protection line should not be less than 365 km^2, accounting for no less than 30% of the city's planned construction land. The industrial land area within the industrial protection line should not be less than 70% of the total land scale of the industrial protection line.
Guangzhou	November 2020	Guangzhou City Industrial Zone Management Regulations	The total scale of industrial blocks is 621 km^2, with 194 blocks at the primary control line covering an area of 443 km^2, accounting for 71%, and 475 blocks at the secondary control line with a scale of 178 km^2.

2.2. Literature Review

Optimal resource allocation is essential for achieving high-quality economic development. The efficient allocation of land resources is particularly challenging due to its scarcity and the competing demands of multiple land users [16]. Efficient land allocation implies that land resources can transfer from underperforming firms to more productive ones, facilitating a more effective use of this limited resource [17]. Scholars have presented evidence that land prices serve as a selection mechanism, promoting efficient land allocation by guiding resources towards higher productivity [15]. However, studies [8] have found that local governments in China are eager to sell industrial land at a low price to attract foreign capital and manufacturing investment to local regions. Local governments are incentivized to do so because manufacturing activities can directly contribute tax revenue and economic growth to local regions [18], increase labor demand and consumption by local residents [19], and generate positive spillover effects on non-manufacturing sectors [20]. As local government officials are evaluated mainly on economic performance [21], the promotion tournament results in a race to the bottom in the use of land resources to promote local economic growth [9]. Offering industrial land at a low or zero price leads to the inefficient allocation of land resources and environmental deterioration through the oversupply of land to low-productivity and even pollution-intensive industries [22–26].

It has become a global trend for cities to redevelop industrial land to support higher-yielding residential or commercial uses. However, industrial protection policies are often crafted to safeguard industrial activities, ensuring that adequate land supply is reserved to sustain them [1]. Only a few studies explore land protection policies and their impacts on industrial land supply. Danilo (2018) discussed the evaluation process of industrial land use policies adopted by the city of Chicago from the 1980s to the 2010s, including a strategy to establish the PMD in 1988, a strategy to establish industrial corridors to protect industrial sites in 1990 and the Industrial Corridor Modernization Initiative to support competitive manufacturing activities [5]. Lester et al. (2014) found that industrial preservation policies, such as Chicago's Industrial Corridor program, are effective in limiting the conversion of industrial land for residential and commercial developments [4]. Davis and Renski (2020) also found that industrial preservation policies in New York City effectively retain industrial land, suggesting that industrial preservation is a useful tool to curb industrial land loss due to the pressure of land use conversion [1]. These studies focused on the retainment of industrial land in the context of industrial land conversion in cities in developed countries. In China, where industrial land protection policies have only been implemented in recent years and local governments have strong incentives to boost local economic growth through a low-price industrial land strategy, it is unclear whether industrial land protection can remove the distortions from the race to the bottom in the supply of industrial land and thus improve land resource allocation efficiency.

Studies on how industrial land related policies affect land allocation efficiency in China remain scant. Two papers investigate the effects of the minimum price policy for industrial land on land use efficiency. Tu et al. (2014) found that industrial land prices increased significantly immediately after the implementation of the minimum price policy in 2007 but remained stable afterward, suggesting that industrial land prices are set by local governments slightly above the minimum prices and do not reflect the actual market price [11]. Lin et al. (2020) found that the imposition of the minimum price policy leads to higher industrial land transfer prices, lower land supply, higher productivity of land users, and higher industrial output per unit of land [15]. However, none of these studies explore whether industrial land protection policies can improve industrial land allocation efficiency in China. Our study fills this notable research gap.

2.3. Hypothesis Development

The distortion of land allocation in China can be attributed to the race to the bottom as local governments offer industrial land at prices well below the market price to attract manufacturing activities to local regions [8,10]. An industrial land protection policy not only limits industrial land conversion to commercial and residential uses but also aims to improve land use efficiency and promote spatial aggregation to develop advanced manufacturing industries. The policy aims to screen out low-productivity manufacturing activities in local regions [15]. Hence, once the industrial land protection policy is implemented, industrial land should be more likely to be allocated to firms that can generate higher revenues and industrial output per unit of land. These firms can afford to pay a higher cost for land. As a result, in regions with industrial land protection, industrial land prices should be higher and industrial land use intensity should also be higher to achieve higher land use efficiency [11]. It is expected that, on average, the efficiency of industrial land allocation, in terms of land prices and land use intensity, will increase after the policy is implemented. The first hypothesis is provided as follows:

H1: *Industrial land protection policy improves local industrial land allocation efficiency.*

Although the industrial land protection policy may curb local governments from offering industrial land at low prices to low-productivity firms, local governments remain keen to compete for economic growth, industrial output, and tax revenue from high-end manufacturing activities. In regions with an industrial land protection policy, local governments might phase out low-productivity manufacturing activities by imposing a higher industrial land price, but they might continue to offer favorable treatment to high-end manufacturing industries, especially given that supporting these industries is one of the goals of industrial land protection policies. Competition for advanced manufacturing activities could thus undermine the positive effect of the industrial land protection policy on the industrial land price offered. The second hypothesis is as follows:

H2: Industrial land allocation efficiency increases less in regions with an industrial land protection policy if they offer land to advanced manufacturing industries.

We further explore whether the industrial land protection policy generates spillover effects on land allocation efficiency in neighboring regions. The spillover effect could depend on whether neighboring regions pursue regional competition or regional cooperation. On the one hand, as Li et al. (2015) found in their study of the three cities of Shantou, Chaozhou, and Jieyang, although Guangdong province promotes cooperation across cities, some neighboring cities engage in regional competition [27]. Following this observation, low-end industrial investments that are screened out by the industrial land protection policy could be re-located to neighboring regions that do not have such a policy. In such cases, the industrial protection policy would generate a negative effect on land allocation efficiency in neighboring regions [28]. On the other hand, regional cooperation across regions can improve land use efficiency and curb urban sprawl [29]. The implementation of the industrial land protection policy in one region would improve industrial land allocation efficiency in neighboring regions if these regions have a joint industrial development plan. Industrial land prices can increase in neighboring regions if these regions also phase out low-end industrial activities to achieve industrial agglomeration. The third hypothesis is provided as follows:

H3: Industrial land protection policy generates a positive spillover effect on industrial land allocation efficiency in neighboring regions.

According to the three hypotheses outlined above, the analytical framework is illustrated in Figure 1.

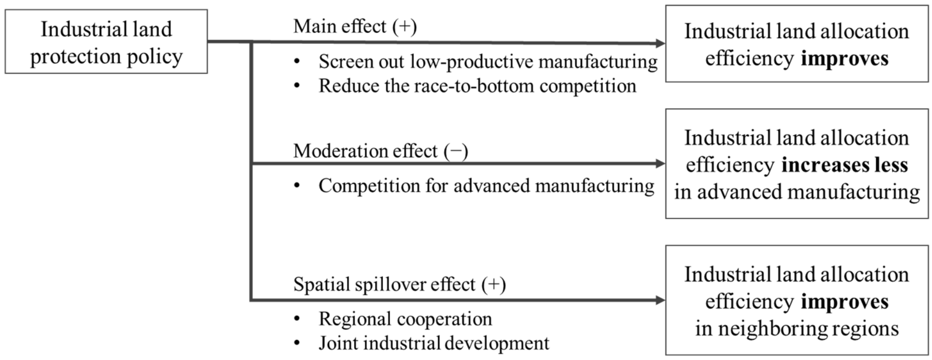

Figure 1. Analytical framework.

3. Methodology and Data

3.1. Variables

We evaluated land allocation efficiency from two aspects, namely land price and land use intensity. Land price indicates the cost of using land resources. A higher land price propels land users to improve productivity and screens out low-productivity land users. The first dependent variable is the logarithm of the average price of industrial land ($lnPRICE$), calculated based on all industrial land transaction prices of a specific county for a given quarter [9,30]. The second dependent variable, representing land use intensity, is the average floor area ratio (FAR) of industrial land parcels conveyed by a county in a quarter, which is an important indicator of land characteristics in land transactions [11]. In the robustness test, we also used the land price premium variable (PPR), which is the average ratio of the actual land price to the minimum land price set by the central government, to capture potential distortions in land prices [31]. The higher the industrial land price, the greater the land use intensity, or a higher land price premium indicates fewer distortions in land conveyance and, consequently, a greater land allocation efficiency.

The key independent variable is a dummy variable for the industrial land protection policy (ILP). It is set to one if county i is implementing the industrial land protection policy and quarter t is in or after the quarter when the local industrial land protection policy was implemented, and zero otherwise.

AM_{it} is a dummy variable to capture industrial land conveyance to advanced manufacturing industries, set to one if there were industrial land parcels transacted to advanced manufacturing industries in county i in quarter t. Advanced manufacturing industries are identified with reference to the 85 advanced manufacturing sectors classified into six categories listed in the "Manufactural High-tech Industry Classification (2017)" document issued by the National Bureau of Statistics[4].

To control for the effect of urban regeneration, which was implemented during the same period and may influence the allocation of industrial land in Guangdong province, we added a dummy variable, URP, to the empirical analysis. URP equals one if county i issued a local document setting out an urban regeneration policy in quarter t, and zero otherwise. Moreover, some county socioeconomic variables were used as control variables, including the logarithm of GDP ($lnGDP$), the logarithm of fixed asset investment per capita ($lnPFAI$), fiscal pressure measured by the ratio of fiscal expenditure to revenue (FP), and the logarithm of population density ($lnPOPDEN$) [12].

3.2. Model Specification

We used a DID specification to assess the impacts of the industrial land protection policy on the industrial land market and its allocation efficiency (**H1**), based on the following regression model:

$$Y_{it} = \alpha + \beta ILP_{it} + \gamma_1 Z_{it} + \gamma_2 X_{is-1} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

In model (1), Y_{it} represents the land allocation efficiency of county i in quarter t, measured by $lnPRICE$ and FAR. The main coefficient of interest is β, which captures the effects of the implementation of the industrial land protection policy on the treated counties compared to counties without the policy. To support our hypothesis that the industrial land protection policy improves land allocation efficiency, β should be positive. Z_{it} and X_{is-1} denote the control variables of URP and the socioeconomic factors of the previous year, respectively. County-specific effects, μ_i, are included to control for variations arising from geographic location and economic conditions by counties. Quarter fixed effects, δ_t, are also included. ε_{it} is a stochastic disturbance term.

Regarding **H2**, to test whether advanced manufacturing sectors are treated differently in the industrial land market in the context of industrial land protection, we added a dummy variable of advanced manufacturing industry (AM) and its interaction with the policy ($AM * ILP$) to model (1) as follows:

$$Y_{it} = \alpha + \beta ILP_{it} + \varphi_1 AM_{it} * ILP_{it} + \varphi_2 AM_{it} + \gamma_1 Z_{it} + \gamma_2 X_{is-1} + \mu_i + \delta_t + \varepsilon_{it} \quad (2)$$

In this regression, we mainly focused on the coefficient of φ_1 to confirm whether advanced manufacturing sectors are still privileged in the industrial land market even after the implementation of the industrial land protection policy.

To examine the spillover effects of the industrial land protection policy on neighboring regions, we added a spatial factor to model (1). According to Anselin (1988) and Elhorst (2014), standard spatial analyses begin with a full model called the general nesting spatial (GNS) model, which for this study is expressed as follows [32,33]:

$$Y_{it} = \alpha + \delta W_{ij} Y_{it} + \beta ILP_{it} + \theta W_{ij} * ILP_{it} + \gamma_1 Z_{it} + \gamma_2 X_{is-1} + \mu_i \quad (3a)$$

$$\mu_i = \lambda W_{ij} * \mu_i + \varepsilon_{it} \quad (3b)$$

where δ represents the space lag factor of the dependent variable; θ is the spatial regression coefficient that measures the spatial spillover effects of the industrial land protection policy; and λ is the spatial coefficient of the error term. By imposing restrictions on δ, θ, and λ, the GNS can be simplified to a spatial lag model (SLM), a spatial error model (SEM), a spatial Durbin model (SDM), or a spatial Durbin error model (SDEM). W_{ij} is the spatial weight matrix. We chose the binary continuity matrix to capture the spatial correlation of industrial land markets among counties. Because manufacturing sectors, which are the eventual users of industrial land, are less sensitive to location than they are to land price [34], they are likely to choose the neighboring location if the industrial land price in the initially targeted county goes up and increases their production costs. Specifically, if county i and county j are contiguous, W_{1ij} is set to one, and otherwise zero. For the robustness check, we also used the geographic proximity weight (W_{2ij}), which is based on the Euclidean distance between counties (the weighting elements are set to the reciprocal of d_{ij} for $j \neq i$, where d_{ij} is the Euclidean distance between the centers of counties i and j).

3.3. Data and Sample

The empirical analyses were based on a county-level panel dataset involving 85 counties[5] in Guangdong province. In China's administrative system, a city generally covers several districts and counties within its jurisdiction, over which governments exercise the rights to supply land. Considering that land policies and regulations are more consistent among districts (the so-called urban areas), which are under the direct administration of prefectural governments, than within counties, which have relative autonomy, we combined the districts of the same city into one county-level unit and retained each county as a single sample unit in the statistics. Figure 2 shows the distribution of the county samples in Guangdong province. The highlighted areas are those that have implemented the industrial land protection policy. Overall, during the sample period, counties in the cities of Shenzhen, Guangzhou, and Dongguan implemented industrial land protection policies; in the city of Foshan, only Shunde county implemented the policy; and in the city of Huizhou, only the urban area adopted such a policy. No counties in other cities in Guangdong province started industrial land protection.

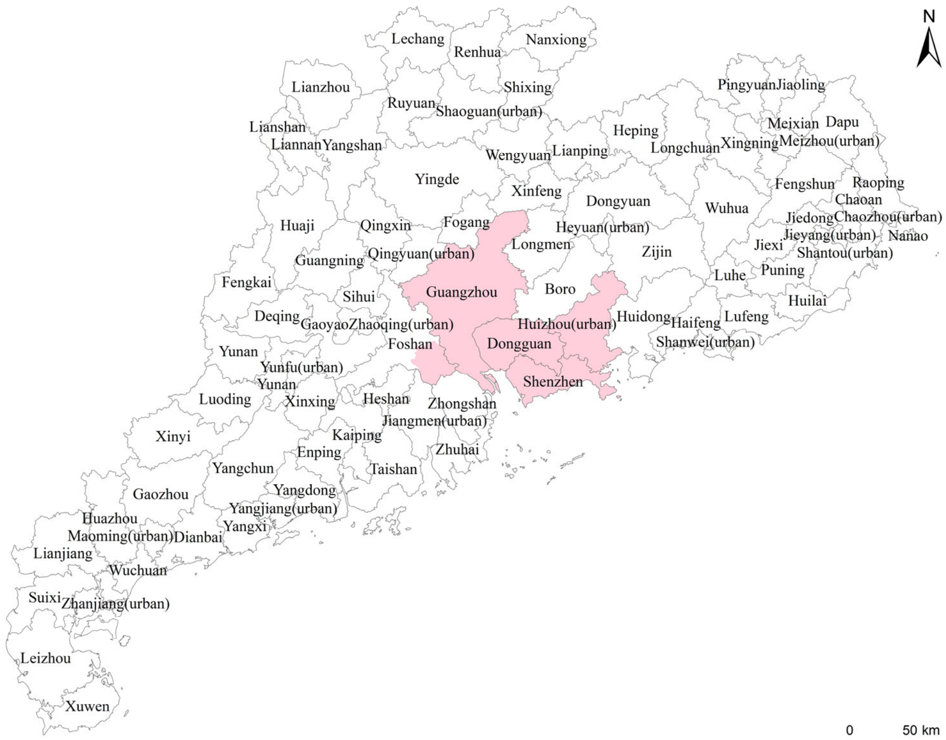

Figure 2. The distributions of counties with and without industrial land protection policy under study. Note: This figure shows all cities in Guangdong province, China. The counties (cities) that adopted industrial protection policy are highlighted by red.

The dataset comprised three parts: quarterly county land transactions, county-related land policy information, and yearly county statistical data. County-level land transaction data were calculated based on land sale data collected from China's Land Market Network website[6]. After excluding duplicate records and those missing key information, a total of 19,781 transaction records of industrial parcels in Guangdong province for the 2010–2021 period were used. The industrial parcel transactions were grouped according to their location (county) and transaction date (year-quarter) to calculate the average land price in logarithm form ($lnPRICE$) and the floor area ratio (FAR) of the county in the considered quarter. Land policy-related information is presented as dummy variables, specifically ILP and URP. County socioeconomic data were obtained from *Guangdong Statistical Yearbooks* from 2010 to 2021. Our final dataset contained 2843 county-quarter observations spanning from 2010 to 2021.

Table 2 shows the summary statistics of the variables used in this study. As industrial land protection policies have only been implemented in recent years and in only four cities, 3% of the county-quarter observations are for counties that implemented protection policies. The mean industrial land price is CNY 297.49 per square meter and the lowest price is CNY 2.45 per square meter. The average floor area ratio of industrial land is 1.73 and the lowest is only 0.02. Among all county-quarter observations, 54% involve conveying industrial land to advanced manufacturing industries. The statistics for the control variables are also reported in the table.

Table 2. Summary statistics.

Variable	Definition	Obs.	Mean	Std. Dev.
ILP	Dummy of industrial land protection policy	2843	0.03	0.16
PRICE	Industrial land price (yuan/m^2)	2843	297.49	295.57
FAR	Floor area ratio	2843	1.73	0.77
PPR	Price premium ratio (%)	2843	1.66	1.15
AM	Dummy of advanced namufcturing industry	2843	0.54	0.50
URP	Dummy of urban regeneration policy	2843	0.14	0.35
GDP	County's GDP (10^4 yuan)	2843	10,500,000	30,300,000
PFAI	Per capita fixed asset investment (10^4 yuan)	2843	2.47	2.48
FP	Fiscal pressure	2843	3.55	2.85
POPDEN	Population density (persons/km^2)	2843	607.24	520.85

Notes: (1) All the nominal variables are deflated using 2009 as the base year. (2) The detailed implementation date of urban regeneration policy in each city are in Table A1. (3) Detailed variable definitions and measurement are in Table A2.

4. Empirical Results

4.1. Effects of the Industrial Land Protection Policy on Industrial Land Prices

The main results for testing the effects of the industrial land protection policy on land prices (real values) are shown in Table 3. In the baseline regression without control variables (Column (1)), the results show that the industrial land price increases by 16.6% after the implementation of the protection policy compared to the untreated counties in Guangdong. This positive effect on industrial land prices is significant at the 1% level. In Column (2) with control variables, the coefficients of URP are also significant at a 5% level and positive. The results demonstrate that both the industrial land protection policy and the urban regeneration policy were useful tools for governments to improve land allocation efficiency during the period under study. The coefficients further imply that the industrial land protection policy might be more effective in increasing land prices than the policy of urban regeneration, as the magnitude of the coefficient on *ILP* is much larger than the magnitude of the coefficient on *URP*.

Regarding other control variables, the coefficients of $lnGDP$ and $lnPFAI$ are positive, while those of FP and $lnPOPDEN$ are negative, as expected. After considering the influences of several main control variables, the coefficients of ILP remain positive and significant, showing a robust effect of the industrial land protection policy to increase industrial land prices. The hypothesis H1 is supported by the empirical results.

H2 predicts that industrial land prices increase less if regions with an industrial land protection policy offer land to advanced manufacturing industries. The results shown in Column (3) of Table 3 demonstrate that advanced manufacturing sectors can obtain industrial land at a price 69.6% lower than other sectors. This result confirms that advanced manufacturing industries are still provided preferential land prices in regions with an industrial land protection policy, although the land prices to these industries are also increased by 16.6% after the implementation of the industrial land protection policy[7].

Table 3. Effects of industrial land protection policy on industrial land price.

	Dependent Variable: *lnPRICE*		
	(1)	**(2)**	**(3)**
ILP	0.166 ***	0.172 ***	0.862 ***
	(4.04)	(3.42)	(9.14)
$AM * ILP$			−0.696 ***
			(−8.84)
AM			0.043 **
			(2.57)
URP		0.065 **	0.063 **
		(2.19)	(2.12)
$lnGDP$		0.210 ***	0.212 ***
		(2.61)	(2.64)
$lnPFAI$		0.033	0.034
		(1.56)	(1.60)
FP		−0.011 *	−0.011 *
		(−1.86)	(−1.82)
$lnPOPDEN$		−0.296	−0.297
		(−1.44)	(−1.45)
constant	5.431 ***	4.155 ***	4.113 ***
	(753.23)	(2.98)	(2.96)
County dummies	Yes	Yes	Yes
Quarter dummies	Yes	Yes	Yes
N	2843	2843	2843
R^2	0.6954	0.6991	0.7001

Notes: t-values are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

To further check the robustness of the baseline results, we replaced the dependent variable of land price with a price premium ratio, PPR, measured by the average industrial land price divided by the regulated bottom price of the county or district. The results are reported in Table 4. The price premium ratio increases by 50.6% following the implementation of the industrial land protection policy, which is consistent with our main results. In addition, the finding that advanced manufacturing industries enjoy a price discount is robust when using PPR as the dependent variable.

Table 4. Robustness test by an alternative land price measurement.

	Dependent Variable: Price Premium Ratio (*PPR*)	
	(1)	**(2)**
ILP	0.500 ***	6.466 ***
	(2.76)	(17.65)
$AM * ILP$		−6.034 ***
		(−20.05)
AM		0.045
		(1.17)
Control variables	Yes	Yes
County dummies	Yes	Yes
Quarter dummies	Yes	Yes
N	2843	2843
R-squared	0.4913	0.5007

Notes: t-values are reported in parentheses. *** $p < 0.01$.

4.2. Effects of the Industrial Land Protection Policy on Land Use Intensity

Table 5 presents the results when using the average floor area ratio (FAR) as a proxy for land use intensity at the county level. The implementation of the industrial land protection policy significantly increases the average floor area ratio of counties by 0.473, equivalent to an increase of 0.61 standard deviations in the floor area ratio in the sample. This result indicates that the industrial land protection policy can improve local land use intensity. The increase in land use intensity is even higher (at 0.882) if advanced manufacturing sectors are excluded, as land use intensity is significantly lower for these sectors, as shown in Column (2) of Table 5. As local governments that are still competing for advanced manufacturing industries prefer a low intensity of land use, they have a greater gaming power to achieve their demands to offer low density land to these industries.

Table 5. Effects of industrial land protection policy on land use intensity.

	Dependent Variable: *FAR*	
	(1)	**(2)**
ILP	0.473 ***	0.882 ***
	(6.01)	(6.28)
$AM * ILP$		−0.412 ***
		(−3.47)
AM		0.026
		(1.12)
URP	0.169 ***	0.168 ***
	(3.54)	(3.52)
$lnGDP$	0.066	0.067
	(0.68)	(0.69)
$lnPFAI$	−0.083 ***	−0.082 ***
	(−2.89)	(−2.86)
FP	−0.008	−0.008
	(−1.30)	(−1.28)
$lnPOPDEN$	0.243	0.242
	(1.35)	(1.34)
constant	−0.696	−0.721
	(−0.45)	(−0.47)
County dummies	Yes	Yes
Quarter dummies	Yes	Yes
N	2843	2843
R^2	0.5942	0.5945

Notes: t-values are reported in parentheses. *** $p < 0.01$.

4.3. Placebo Test

To account for the endogeneity problem that counties that have implemented the industrial land protection policy tend to have better industrial development and therefore a higher industrial land price and average floor area ratio than the control counties without such a policy, we conducted a placebo test by randomly generating the simulated event of the industrial land protection policy. The procedure was repeated 500 times, with the distribution of the estimated coefficients illustrated in Figure 3. The results from the 500 Monte Carlo simulations show that the coefficients of both ILP and $AM * ILP$ in the functions of either $lnPRICE$ or FAR are consistently lower or higher than those obtained using real data, forming a normal distribution centered around zero. Therefore, it can be inferred that the baseline regression results are not influenced by random factors.

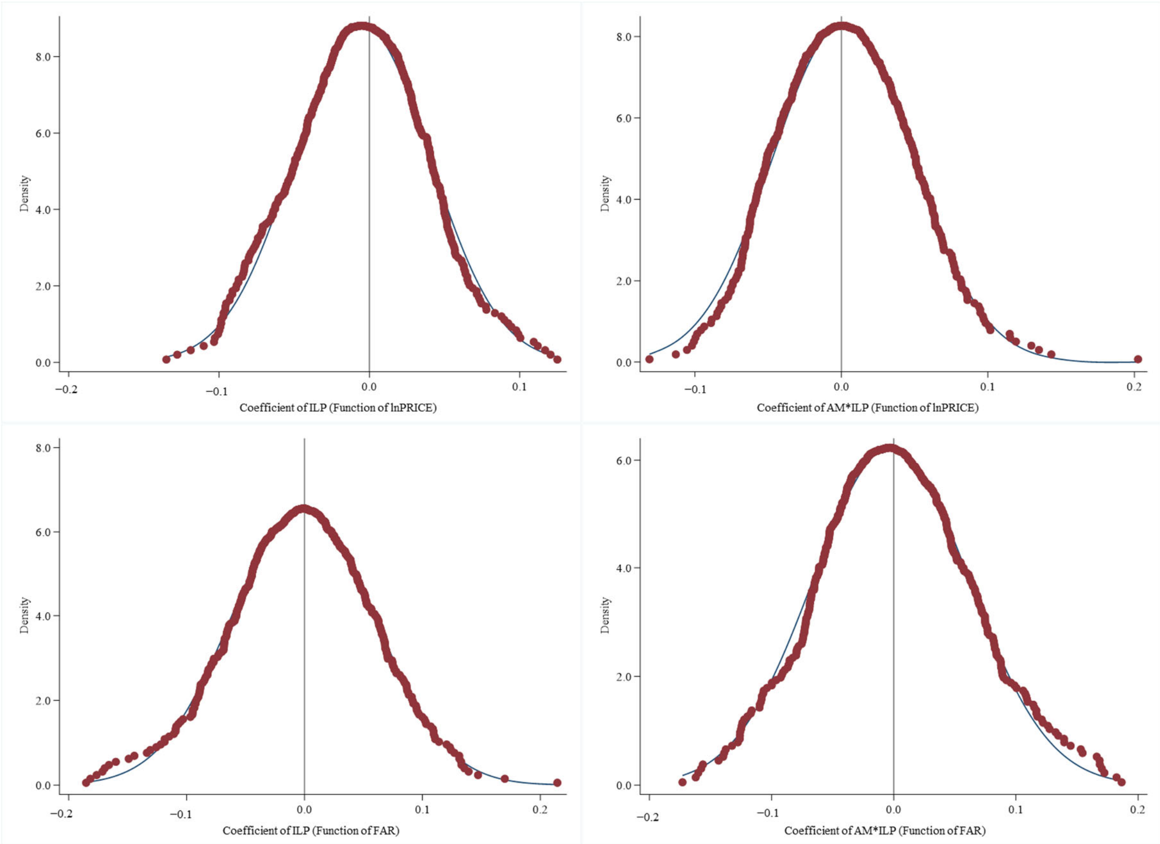

Figure 3. Distribution of coefficients in the placebo test.

4.4. Spatial Spillover Effects of the Industrial Land Protection Policy

Our baseline model confirms that the industrial land protection policy effectively improves the overall efficiency of land allocation in counties in which it is implemented. In this section, we further explore whether the industrial land protection policy generates spillover effects on industrial land allocation efficiency in neighboring regions.

Before conducting the spatial analyses, Moran's I index was used to determine the spatial correlations of industrial land markets between counties. The results (available in Table A2) show that Moran's I values for $lnPRICE$ and FAR are significant and positive for most of the quarters from 2010 to 2021, implying the existence of spatial correlations between Guangdong counties in terms of allocation efficiency in industrial land markets. These results are consistent with studies that found that local governments strategically interact with governments in neighboring regions, leading to the industrial land prices in a region being affected by the industrial land prices in neighboring regions [9].

Figure 4 shows the overall spatial distribution of $PRICE$ and FAR for Guangdong's 85 counties in 2010Q1 and 2021Q1. There is an agglomeration of the industrial land market to the Pearl River Delta region. In both 2010Q1 and 2021Q1, the industrial land price is much higher in the Pearl River Delta region and the eastern region of Guangdong. However, the divergence of industrial land prices between the Pearl River Delta region and the other regions of Guangdong shrinks from 2010 to 2021. Regarding industrial land use intensity, it was mostly evenly distributed in 2010 but became extremely agglomerated in the Pearl River Delta region and expanded northward in 2021.

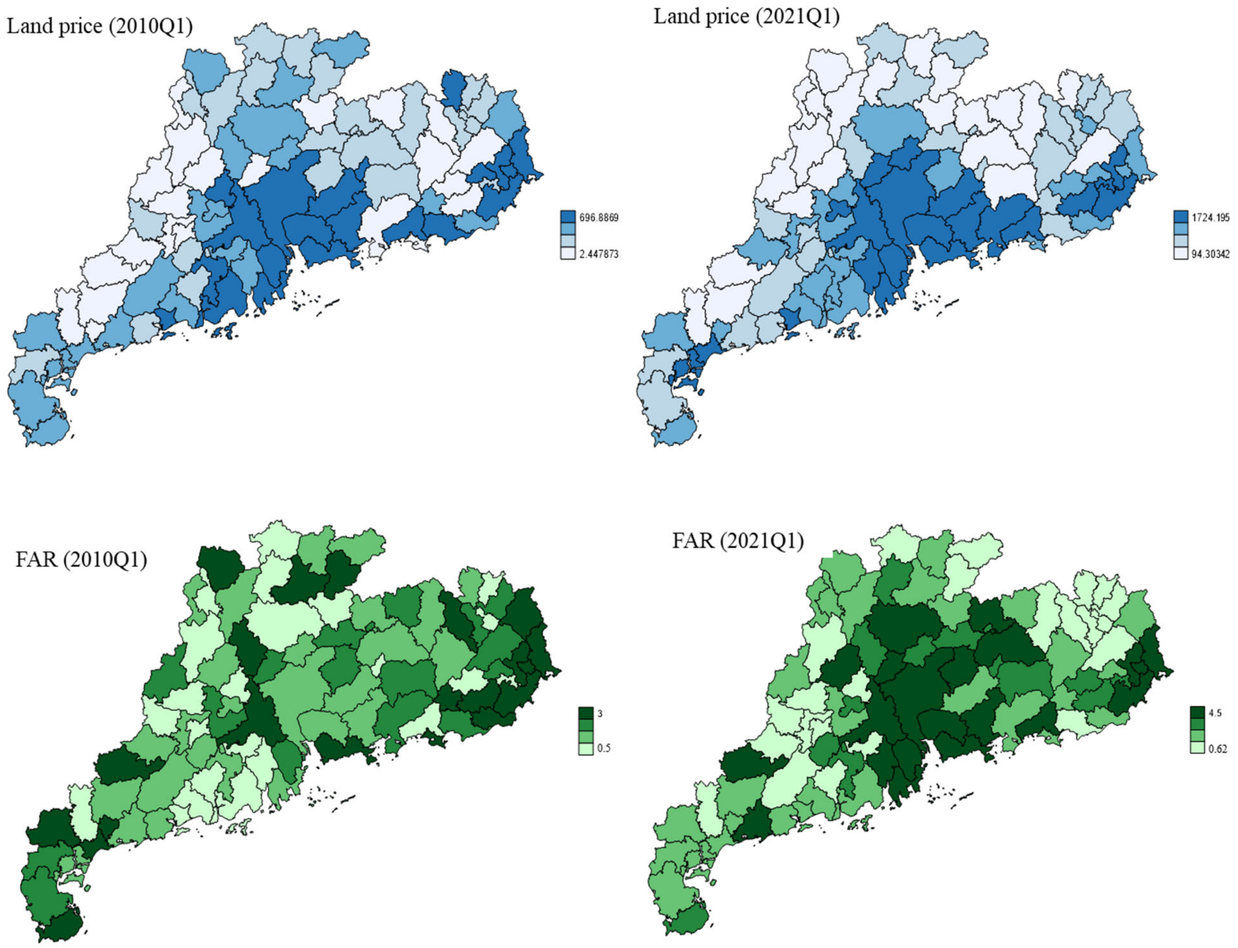

Figure 4. Spatial distribution of industrial land price (*PRICE*) and floor area ratio (*FAR*) of counties of Guangdong in 2010Q1 and 2021Q1.

For model (3) (Equations (3a) and (3b)), the first step is to decide which specific spatial econometric model is suitable for our study. We examined the model using the Lagrange Multiplier (LM) test, the robust LM test, the likelihood ratio (LR) test, and the Wald test. Second, considering that spatial and time-specific effects may be treated as fixed effects or as random effects, the Hausman test was conducted. The results of the above-mentioned tests are presented in Table 6. The overall results indicate that the SDEM is more appropriate for both $lnPrice$ and FAR when considering all kinds of spatial interactions, namely endogenous interaction effects, exogenous interaction effects, and interaction effects among error terms. Furthermore, the Hausman test results suggest that the fixed effects model is preferred. In conclusion, the SDEM with fixed effects was applied to interpret the spillover effects of the industrial land protection policy on the allocation efficiency of industrial markets.

Table 6. Results of the spatial econometric model tests.

	lnPrice	*FAR*
LM test spatial lag	165.663 ***	225.448 ***
Robust LM test spatial lag	100.641 ***	83.933 ***
LM test spatial error	75.229 ***	160.807 ***
Robust LM test spatial error	10.207 ***	16.293 ***
LR test (SLM nested within SDM)	6.43 **	16.71 ***
LR test (SEM nested within SDM)	31.93 ***	39.41 ***
Wald test (SLM nested within SDM)	6.43 **	16.72 ***
Wald test (SEM nested within SDM)	7.21 ***	22.44 ***
Hausman test	30.83 ***	18.43 ***

Notes: Lagrange Multiplier (LM), likelihood ratio (LR), spatial lag model (SLM), spatial error model (SEM), spatial Durbin model (SDM), and spatial Durbin error model (SDEM). ** $p < 0.05$, *** $p < 0.01$.

Table 7 presents the results of the spatial regressions. In the main spatial regression, we considered counties with contiguity as neighboring counties. Furthermore, the spatial weight matrix was replaced with the reciprocal of distance to describe the spatial relationships of Guangdong counties. For all regressions, the spillover effects of the industrial land protection policy were positive and significant, for both $lnPrice$ and FAR. This indicates that, when a county implements the policy, the industrial land price and land use intensity of neighboring counties improve. The policy's indirect effects (also called spillover effects) on both $lnPrice$ and FAR are in fact much larger than its direct effects. This indicates that the implementation of the industrial land protection policy is more influential on neighboring regions than on the targeted counties. A possible explanation is that the policy raises the requirements for potential land users and generates an industry screening function in the implemented counties. Priority is offered to, and favorable policies enacted for, certain preferential industries, which are mostly advanced manufacturing industries, and thus, the land price and land use intensity do not improve greatly in the local region. Meanwhile, some industries that are not on the priority list are screened out to neighboring counties and drive up their industrial land price and land use intensity.

Table 7. Spillover effects of the industrial land protection policy.

Dependent Variable:	***lnPrice***	***FAR***	***lnPrice***	***FAR***
Spatial weight matrix:	W_{1ij} = Binary contiguity		W_{2ij} = 1/distance	
	(1)	(2)	(3)	(4)
ILP	0.017	0.168 *	0.094	0.370 ***
	(0.26)	(1.92)	(1.55)	(4.81)
$W * ILP$	0.171 *	0.415 ***	0.631 *	5.867 ***
	(1.71)	(3.24)	(1.83)	(6.76)
$W * Y$	0.396 ***	0.519 ***	0.522 ***	0.058
	(8.99)	(14.43)	(8.01)	(0.48)
$W * Error$	−0.294 ***	−0.464 ***	−0.324 **	0.081
	(−5.12)	(−8.55)	(−2.33)	(0.63)
Direct effects of ILP	0.036	0.245 ***	0.107 *	0.378 ***
	(0.55)	(2.97)	(1.76)	(4.75)
Indirect effects of ILP	0.276 **	0.968 ***	1.408 **	6.242 ***
	(2.04)	(4.76)	(2.21)	(12.75)
Total effects of ILP	0.311 **	1.214 ***	1.516 **	6.620 ***
	(2.28)	(5.98)	(2.35)	(13.50)
Control variables	Yes	Yes	Yes	Yes
County & Quarter dummies	Yes	Yes	Yes	Yes
N	4080	4080	4080	4080
pseudo R^2	0.5180	0.2271	0.5367	0.2383

Notes: t-values are reported in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

To check the robustness of our spatial regression results, we used a spatial DID design to further test the spillover effects (see Table 8). For this test, the sample was limited to counties without the industrial land protection policy. The dummy variable $ADJACENT$ was set to one if county i was contiguous to a county that implemented the industrial protection policy at or after the quarter of implementation, and zero otherwise. The results confirm the results of the above spatial analyses. For both land prices and land use intensity, the spillover effects of the industrial land protection policy on contiguous counties are positive and significant compared to those on peripheral counties that are far from counties that implemented the industrial protection policy.

Table 8. Robustness test for the spillover effects.

Dependent Variable	*lnPrice*	*FAR*
	(1)	(2)
$ADJACENT$	0.157 ***	0.143 **
	(5.19)	(2.50)
Control variables	Yes	Yes
County dummies	Yes	Yes
Quarter dummies	Yes	Yes
N	2603	2603
R-squared	0.6010	0.4985

Notes: t-values are reported in parentheses. ** $p < 0.05$, *** $p < 0.01$.

5. Discussion and Conclusions

This study investigates the impacts of the industrial land protection policy that has been implemented in some areas of Guangdong province on local industrial land allocation efficiency and the policy's spillover effects on industrial land allocation efficiency in neighboring regions. Particular attention is paid to land conveyed to advanced manufacturing industries. Three hypotheses related to whether industrial land protection policy can improve industrial land allocation efficiency, whether the positive effect is still valid in the advanced manufacturing industries, and whether the positive effect can spill over to other regions are proposed. The main findings are as follows. The implementation of the industrial land protection policy improves local industrial land allocation efficiency, as reflected by increases in industrial land prices and land use intensity. This confirms the first hypothesis. However, advanced manufacturing sectors are offered preferential prices and floor area ratios, indicating that the race-to-bottom competition among industrial land conveyance across local governments still occurs in some industries, following the prediction from the second hypothesis. Furthermore, the spatial analysis demonstrates that the industrial land protection policy has positive effects on neighboring regions, driving up their industrial land prices and land use intensity. The third hypothesis is also confirmed. Overall, this research suggests that the industrial land protection policy in Guangdong province can effectively reduce the distortions in industrial land allocation that are prevalent in industrial land conveyance by Chinese local governments [10].

Unlike prior research [11], the results of this study suggest that government intervention can improve land allocation efficiency. It is also important to understand why the industrial land protection policy adopted in Guangdong province can achieve its objective. We conjecture that the policy has succeeded because it is consistent with the development goals of local governments in the treated regions. After rapid industrialization and urbanization over the past four decades, China has entered a stage of industrial upgrading and introduced policies to promote high value-added manufacturing activities [35,36]. For instance, Made in China 2025 was proposed in 2015 to encourage high-technology production and services. As one of China's richest provinces and a manufacturing hub, Guangdong is a pioneer in promoting smart manufacturing[8]. For example, Dongguan has adopted the Dongguan Manufacturing 2025 strategy, which aims to transform the city from a "big manufacturing city" to a "strong manufacturing city" [37]. Similar strategies have been announced in Guangzhou, Shenzhen, and Foshan. The increase in industrial land prices and land use intensity can generate positive effects on the upgrading of the industrial structure [38]. As the industrial protection policy is aligned with the incentives of local governments to promote advanced manufacturing, the policy can achieve its goal of improving land allocation efficiency.

Indeed, following Guangdong, other provinces that are targeting advanced manufacturing, such as Shanghai, Zhejiang province, and Jiangsu province, also implemented industrial land protection policies to upgrade their industrial structure[9]. Industrial land protection policy may also help to improve land allocation efficiency because industrial land becomes a scarce resource in these regions and local governments have strong incentives to preserve industrial land for advanced manufacturing industries.

Our analysis focuses on counties/cities that have a strong industrial base and are eager to migrate from labor-intensive industries to technology- and innovation-driven industries. One question is whether the industrial land protection policy can also effectively reduce distortions in industrial land allocation in regions that are not ready to promote high value-added manufacturing activities. This study does not directly answer this question but does show that the industrial protection policy can generate positive spillover effects on neighboring regions where the industrial structure can also be upgraded to achieve agglomerations. The important policy implication is that the improvement in industrial land allocation is also important for less developed regions and can be achieved by market forces: enterprises that can benefit from the modernization of the industrial structure in nearby regions are willing to pay more for industrial land.

Through the case study of Guangdong province, we substantiate the notion that effective protection strategies and policy systems for industrial land protection can, to a certain extent, facilitate the scientific planning and rational utilization of industrial land. However, improving the effectiveness of industrial land protection policies requires further research and practical implementation. These research findings can contribute to guiding decision-making and policy formulation regarding industrial land protection in other regions, thereby advancing the development of industrial land preservation efforts.

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Appendix A

Table A1. Detailed variable definitions.

Variable	Definition
ILP	Dummy variable of the implementation of industrial land protection policy in a county in a quarter, equal to one if the policy is implemented and zero otherwise
PRICE	Average price of industrial land for a county in a quarter in CNY/m^2
lnPRICE	Log of average industrial land price in a county in a quarter
FAR	Average floor area ratio for a county in a quarter
PPR	Average industrial land parcel premium ratio in a county in a quarter; land parcel premium ratio is calculated by the actual land price divided by the minimum land price
AM	Dummy variable of advanced manufacturing industry, equal to one if there are industrial land parcels transacted to advanced manufacturing industries in a county in a quarter and zero otherwise
ADJACENT	Dummy variable of the neighboring counties adjacent to counties that implemented industrial land protection policy, equal to one if a county is contiguous to a county that implemented industrial protection policy during or after the implementing quarter and zero otherwise
URP	Dummy variable of urban regeneration policy, equal to one if the policy is implemented in a county in a quarter and zero otherwise
GDP	Gross domestic product in a county in a year
lnGDP	Log of gross domestic production in a county in a year
PFAI	Fixed asset investment per capita in a county in a year; total fixed asset investment/population
lnPFAI	Log of fixed asset investment per capita in a county in a year
FP	Fiscal pressure; fiscal expenditure/fiscal revenue
POPDEN	Population density in a county in a year; population/county area
lnPOPDEN	Log of population density in a county in a year

Table A2. Moran's I index of lnPRICE and FAR.

Year–Quarter	I (*lnPRICE*)	I (*FAR*)	Year–Quarter	I (*lnPRICE*)	I (*FAR*)
2010Q1	0.348 ***	0.279 ***	2016Q1	0.335 ***	0.113 *
2010Q2	0.260 ***	0.112 *	2016Q2	0.443 ***	0.209 ***
2010Q3	0.280 ***	0.133 **	2016Q3	0.481 ***	0.278 ***
2010Q4	0.184 ***	0.085	2016Q4	0.395 ***	0.096
2011Q1	0.252 ***	0.002	2017Q1	0.435 ***	0.253 ***
2011Q2	0.226 ***	−0.016	2017Q2	0.487 ***	0.234 ***
2011Q3	0.196 ***	0.040	2017Q3	0.572 ***	0.206 ***
2011Q4	0.325 ***	0.047	2017Q4	0.469 ***	0.259 ***
2012Q1	0.350 ***	0.128 **	2018Q1	0.501 ***	0.181 ***
2012Q2	0.265 ***	0.254 ***	2018Q2	0.430 ***	0.281 ***
2012Q3	0.195 ***	0.142 **	2018Q3	0.432 ***	0.285 ***
2012Q4	0.297 ***	0.105	2018Q4	0.393 ***	0.293 ***
2013Q1	0.305 ***	0.079	2019Q1	0.470 ***	0.209 ***
2013Q2	0.320 ***	0.066	2019Q2	0.515 ***	0.322 ***
2013Q3	0.327 ***	0.092	2019Q3	0.479 ***	0.347 ***
2013Q4	0.295 ***	0.086	2019Q4	0.457 ***	0.317 ***
2014Q1	0.422 ***	0.075	2020Q1	0.522 ***	0.281 ***
2014Q2	0.386 ***	0.137 **	2020Q2	0.418 ***	0.292 ***
2014Q3	0.283 ***	0.173 **	2020Q3	0.432 ***	0.353 ***
2014Q4	0.297 ***	0.107 *	2020Q4	0.511 ***	0.339 ***
2015Q1	0.338 ***	0.087	2021Q1	0.513 ***	0.415 ***
2015Q2	0.344 ***	0.058	2021Q2	0.520 ***	0.319 ***
2015Q3	0.411 ***	0.091	2021Q3	0.516 ***	0.387 ***
2015Q4	0.250 ***	0.130 **	2021Q4	0.513 ***	0.276 ***

Notes: Two-tailed test. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes

1 https://www.ndrc.gov.cn/xwdt/ztzl/jdstjjqycb/zccs/201705/t20170516_1028523_ext.html (accessed on 15 October 2024).

2 http://f.mnr.gov.cn/201905/t20190521_2412167.html (accessed on 15 October 2024).

[3] https://www.sz.gov.cn/zfgb/2018/gb1068/content/post_4960619.html (accessed on 15 October 2024).

[4] https://www.stats.gov.cn/sj/tjbz/gjtjbz/202302/t20230213_1902772.html (accessed on 15 October 2024).

[5] The sample includes the urban areas of 21 cities and 64 counties, as shown in Figure 1. Nan'ao County of Shantou city is excluded because of no industrial land transaction records.

[6] http://www.landchina.com (accessed on 15 October 2024).

[7] The regression results show that land prices for non-advanced manufacturing industries increase by 86.2% after the land protection policy. The increase for advanced manufacturing industries is 16.6% (0.862–0.696).

[8] The Guangdong provincial government issued the Guangdong Province Plan for the Development of Smart Manufacturing (2015–2025) on 23 July 2015. Available online: https://www.gd.gov.cn/gkmlpt/content/0/144/post_144148.html#7 (accessed on 15 October 2024).

[9] Located in the Yangtze River Delta area, Shanghai, Zhejiang, and Jiangsu are important manufacturing hubs in China. An industrial land protection policy was issued by Shanghai in 2020 (https://www.shanghai.gov.cn/hqcyfz2/20230506/bee7070da3f74f15afe568d6133bb646.html, accessed on 15 October 2024), in Zhejiang (https://www.zj.gov.cn/art/2021/11/2/art_1229017138_2371770.html, accessed on 15 October 2024), and Jiangsu (http://zrzy.jiangsu.gov.cn/gtxxgk/nrglIndex.action?messageID=2c908254845e68a1018460c0dfe2006d, accessed on 15 October 2024) in 2021.

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