The Visible Hand and the Invisible Hand in China's Industrial Land Market Post-2007*

Wenjia Tian♣, Zhi Wang♥, Qinghua Zhang♠

January 18, 2022

Abstract

This paper investigates how market forces and government preferences have jointly shaped China's industrial land sale prices since 2007, when industrial land transactions were required to be conducted via public auction where firms competitively bid for land supplied by governments. We develop a monopoly-supply model in which *local governments* who care about both land sales revenues and local industrial development decide on land supply to various industries, and *upper-level governments* regulate the local market through imposing minimum price constraints, which in turn generates equilibrium land price schedules. Our empirical results demonstrate that while market forces drove up land sale prices after 2007, the role of the visible hand of government was non-negligible. Industries that can generate stronger spillover effects to local incumbents through agglomeration economies were favored in land allocation by governments. These preferences depressed land sale prices and made downward adjustments of the minimum price limits more likely. We also find significant regional differences in the industry preferences of local and upper-level governments, suggesting different roles played by multi-level governments in China's industrial development.

JEL Classification: R1; R52; H7

Keywords: Industrial land market; Price determination; Price regulation; Concentration and coagglomeration; Industrial policy

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*We thank all the seminar participants at the 2020 Summer Urban Webinar, Fudan University, Zhejiang University, Southwestern University of Finance and Economics, 2020 Chinese Economy Early Stage Workshop, 2020 SMU Virtual Conference on Urban and Regional Economics Virtual Conference on Urban and Regional Economics, Peking University, and Jinan University for their helpful comments and suggestions. Zhang gratefully acknowledges the support from the Chinese National Natural Science Foundation (Grant#71673010). Wang acknowledges the support from the Chinese National Natural Science Foundation (Grant # 72003036). Tian acknowledges the support from the Chinese National Science Foundation (Grant#72003216).

♣ *Corresponding author.* School of Statistics and Mathematics, Central University of Finance and Economics. Email address: tianwenjia@cufe.edu.cn.

♥ *Corresponding author.* China Center for Economic Studies, Fudan University, and Shanghai Institute of International Finance and Economics. Email address: wangzhi@fudan.edu.cn.

♠ *Corresponding author.* Guanghua School of Management, Peking University. Email address: zhangq@gsm.pku.edu.cn.

1. Introduction

Local governments in China are the sole suppliers of urban land and have long used land allocation policy to boost industrial development (Wang, Zhang & Zhou, 2020). They have the authority to allocate industrial land at their own discretion, subject to certain regulations from upper-level governments. According to official statistics, every year more than half of newly developed urban land is for industrial use.[1] Industrial land was historically sold mainly through negotiations, and its price was far below market value. In 2002, the central government dictated that all urban leasehold sales for purely private development must occur through public auctions (Cai, Henderson & Zhang, 2013). In September 2004, it began strictly enforcing this policy in the residential land market. The extension of this requirement to industrial land in July 2007 resulted in the rapid appreciation of industrial land prices. However, large gaps have persisted between the prices of residential and industrial land since 2007 (Henderson et al. 2020), which suggests that the visible hand of government is still playing a non-negligible role in the industrial land market.

Few studies have examined how the invisible hand of market forces and the visible hand of government influence have jointly shaped China's industrial land market since 2007. This paper fills the gap by investigating the micro-foundations of the price determination mechanism operating in China's industrial land market. It first constructs a monopoly-supply model to demonstrate how local governments allocate land to various industries, incorporating China's unique institutional features. Local governments seek not only to generate revenues from land sales, which are largely determined by market demand factors such as local production amenities through public auction, but also to boost the locality's overall industrial development. Therefore, local governments depress land prices by supplying more land to industries that can generate higher externalities through positive spillover effects.

Upper-level governments in China impose a minimum price limit on industrial land sales as a means for regulating local land allocation. When such constraints are

[1] Appendix Table A1 reports the annual land sale area for each type of land use from 2003 to 2015. The data sources are the 2004 to 2012 editions of the *Yearbooks of Land and Resources* and the land transaction data collected from the official website of China's Ministry of National Land and Resources (www.landchina.com).

binding, local governments may apply to their upper-level governments for further reducing the prices, which is a costly process referred to as downward adjustment of the minimum price limit. Different levels of government may have different preferences. If the upper-level governments also value the spillover effects on local incumbents generated by certain industries, the adjustment cost could be lower for these industries.

Against the above backdrop, our model theoretically shows how the equilibrium land prices of various industries are jointly determined by both market demand factors and governments' interest in facilitating such spillover effects, in addition to the supply costs of land. The model predicts two different price schedules: (1) where the minimum price limit is not binding and (2) where the minimum price limit is binding and a downward adjustment occurs. The difference between these two price schedules may reveal upper-level governments' attitudes toward local land subsidization, which will help generate inferences in the empirical analysis.

Our empirical analysis utilizes a large data set of 200,000 industrial land transactions from 2007 to 2015. This data set contains detailed information on each land sale, including the location, size, sale price, sale date, and two-digit code indicating the type of industry for which the land is designated to be used. To investigate the determinants of land prices, in addition to the general local production environment, typical supply costs, and land conditions, we are particularly interested in the local production amenities specific to industry type that are of private value to firms and social value to the locality.

We consider two main industry-location-specific amenities. The first is own-industry concentration, which captures agglomeration economies among firms within the same industry clustering in the locality. The second is cross-industry coagglomeration, which captures agglomeration economies among firms of different yet related industries clustering in the locality. We estimate their effects on land price separately since understanding the industry scope of agglomeration economies has long been of great interest to researchers and policy makers (Greenstone, Hornbeck & Moretti, 2010). On the one hand, if a plot of land is designated to be used for an industry with higher agglomeration economies in the area, it would be more valuable to potential entrants in this industry; hence, they would be willing to bid more for it.

This is the demand-driven force that pushes up land prices. On the other hand, once these types of entrants start to operate in the area, they can generate higher positive externalities to incumbents from the same or related industries. The local government values the social benefits of such externalities and is willing to supply more land ex ante to the industry, which depresses land prices for the industry. Because the regression analysis should return the net effect of these amenities on the land prices resulting from the above two opposing forces, it is challenging to demonstrate empirically the role of governments' industry preferences in determining land prices. That is why although it has long been argued that the rationale for governments' subsidization of industrial land lies in the positive externality that the land can bring in, little empirical literature has shown how the visible hands of governments select the winners.

We address this challenge from two novel angles guided by the model predictions. First, from the perspective of local governments, following Wang, Zhang, and Zhou (2020) and Tian, Yu, and Gong (2019), we expect that local governments led by leaders with higher career incentives value more those industries that can generate higher positive externalities to local industrial development and thus are willing to give more land subsidization to them. We test this hypothesis empirically. Second, from the perspective of multi-level governments, we exploit the 14% of land transactions in our sample that were sold below the minimum price limit set by the upper-level governments. By comparing the price schedules for non-binding and binding cases and investigating which factors affect the likelihood of downward adjustments, we can infer how local governments and upper-level governments favor industries *differently* according to their scope of agglomeration economies.

We use employment data from the 2004 Chinese Economic Census to construct two industry-county-specific indices to capture the aforementioned industry-locality-specific production amenities, reflecting two different scopes of agglomeration economies.[2] We measure each industry's concentration in each county by its local

[2] In this paper, counties refer to urban districts, county towns, and rural counties. They are the geographic units administered by prefecture-level governments under the supervision of their respective upper-level governments. Comparable to U.S. metro areas, a typical Chinese prefecture has one core city (comprised of urban districts), numerous rural counties, and several county towns.

employment share using the county's industrial employment information. Following the literature on localization economies, this concentration index captures the extent of agglomeration benefits enjoyed by local firms in the same two-digit industry.[3] In addition, firms enjoy benefits from cross-industry coagglomeration (Ellison, Glaeser & Kerr, 2010; Helsley & Strange, 2014). To measure the strength of an industry's connection to other industries in a given county, we calculate a coagglomeration index, which is the weighted average of the industry-pairwise colocation likelihood across all the other industries in the county. The construction of this colocation likelihood between industry pairs follows the method developed by Ellison, Glaeser, and Kerr (2010) using employment data from the 2004 Economic Census. We then match both indices to our land data by industry type and county.

Our empirical analysis yields three main findings. First, from the estimated price schedule for the case when the minimum price constraint is not binding, we observe that the price effects of both own-industry concentration and cross-industry coagglomeration are positive and significant; however, the positive effect of own-industry concentration is significantly mitigated by how much local governments care about industrial development, especially in the less developed region. The results indicate that local governments favor high-concentration industries in land allocation to boost industrial development, although in equilibrium the negative price effect caused by local governments' favoritism is overshadowed by the positive price effect due to high market demand from potential entrants.

Second, 14% of the land transactions in our sample involved sales below the minimum price limit. The estimated downward adjustment price schedule suggests that the preferences of upper-level governments for industry types are heterogeneous across regions. In the developed region, downward adjustments are more likely for industries with a higher own-industry concentration index; the degree of downward adjustment also increases with this index, which indicates that upper-level governments are more supportive of industries that can generate higher *within-industry spillover effects* than the local governments. By contrast, in the less developed region, both the likelihood of downward adjustments and the magnitude of

[3] For example, see Henderson (1986, 2003); Glaeser et al. (1992); Henderson, Kuncoro, and Turner (1995); Rosenthal and Strange (2003); and Duranton and Overman (2005).

such adjustments increase with the extent of *coagglomeration economies*, which suggests that upper-level governments favor industries that can generate higher *cross-industry spillover effects* more than the local governments. We discuss possible explanations for the regional differences in the industry preferences of multi-level governments later in the paper.

As corroborative evidence, we examine the upper-level governments' choices of local priority industries in China's Eleventh (2006–2010) and Twelfth (2011–2015) Five-Year Plans since the minimum price regulation policy allows priority industries to be eligible for downward adjustments. We find that in the developed region provincial governments (at the upper level above local governments) tend to choose industries with higher local concentration, while in the less developed region, provincial governments prioritize those with stronger cross-industry linkages with local incumbent firms.

Finally, our empirical results demonstrate that land prices are quite responsive to typical county-specific demand factors and supply cost factors, such as the gross domestic product (GDP), GDP shares in the secondary and tertiary sectors, population size, total developable land area, farmland productivity, and so forth.

Our paper speaks to several strands of the literature. First, the paper is related to the literature on place-based policies. While such policies are generally industry neutral in developed countries such the United States and the United Kingdom (Kline & Moretti, 2014), in developing countries like China, they often involve decisions on which industry to select to grant various kinds of preferential treatment for land, tax and customs duty, property rights, and so on (Perkins, 2004; Chen, Poncet & Xiong, 2017). Despite the profound efficiency implications, few studies have examined the considerations underlying those decisions. We contribute to the literature by providing empirical evidence from land sale prices on what kinds of industries are favored by China's policy makers. We provide evidence that government preferences for industry types tend to align with the strengths of an industry's linkages to local incumbent industries. We also find significant regional differences in the industry preferences of local and upper-level governments, suggesting different roles played by governments at multiple levels in China's industrial development, for which there has been limited empirical evidence in the literature.[4]

Second, this paper contributes to the literature on spatial concentration and coagglomeration of industrial establishments.[5] A vast body of empirical studies has shown that firms tend to form clusters to reduce the costs of obtaining inputs or shipping goods to downstream customers, to take advantage of scale economies associated with a large labor pool, or to speed the flow of ideas. We find that industrial firms in China value both own-industry concentration and cross-industry coagglomeration when bidding for land. Our results provide important insights into how agglomeration economies affect the location choices of Chinese industrial firms, and how these in turn influence the market value of industrial land, which prior research has largely overlooked.

Third, a growing body of literature evaluates land development and regulations in urban China.[6] Although industrial use accounts for more than half of newly developed urban land, most prior research focuses on residential land. Exceptions include Chen & Kung (2019) and Henderson et al. (2020), who consider the allocation of industrial land versus residential land. Lin et al. (2020) additionally study the impact of the minimum price regulation on industrial output per unit of land. This paper contributes to the literature by identifying the mechanisms that have shaped the equilibrium land prices of various industries post 2007, taking market forces, government preferences, and minimum price regulation into consideration.

The rest of the paper is organized as follows. Section 2 describes the institutional background of industrial land development. In section 3, we construct a theoretical framework to illustrate the monopolistic land supply decision of a local government subject to a price regulation imposed by the upper-level government and show what

[4] Kahn, Li, and Zhao (2015); Cai, Chen, and Gong (2016); and He, Wang, and Zhang (2020) illustrate the conflict of interests between the upper- and lower-level governments in the implementation of environmental regulations in China.

[5] For reviews, see Duranton and Puga (2004); Rosenthal and Strange (2004); and Combes and Gobillon (2015).

[6] For example, see Deng et al. (2008); Lichtenberg and Ding (2009); Brueckner et al. (2017); Cai, Wang, and Zhang (2017); Tan, Wang, and Zhang (2020); and Wang, Zhang, and Zhou (2020).

shapes the equilibrium land sale price. Section 4 discusses the data and main variables. In section 5, we specify the estimation equations and present the main results. Section 6 concludes.

2. Institutional background of China's industrial land market post 2007

China has a multi-level administration hierarchy. At the top level is the central government. At the second level are provincial governments. In this paper, we refer to the central and the provincial governments as upper-level governments. Below those are the prefecture-level governments. Within each prefecture, there are typically several county-level administrative units, including urban districts, county towns, and rural counties. We refer to the county-level governments as local governments. China has granted de jure ownership of urban land to prefectural governments along with county governments within its jurisdiction since 1988. According to the Law of Land Management, prefecture-level governments play a central role in planning urban land development, which has been subject to a hierarchical, top-down land quota regulation since 1998.[7] In practice, the prefecture's land reserve and allocation committee is in charge of general land use planning and guideline setting. Its members include the prefecture's key leaders and bureau directors from relevant government departments (e.g., the Urban Planning and Land Bureau, Development and Reform Committee, and Economy and Information Technology Committee).

Each prefectural government develops the land use plan for the short term as well as five-year plans, considering the spatial layout of the economic activities and population across the prefecture. These plans designate certain amounts of land for industrial use for each year for each county in the prefecture. Each county government then allocates this amount of industrial land to various industrial firms following the general guideline of the prefectural government. The county government seeks not

[7] The central government allocates land quotas for each province; each province then sets quotas for prefectures under its jurisdiction based on each prefecture's economic development, population growth, and arable land for food security. The land quota constraint is imposed on all urban land, including residential land, commercial land, and industrial land. Local governments have incentives to bargain with upper-level governments for higher quotas, and they sometimes succeed (Wang, Zhang & Zhou, 2020).

only to capture direct revenues from the land sales, but also to enhance the overall local industrial development. If the prefecture leader has stronger career incentives and eagerly wants to increase GDP, then each county government subordinate to the prefecture's leadership will care more about industrial development under the pressure. By controlling the supply of land to various industries, the county government manipulates the land prices to maximize its own objectives.

Before 2007, most industrial land sales took place through non-competitive, non-transparent negotiations (Zhang 2006; Xing & Bo, 2007).[8] This led to a loss of revenue and other problems, such as over-erosion of farmland and under-compensation of farmers. To regulate local governments' industrial land development and stop them from selling land at undervalued prices to attract investments, the Chinese central government implemented two policies in 2007 that restructured the mechanism of the industrial land market. First, starting in July 2007, all urban industrial land sales were required to be conducted via public auction. During our study period (July 2007 to December 2015), 90% of land transactions were conducted through public auctions.

Second, there has been a minimum land price constraint on all industrial land sold since January 2007. The minimum price constraints are set and imposed by upper-level governments, that is, the central government and provincial governments. Each county's land was graded into one of 15 classifications based on the local value of land, which was largely determined by the county's initial economic and geographic conditions (see Table 1).[9] According to this grade, a minimum land price was set for almost every county-level unit in China.[10] Figure A1 displays the negative

[8] According to our land sample, an estimated 92% of industrial land parcels were still transacted through negotiated sales from January 2004 through June 2007.

[9] Based on an ordered probit regression, we find that each county's land classification grade decreases with its total economic scale (as measured by GDP and population) and its shares in the secondary and tertiary sectors. In addition, we find that its grade increases with the county's developable land area and decreases with its farmland productivity, which are associated with the cost of supplying land for industrial construction. These variables together explain about 70% of the variation in the minimum prices across the counties in our sample. See Table 1.

[10] In August 2006, the State Council announced guidelines for setting minimum sale prices for industrial land transactions. In December 2006, the Ministry of National Land and Resources

relationship between minimum prices (range 60–840 yuan per square meter) and classification grades. Shanghai's nine core urban districts are ranked in the first classification grade, which has the highest price. Its *Pudong* district and Beijing's eight core urban districts are in the second category with a minimum price of 720 yuan per square meter. These are followed by 600 yuan per square meter in Shenzhen and Guangzhou. At the other extreme are counties that are mostly located in poorer provinces in western China; those in Tibet and Yunnan are in the bottom category with a minimum price of 60 yuan per square meter. Combined with the auction reform, the county-specific minimum price constraints can serve as an effective upper bound on the local industrial land supply given the demand for land.

There is a certain degree of flexibility in implementing the minimum price regulation. According to the Ministry of National Land and Resources, upon approval by the upper-level government (i.e., the provincial and central governments), a local government can sell land below the price limit under the following special conditions: (i) the land is meant to be used for priority industries, (ii) the land is meant to be used by the seven specific two-digit industries for which production directly uses raw materials,[11] (iii) the land is from existing urban land stock (versus newly converted from farmland), and (iv) the county is located in a poorer region (Ministry of National Land and Resources, 2006, 2009).

When the minimum price constraint is binding on a land transaction, the local government typically applies for a downward adjustment of price by bringing the case to the upper-level government. On the one hand, because the upper-level government seeks to prevent the loss of land sales revenues, it will be more difficult to obtain approval (or, equivalently, the adjustment costs will be higher) if there is a large gap between the minimum price limit and the proposed price. Adjustment costs include lengthy applications, lobbying costs, and even the possible sacrifice of intergovernmental transfers. On the other hand, adjustment costs are generally lower

(which became the Ministry of Natural Resources in March 2018) published the "Minimum Price Standards for Industrial Land Leasehold Sales."

[11] These two-digit industries include Food Processing (13); Food Production (14); Beverage Production (15); Textile Industry (17); Garments and Other Fiber Products (18); Leather, Furs, Down, and Related Products (19); and Timber Processing, Bamboo, Cane, Palm Fiber, and Straw Products (20).

for less developed localities and priority industries. Since the minimum price is set based on initial *county-specific* economic conditions, local governments typically justify a downward adjustment with *industry-locality-specific* reasons. For instance, the local government may argue that the land is for a specific industry use and that this industry can generate a high externality to local industrial development through, for example, knowledge spillovers, input sharing, or upward-downward linkages.

Panel A in Figure 1 shows the yearly trends of the fraction of land sales conducted through public auctions for the developed (represented by dots) and less developed regions (represented by diamonds). The developed region consists of the provinces or provincial cities with per capita GDP greater than 20,000 yuan in 2007, including Shanghai, Beijing, Tianjin, Zhejiang, Jiangsu, Guangdong, Fujian, Inner Mongolia, and Liaoning. Most of them are located in the coastal area. The remaining mainland provinces are in the less developed region. Panel B displays the yearly trends of unit land sale prices for these two regions. In both regions, the land sale prices jumped after 2007 (panel B), which is consistent with the increase in the proportion of sales made via auction (panel A). Figure 2 plots the distributions of the ratio of sales to minimum prices in the two regions, using all land transactions post-July 2007. The ratio tends to mass around 1 in both, where sales equal minimum prices. In the developed region, while about 80% of the transactions had a sale price above the minimum, around 11% had an actual sale price strictly below the minimum. Downward adjustments are more likely to occur in the less developed region, where 22% of the land sales had a sale price below the minimum.

3. Theoretical framework

3.1 Model

We construct a simple model to illustrate how the equilibrium land sale price is determined by both market forces and the interest of governments at multiple levels in the social benefits generated by positive externalities of industries. In the model, the local government (a monopolistic supplier) makes decisions about supplying land to different industries subject to a minimum price limit imposed by the upper-level government. The model also shows whether (and how much) a downward adjustment is possible when the price regulation is binding.[12]

Consider a local government that supplies land parcels to each of $J > 2$ industries, subject to a total land quota L. Let n_j represent the number of parcels supplied to industry $j = 1, \dots, J$. For simplicity, assume that all the land parcels are identical. They are auctioned off simultaneously. Each parcel is sold to a single firm.

If a firm in industry j is interested in doing business in this locality, it must buy exactly one parcel of land to enter. The number of potential entrants from industry j increases with the value of the local production amenities, denoted as m_j. The local production amenity depends on both t, the general local economic conditions, and t_j, the industry-locality-specific characteristics (e.g., the concentration and coagglomeration of industry j in the area); $\frac{\partial m_j}{\partial t} > 0$, and $\frac{\partial m_j}{\partial t_j} > 0$. Each firm has an independent private value for each land parcel. Suppose this private value is drawn from a distribution, denoted by $F(V_j)$; the mean of V_j also increases with m_j. These potential entrants bid for the n_j parcels of land up for auction. For simplicity, we specify the following function to characterize the demand for local land from firms in industry j:

$$n_j = \alpha m_j - \beta p_j, \tag{1}$$

where p_j is the expected sale price, $\alpha > 0$, and $\beta > 0$. The value of local production amenities m_j drives up the demand by increasing both the number of bidders and the mean private value of all the potential bidders.

If a firm successfully bids on a land parcel, it pays the local government and enters the locality. In addition to the land sales revenues, each firm will generate tax revenues in the future and may generate a positive spillover effect e_j in the local economy. The size of the spillover effect depends on the industry-locality characteristics t_j. For example, if the entrant is from an industry that has close connections to the locality's industrial composition, reflected by a stronger own-

[12] This is a partial equilibrium model in the sense that we do not consider the interactions between the industrial and residential land markets. In an extension, we incorporate a convex cost function of industrial land supply into the model to capture the increasing marginal cost of industrial land supply due to squeezed residential land supply and increased housing prices. As shown in footnote 16, the model's key predictions remain valid.

industry concentration or greater cross-industry coagglomeration, it will generate larger spillovers. Here, we define $e_j = e(t_j)$.

Each land parcel's marginal supply cost to the local government is c. In addition, if the land sale price is below the regulated minimum price denoted by MLP, then a downward adjustment of the price is necessary and the local government incurs an adjustment cost, which is set by the upper-level government.

As a monopoly supplier, the local government allocates the available land to different industries to maximize its own objectives. Equivalently, it sets the land price for each industry to fulfill its goal. The objective function is defined as follows:

$$\underset{p_1,\ldots,p_J}{Max} \sum_{j=1}^{J} n_j \times p_j + n_j \times \theta \times e_j - n_j \times c - I\big(MLP > p_j\big) \times (\psi_0 + n_j \times \psi_j)$$

$$s.t. \sum_{j=1}^{J} n_j \leq L \quad ,$$

$$n_j = \alpha m_j - \beta p_j, j = 1, \ldots, J \qquad (2)$$

where the local government's objective is to maximize the land sales revenues from land developments plus the spillover effects net of costs. In equation (2), e_j is the industry-locality-specific positive spillover effect and $\theta \times e_j > 0$ is the social benefit of the spillover effect evaluated by the local government; c is the supply cost per unit of land.[13]

In equation (2), $I(.)$ is an indicator function of $MLP > p_j$. We specify the functional form of the adjustment cost as $\psi_0 + n_j \times \psi_j$, where $\psi_0 > 0$ is the constant part of the total adjustment cost, and $\psi_j > 0$ is the adjustment cost per land parcel defined as follows:

$$\psi_j = MLP - p_j - \theta' \times e_j. \qquad (3)$$

This per unit adjustment cost consists of two parts: (i) $MLP - p_j > 0$ reflects that the upper-level government cares about the loss in land sales revenues due to the downward adjustment; the larger the gap, the more costly the adjustment; and (ii) $\theta' > 0$ indicates that the adjustment cost can be lowered if the externality is high;

[13] Our model is static. To ensure its tractability, we assume that when making land supply decisions, the local government takes t, t_j, and c as exogenously determined by natural amenities or initial economic conditions, but not influenced by its own decisions.

however, the upper-level government's valuation of the externality might differ from that of the local government since $\theta \neq \theta'$ in general. As general local conditions, both t and c are the determinants of MLP and both are well known to the upper-level government (see section 2 on the determination of MLP). However, because e_j is specific to each industry-locality pair, the upper-level government cannot consider it ex ante. Thus, the upper-level government must consider e_j ex post when deciding the adjustment cost, when the local government brings e_j to its attention to obtain approval for the downward adjustment of a specific land transaction.

We illustrate the solution of the optimization problem for a case in which the minimum price limit can effectively prevent the local government from supplying industrial land beyond a certain upper bound that is lower than L.[14] The optimal price p_j of industry j is defined as follows:

$$p_j = \begin{cases} p_{0j} = \dfrac{\alpha m(t, t_j)}{2\beta} - \dfrac{\theta e(t_j)}{2} + \dfrac{c}{2} & if\ p_{0j} > MLP \\ MLP & if\ p_{1j} > MLP \geq p_{0j}\,, \\ p_{1j} = \dfrac{\alpha m(t, t_j)}{2\beta} - \dfrac{(\theta + \theta')e(t_j)}{4} + \dfrac{MLP(t, c) + c}{4} & if\ MLP \geq p_{1j} \end{cases} \quad (4)$$

where p_{0j} is the price level that maximizes the objective function when the minimum price regulation is non-binding, and p_{1j} is the optimal price level conditional on the downward adjustment of MLP.

3.2 Testable implications

Our model demonstrates how market forces and the preferences of governments at multiple levels affect industrial land sale prices. We draw the following implications from the model that we test empirically.

Price effect of industry-locality-specific characteristics t_j when the minimum price constraint is not binding

First, because $\frac{\partial p_0}{\partial t_j} = \frac{\alpha}{2\beta} * \frac{\partial m_j}{\partial t_j} - \frac{\theta}{2} * \frac{\partial e_j}{\partial t_j}$, the sign of $\frac{\partial p_0}{\partial t_j}$ will be determined by the

[14] In Appendix B, we discuss the case where the market demand is high enough such that the MLP is not binding and the total industrial land is bounded by L. The predictions for how the equilibrium price and quantity change with t_j, t, and c are similar.

relative influences of market demand and the local government's preference for the positive spillover brought in by t_j. Therefore, $\frac{\partial p_0}{\partial t_j} > 0$ implies that the former overshadows the latter. Second, because $\frac{\partial(\partial p_0/\partial t_j)}{\partial \theta} < 0$, $\frac{\partial p_0}{\partial t_j}$ will decrease as the local government's valuation of the externality increases.

Price effect of industry-locality-specific characteristics t_j when the minimum price constraint is binding and a downward adjustment occurs

Because $\frac{\partial p_1}{\partial t_j} = \frac{\alpha}{2\beta} * \frac{\partial m_j}{\partial t_j} - \frac{\theta+\theta'}{4} * \frac{\partial e_j}{\partial t_j}$, the sign of $\frac{\partial p_1}{\partial t_j}$ will be determined by the relative influences of market demand and the upper-level government's and the local government's preferences for the positive spillover brought in by t_j. Because $\frac{\partial(\partial p_1/\partial t_j)}{\partial \theta'} < 0$, $\frac{\partial p_1}{\partial t_j}$ will decrease as the upper-level government's valuation of the externality increases. Because $\frac{\partial p_1}{\partial t_j} - \frac{\partial p_0}{\partial t_j} = \frac{\theta-\theta'}{4} * \frac{\partial e_j}{\partial t_j}$, whenever $\theta' > \theta$, or, in other words, whenever the upper-level government values $e(t_j)$ more than the local government does, we have $\frac{\partial p_1}{\partial t_j} < \frac{\partial p_0}{\partial t_j}$. If $\frac{\partial p_1}{\partial t_j} \geq \frac{\partial p_0}{\partial t_j}$ instead, we can infer $\theta' \leq \theta$; that is, the upper-level government is less supportive of the industry with higher $e(t_j)$ than the local government is.

Effect of t_j on downward adjustment probability

Both p_0 and p_1 increase as the general local economic conditions t improve. However, the range of t in which downward price adjustments occur (which determine the downward adjustment probability) differs with the industry-locality-specific condition t_j. Suppose that $\frac{\alpha}{2\beta} * \frac{\partial m_j}{\partial t} > \left(1 - \frac{1}{4}\right) * \frac{\partial MLP}{\partial t}$,[15] then, given any industry-locality-specific condition t_j and government preferences, there exists a corresponding unique threshold for the general local economic conditions, $\bar{t}\left(t_j, \theta, \theta'\right)$, such that a downward adjustment occurs if and only if $t < \bar{t}\left(t_j, \theta, \theta'\right)$. This threshold $\bar{t}\left(t_j, \theta, \theta'\right)$ can be pinned down by equation $p_1\left(\bar{t}, t_j, \theta, \theta'\right) = MLP(\bar{t}, c)$. Applying the

[15] This inequality means that the market value of land is more responsive to local economic conditions than MLP. This is quite likely to be true in practice.

implicit function theorem to the above equation, we can obtain $\frac{\partial \bar{t}}{\partial t_j} = -\left(\frac{\partial p_1}{\partial t_j}\right) / \left(\frac{\alpha}{2\beta} * \frac{\partial m_j}{\partial t} - \left(1 - \frac{1}{4}\right) * \frac{\partial MLP}{\partial t}\right)$. Because the denominator is positive (see footnote 15), we can conclude that $\frac{\partial \bar{t}}{\partial t_j} > 0$ (< 0) if and only if $\frac{\partial p_1}{\partial t_j} < 0$ (> 0). Therefore, whenever $\frac{\partial p_1}{\partial t_j} < 0$, the probability of downward adjustment will increase if the land is used for an industry with a higher t_j.

Recall that $\frac{\partial p_1}{\partial t_j} = \frac{\alpha}{2\beta} * \frac{\partial m_j}{\partial t_j} - \frac{\theta + \theta'}{4} * \frac{\partial e_j}{\partial t_j}$; we have $\frac{\partial(\partial p_1/\partial t_j)}{\partial \theta\prime} < 0$ and $\frac{\partial(\partial p_0/\partial t_j)}{\partial \theta} < 0$. We thus know that as the upper-level government or the local government values the externality generated by t_j more, it is more likely that $\frac{\partial p_1}{\partial t_j} < 0$ and hence the likelihood of a downward adjustment of the minimum price limit increases with t_j.

Effects of general local economic conditions t and land supply cost c

From the model, we have $\frac{\partial p_0}{\partial t} = \frac{\alpha}{2\beta} * \frac{\partial m_j}{\partial t}$, and $\frac{\partial p_1}{\partial t} = \frac{\partial p_0}{\partial t} + \frac{1}{4} * \frac{\partial MLP}{\partial t}$. Therefore, we expect that both p_0 and p_1 increase with t. In addition, we expect that $\frac{\partial p_1}{\partial t} > \frac{\partial p_0}{\partial t}$ because MLP increases with t. From the model, we have $\frac{\partial p_0}{\partial c} = \frac{1}{2}$, and $\frac{\partial p_1}{\partial c} = \frac{1}{4} + \frac{1}{4} * \frac{\partial MLP}{\partial c}$. Therefore, we expect that both p_0 and p_1 increase with c. Furthermore, when $\frac{\partial MLP}{\partial c} > 1$ or, equivalently, when a one-unit increase in land supply cost (c) causes more than a one-unit increase in MLP (probably because the upper-level government is more concerned about the potential social cost of land supply, such as ecological and environmental damages), we will have $\frac{\partial p_1}{\partial c} > \frac{\partial p_0}{\partial c}$.[16]

[16] For simplicity, the model assumes a constant marginal cost of land supply. In reality, however, the marginal cost increases with the amount of total land supply. We assume the marginal cost to be

$MC = c + 2bn, b > 0.$

It implies that the average cost per land unit is

$AC = c + bn.$

When the MLP regulation is binding, the downward adjustment cost per land unit becomes

$\psi_j = MLP - p - \theta' e_j + bn.$

This is because when the MLP was initially set, the upper-level government could not observe

4. Data and variable construction

4.1 Data

Land transaction data

The parcel-level land transaction data were collected from the official website of China's Ministry of National Land and Resources (www.landchina.com). About 1.5 million (1,566,696) parcel transactions were recorded from 1989 to 2015. The full sample contains 437,409 industrial land transactions, including land parcels used for industry, warehousing, and mining[17]; 97% of these transactions occurred after 2004. A cross-check with data from the *Yearbooks of Land and Resources* suggests that the land transaction data has been completely recorded since 2007 (see Table A1). The land transaction data contains the following key variables: lot size, urban construction land source,[18] transaction type (negotiation, English auction, two-stage auction, or sealed bid auction), two-digit industry sector, sale price, sale date, buyer identity, and address.

County-level characteristics

The minimum price information was collected from the website of the Ministry of National Land and Resources of China. Appendix C describes how we assign the minimum price to each land observation in our sample.

We collected data on county-level economic characteristics, such as GDP and its sectoral decomposition of primary, secondary, and tertiary industries, and registered population size from the Fiscal Statistical Compendium for All Prefectures and

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n and hence did not take bn into consideration. Ex post, when a downward adjustment is involved, the upper-level government knows bn and wants to correct this missing cost in MLP by adding the amount of bn to the adjustment cost per unit of land. We can then derive the corresponding p_0 and p_1. All the model predictions discussed in section 3 remain valid.

[17] There are 243,314 commercial land transactions in the full sample, which includes land for retail and wholesale, business and finance, hotel and restaurant use, and other commercial use. The full sample also contains a total of 727,066 residential land parcels.

[18] There are two main sources of urban construction land: newly converted farmland and existing urban land stock.

Counties (*Quanguo Dishixian Caizheng Tongji Ziliao*).[19] We collected data on each county's land area and the share of land area with a slope above 15% from the Resource and Environmental Data Cloud Platform. To measure farmland productivity, we collected data on the grain output per unit of farmland in 1995 from the Summary of Rural Economic Statistics of Counties in China (*Zhongguo Fenxian Nongcun Jingji Tongji Gaiyao*).

4.2 Construction of industry-county-specific characteristics

The data we use to construct the industry-county variables are mainly drawn from the 2004 Economic Census conducted by China's National Bureau of Statistics, which covers all mining, manufacturing, and utility firms in China.[20] The census data report the administrative location code (from which we can extract county information), industry affiliation (a four-digit industry code), employment, output, and capital for each firm. To measure how a two-digit industry is related to each county, we construct the following variables.

Own-industry concentration index

Following Henderson, Kuncoro, and Turner (1995), we measure the historical concentration of industry j in county k as follows:

$$concentration_{kj} = \frac{industry\ j's\ employment\ in\ county\ k}{total\ employment\ in\ county\ k}. \tag{5}$$

This concentration index captures the extent of the agglomeration benefits enjoyed by firms in the same two-digit industry. Localities with historical concentration of an industry and related local knowledge accumulation present a more productive environment for firms in that industry than those without these characteristics.

[19] Each county's population size is available from 1993 to 2001. While GDP data are available from 1997 to 2005, GDP sectoral decomposition information is only available from 2001 to 2005.

[20] The 2004 Economic Census contains a total of 39 two-digit industries and 190 three-digit industries.

Cross-industry coagglomeration index

For a given industry in each county, we construct a coagglomeration index to measure the strength of the industry's connection to other industries located in the county. We first quantify the coagglomeration likelihood for each industry pair j and j' following Ellison and Glaeser (1997) and Ellison, Glaeser, and Kerr (2010):

$$\gamma_{jj'} = \frac{\sum_{k=1}^{N}(s_{kj} - \bar{s}_k)(s_{kj'} - \bar{s}_k)}{1 - \sum_{k=1}^{N}\bar{s}_k^2}, \tag{6}$$

where k indexes counties, s_{kj} represents the share of industry j's employment in county k, and $\bar{s}_k$ is the mean employment share in county k across manufacturing industries. Next, for industry j, we measure the strength of its connection to all the other industries in county k using the following coagglomeration index:

$$coagglomeration_{kj} = \sum_{j'=1}^{J} \gamma_{jj'} * concentration_{kj'}\,, \tag{7}$$

where $concentration_{kj'}$ is the share of county k's employment in industry j'.

Table A2 lists the 39 two-digit industries contained in our land sample, ranked by the average land sale price. Table A3 shows the industry pairs with the highest coagglomeration likelihoods.

4.3 Summary statistics

Column (1) in Table 2 reports the summary statistics of the land and industry-county characteristics for our land sample. These land observations are from 2,345 counties in 329 prefectural cities and four provincial cities.[21] Between July 2005 and December 2015, more than 90% of all land transactions were conducted through public auctions. The average sale price was 220 yuan per square meter. About 70% of the transactions had an actual sale price that was strictly higher than the minimum price limit. The average lot size is 3.7 hectares, and the average distance to the city center is about 44 kilometers.

Columns (2) and (3) in Table 2 report the summary statistics for the subsamples

[21]Mainland China had a total of 2,866 county units in 2007.

of land transactions from developed and less developed regions, separately. Both sales and minimum prices are higher in the former than the latter. While 19% of the land transactions in the less developed region had actual sale prices that were strictly lower than the minimum prices, only 10% of the transactions in the developed region featured a downward price adjustment.

5. Estimation specifications and main results

5.1 Regression specifications

Let i index each land observation in the sample, c the prefectural city in which it is located, k the county, and j the industry type. We rewrite the equilibrium price equation (4) as follows:

$$p_i = \begin{cases} log\, p_{0i} = t'_{kj}\eta_{01} + X'_k\eta_{02} + W'_{kji}\upsilon_0 + \xi_{0c} + u_{0i} & if\ p_{0i} > MLP \\ MLP_k & if\ p_{1i} > MLP \geq p_{0i}, \\ log\, p_{1i} = t'_{kj}\eta_{11} + X'_k\eta_{12} + W'_{kji}\upsilon_1 + \xi_{1c} + u_{1i} & if\ MLP \geq p_{1i} \end{cases} \quad (8)$$

where t_{kj} is a vector of the industry-county-specific characteristics, including the own-industry concentration and cross-industry coagglomeration indices; X_k is a vector of the key initial county-specific economic conditions, including the land supply cost variables (such as county k's developable land area[22] and farmland productivity) and a set of demand factors (such as county k's GDP level, GDP shares in the secondary and tertiary sectors, and population size); and u_{0i} and u_{1i} are the error terms. In equation (8), we also include W_{kji}, which contains the following four sets of controls: (i) a dummy indicating whether the land was sold through a negotiation sale, the land's distance to the city center (in log), lot size (in log), land transaction year and month dummies, and land source dummies interacted with time trends; (ii) two-digit industry dummies and industry-specific linear year trends; (iii) regional dummies (i.e., Middle and West) interacted with linear year trends; and (iv) a set of other county characteristics such as a dummy indicating whether the county unit is an urban district, its elevation range, its annual precipitation (in log), and its annual average temperature. In addition, following Rosenthal and Strange (2003), we include

[22] Following Saiz (2010), we calculate the developable land area as the area of land (excluding water area) with a slope of less than 15%.

the prefecture fixed effects ξ_{0c} and ξ_{1c} to control for all characteristics common to a prefecture that affect the market supply and demand, including natural advantages, local economic policies, workforce quality, and so forth.

We adopt a maximum likelihood estimation approach to address the nonlinear nature of the price schedules in the presence of the minimum price limit. We assume that the error terms u_{0i} and u_{1i} are normally distributed with means of zero and standard deviations of σ_0 and σ_1. For each parcel of land i in our sample, we define two variables: $w_i \equiv max\{0, log\, p_i - log\, MLP_k\}$ and $z_i \equiv min\{0, log\, p_i - log\, MLP_k\}$. Appendix Figure A2 illustrates the density distributions of w_i and z_i for the overall sample. Because they are left-censored and right-censored, respectively, we utilize tobit regression models to estimate the parameters in equation (8).

5.2 Main results: Dominant role of market forces

Table 3 reports the results of the price regressions corresponding to p_0 and p_1 in equation (8). In addition to the controls in columns (1) and (3), columns (2) and (4) include prefecture fixed effects to control for all characteristics common to a prefecture that affect industrial land prices.

The estimates in columns (1) and (2) are for the price schedule p_0 when the minimum price regulation is not binding; in both columns, the effects of concentration and coagglomeration are positive and significant. The inclusion of prefecture fixed effects to a large extent reduces the magnitudes of the effects of these two indices. This implies that a given prefecture's characteristics that are associated with sale price may also correlate with local industrial concentration and coagglomeration at the county level within the prefecture. Therefore, we focus on column (2) for the effects of concentration and coagglomeration. The results demonstrate that the sale price is significantly higher for land located in a county where its designated industry type has a higher degree of own-industry concentration or a stronger cross-industry connection to local incumbents. This suggests that on average the positive effects due to high market demand from potential entrants overshadow the subsidization effects caused by local governments' preference for spillover externalities. The price results also demonstrate that productivity spillovers due to the spatial concentration of industrial plants depend on their industrial linkages.

Columns (3) and (4) report the estimates for price schedule p_1 when the minimum price regulation is binding and a downward adjustment occurs. The coefficients of concentration and coagglomeration are still positive, indicating that in this constrained optimal case, market demand forces still dominate.

On the county-level characteristics, column (1) shows that the prices in the non-binding case, on average, are higher for land in counties with better initial economic conditions, such as a higher GDP level, a higher GDP share in the secondary sector, a higher GDP share in the tertiary sector, and a larger population size. These factors are likely associated with a high demand for local land. Meanwhile, the land sale price decreases as the total developable land area increases, and it increases as the productivity of farmland increases. This implies that in addition to the demand factors, the sale price also captures the costs of converting rural land into urban industrial land. Although the magnitudes of these county characteristics become smaller when we also include prefecture fixed effects, as shown in column (2), the sign and significance of the effects remain largely unchanged, except for farmland productivity, as its effect is fully absorbed by the prefecture fixed effects.

In columns (3) and (4), for price schedule p_1 in the downward adjustment case, the estimated coefficients of all the county characteristics have the same sign and significance as those for p_0, the price of the non-binding case, as shown in columns (1) and (2). In addition, the coefficients of all the demand factors are larger for p_1 than for p_0, as the model predicts. This is because these demand-side county characteristics increase the minimum price limit, as discussed in section 2 (see Table 1 on the determination of the minimum price limit), and thus raise the adjustment cost, which increases with the gap between the minimum and actual prices. The estimated coefficients of the supply cost factors are also larger for p_1 than for p_0, implying that local land supply costs have a large effect on minimum price limits.

One concern is that the 2008 global financial crisis, which severely hit China’s imports and exports, may have affected the industrial land market and its price determination. To check the robustness of our main results, we rerun the tobit regressions excluding land sold between November 2008 and October 2009. The results, reported in columns (1) and (2) in Appendix Table A4, demonstrate that the main results are robust. Another robustness check includes the average sale price of residential land parcels located within a 3-kilometer ring around each industrial land observation, to capture the price effects of unobserved neighborhood amenities. The main results are also robust, as shown in columns (3) and (4) in Table A4.

5.3 Industry preferences of local governments

Enhancing GDP performance may be a more important goal for a younger prefecture leader who has relatively stronger career incentives (Wang, Zhang & Zhou, 2020). This may put more pressure on the county governments, which are subordinate to the prefecture's leadership, to boost local industrial development. This section investigates the price effect of local governments' industry preferences by exploiting a rule-derived variation in the career incentives of prefecture leaders. We focus on the age of the prefecture party secretary.[23] Since the establishment of a mandatory retirement age in the early 1980s, age has become a critical factor in career advancement. When a prefecture leader approaches the mandatory retirement age (which is 60 in our sample), his/her chances for promotion decrease sharply.[24] We use each prefecture leader's remaining years before retirement at the time of a land transaction to measure his/her career incentives. The more are the remaining years, the higher the career incentives will be.

We suppose that local governments led by more incentivized prefecture leaders have higher valuations of the industrial spillover effect as they care more about overall local industrial development. Thus, the career incentives of prefecture leaders are positively associated with the respective local governments' preferences for

[23] The top prefectural officials include the party secretary and the prefecture mayor. The party secretary is more powerful than the prefecture mayor due to the ruling position of the Chinese Communist Party.

[24] The retirement age for government officials varies with hierarchy level: it is 60 for both prefecture-level and deputy-province-level prefecture leaders and 65 for province-level prefecture leaders. All the province-level prefecture leaders are from the four provincial-level cities, Beijing, Shanghai, Tianjin, and Chongqing. The leaders of these four cities may have quite different career horizons as most of those eventually become central leaders of the country. Therefore, we exclude these four cities when analyzing the preferences of local governments.

spillover externalities. Based on our model implications, we hypothesize that stronger career incentives will weaken the positive effect of own-industry concentration or cross-industry coagglomeration on land prices due to high market demand. To test this hypothesis, we match the industrial land transactions with the biographical information on the prefecture leader who was in office when the land was sold.[25] We then run the tobit regression for p_0 by additionally including the interaction terms of the above industry-county characteristics and the career incentive measure. To explore the regional heterogeneity of local governments' preferences, we also run the regression with two subsamples: counties in the developed region and counties in the less developed region.

Column (1) in Table 4 reports the results for the full matched sample. As expected, the positive effect of own-industry concentration on p_0 decreases as the career incentives of prefecture leaders increase. Columns (2) and (3) in Table 4 report the estimates for the developed and less developed regions, respectively. The results show that the effect of prefecture leaders' career incentives is more prominent in the less developed region. In addition, regardless of region, the price effect of coagglomeration does not change significantly with prefecture leaders' career incentives. Together, the results imply that when granting land subsidization, local governments in the less developed region favor industries that can generate higher within-industry agglomeration externality. However, they seem not to value much the agglomeration economies through inter-industry connections, such as upstream-downstream connections or complementarity. By contrast, local governments in the developed region appear to support neither high-concentration industries nor high-coagglomeration industries.

5.4 Industry preferences of upper-level governments

Upper-level governments regulate land allocation and subsidization by local governments by imposing minimum price constraints. Comparing the coefficients of

[25] We manually collected biographical information on prefecture leaders who were in office during 2007–13 in the 271 prefectures of our sample. The matched sample contains 137,940 land observations from the full sample. The main results in Table 3 are robust when using this subsample to run the regressions.

concentration and coagglomeration between p_0 and p_1 reveals the upper-level governments' industry preferences. When the minimum price constraint is binding on a land transaction, the local government may apply to the upper-level government for a downward adjustment of the price. Local governments typically justify such applications by arguing that the land is used for a certain industry type that can generate spillover effects through agglomeration economies within the industry or across industries. If the upper-level government values the spillover effects more than the local governments do and is willing to reduce the adjustment costs sufficiently, then the resulting downward adjustment pricing schedule (p_1) with respect to the concentration index or the coagglomeration index will have a flatter slope than the pricing schedule absent the price regulation (p_0), as the model predicts.

As Table 3 shows, the coefficients of concentration and coagglomeration are statistically insignificant between the two price schedules (p_0 and p_1). This suggests that, on average, the industry preferences of local governments and their respective upper-level governments are similar. However, we find that upper-level governments' industry preferences vary across regions. Table 5 reports the results of the price regressions corresponding to p_0 and p_1 in equation (8) for the developed and less developed regions, separately. Interestingly, in the developed region, the effect of local concentration on p_1 is negative and significant (column (2)), and it is significantly different from the coefficient for p_0 (columns (1) and (3)), which suggests that upper-level governments are more supportive of high concentration industries than local governments are. Upper-level governments so strongly support high-concentration industries that the subsidization effect dominates demand forces; hence, the net effect of concentration on the price in the downward adjustment case becomes negative. However, we find that coagglomeration has a positive effect on p_1 and it is not statistically different from that on p_0 (see columns (1) to (3)), which indicates that in the developed region, upper-level governments have similar preferences to local governments for high-coagglomeration industries.

By contrast, in the less developed region, coagglomeration has a negative and marginally significant effect on p_1 (column (5)) and the coefficient is statistically smaller than that for p_0 (columns (4) and (6)). This suggests that the respective upper-level governments favor industries with close cross-industry connections to local incumbents much more than local governments do. The upper-level governments are willing to approve downward adjustment applications from local governments at considerably lowered prices for such industries. The subsidization effect dominates market forces, causing the net effect of coagglomeration on p_1 to be negative. However, we find that the effect of local concentration on p_1 is positive and significantly larger than that on p_0 (see columns (4) to (6)), indicating that upper-level governments seem to be less supportive of high-concentration industries than local governments are in the less developed region. In other words, the results suggest that upper-level governments in the less developed region effectively regulate the land subsidization granted to local high-concentration industries by the local governments.

5.5 Downward adjustments

The results in Table 5 show that in the developed region, p_1 decreases as the own-industry concentration increases, whereas in the less developed region, p_1 decreases as the cross-industry coagglomeration increases. According to our model, these findings imply that: (i) in the developed region, a downward adjustment is more likely for industries with high own-industry concentrations than for other industries, and (ii) in the less developed region, a downward adjustment is more likely for industries with high cross-industry coagglomeration than for other industries. To check whether this is the case, we run probit regressions and report the estimated coefficients in Table 6. The results confirm these two implications. Table 6 also shows that downward price adjustments are less likely in counties with more advantageous economic conditions (a higher GDP level, higher GDP shares in the secondary and tertiary sectors, and a larger population) and more likely in counties with low land supply costs (a larger developable land area). This is consistent with Figure 2, which illustrates that the proportion of downward adjustments is higher in the less developed region.

To investigate further how the industry preferences of local governments affect downward adjustments, we add the interaction terms of the industry-county amenities and the career incentive measure (as constructed in section 5.3) to the probit regressions of Table 6. The results reported in Table 7 show that a downward adjustment is more likely for high-concentration industries in the less developed region with strongly incentivized prefecture leaders in office. This is driven by the local governments' preferences for industries that can generate high within-industry spillover effects, consistent with the findings presented in Table 4.

5.6 Local priority industries

The price estimation above reveals the upper-level governments' preferences for industry types. As corroborative evidence, this subsection investigates the provincial government choices of local priority industries in China's Eleventh Five-Year Plan (2006–2010) and Twelfth Five-Year Plan (2011–2015), which reflect upper-level governments' considerations on local industrial policy.[26] We analyzed all the provincial government work reports related to both five-year plans and recorded each province's priority manufacturing industries. In our regression analysis, we match the 2,345 counties in our sample to each of the 30 two-digit manufacturing industries. For each county-industry observation, we define a dummy variable to indicate whether the industry has been classified as a local priority industry in the Eleventh or Twelfth Five-Year Plan of the province where the county is located. To understand the relationship between the likelihood of being designated a local priority industry and the industry-locality-specific characteristics, we regress the priority-industry dummy on (i) a dummy indicating whether the industry was present in the county in 2004 (the incumbent-industry dummy), (ii) the interaction term of the incumbent-industry dummy and industry-county concentration, and (iii) the industry-county coagglomeration index. We also include county and industry fixed effects. Standard errors are clustered at the prefecture level.

Column (1) in Table 8 reports the results for the full sample. It shows that an industry's local concentration and coagglomeration both have significantly positive effects on the likelihood it will be designated a local priority industry. Columns (2) and (3) report the results for the developed and less developed regions, respectively. The results show that in the developed region, industries with higher historical own-industry concentration (rather than cross-industry coagglomeration) are more likely to be designated a local priority industry. However, in the less developed region, this

[26] Five-year plans are a series of social and economic development initiatives that have been issued by the Chinese government since 1953. Each plan contains detailed economic development strategies, growth targets, and reforms.

likelihood is higher for industries with stronger local cross-industry linkages reflected by higher levels of coagglomeration. Although in the less developed region higher historical concentration also increases the likelihood of being considered a priority industry, the magnitude of this effect is much smaller than in the developed region. Overall, these findings are consistent with the results of the price estimation of upper-level governments' industry preferences.

5.7 Discussion

In sum, in the developed region, downward adjustments are more likely for industries with a higher concentration index; the degree of the downward adjustment also increases with this index, which indicates the upper-level governments' strong support for local subsidization of industries that can generate higher within-industry spillover effects. By contrast, in the less developed region, both the likelihood of downward adjustment and the magnitude of such adjustment increase with the extent of coagglomeration economies, which suggests that upper-level governments are strongly supportive of local subsidization of industries that can generate higher cross-industry spillover effects. Upper-level governments in the less developed region also effectively regulate the land subsidization granted to local high-concentration industries by local governments.

Why do upper-level governments' industry preferences differ from those of local governments? Why do the preferences vary between developed and less developed regions? The difference in the initial local industrial development status between the two regions may explain why. In the developed region, high local concentration industries are likely to be of high comparative advantage region-wide as well. Upper-level governments that want to internalize the positive externality generated by specialization and trade in the whole region are willing to grant permission to subsidize land in favor of high local concentration industries initiated by the local government. However, in the less developed region, a county may not have comparative advantage in its high-concentration industries relative to the region due to incomplete markets or high trade costs. Thus, upper-level governments may be less supportive of such industries than local governments; upper-level governments may instead want to coordinate the relocation of industrial plants from developed regions (e.g., due to soaring production costs) by allowing land subsidization to firms with strong industrial linkages to local incumbents since they can potentially generate larger positive spillovers in the region.

Imbs and Wacziarg (2003) provide a more general explanation of governments' heterogeneous industry preferences across regions with different income levels. They suggest that when trade costs are high and markets are incomplete, the governments of poor regions may find that it is in their best interest to diversify industries. As trade costs fall and markets deepen, these governments may promote industrial specialization as comparative advantage considerations come to dominate the insurance motive.

6. Conclusion

Although it has been widely documented that local governments largely control China's industrial land market, little is known about this market's price determination mechanisms since 2007, when industrial land transactions were required to be conducted via competitive bidding and a minimum land price constraint was imposed by the upper-level governments. To fill this gap, we studied how market forces and government preferences have jointly affected China's industrial land prices since 2007. We developed a simple model to characterize this market, which incorporates China's institutional features. Based on the model's implications, we combined a large data set of industrial land transactions with industry-county-specific and county-specific characteristics to estimate the price schedules, along with information on the regulatory minimum prices for all Chinese counties. The results show that industrial firms in China value both own-industry concentration and cross-industry coagglomeration when bidding for land. While market forces have been responsible for driving up land prices after 2007, we found that government preferences still play a non-negligible role in land allocation.

In particular, the results show that local governments led by leaders with higher career incentives are willing to give more land subsidization to industries that can generate higher within-industry spillover effects, especially in the less developed region. While upper-level governments regulate the local subsidization of industrial land by imposing the minimum price limit, they are open to local-industry-specific information brought to their attention by local governments and may grant downward adjustments of the price constraints. The downward price adjustments reveal that the upper-level governments in the developed region favor high-concentration industries more than the local governments do. By contrast, the upper-level governments in the less developed region are more supportive of high-coagglomeration industries than the local governments are. Overall, the results suggest that government considerations of which industry to support align with industries' local comparative advantages.

Our findings also point to the different roles played by multi-level governments in the land market. While local governments are interested in facilitating local industrial development through land allocation, upper-level governments with broader views and information assume the role of regulation and coordination, in an effort to avoid over competition of land subsidization among local governments, to coordinate the geographic redistribution of industrial production, and to internalize the region-wide (or nation-wide) externalities.

Over the past four decades, China has experienced rapid industrialization and urbanization, and land has played an essential role in this process. On the one hand, local governments have used land allocation as an effective tool to promote local economic growth. On the other hand, the upper-level governments have launched various policies, such as imposing the auction reform and setting the minimum price constraints, to improve land use efficiency. More research is needed to evaluate the welfare implications of those policies, to study the respective roles of the market and governments of different administrative hierarchy levels in land allocation, and to understand how each affects productivity and welfare.

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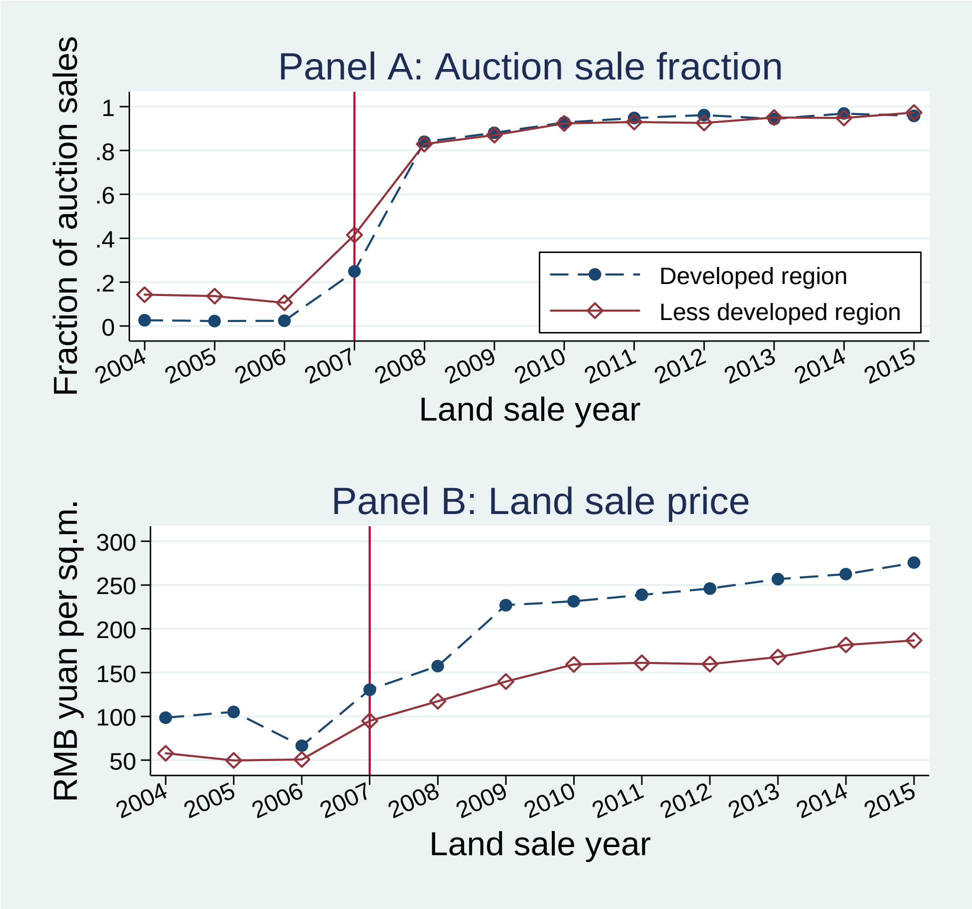
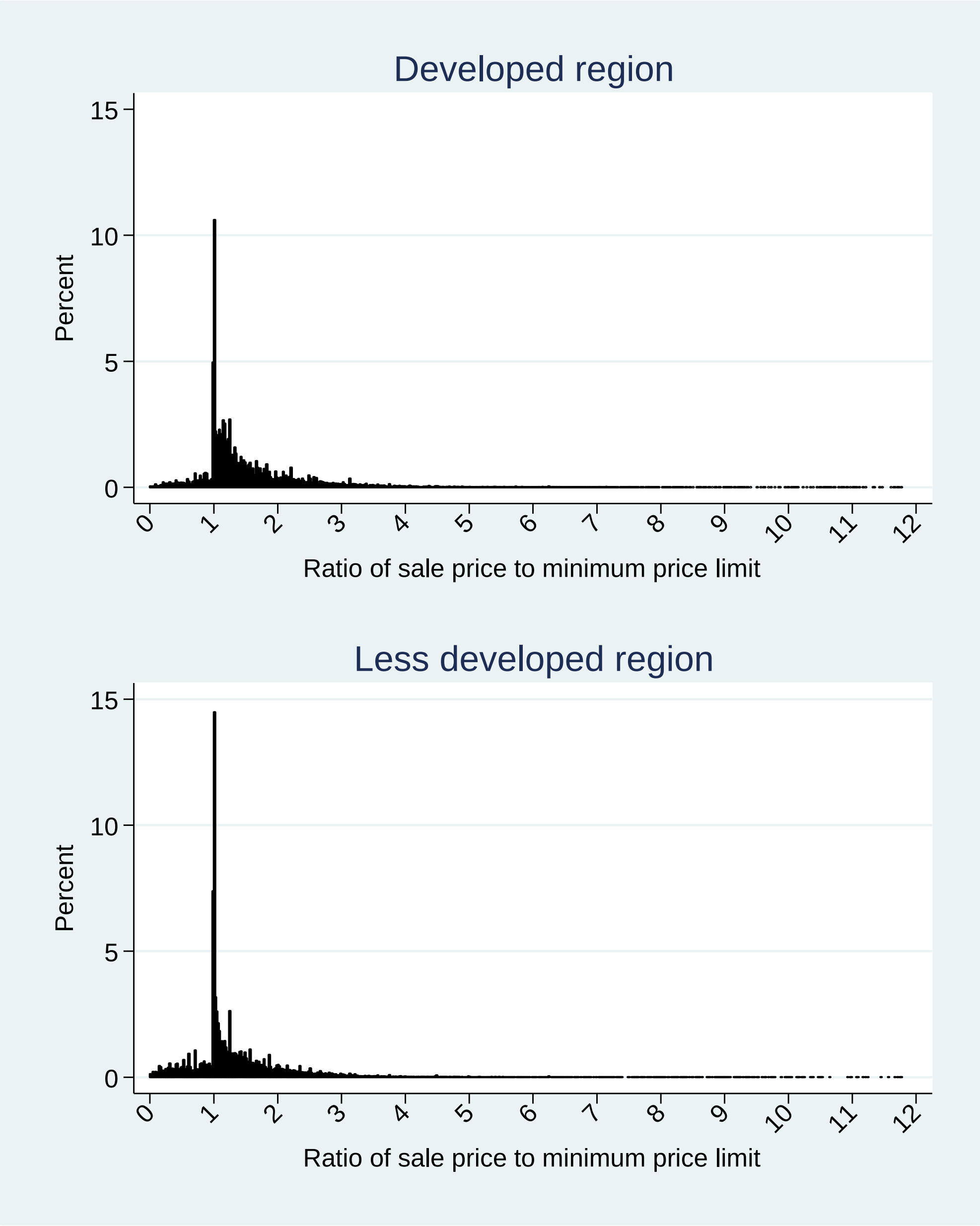
Figure 1: Yearly trends of auction fraction and land sale price



Note: Panel A plots the yearly trends of the fraction of land sales conducted through public auctions for the developed (represented by dots) and less developed regions (represented by diamonds). Panel B displays the yearly trends of average unit land sale prices for these two regions. The land transaction data were obtained from the official website of China's Ministry of National Land and Resources. The developed region consists of the provinces with per capita gross domestic product greater than 20,000 RMB in 2007, including Shanghai, Beijing, Tianjin, Zhejiang, Jiangsu, Guangdong, Fujian, Inner Mongolia, and Liaoning. The remaining mainland provinces are in the less developed region.

Figure 2: Distribution of the ratio of sales to minimum prices



Note: The figure plots the distributions of the ratio of sales to minimum prices in developed and less developed regions, using all land transactions conducted between July 2007 and December 2015. The bar width is set to be 0.02.

Table 1: Determinants of the regulatory minimum land price

	Land classification grade, ordered probit model	
	(1)	(2)
Log GDP in 2005	-0.5863***	-0.5224***
	(0.0355)	(0.0503)
Industrial sector GDP share in 2005	-2.3544***	-4.6399***
	(0.2211)	(0.3195)
Tertiary sector GDP share in 2005	-4.7423***	-6.0286***
	(0.2700)	(0.3750)
Log population in 2001	-0.0746*	-0.4540***
	(0.0432)	(0.0661)
Log developable land area	0.4891***	0.8907***
	(0.0241)	(0.0414)
Farmland productivity	-0.0191**	-0.0436**
	(0.0093)	(0.0204)
Prefecture fixed effects		Y
Observations	2,501	2,501
Pseudo-R-squared	0.2331	0.3869
Correlation coefficient: actual and predicted MLP	0.8384	0.8896

Note: Standard errors are in parentheses. GDP = gross domestic product; MLP = minimum price limit.

Table 2: Summary statistics

	(1) Full sample (July 2007-December 2015)	(2) Developed region	(3) Less developed region
Sales price (yuan per sq m)	220.123	266.085	167.885
	(161.281)	(179.519)	(117.548)
Minimum price (yuan per sq m)	158.766	181.394	133.047
	(84.954)	(88.075)	(73.213)
Dummy: sales/minimum prices > 1.02	0.674	0.744	0.594
	(0.469)	(0.436)	(0.491)
Dummy: sales/minimum prices < 0.995	0.144	0.102	0.191
	(0.351)	(0.303)	(0.393)
Dummy: auction sale	0.912	0.920	0.904
	(0.283)	(0.272)	(0.294)
Lot size (10,000 sq m)	3.714	3.201	4.298
	(9.767)	(8.980)	(10.561)
Distance to city center (km)	44.100	42.222	46.234
	(30.344)	(25.892)	(34.595)
Own-industry concentration index	0.0855	0.0796	0.0923
	(0.1199)	(0.1006)	(0.1384)
Cross-industry coagglomeration index	0.00022	0.00024	0.00020
	(0.00087)	(0.00087)	(0.00086)
Observations	196,740	104,657	92,083

Note: Standard deviations are in parentheses. The parcel-level land transaction data were collected from the official website of China's Ministry of National Land and Resources (www.landchina.com). The minimum price data are from the "Minimum Price Standards for Industrial Land Leasehold Sales" published by the Ministry of National Land and Resources in December 2006. The data for constructing the concentration index and coagglomeration index were drawn from the 2004 Economic Census conducted by China's National Bureau of Statistics, which covered all firms in mining, manufacturing, and utilities in China. The developed region consists of the provinces with per capita gross domestic product greater than 20,000 RMB in 2007. The other mainland provinces are in the less developed region.

Table 3: Land sale price determinants, full sample post July 2007

	(1)	(2)	(3)	(4)
	Log p_0		Log p_1	
Industry-county characteristics				
Concentration	0.159***	0.076***	0.129***	0.057*
	(0.009)	(0.008)	(0.035)	(0.034)
Coagglomeration	28.882***	6.301***	30.683***	2.048
	(1.092)	(0.907)	(4.531)	(4.306)
County characteristics				
Log GDP in 2005	0.095***	0.031***	0.119***	0.071***
	(0.002)	(0.002)	(0.007)	(0.009)
Industrial sector GDP share in 2005	0.694***	0.393***	1.324***	0.628***
	(0.012)	(0.014)	(0.043)	(0.059)
Tertiary sector GDP share in 2005	0.617***	0.428***	0.900***	0.784***
	(0.016)	(0.017)	(0.052)	(0.067)
Log population in 2001	0.056***	0.040***	0.151***	0.091***
	(0.002)	(0.003)	(0.009)	(0.012)
Log developable land area	-0.122***	-0.045***	-0.144***	-0.045***
	(0.002)	(0.002)	(0.005)	(0.008)
Farmland productivity	0.008***	0.001	0.015***	0.000
	(0.001)	(0.001)	(0.002)	(0.003)
Prefecture fixed effects		Y		Y
Land, industry, and other county characteristics	Y	Y	Y	Y
Observations	196,740	196,740	196,740	196,740
Pseudo R-squared	0.259	0.546	0.232	0.317

Note: Standard errors are in parentheses. In all the regressions, we additionally include the following four sets of controls: (1) a dummy indicating whether the land was sold through a negotiation sale, the log of the land's distance to the city center, the log of the lot size, land transaction year and month dummies, and land source dummies interacted with time trends; (2) two-digit industry dummies and their interactions with linear year trends; (3) regional dummies (i.e., Middle and West) interacted with linear year trends; and (4) a set of other county characteristics, such as a dummy indicating whether the county unit is an urban district, its elevation range, its annual precipitation (in log), and its annual average temperature. The regression sample includes the industrial land transactions conducted from July 2007 to December 2015.

Table 4: Career incentives and local governments' industry preferences

Log land sale price when MLP is not binding (log p0)			
	(1)	(2)	(3)
	Matched sample	Developed region	Less developed region
Industry-county characteristics			
Concentration	0.139***	0.147***	0.147***
	(0.019)	(0.026)	(0.027)
Concentration*Leader's years before retirement	-0.010***	-0.003	-0.018***
	(0.002)	(0.003)	(0.003)
Coagglomeration	6.133**	4.254	1.389
	(2.560)	(3.016)	(4.830)
Coagglomeration*Leader's years before retirement	-0.163	0.280	-0.329
	(0.297)	(0.359)	(0.519)
County characteristics			
Log GDP in 2005	0.026***	0.089***	0.007**
	(0.002)	(0.004)	(0.003)
Industrial sector GDP share in 2005	0.387***	0.660***	0.171***
	(0.016)	(0.026)	(0.022)
Tertiary sector GDP share in 2005	0.439***	0.759***	0.203***
	(0.019)	(0.030)	(0.027)
Log population in 2001	0.050***	-0.026***	0.110***
	(0.003)	(0.005)	(0.005)
Log developable land area	-0.041***	-0.049***	-0.066***
	(0.002)	(0.003)	(0.004)
Farmland productivity	-0.001	-0.000	-0.005***
	(0.001)	(0.001)	(0.001)
Prefecture fixed effects	Y	Y	Y
Land, industry, and other county characteristics	Y	Y	Y
Observations	137,940	77,487	60,453
Pseudo R-squared	0.538	0.641	0.412

Note: See Table 3 for notes. For estimation, we use the tobit regression model, the same as the one used in columns (1) and (2) in Table 3. GDP = gross domestic product; MLP = minimum price limit.

Table 5: Industry preferences of upper-level governments, price effects

	(1)	(2)	(3)	(4)	(5)	(6)
	Developed region			Less developed region		
	Log p_0	Log p_1	P-value (col.1-col.2)	Log p_0	Log p_1	P-value (col.4-col.5)
Industry-county characteristics						
Concentration	0.147***	-0.179***	0.000	0.033***	0.157***	0.002
	(0.011)	(0.062)		(0.011)	(0.042)	
Coagglomeration	3.886***	8.438	0.484	3.647**	-9.949	0.026
	(1.181)	(6.479)		(1.702)	(6.900)	
County characteristics						
Log GDP in 2005	0.096***	0.249***		0.008***	-0.002	
	(0.004)	(0.017)		(0.003)	(0.011)	
Industrial sector GDP share in 2005	0.706***	1.198***		0.190***	0.323***	
	(0.023)	(0.115)		(0.019)	(0.070)	
Tertiary sector GDP share in 2005	0.777***	1.068***		0.225***	0.521***	
	(0.026)	(0.128)		(0.023)	(0.081)	
Log population in 2001	-0.033***	-0.016		0.093***	0.155***	
	(0.004)	(0.019)		(0.004)	(0.016)	
Log developable land area	-0.054***	-0.184***		-0.060***	-0.012	
	(0.003)	(0.015)		(0.003)	(0.010)	
Farmland productivity	0.001	-0.006		-0.003***	0.005	
	(0.001)	(0.005)		(0.001)	(0.004)	
Prefecture fixed effects	Y	Y		Y	Y	
Land, industry, and other county characteristics	Y	Y		Y	Y	
Observations	104,657	104,657		92,083	92,083	
Pseudo R-squared	0.647	0.324		0.457	0.297	

Note: Provinces with per capita GDP greater than 20,000 RMB in 2007 are in the developed region. The remaining mainland provinces are in the less developed region. See Table 3 for notes.

Table 6: Industry preferences of upper-level governments, downward adjustments

	Downward price adjustment, probit model		
	(1)	(2)	(3)
	Full sample	Developed region	Less developed region
Industry-county characteristics			
Concentration	-0.063	0.405***	-0.251***
	(0.046)	(0.083)	(0.058)
Coagglomeration	-2.103	-18.573**	24.180**
	(5.787)	(8.387)	(9.915)
County characteristics			
Log GDP in 2005	-0.094***	-0.466***	0.057***
	(0.012)	(0.023)	(0.015)
Industrial sector GDP share in 2005	-0.949***	-1.588***	-0.455***
	(0.081)	(0.148)	(0.101)
Tertiary sector GDP share in 2005	-1.147***	-1.274***	-0.905***
	(0.093)	(0.166)	(0.117)
Log population in 2001	-0.095***	0.188***	-0.297***
	(0.016)	(0.025)	(0.022)
Log developable land area	0.107***	0.332***	0.069***
	(0.011)	(0.019)	(0.015)
Farmland productivity	-0.008*	-0.006	-0.010*
	(0.004)	(0.007)	(0.006)
log minimum land price	1.683***	2.177***	1.474***
	(0.024)	(0.044)	(0.031)
Prefecture fixed effects	Y	Y	Y
Land, industry, and other county characteristics	Y	Y	Y
Observations	195,919	104,227	91,692
Pseudo R-squared	0.422	0.415	0.423

Note: Standard errors are in parentheses. For the regressions, we use the probit model. See Table 3 for notes on additional controls. See Table 5 for the definitions of developed and less developed regions.

Table 7: Industry preferences of local governments, downward adjustments

	Downward price adjustment, probit model		
	(1)	(2)	(3)
	Matched sample	Developed region	Less developed region
Industry-county characteristics			
Concentration	-0.233**	0.405**	-0.616***
	(0.113)	(0.181)	(0.153)
Concentration*Leader's years before retirement	0.033***	0.007	0.052***
	(0.012)	(0.019)	(0.015)
Coagglomeration	12.672	-12.117	53.669**
	(15.806)	(21.230)	(26.104)
Coagglomeration*Leader's years before retirement	-1.919	-1.172	-3.437
	(1.820)	(2.512)	(2.821)
County characteristics			
Log GDP in 2005	-0.103***	-0.510***	0.045***
	(0.014)	(0.027)	(0.017)
Industrial sector GDP share in 2005	-1.070***	-1.643***	-0.485***
	(0.096)	(0.169)	(0.122)
Tertiary sector GDP share in 2005	-1.145***	-1.144***	-0.888***
	(0.110)	(0.191)	(0.140)
Log population in 2001	-0.128***	0.177***	-0.335***
	(0.019)	(0.029)	(0.026)
Log developable land area	0.150***	0.377***	0.133***
	(0.013)	(0.023)	(0.018)
Farmland productivity	-0.006	-0.007	0.001
	(0.005)	(0.007)	(0.007)
Log minimum land price	1.681***	2.180***	1.503***
	(0.029)	(0.052)	(0.037)
Prefecture fixed effects	Y	Y	Y
Land, industry, and other county characteristics	Y	Y	Y
Observations	137,382	77,109	60,252
Pseudo R-squared	0.381	0.408	0.360

Note: Standard errors are in parentheses. For the regressions, we use the probit model. See Table 3 for notes on additional controls. See Table 5 for the definitions of developed and less developed regions.

Table 8: Local priority industries

Dummy: being a local priority industry			
	(1)	(2)	(3)
	Full sample	Developed region	Less developed region
Dummy: Incumbent industry*Concentration	0.185***	0.252***	0.153***
	(0.039)	(0.084)	(0.036)
Coagglomeration	7.283**	-4.063	16.552***
	(3.329)	(4.276)	(4.483)
Dummy: Incumbent industry	0.007	-0.006	-0.001
	(0.005)	(0.012)	(0.005)
County fixed effects	Y	Y	Y
Industry fixed effects	Y	Y	Y
Observations	70,350	19,800	50,550
R-squared	0.558	0.618	0.560

Note: Robust standard errors in parentheses are clustered at the prefecture level. We use the linear probability model. See Table 5 for the definitions of developed and less developed regions.

Appendix A: Supplementary Figures and Tables

Figure A1: Minimum land price, by classification grade

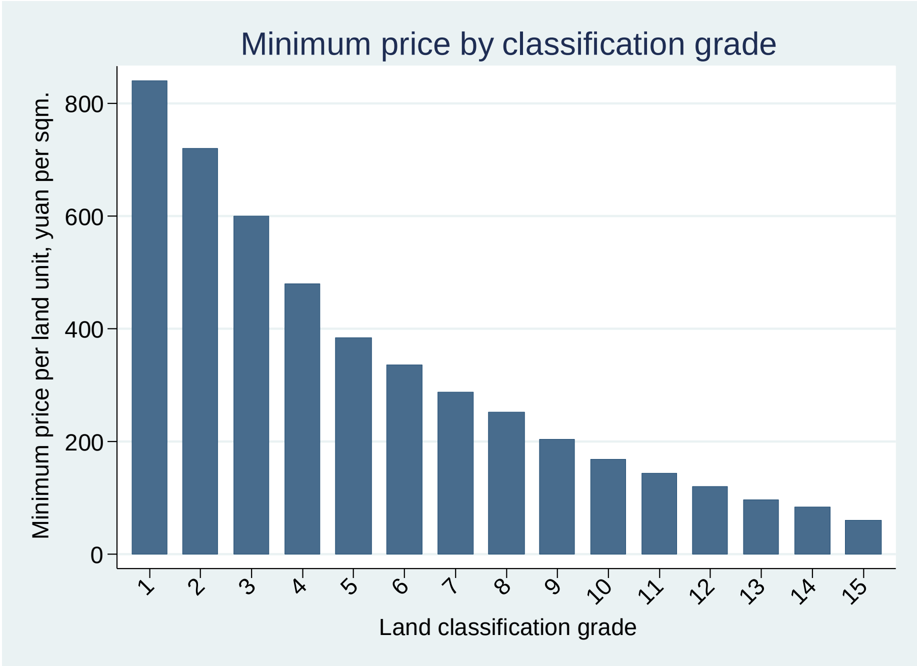
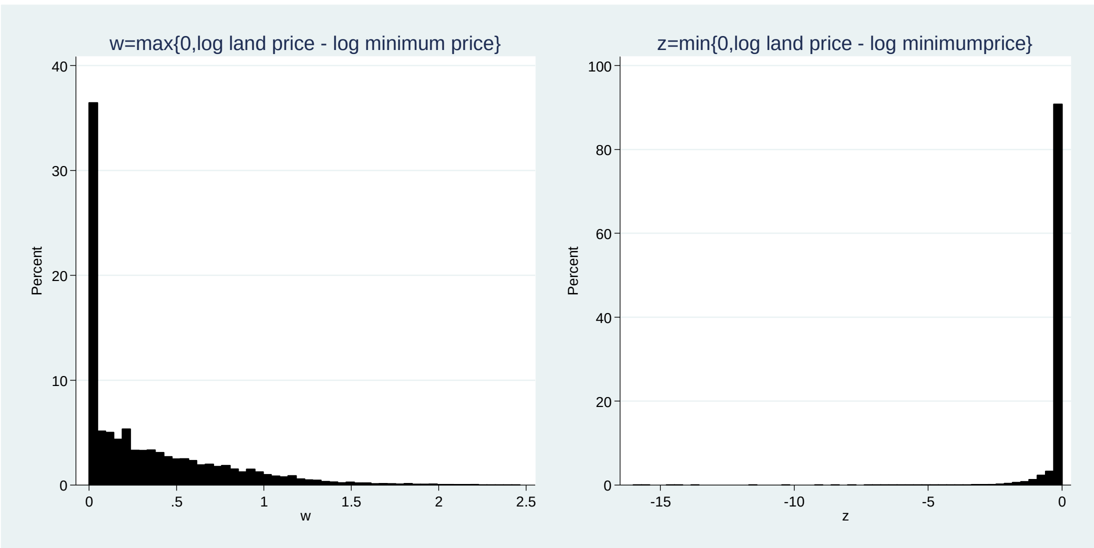


Figure A2: Distributions of the constructed variables for estimation



Note: For each land i in our sample, we define two variables: $w_i \equiv max\{0, log\, p_i - log\, MLP_k\}$ and $z_i \equiv min\{0, log\, p_i - log\, MLP_k\}$. The graphs present the density distributions of these two constructed variables, which are left-censored (left panel) and right-censored (right panel), respectively.

Table A1: Land sale area, by land use type

	Annual land transfer area (hectares)					
	Commercial		Industrial		Residential	
Year	Yearbooks of Land & Resources	Land transaction data	Yearbooks of Land & Resources	Land transaction data	Yearbooks of Land & Resources	Land transaction data
2004	33,798	7,608	89,788	37,235	48,677	25,149
2005	23,268	4,914	90,512	31,404	43,675	18,503
2006	25,394	7,478	144,452	77,771	55,016	23,731
2007	26,975	23,721	135,629	138,810	66,575	86,055
2008	21,802	23,459	86,414	107,763	51,507	76,400
2009	27,571	23,262	141,486	126,724	81,548	96,037
2010	38,905	37,633	153,978	166,651	115,273	142,663
2011	42,630	40,507	191,314	213,164	126,453	153,136
2012	NA	47,315	NA	212,429	NA	132,890
2013	NA	64,336	NA	211,995	NA	158,916
2014	NA	47,263	NA	152,759	NA	117,415
2015	NA	28,505	NA	105,302	NA	73,755

Note: The unit is hectares. The data sources are the 2004 to 2012 editions of the *Yearbooks of Land and Resources* and land transaction data collected from the official website of China's Ministry of National Land and Resources (www.landchina.com). In constructing the total land area transacted in each year for each land use type from the land transaction data, we exclude land parcels having a lot size that is in the top 0.01% of the distribution.

Table A2: List of two-digit industries and average industry land sale price

Two-digit industry	Industry	Sale price (yuan per sqm)
16	Tobacco processing	299
40	Electronic & telecommunications	283
39	Electric equipment & machinery	257
41	Instruments, meters, cultural, & official machinery	254
37	Transportation equipment manufacturing	251
7	Extraction of petroleum and natural gas	245
35	Machinery & equipment manufacturing	236
36	Special equipment manufacturing	230
23	Printing & recording press	229
28	Chemical fibers	227
24	Stationery, educational, & sports goods	219
27	Medical & pharmaceutical products	215
43	Recycling and disposal of waste	210
29	Rubber products	208
18	Garments & other fiber products	202
17	Textile industry	200
34	Metal products	195
42	Other manufacturing	195
30	Plastic products	194
19	Leather, furs, down, & related products	194
21	Furniture manufacturing	191
22	Papermaking & paper products	188
32	Smelting & pressing of ferrous metals	184
14	Food production	183
15	Beverage production	177
33	Smelting & pressing of nonferrous metals	176
26	Raw chemical materials & chemical products	170
45	Production and distribution of gas	167
25	Petroleum processing, coking products, & gas production & supply	159
46	Production and distribution of water	153
13	Food processing	153
20	Timber processing, bamboo, cane, palm fiber, & straw products	150
31	Nonmetal mineral products	144
44	Production and distribution of electric power and heat power	137
11	Mining of other ores	119
10	Mining and processing of nonmetal ores	116
8	Mining and processing of ferrous metal ores	113
6	Mining and washing of coal	95
9	Mining and processing of non-ferrous metal ores	82

Table A3: Industry-pairwise colocation likelihood, top 20 industry pairs

Industry j	Industry j’	Gamma
Stationery, educational, & sports goods	Electronic & telecommunications	0.0219817
Furniture manufacturing	Stationery, educational, & sports goods	0.0143726
Instruments, meters, cultural, & official machinery	Stationery, educational, & sports goods	0.0134864
Instruments, meters, cultural, & official machinery	Electronic & telecommunications	0.0134716
Leather, furs, down, & related products	Stationery, educational, & sports goods	0.0133422
Mining of other ores	Extraction of petroleum and natural gas	0.0130491
Plastic products	Stationery, educational, & sports goods	0.0129724
Electric equipment & machinery	Stationery, educational, & sports goods	0.012722
Electric equipment & machinery	Electronic & telecommunications	0.0115519
Furniture manufacturing	Electronic & telecommunications	0.0110412
Electronic & telecommunications	Plastic products	0.0109288
Electronic & telecommunications	Leather, furs, down, & related products	0.0074795
Electric equipment & machinery	Furniture manufacturing	0.0071685
Instruments, meters, cultural, & official machinery	Electric equipment & machinery	0.0066391
Plastic products	Furniture manufacturing	0.0065068
Furniture manufacturing	Instruments, meters, cultural, & official machinery	0.0064619
Instruments, meters, cultural, & official machinery	Plastic products	0.0063846
Electric equipment & machinery	Plastic products	0.0062483
Furniture manufacturing	Leather, furs, down, & related products	0.0061149
Instruments, meters, cultural, & official machinery	Leather, furs, down, & related products	0.0057867

Note: The value of gamma for each industry pair is calculated based on formula (6).

Table A4: Price regression results: Robustness checks

	(1)	(2)	(3)	(4)
	Log p_0	Log p_1	Log p_0	Log p_1
Industry-county characteristics				
Concentration	0.076***	0.034	0.081***	0.089**
	(0.008)	(0.033)	(0.008)	(0.038)
Coagglomeration	5.873***	4.125	6.198***	5.794
	(0.935)	(4.115)	(0.957)	(4.619)
County characteristics				
Log GDP in 2005	0.032***	0.069***	0.024***	0.053***
	(0.002)	(0.009)	(0.002)	(0.010)
Industrial sector GDP share in 2005	0.392***	0.557***	0.460***	0.802***
	(0.014)	(0.057)	(0.015)	(0.067)
Tertiary sector GDP share in 2005	0.446***	0.790***	0.479***	0.961***
	(0.017)	(0.066)	(0.018)	(0.075)
Log population in 2001	0.039***	0.080***	0.039***	0.087***
	(0.003)	(0.012)	(0.003)	(0.013)
Log developable land area	-0.045***	-0.046***	-0.034***	-0.020**
	(0.002)	(0.008)	(0.002)	(0.009)
Farmland productivity	-0.001	-0.002	-0.001	-0.004
	(0.001)	(0.003)	(0.001)	(0.004)
Log average sale price of adjacent residential land			0.050***	0.099***
			(0.001)	(0.005)
Exclude land sales during Nov.2008-Oct. 2009	Y	Y		
Prefecture fixed effects	Y	Y	Y	Y
Land, industry, and other county characteristics	Y	Y	Y	Y
Observations	190,012	190,012	165,674	165,674
Pseudo R-squared	0.550	0.333	0.565	0.317

Note: See Table 3 for notes.

Appendix B: Optimization problem under the case where the MLP constraint is not binding and the land quota constraint is binding

In this case, the demand for industrial land is high enough such that the quota constraint is binding. For illustrative simplicity, suppose the minimum land price constraint is not binding for any industry in this case. Then the objective function of the local government becomes

$$\underset{p_1,\ldots,p_J}{Max} \sum_{j=1}^{J} n_j \times p_j + n_j \times \theta \times e_j - n_j \times c$$

$$s.t. \sum_{j=1}^{J} n_j = L$$

$$n_j = \alpha m_j - \beta p_j, j = 1, \ldots, J \tag{B.1}$$

Solving the above function, we have the optimal price and quantity for any industry *j* as follows:

$$p_j^* = \frac{J-2}{2\beta J}\alpha m(t,t_j) - \frac{J-1}{2J}\theta e_j + \frac{\sum_{r\neq j}^{J}\frac{1}{\beta}\alpha m(t,t_r) + \sum_{r\neq j}^{J}\theta e_r}{2J} - \frac{L}{\beta J}, \tag{B.2}$$

$$n_j^* = \frac{J-1}{2J}\alpha m(t,t_j) - \frac{J-1}{2J}\beta\theta e_j - \frac{\sum_{r\neq j}^{J}\alpha m(t,t_r) + \sum_{r\neq j}^{J}\beta\theta e_r}{2J} + \frac{L}{J}. \tag{B.3}$$

Clearly, like what presented in section 3, here the price increases with the local comparative advantage of the industry (t_j) as well as the local general economic conditions (t), and it decreases with the spillover effects (e_j) generated by the industry. The supply cost c does not matter here because the total amount of land supplied is fixed.

Appendix C: Data appendix

Assigning MLP to land observations

The minimum land price (MLP) is assigned to each county. We use two methods to extract information on each land parcel's county information. In the first method, we directly use the administrative code of the land transaction data.[27] We can identify the county information for 349,627 land parcels using this method (about 80% of the industrial land sample). The second method is to project the coordinates of each land parcel onto a GIS map of county-level boundaries in 2015. We can identify the county information for 408,352 land parcels using this method (about 93% of the industrial land sample). We rely on the second method for county information since it gives a larger sample for analysis.[28] The rules for assigning *MLP* to the counties that experienced administrative boundary changes from 2007 through 2015 are as follows:

Upgrades. Some counties or county cities were upgraded to urban districts during the period from 2007 through 2015 and were given new names. The minimum prices of the current urban districts follow those of their predecessors.

Merges. For the cases where the pre-merge county-level units shared the same minimum prices, the minimum prices for land observations located in the new county unit follow those that existed before the merge. For the cases where the pre-merge county-level units had different minimum prices, we assign the minimum prices to each land parcel based on the county information recorded in the land transaction data as long as it is available. We exclude land observations for which we are not able to identify the respective counties using the administrative information.

Splits. The minimum prices for land observations located in the post-split

[27] In particular, for each land transaction, the data contain a monitoring number. The first six digits of this number correspond to the administrative code of the county unit where the land is located. For land parcels missing this information, we use county names as a supplement as long as they are recorded in the land transaction data. (A lot of transactions are missing them.)

[28] Among the 349,616 land observations for which we can identify the respective county information using both methods, the county information provided by the two methods did not match for 11,819 parcels. We exclude these observations because their geographic coordinates are not reliable for calculating the location characteristics (such as the distance to the city center).

county-level units follow the minimum price of the pre-split county unit. Because we cannot separately measure the initial characteristics for each county unit after the split, we consolidate these counties for the regression analysis.

Regression sample restrictions

We drop 28,789 land observations for which we cannot identify coordinates from their addresses. We drop an additional 268 land observations for which we cannot locate their county information based on their coordinates. We exclude an additional 11,819 land observations for which the county information obtained from the administrative information recorded in the land transaction data and that obtained from the GIS method do not agree. We drop another 7,928 observations associated with land parcels that were sold before 2004. We drop an additional 328 land observations that are located in the county units for which minimum land prices were not specified in the 2007 official document. Among the land observations located in the counties that underwent merges whereby the county units had different minimum prices before the merge, we exclude 1,336 observations for which we cannot identify county locations using the administrative information.

We further make the following sample restrictions. We drop another 470 land observations that are missing land transfer type information. We drop an additional 1,921 land observations that were rented. We drop an additional 14,321 land observations that were allocated by the governments for free. We drop an additional 263 land observations that are missing the land sale price. We drop another land observation that has a negative sale price. We drop another 24 land observations having a lot size of zero. We drop another 12 outliers of lot size (greater than 2,050 hectares or 20.5 square kilometers). We drop another 370 land observations with per land unit sale prices greater than 3,274 yuan per square meter (top 0.1% in the distribution). We drop another 374 observations having ratios of per land unit sale price to minimum price greater than 11.8 (top 0.1% in the distribution).

The land transaction data contain a name (in Chinese) of the industry type to which the buyer belongs. About 90,000 land observations are missing this information. For about 40,000 of them, we are able to identify the names of the buyers. We then try to locate their industry-type information through tianyancha.com, a data vendor of registered firms in China, based on the buyers' names. We are able to identify the industry-type information (a two-digit code) for about 32,000 land observations. We thus exclude about 60,000 land observations for which we are unable to identify industry types. We further exclude about 4,000 land observations for which we cannot infer the two-digit industry codes from the industry names. In addition, we restrict our sample to the land observations whose buyers are under three one-digit industrial categories: (1) mining, (2) manufacturing, and (3) production and distribution of electricity, gas, and water.

When merging the industry-county characteristics with the industrial land sample, we encounter the following two data issues. First, because the National Bureau of Statistics adjusted the industry coding standards in 2011 from the 2002 standards to the 2011 standards, we manually match the industry names and codes reported in the industrial land data to the names and codes of the old standard used in the 2004 Economic Census (i.e., the 2002 standards). Second, the two-digit industry codes for about 13,000 industrial land observations did not appear in the corresponding counties when the 2004 Economic Census was conducted. We exclude them from our regression sample.