

Land (Mis)allocation and Local Public Finance in China*

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Abstract

Residential land in China sells for about ten times the price of industrial land, a gap often read as evidence of severe misallocation. We show that this gap largely reflects tax capitalization: industrial land generates long-run tax payments, whereas residential land does not, so efficiency must be judged by tax-inclusive prices. Accounting for taxes, land misallocation is modest overall, with industrial oversupply in developed cities and undersupply elsewhere. Local fiscal incentives shape the allocation: cities supply less industrial land when their governments retain a smaller share of industrial taxes or face higher borrowing costs.

Keywords: Land Misallocation, Local Public Finance, Implied Discount Rate, Tax Capitalization, Municipal Corporate Bonds

JEL classifications: H70, G31, R14, R38

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1 Introduction

Government policies that allocate resources across uses, such as land zoning, have fiscal consequences: different uses generate different tax streams, so governments have a financial stake in the allocation. This stake cuts both ways. It complicates the measurement of allocative efficiency, because future taxes are capitalized into the prices at which resources trade, and it shapes government incentives, because an allocation's value to the government depends on how and when its fiscal returns arrive.

Allocating land between production and housing is a first-order policy decision in developing economies ([Dasgupta et al., 2014](#); [Duranton and Venables, 2018](#)), and one with an especially large fiscal stake, because the two uses generate very different tax streams over different horizons. China's urban land market makes this stake unusually visible: local governments sell land-use rights for residential and industrial uses, which differ sharply in both upfront prices and future taxes. During 2007–2019, residential land sold for roughly ten times the price of comparable industrial land, a gap often read as evidence of substantial misallocation and industrial subsidy.¹

This interpretation overlooks the two-sided role of future taxes. On the demand side, future taxes are buyer liabilities: holding productive value fixed, they lower buyers' willingness to pay today. The upfront price alone therefore does not reveal land's marginal value; the relevant measure is the tax-inclusive valuation, the land price plus the present value of the marginal future taxes per unit of land. Industrial land carries a long-lived stream of production-related taxes, whereas residential land generates mainly one-time development taxes and, absent a recurring property tax in China, little ongoing liability. The upfront price wedge may thus partly reflect tax capitalization rather than misallocation. On the supply side, land sales deliver both immediate proceeds and future

¹The wedge underlies the view that residential land sales are a source of current fiscal revenue, whereas industrial land is sold at subsidized prices to pursue local policy objectives. As [Liu and Xiong \(2020, 193\)](#) notes, "it is a common practice for local governments throughout China to offer industrial land at subsidized prices to support local industries." See also [Liu \(2019\)](#).

tax receipts, and how much the local government values the latter depends on tax-sharing arrangements and its borrowing costs. These fiscal incentives may lead governments to depart from the efficient allocation. We therefore proceed in two steps, first using demand-side tax-inclusive valuations to assess allocative efficiency and then examining the supply-side fiscal incentives that distort it.

To assess efficiency, we add the present value of each use's future tax payments to its upfront land price. In our model of local land allocation, industrial land yields a perpetual stream of output taxes and residential land a one-time tax at sale; with competitive land demand, these tax-inclusive valuations measure the marginal value of land, and allocation is efficient when they are equalized across uses. This condition is a sufficient statistic for allocative efficiency: it rests only on demand-side valuations, holds however the government sets the allocation, and is directly testable through the implied discount rate (IDR), the rate at which future taxes must be discounted for the condition to hold. Comparing IDR with firms' cost of capital reveals whether the condition holds and, if not, which land use is oversupplied. Empirically, accounting for future taxes substantially reduces the apparent misallocation: observed industrial land shares differ from their efficient levels by 2.6 percentage points on average in absolute value, rising to 5.2 percentage points under the most conservative specification.

On the supply side, we show that a benevolent local government with a flexible tax instrument allocates land efficiently: because it can raise the revenue needed for the optimal level of public goods, land's marginal fiscal contribution has zero shadow value. Fiscal considerations distort land allocation only when the government lacks such an instrument—or, more broadly, faces a binding budget constraint—so that land sales take on a “financing” role and the government equalizes across uses each parcel's social value plus the shadow value of its fiscal contribution. Two features of China's fiscal system then shape the allocation: intergovernmental tax sharing lowers the share of industrial taxes the local government retains, and limited credit access raises local borrowing costs.

Both lower the value of future industrial taxes relative to upfront residential proceeds, and so shift land toward residential use and narrow the residential–industrial price wedge. Consistent with these predictions, local governments that retain smaller shares of industrial taxes or face higher borrowing costs sell more residential and less industrial land and have a smaller price wedge. More broadly, shocks to local public finances can have persistent effects on land allocation and industrial structure.

To assess efficiency empirically, we compute IDR from three inputs: the quality-adjusted price premium of residential over industrial land (the “industrial discount”); the increase in tax payments by firms that purchase industrial land; and the one-time taxes generated by residential development. We draw on three datasets: the universe of land parcels sold by local governments during 2007–19, with each parcel’s price, zoning, buyer, location, and size; a census of large industrial firms during 1998–2013; and annual reports of listed home developers during 2007–21. Matching land buyers to industrial firms lets us trace their tax payments for at least three years after 2007–10 purchases, so our primary IDR estimates use land sales from this period.

We estimate the industrial discount in a potential-outcomes framework: hedonic models fit to observed residential (industrial) sales predict what each industrial (residential) parcel would have fetched under the other zoning, and the discount is the difference between the residential and industrial price, actual or predicted. Averaged within city-years and weighted by parcel size, the industrial discount during 2007–10 is 1714.9 RMB/m², or 87% of the average residential land price.

To estimate industrial taxes, we combine propensity-score matching with a difference-in-differences design to identify the effect of land purchases on firms’ sales, then apply an effective tax rate that includes taxes paid by upstream suppliers. For 2007–10 purchases, the marginal tax is 71.4 RMB/m² per year in the first three years and 183.5 RMB/m² thereafter. To extend these estimates over the long run, we assume they scale with economy-wide land productivity, proxied with average long-run forecasts of real GDP

growth adjusted by inflation and urban land expansion. For city-level estimates, we let the sales effect vary with the city's industrial discount and residential tax. Residential taxes—from developers, home buyers, and upstream suppliers—are estimated at the city-year level and average about 2206 RMB/m² during 2007–10.

The resulting national IDR for 2007–10 is 7.4%. The natural benchmark is the cost of capital of industrial firms ([Berk and DeMarzo, 2017](#)),² which averages 8.0% for listed industrial firms over the same period. The national IDR falls slightly below this benchmark, indicating modest misallocation under the national aggregation. This conclusion survives adjustments for government subsidies, tax rebates, and alternative cash-flow timing; under the most conservative specification, IDR is 5.6%.

The national figure masks substantial heterogeneity across cities. City-level IDR is negatively correlated with GDP per capita: 70 of 204 cities have IDR below 8.0%, indicating industrial oversupply, and 134 have IDR above it. Efficiency would thus improve by shifting land toward residential use in developed cities—which see population inflows and high house prices—and toward industrial use in less developed ones, where housing demand is weaker. The misallocation is nonetheless modest: the average absolute gap between city-level IDR and the cost of capital is about 1.6 percentage points. Translated into quantities using estimated semi-elasticities of tax-inclusive land values with respect to the industrial land share, these gaps imply that observed industrial land shares deviate from their efficient levels by 2.6 percentage points on average in absolute value, rising to 5.2 under the most conservative specification.

Over time, IDR declines and its gap below the cost of capital widens from 2007 to 2019. Together with the sharp rise in house prices over this period, this suggests that reallocating land from industrial to residential use would raise welfare.

We then test the model's supply-side predictions, using as the outcome the indus-

²Following the Modigliani–Miller theorem ([Modigliani and Miller, 1958](#)), the discount rate should reflect the risk of the underlying cash flows. Because firms' tax payments are about as risky as their free cash flows, the cost of capital is a natural discount rate for future taxes.

trial discount, which is strongly correlated with city-level IDR and, unlike IDR, can be measured annually for each city. We find support for both. First, we exploit the 2016 tax reform, which raised the local share of VAT from 25% to 50% and, because provinces split the increment with their cities unevenly, generated cross-city variation in the retained share of industrial taxes. In an event-study design, cities that gained a larger VAT share saw their industrial discounts rise from 2016 onward, with no differential pretrends; residential land prices rose, industrial prices fell, and land supply shifted toward industrial use over the following two years. Second, cities with higher municipal corporate bond yields, our measure of local borrowing costs, have smaller industrial discounts. To address endogeneity, we instrument yields with a political-economy shifter based on [Chen et al. \(2020\)](#): cities whose provincial governors were late in their terms in 2009 invested more heavily during the four-trillion-RMB stimulus, strengthening their later fiscal positions and lowering their bond yields in 2012–19. The instrumented effect remains negative and significant, even controlling for ex ante and ex post fiscal and economic conditions. In quantities, a one-percentage-point increase in bond yields shifts annual land supply toward residential use by about 0.5 square meters per capita.

Together, these results indicate that local governments value the future tax revenues from industrial land and weigh them against upfront proceeds from residential sales when zoning land. They also imply that shocks to local public finance—whether through tax-sharing rules or credit conditions—propagate into land markets and, because land allocation shapes the relative size of manufacturing and real estate, can have persistent effects on local industrial structure. For the central government, tax-sharing arrangements therefore offer a lever to counteract other distortions in local land supply.

Literature review. Our paper is related to the factor misallocation literature. Building on seminal work by [Restuccia and Rogerson \(2008\)](#) and [Hsieh and Klenow \(2009\)](#), this literature measures misallocation by the cross-sectional dispersion of marginal products and quantifies the resulting welfare losses with structural methods. We differ in two ways.

First, these papers estimate marginal products from specific production functions and compare them across firms, a method with well-known limitations such as measurement error and adjustment costs ([Asker et al., 2014](#); [Bils et al., 2021](#)); we instead proxy marginal output by firms' marginal payments for land and compare sectors (residential and industrial), abstracting from within-sector variation across firms because our interest is cross-sector allocation.

Second, rather than quantifying welfare losses, we address a conceptual issue in assessing misallocation when sectors face different tax treatment. We show that ignoring differences in firms' tax payments can mislead assessments of land misallocation in China, an issue overlooked by the large urban and public finance literature on China, most of which holds that local governments subsidize industrial land for nonpecuniary reasons. For example, [Tao et al. \(2010\)](#) propose that local governments use subsidized industrial land to compete for investment. [Huang and Du \(2017\)](#) and [Liu and Xiong \(2020\)](#) view the price gap between residential and industrial land as evidence of misallocation and discuss the government incentives behind it. [Zhou et al. \(2022\)](#) study its effects on carbon emissions, and [Xie et al. \(2022\)](#) on green total factor productivity.

Our paper also relates to work on how fiscal incentives attached to different land uses shape land regulation ([Altshuler and Gomez-Ibanez, 2000](#); [Blöchliger et al., 2017](#)). [Quigley and Raphael \(2005\)](#) contend that California's tax policies favor retail development over housing, because property taxes are constitutionally capped while cities receive a share of local sales taxes. [Burnes et al. \(2014\)](#) find that Florida jurisdictions with higher sales tax rates use fiscal zoning to attract large shopping malls rather than manufacturing firms. [Cheshire and Hilber \(2008\)](#) show that shifting UK commercial property taxes from local authorities to the central government discouraged commercial development and raised office prices. The mechanism is general—a government that captures use-specific revenues steers land toward those uses, driving a wedge between the value of land in the permitted and excluded uses—but measuring that wedge requires comparable prices for

land under each use, which zoning regimes rarely generate: the existing literature instead measures the cost of regulatory stringency on development as a whole.³ In our setting the government sells use rights to vacant land under each designation, through the same mechanisms in the same city and years, so a hedonic comparison across designations prices the same object under alternative uses and the across-use wedge can be traced to specific fiscal incentives.

More broadly, our paper relates to work on how local governments' fiscal conditions and borrowing capacity affect their spending, other revenue sources, local policies, and real outcomes.⁴ Our findings on how intergovernmental tax sharing and government borrowing costs affect land zoning add land allocation to the set of margins on which local governments respond to fiscal pressure.

This paper contributes to finance by developing an implied-discount-rate test for the pricing of land as a real asset. The test applies a standard valuation idea—backing out the discount rate that equates an asset's price to the present value of its cash flows—to a relative pricing problem. The implied cost of capital literature reverse-engineers discount rates from equity prices and forecasted earnings (Claus and Thomas, 2001; Pástor et al., 2008); Giglio et al. (2015) apply the same logic to real estate, inferring long-run discount rates from hedonic price differences between leaseholds and freeholds. Our IDR likewise compares two claims on the same underlying asset: the quality-adjusted price wedge between residential and industrial zoning must equal the present value of the difference in tax streams the two uses generate, and whether the rate at which this holds matches firms'

³Glaeser and Gyourko (2003) compare the hedonic value of lot size on existing homes with the land value implied by house prices net of construction costs; Gyourko and Krimmel (2021) replace the latter with vacant-lot transaction prices; Turner et al. (2014) compare vacant-lot prices across municipal borders with different regulatory stringency. These methods recover a total regulatory wedge on development rather than a wedge across uses.

⁴Zhuravskaya (2000) shows that tax sharing between regional and local governments in Russia discourages local governments from expanding the tax base or providing public goods. Yi (2021), Posenau (2021), and Agrawal and Kim (2021) show that credit-constrained municipalities cut spending, especially on public facilities, lowering public service quality. Giesecke and Mateen (2022) show that local governments respond to fiscal shocks from falling property values by raising property tax rates. Adelino et al. (2017) show that local governments' financing costs affect public and private employment and income.

cost of capital is a sufficient statistic for allocative efficiency. That taxes are capitalized into asset prices is well established for property taxes (Palmon and Smith, 1998; Coven et al., 2026) and equity valuations (McGrattan and Prescott, 2005; Sialm, 2009); we show that ignoring it leads to a misdiagnosis of land misallocation.

The remainder of the paper is organized as follows. Section 2 describes the institutional background and data, Section 3 lays out the conceptual framework, Section 4 estimates IDR and land misallocation, Section 5 examines supply-side fiscal incentives, and Section 6 concludes.

2 Institutional Details and Data

2.1 Land Allocation in China

In China, local governments intermediate most land transactions: they repossess “under-utilized” land, compensate the occupants, and resell land-use rights to private buyers.⁵ Both the sale proceeds and the taxes generated by the land’s subsequent use are major sources of local government revenue.

The central government largely sets the total quantity of land supplied, while local governments have substantial discretion over zoning. Each parcel is designated for one of four uses—residential, industrial, commercial, or public utility. We focus on residential and industrial land, which accounted for 86% of land supplied during 2007–19.

Zoning is governed by a hierarchy of plans under the [Land Administration Law](#) and the [Urban and Rural Planning Law](#).⁶ Upper-level (central and provincial) governments set planning guidelines, such as caps on city size; lower-level (city, county, and town)

⁵China’s system separates ownership from use rights: urban land is state-owned, while private actors acquire transferable land-use rights with maximum terms of 70 years for residential use and 50 years for industrial use. Throughout the paper, “land price” refers to the transaction price of a land-use right, not the sale of land ownership.

⁶During our sample period, these laws were implemented through “Land Use Overall Plans” at all levels of government, which regulate city scale, and “Urban Overall Plans” at the city level and below, which specify zoning.

governments specify zoning down to the parcel level. Although lower-level plans require upper-level approval, the choice between uses rests largely with local governments. This non-market allocation raises concerns about efficiency.

Land parcels are transferred through five methods. Three involve competitive bidding: (1) *paimai* (拍卖), a standard English auction in which bidders openly raise bids until only one bidder remains; (2) *guapai* (挂牌), a two-stage auction in which bidders submit ascending bids—displayed publicly but anonymously—during the listing period, and if multiple bidders remain, the sale converts to an on-site ascending auction; and (3) *zhaobiao* (招标), sealed bids judged on price and non-price criteria (e.g., design, quality). The other two are non-market transfers: negotiated agreements, and administrative allotments, which involve no payment and are used for infrastructure, government offices, and military facilities.

These institutional features make China a useful setting for studying how local fiscal incentives shape land allocation and for measuring allocative efficiency. First, our data contain nearly one million auction-based land-parcel transfers during 2007–2019, including residential, industrial, and commercial land, providing a large sample for precise hedonic comparisons across uses within cities and years.⁷ Second, local governments sell both residential and industrial land-use rights through the same auction mechanisms, so comparing parcels offered by the same seller in the same city and year, conditional on transaction method and parcel characteristics, gives a firm basis for counterfactual prices under the other use. Third, the absence of a broad-based recurring residential property tax makes the contrast between upfront residential land payments and long-lived industrial tax payments especially pronounced. The distinction between upfront prices and tax-inclusive land values is therefore particularly consequential here.

⁷For comparison, U.S. studies using CoStar COMPS data analyze approximately 69,000 land sales across 324 metropolitan areas during 2005–2010 (Albouy et al., 2018) and 180,000 land sales across 23 metropolitan areas from the mid-1990s through the first half of 2011 (Nichols et al., 2013).

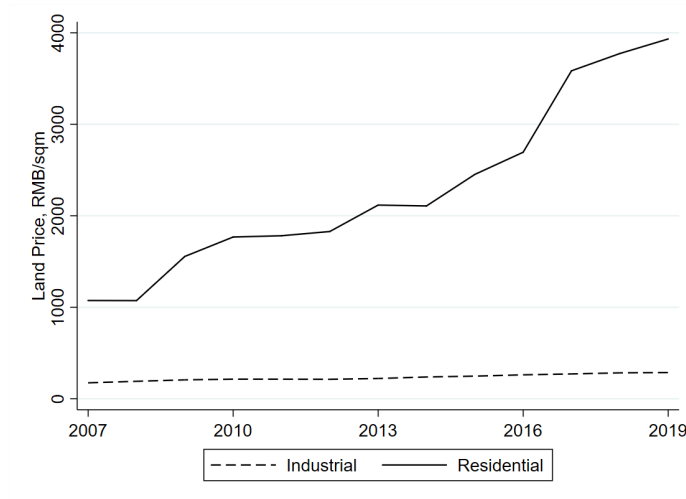


Figure 1: Average Land Prices over Time by Land Use: Industrial vs. Residential

Note: This figure reports the average price (per square meter) of residential and industrial land weighted by land size that are sold through English or two-stage auctions during 2007–19.

2.2 Data

Table 1 reports summary statistics of our data.

Land sales. Data from the Ministry of Natural Resources cover the universe of land sales by local governments during 2007–19, recording each parcel’s location, size, transaction date, price, and designated use. We geocode parcels using the Gaode Maps API. When analyzing prices, we restrict the sample to English and two-stage auctions, whose prices best reflect market values. Figure 1 shows that residential land prices far exceed industrial prices, and the gap widens over time.

Industrial firms. The Annual Survey of Industrial Firms (ASIF), administered by the National Bureau of Statistics, covers all manufacturing, mining, and utility firms in China during 1998–2013 and reports each firm’s name, industry, sales, profits, and tax payments. Despite some data quality concerns (Nie et al., 2012), the data are widely used.⁸

We match firms to industrial land purchases by name, including purchases made

⁸Prior work uses the data through 2005 (Hsieh and Klenow, 2009), 2007 (Liu and Lu, 2015; Bai et al., 2019), and 2013 (Heinrich et al., 2020; Cen et al., 2021; Tang et al., 2021). We drop 2010, for which all operating information except sales and employment is missing. Online Appendix B.6 analyzes censoring and attrition.

Table 1: Data Summary

	Obs	Mean	Std Dev	P10	P50	P90
A. Land characteristics						
Residential-use parcels						
Transaction land price, RMB/m ²	295,077	2,121.47	2,585.74	270.00	1,200.17	5,118.73
Parcel area, 1,000 m ²	295,077	29.59	45.03	0.19	15.41	69.28
Distance to urban-unit center, km	295,077	9.19	11.47	0.90	5.02	22.05
Industrial-use parcels						
Transaction land price, RMB/m ²	379,094	252.15	261.92	96.00	198.00	444.66
Parcel area, 1,000 m ²	379,094	36.75	73.88	3.33	17.48	80.83
Distance to urban-unit centers, km	379,094	10.34	11.13	1.45	7.56	21.94
B. Firm-year characteristics						
Listed residential developers						
Operating revenue, million RMB	1,729	9275.22	28673.80	443.59	2352.02	18326.41
Operating cost, million RMB	1,729	6328.86	20170.43	281.86	1450.66	12380.30
Taxes and surcharges excl. income tax, million RMB	1,729	737.26	2203.76	10.15	189.44	1453.62
Income tax expense, million RMB	1,729	432.19	1406.95	5.80	115.95	807.18
Industrial firms:						
–with land purchase						
Profit margin	21,976	0.05	0.08	0.00	0.04	0.13
Operating revenue, 1,000 RMB	21,752	179,459	371,021	11,457	61,288	411,539
Purchased land area, 1,000 m ²	4,349	34.11	45.43	4.55	18.83	80.00
–without land purchase						
Profit margin	22,345	0.05	0.14	0.00	0.04	0.13
Operating revenue, 1,000 RMB	22,110	174,007	353,169	10,815	60,484	402,751
C. City characteristics						
Industrial land discount, RMB/m ²	3,092	1,520.86	1,416.96	223.86	1,082.47	3,472.72
City VAT retention share, pp	2,839	23.94	10.15	15.00	20.00	40.00
2016 change in city VAT retention share, pp	216	20.29	6.41	16.25	20.00	27.50
Municipal corporate bond coupon rate, pp	257	6.96	0.80	5.88	6.98	8.00
Fiscal deficit-to-GDP ratio	257	0.09	0.08	0.01	0.07	0.17
GDP growth rate, pp	257	13.39	3.19	10.10	13.20	16.50
GDP per capita, 10,000 RMB	257	2.46	1.71	0.97	1.93	4.98
Late-term governor indicator	257	0.14	0.35	0.00	0.00	1.00

Note: This table reports summary statistics at the parcel, firm-year, and city levels. Panel A uses residential and industrial land transactions through English or two-stage auctions from 2007–19. Land price is the winning transaction price per square meter, and distance is measured to the nearest urban-unit center. Panel B reports financial characteristics of listed residential developers and the matched sample of industrial firms. Profit margin is profit divided by sales. Panel C reports city-level variables. Industrial land discount is the estimated wedge between residential and industrial land price. The 2016 change in city value-added tax (VAT) retention share is measured in percentage points. Municipal corporate bond coupon rate, deficit/GDP, GDP growth, and GDP per capita are measured in 2008. Late-term governor indicator equals one if the provincial governor had served more than three years by end-2008.

through subsidiaries,⁹ and focus on purchases during 2007–10 so that we observe at least three post-purchase years of sales. We match 22,636 of the 124,341 industrial land purchases by firms in this period, corresponding to about 3% of ASIF firm-years during 2003–13. Matched parcels are slightly more expensive than, but similar in size and location to, the universe of industrial parcels; matched firms are slightly larger than the average ASIF firm (Appendix Table A.1).

Residential developers. To estimate developers’ taxes, we use annual reports of listed home developers together with city-level house prices and floor ratios during 2007–21.

City data. City-level GDP and population come from the NBS Urban Statistical Yearbook, 2007–19.

3 Conceptual Framework

We model how a local government allocates land between industrial and residential uses. The model delivers two results: the efficiency of land allocation can be assessed with a simple equality of equilibrium prices and taxes, which we take to the data (Section 3.2), and frictions in local public finance—inflexible taxation, tax sharing, and high government borrowing costs—can distort the government’s allocation away from the efficient level (Section 3.3).

3.1 Model Setup

Timing, financial markets, and the local government. Consider a jurisdiction, modeled as a small open economy with a representative residential and a representative industrial sector, in discrete time $t = 1, 2, \dots$. The residential sector builds houses at $t = 1$ for local households, who are immobile across jurisdictions, whereas industrial goods are produced every period. Local firms and households borrow and save at an exogenous

⁹We exclude land transferred by administrative allotment, which is not used for production.

interest rate r and, because industrial goods are tradable across jurisdictions, take their price as given. We take industrial goods at $t = 1$ as the numéraire, so one unit of date- t goods has a date-one price of $(\frac{1}{1+r})^{t-1}$.

The local government owns a fixed land stock $\bar{L}$. At $t = 1$, it divides this land between industrial and residential uses, $L_I + L_R = \bar{L}$, and chooses infrastructure spending G , which raises industrial productivity, and a stream of amenity spending $\{A_t\}$, which raises household utility. Each unit of G or A_t costs one unit of industrial goods.

Households. A representative household owns the industrial firms and receives π_I , the present value of industrial post-tax profits. In each period, the household faces a lump-sum tax T_t^h (a transfer if negative). Taking A_t , π_I , and T_t^h as given, the household chooses consumption of industrial goods c_t and housing h to maximize lifetime utility:

$$\max_{c_t, h} \sum_{t=1}^{\infty} \beta^{t-1} \cdot u(c_t, h; A_t) \quad \text{s.t.} \quad \sum_{t=1}^{\infty} \frac{c_t}{(1+r)^{t-1}} + P_h h = \pi_I - \sum_{t=1}^{\infty} \frac{T_t^h}{(1+r)^{t-1}}. \quad (1)$$

Industrial firms. A representative industrial firm produces industrial goods from land and infrastructure with the production function $y_t = f(L_I, G)$, where f is continuous, increasing, and strictly concave, with $\frac{\partial^2 f}{\partial L_I \partial G} > 0$ (land and infrastructure are complements), and $f(L_I, 0) > 0$ for all $L_I > 0$. Output is taxed at rate τ . The firm buys land at $t = 1$ at price P_I , choosing L_I to maximize the present value of post-tax profits:

$$\pi_I = \max_{L_I} \sum_{t=1}^{\infty} \frac{(1-\tau)y_t}{(1+r)^{t-1}} - P_I L_I. \quad (2)$$

The first-order condition is $\sum_{t \geq 1} \frac{1-\tau}{(1+r)^{t-1}} \frac{\partial y_t}{\partial L_I} = P_I$.

Residential developers. Housing is produced competitively from residential land L_R with the linear technology $y_h = \phi L_R$. Developers pay the same tax rate τ on house sales,

so free entry drives the residential land price to

$$P_R = (1 - \tau) \times \phi P_h,$$

where P_h is the house price. All houses are built and sold at $t = 1$, so residential land generates a one-time tax payment, $\tau P_h y_h$, at the time of sale.

Equilibrium. Let $X \equiv [L_I, L_R, G, \{A_t\}]$ collect the government's choices. Given X , the optimization problems of households, industrial firms, and residential developers determine the demand for industrial land, residential land, and houses, so the market-clearing prices (P_I, P_R, P_h) are functions of X . Which values of X are feasible depends on the government budget constraint, introduced in Section 3.3; for now, we take X as given.

Combining the budget constraints of households, firms, developers, and the government yields the aggregate resource constraint—that is, the present value of household consumption equals that of local output net of public spending. With housing $h = y_h = \phi L_R$ in equilibrium, the household's equilibrium utility given X is

$$\mathcal{U}(X) = \max_{c_t} \sum_{t \geq 1} \beta^{t-1} u(c_t, h; A_t) \quad \text{s.t.} \quad \sum_{t \geq 1} \frac{c_t}{(1+r)^{t-1}} = \sum_{t \geq 1} \frac{y_t - A_t}{(1+r)^{t-1}} - G. \quad (3)$$

Let λ_h denote the Lagrange multiplier on this constraint.

3.2 Land Allocation Efficiency

Given the land stock $\bar{L}$, an allocation (L_I, L_R) is efficient if no alternative allocation raises household welfare, holding the interest rate r and $[G, \{A_t\}]$ fixed. Formally,

$$(L_I, L_R) = \arg \max_{(L'_I, L'_R) \in \mathcal{L}} \mathcal{U}(L'_I, L'_R; G, \{A_t\}), \quad (4)$$

where $\mathcal{L} = \{(L'_I, L'_R) : L'_I + L'_R = \bar{L}, L'_I \geq 0, L'_R \geq 0\}$.

Proposition 1. (*Efficient land allocation.*) For any X and the corresponding equilibrium prices (P_I, P_R, P_h) , efficiency of land allocation requires:

$$P_I + \sum_{t \geq 1} \frac{1}{(1+r)^{t-1}} \times \overbrace{\tau \frac{\partial y_t}{\partial L_I}}^{\text{Industrial Tax}} = P_R + \overbrace{\tau P_h \frac{\partial y_h}{\partial L_R}}^{\text{Residential Tax}}. \quad (5)$$

Condition (5) is the standard efficiency condition—the social marginal value of land is equalized across uses—expressed in tax-inclusive prices. Each side of (5) equals the marginal output value of land in that use, because land prices capitalize future tax obligations. An industrial firm pays P_I , the present value of its marginal output net of the taxes it will owe on that output; adding back these taxes recovers the full marginal output value of industrial land. The same holds for residential land, where the tax is paid once, at sale.

Condition (5) is therefore a sufficient statistic for allocative efficiency: it involves only equilibrium prices and taxes. It relies on a well-functioning private side of the land market: industrial firms and housing developers must compete for land and face no major frictions in acquiring it, so that final transaction prices reflect marginal buyers' willingness to pay, including for the future taxes the land will generate.¹⁰ It does not, however, require the government side to be frictionless. Local governments may face different costs of repossessioning land for each use, or may choose land quantities, zoning, reserve prices, or sale formats strategically, reflecting market power or interjurisdictional competition. Such supply-side distortions may affect equilibrium prices, and hence are reflected in Condition (5), rather than invalidating it.

The two sides differ in timing. The industrial tax on the LHS of (5) is a perpetual stream, whereas the residential tax on the RHS is a one-time payment at sale, because China taxes home development but levies no recurring residential property tax. Hence

¹⁰This assumption of competitive demand is consistent with fairly low buyer concentration: over 2007–2010, the average city-level Herfindahl–Hirschman Index of land-purchase shares was 4.2% for residential land and 3.5% for industrial land. We discuss this assumption in more detail in Section 4.1.

the large gap between P_R and P_I in China does not by itself show that industrial land is oversupplied: whether (5) holds, and in which direction it fails, is an empirical question.

Implied Discount Rate (IDR) and empirical implementation. We summarize Condition (5) in a single number, the implied discount rate (IDR), our sufficient statistic for allocative efficiency. Because the industrial tax stream is long-lived, whether the condition holds depends on the rate at which that stream is discounted; following standard practice in corporate finance, we define IDR as the discount rate ρ at which (5) holds exactly and compare it with firms' cost of capital. Rearranging Condition (5) gives

$$\text{IDR}_v \equiv \left\{ \rho : \sum_{t \geq v} \frac{\overbrace{\text{Tax}_{v,t}^I}^{\text{PV(industrial tax)}}}{(1 + \rho)^{t-v+1}} - \sum_{t \geq v} \frac{\overbrace{\text{Tax}_{v,t}^R}^{\text{PV(residential tax)}}}{(1 + \rho)^{t-v+1}} = \overbrace{P_v^R - P_v^I}^{\text{IndDisc}} \right\}, \quad (6)$$

where $\text{Tax}_{v,t}^I$ and $\text{Tax}_{v,t}^R$ are industrial and residential tax payments per square meter in year t for land purchased in year v , which we call the land's vintage. We assume that land prices are paid at the beginning of year v and taxes at the end of year t . The LHS is the difference between the present values of the two tax streams; the RHS is the upfront premium of residential over industrial land, which we call the "industrial discount" (IndDisc). IDR is the ρ that equates the two. Unlike in the model, we allow residential taxes to arrive one or two years after land purchase, so they are discounted as well.¹¹

If IDR exceeds firms' cost of capital, then at the cost of capital the tax-inclusive value of industrial land—equivalently, its marginal output value—exceeds that of residential land, so industrial land is undersupplied; an IDR below the cost of capital indicates oversupply. Importantly, IDR diagnoses allocative efficiency conditional on G and $\{A_t\}$; it

¹¹Residential and industrial tax cash flows may have different systematic risk; our baseline uses a common discount rate for simplicity and transparency. Because residential taxes are paid shortly after acquisition, the resulting IDR is relatively insensitive to their discount rate: fixing it at 0% or 16% yields implied industrial rates of 7.0% and 7.8%, respectively, compared with 7.4% in the baseline.

is *not* the local government's financial return from industrial land zoning.

3.3 The “Land Finance” Channel

We now turn to the supply side: how the local government chooses X —the allocation of land and the provision of public goods—and when its choice satisfies the efficiency condition (5). The answer depends on the fiscal instruments available to the government, which we define broadly to include land sales, the defining instrument of local public finance in China.

The government's problem. The local government finances its expenditures— G and $\{A_t\}$ —using land-sale proceeds and tax revenues, and borrows and saves at rate r to smooth its budget over time. To model the government's taxation flexibility, we consider two cases for the lump-sum tax $\{T_t^h\}$: (i) it can be set freely, and (ii) it is capped at zero, so that the government may transfer to, but not tax, households. The government takes the linear tax rate τ as given; in China, it is set by the central government.¹²

Given X , the corresponding equilibrium prices, and the lump-sum tax $\{T_t^h\}$, the present value of the government's budget balance, $\mathcal{B}(X; T^h)$, is:

$$\mathcal{B}(X; T^h) = (P_I L_I + \sum_{t=1}^{\infty} \frac{\tau y_t}{(1+r)^{t-1}}) + (P_R L_R + \tau P_h y_h) + \sum_{t=1}^{\infty} \frac{T_t^h}{(1+r)^{t-1}} - G - \sum_{t=1}^{\infty} \frac{A_t}{(1+r)^{t-1}}. \quad (7)$$

To isolate the role of public finance, we assume the government is benevolent: it maximizes household welfare and values fiscal revenue only as a means to that end. Both cases share the same problem:

$$\max_{X, \{T_t^h\}} \mathcal{U}(X) \quad \text{s.t.} \quad \mathcal{B}(X; T^h) = 0, \quad T_t^h \leq \bar{T},$$

¹²This linear tax is non-distortionary because both inputs to industrial production, land and infrastructure, are chosen by the local government, so the tax is capitalized into the land price rather than distorting input choices. Because our aim is to model the government's taxation flexibility, allowing a flexible linear tax rate instead of a flexible lump-sum tax would yield the same insights.

where $\bar{T} = \infty$ in case (i), so the lump-sum tax is unrestricted, and $\bar{T} = 0$ in case (ii), so the government can make transfers to households but cannot tax them. The value zero itself is not essential: what matters is that the cap binds, and any finite $\bar{T}$ at which it binds delivers the same results. Let λ_g denote the Lagrange multiplier on the government budget constraint. Because $\mathcal{U}$ already nets out the resource cost of G and $\{A_t\}$, λ_g is the net shadow value of public funds: the marginal social benefit of public spending minus its resource cost, a measure of how far public goods are underprovided relative to the first best.

“Financing” Role of Land Allocation. In China, local governments fund public goods— G and $\{A_t\}$ —largely through land sales, a practice widely known as “land finance” (Tao et al., 2010; Liu and Xiong, 2020; Chen et al., 2020). Proposition 2 characterizes when this financing role distorts land allocation.

Proposition 2. *The optimal solution to the benevolent local government problem satisfies:*

$$P_I + \sum_{t \geq 1} \frac{\tau}{(1+r)^{t-1}} \frac{\partial y_t}{\partial L_I} + \frac{\lambda_g}{\lambda_h} \cdot \frac{\partial \mathcal{B}}{\partial L_I} = P_R + \tau P_h \frac{\partial y_h}{\partial L_R} + \frac{\lambda_g}{\lambda_h} \cdot \frac{\partial \mathcal{B}}{\partial L_R}. \quad (8)$$

We have the following results:

- (i) *If $\{T_t^h\}$ can be set freely, or the cap on $\{T_t^h\}$ is non-binding, then $\lambda_g = 0$ and the government’s optimal land allocation is efficient, i.e., Condition (5) holds.*
- (ii) *If the cap on $\{T_t^h\}$ binds, then $\lambda_g > 0$, and industrial land is oversupplied relative to the efficient level if and only if $\frac{\partial \mathcal{B}}{\partial L_I} > \frac{\partial \mathcal{B}}{\partial L_R}$.*

Condition (8) says that the government equates, across uses, each parcel’s social marginal value plus the shadow value of its marginal fiscal contribution. Whereas (5) characterizes the unconstrained social optimum, (8) characterizes the constrained-efficient allocation; their wedge measures the distortion from public finance frictions.

Part (i) shows that using land sales and taxes to finance public spending does not, by itself, distort land allocation. With a flexible lump-sum tax, the government funds public goods up to the point where their marginal benefit equals their resource cost, so $\lambda_g = 0$, the fiscal terms in (8) vanish, and (5) holds.

Part (ii) covers the case without a flexible lump-sum tax. When the cap on $\{T_t^h\}$ binds, public goods provision is constrained by fiscal capacity, and land allocation acquires a “financing” role: the government tilts land toward the use with the larger marginal fiscal contribution, $\partial \mathcal{B} / \partial L_I$ or $\partial \mathcal{B} / \partial L_R$ —its tax-inclusive price plus the induced effects on the prices of both land types—and oversupplies that use relative to the efficient level. Two considerations suggest that, through this channel alone, industrial land tends to be oversupplied. First, more industrial land raises household wealth and hence housing demand, pushing up house and residential land prices, whereas more residential land leaves the industrial land price unchanged because industrial output is tradable. Second, the negative own-price effect of expanding supply scales with the price level, so it is smaller for industrial land if its price lies well below the residential price—as in the data—and the demand elasticities of the two types do not differ much. A binding fiscal constraint therefore tends to tilt land toward industrial use; the two frictions we introduce next work in the opposite direction.

In what follows, we assume the cap on $\{T_t^h\}$ binds and set $T_t^h = 0$.

Tax Sharing and Government Borrowing Cost. Beyond inflexible taxation, two features of China’s fiscal system make the financing role of land especially consequential. First, since the 1994 tax-sharing reform, local governments retain only a fraction of the value-added taxes (VAT) and corporate income taxes generated by industrial activity, whereas land-sale proceeds accrue almost entirely to them. Second, local governments face high and heterogeneous borrowing costs: formally barred from borrowing until 2015, they financed spending through local government financing vehicles at rates well above the

sovereign rate (Chen et al., 2020), and have remained subject to bond quotas since. Both frictions reduce the value the government attaches to the deferred tax stream from industrial land relative to the upfront proceeds of residential sales—tax sharing by lowering the share it retains, borrowing costs by raising the rate at which that stream is discounted—so both tilt land allocation toward residential use.

We introduce both frictions into the model. For tax sharing, let $s \in [0, 1]$ be the share of industrial tax revenue that the local government retains, with the remaining $1 - s$ going to the central government; residential taxes, paid once at sale, are retained in full. As part of the same arrangement, the central government rebates a lump-sum transfer T_t^g to the local government, which takes it as given. For borrowing costs, the local government borrows and saves at rate r^g , which may differ from the private rate r . The present value of the government's budget balance is then:

$$\mathcal{B}(X; s, T^g, r^g) = P_I L_I + \sum_{t=1}^{\infty} \frac{s\tau y_t + T_t^g}{(1 + r^g)^{t-1}} + (P_R L_R + \tau P_h y_h) - \sum_{t=1}^{\infty} \frac{A_t}{(1 + r^g)^{t-1}} - G. \quad (9)$$

The aggregate resource constraint combines the household budget, which discounts at r , with the government budget, which discounts at r^g , so flows that pass through the government—retained taxes, transfers, and amenity spending—are valued at r^g . Household welfare and the aggregate resource constraint are:

$$\mathcal{U}(X; s, T^g, r^g) = \max_{c_t} \sum_{t \geq 1} \beta^{t-1} u(c_t, h; A_t) \quad (10)$$

$$\text{s.t. } \sum_{t \geq 1} \frac{c_t}{(1 + r)^{t-1}} = \sum_{t \geq 1} \left(\frac{(1 - \tau)y_t}{(1 + r)^{t-1}} + \frac{\tau s y_t + T_t^g - A_t}{(1 + r^g)^{t-1}} \right) - G. \quad (11)$$

Putting these together, the local government's problem is

$$\max_X \mathcal{U}(X; s, T^g, r^g) \quad \text{s.t.} \quad \mathcal{B}(X; s, T^g, r^g) = 0.$$

To simplify the exposition, we set $T_t^g = (1 - s)\tau y_t^*$, where y_t^* is output under the optimal X . The transfer returns the shared tax revenue in lump-sum form, removing the income effect of s so that only its incentive effect remains.

Proposition 3. *Let $L_I(s, r^g)$ be the government's optimal industrial land allocation. Assume that the marginal revenue from industrial land sales increases with infrastructure G and that household utility is separable, $u(c_t, h; A_t) = \eta(c_t) + \nu(h) + v(A_t)$.*

- (i) (Partial equilibrium.) *Holding (λ_h, λ_g) fixed, $L_I(s, r^g)$ increases in s and decreases in r^g .*
- (ii) (General equilibrium.) *Allowing the multipliers to adjust, and under log utility and Cobb–Douglas production, both $L_I(s, r^g)$ and the equilibrium price wedge $P_R - P_I$ increase in s (with $r^g = r$) and decrease in r^g (with $s = 1$).*

Part (i) isolates the direct incentive effect by fixing (λ_h, λ_g) , which mutes feedback through the household and government budgets. A higher retained share s raises the fiscal return from industrial land accruing to local governments, and a lower borrowing cost r_g raises the present value of that return. Both shift land toward industrial use.¹³

Part (ii) lets the multipliers adjust in general equilibrium. Such adjustments are unlikely to overturn the direct incentive effects when the economy has a positive initial endowment, such as existing infrastructure or household wealth; under log utility and Cobb–Douglas production, both L_I and $P_R - P_I$ indeed rise with s and fall with r^g . These comparative statics are the predictions we test in Section 5.

A third friction works through the same channel: the cost of acquiring land—the compensation the government pays when reposessing it (Section 2.1)—may differ across uses. Because this compensation is a transfer to local residents, it leaves Condition (5) unchanged; but it lowers the government's net proceeds from the costlier use. Holding

¹³The effect on the equilibrium price wedge $P_R - P_I$ requires additional assumptions. While reallocating land from residential to industrial use widens $P_R - P_I$, adjustments in G work against this effect: higher s and lower r^g both raise G , which raises P_I because land and infrastructure are complements. Adjustments in $\{A_t\}$, by contrast, leave housing demand, and hence P_R , unchanged because utility is separable.

the household and government multipliers fixed, a higher acquisition cost for industrial relative to residential land shifts land toward residential use (Appendix A). We lack systematic data on acquisition costs and do not test this prediction.

4 Measuring Land Allocation Efficiency

We now compute the sufficient statistic IDR in Equation (6). It requires three inputs: the industrial discount (Section 4.1), the industrial tax stream per unit of land (Section 4.2), and the one-time residential tax (Section 4.3). Section 4.4 combines them and compares IDR with firms' cost of capital.

4.1 Industrial Discount Estimation

The industrial discount as defined in Equation (6), $P_v^R - P_v^I$, measures how much more a buyer would pay upfront for the same parcel if it were zoned residential rather than industrial. This differs from the raw price gap, because residential parcels tend to be better located—for example, closer to city centers. We therefore adjust for land quality.

For each parcel i , let $P_{i,t}^R$ ($P_{i,t}^I$) denote its price per square meter if sold as residential (industrial). Using observed residential (industrial) prices, we estimate a hedonic model that predicts what industrial (residential) parcels would have sold for under the other zoning (Wu et al., 2014; Chen et al., 2017). Let $\mathcal{J}_R$ and $\mathcal{J}_I$ denote the sets of observed residential and industrial parcels. For $i \in \mathcal{J}_R$, we estimate

$$P_{i,t} = X_{i,t} \cdot \beta^R + \gamma_{u,t}^R + \epsilon_{i,t}, \quad \forall i \in \mathcal{J}_R. \quad (12)$$

To absorb local economic conditions (e.g., economic development, land market corruption), we construct granular “urban units,” contiguous built-up clusters identified from satellite images, averaging only 8.4 square kilometers—roughly the size of a town and

much finer than the cities or counties used as controls in other studies.¹⁴ We match each parcel to its nearest urban unit and include urban unit–year fixed effects $\gamma_{u,t}^R$. Within urban units, we control for parcel characteristics $X_{i,t}$: transfer-method fixed effects, lease length, a second-order polynomial in log parcel area, distance to the nearest urban-unit center, and year-quarter-of-sale fixed effects.¹⁵ We estimate Eq. (12) on parcels sold by English auction (*paimai*) or two-stage auction (*guapai*), whose prices are most likely to reflect marginal buyers’ willingness to pay, as Condition (5) requires.

Because hedonic coefficients may differ across cities and over time, we estimate Eq. (12) separately by prefecture city and period (2007–10 and 2011–19), keeping city-periods with at least 80 (120) industrial and 80 (120) residential sales in 2007–10 (2011–19). This leaves 213 (285) of 341 cities, accounting for 88.6% (98.4%) of auctioned industrial and residential land sales.

Let $\hat{\beta}^R$ and $\hat{\gamma}^R$ be the estimated coefficients from Equation (12). Plugging industrial parcels’ characteristics into the estimated Eq. (12) gives their predicted residential prices:

$$\hat{p}_{i,t}^R = X_{i,t} \hat{\beta}^R + \hat{\gamma}_{u,t}^R, \quad \forall i \in \mathcal{I}_I. \quad (13)$$

Analogously, we fit the same hedonic model to industrial parcels and then predict industrial prices for residential parcels:

$$\hat{p}_{i,t}^I = X_{i,t} \hat{\beta}^I + \hat{\gamma}_{u,t}^I, \quad \forall i \in \mathcal{I}_R. \quad (14)$$

The parcel-level industrial discount is then

¹⁴We describe details of this procedure in Online Appendix B.2.

¹⁵When constructing counterfactual prices, we assign lease lengths of 50 years for industrial and 70 years for residential use, because Chinese urban land lease terms are largely set by use category: in our data, more than 98 percent of industrial parcels have 50-year leases and 90 percent of residential parcels have 70-year leases. We do not include the starting bid, which our data source does not disclose and which, more importantly, is set after zoning. Two problems follow. First, the two uses value different latent characteristics, sometimes with opposite signs. An industrial parcel’s starting bid therefore measures its industrial quality, not the residential quality that determines its counterfactual price. Second, the bid anticipates the upfront price under the designated use; it thus already embeds the industrial discount, and including it would shrink IndDisc by construction.

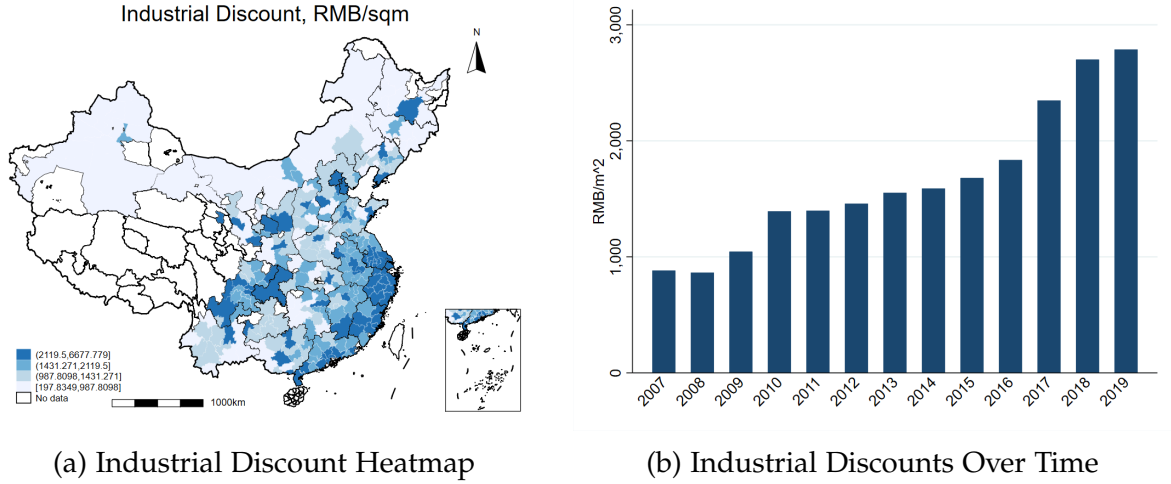


Figure 2: Industrial Discount Estimates Summary.

Note: Panel (a) plots the average industrial land discount across all prefecture cities during 2007–19. Panel (b) shows the average industrial discount estimates across cities for each year from 2007 to 2019.

$$\text{IndDisc}_{i,t} = \begin{cases} p_{i,t}^R - \hat{p}_{i,t}^I & i \in \mathcal{J}_R; \\ \hat{p}_{i,t}^R - p_{i,t}^I & i \in \mathcal{J}_I. \end{cases}$$

Averaging $\text{IndDisc}_{i,t}$ within each city-year, weighting by parcel size, gives $\text{IndDisc}_{c,t}$. Panel (a) of Figure 2 maps the 2007–19 average by city; industrial discounts correlate strongly with local economic development (0.52). Panel (b) shows the national average rising from about 900 RMB/m² before 2009 to about 3,000 RMB/m² in 2019, more than three times its 2007 level.

Robustness checks. We now discuss the assumptions behind these estimates. First, predicting prices under the alternative zoning requires common support. Appendix Figure A.2 shows the distributions of parcel size and distance to urban centers by use. Kolmogorov–Smirnov tests reject equal distributions, but our identifying assumption is only common support: each parcel’s characteristics must lie within the empirical support of the other use. The distributions overlap substantially, so the counterfactual predictions rely on interpolation rather than extrapolation.

Second, final prices may depart from buyers' willingness to pay, especially in two-stage auctions, which prior work finds more prone to underpricing than English auctions. Conditional on parcel characteristics, residential and industrial parcels sold by two-stage auction are 41 and 7.7 log points cheaper, respectively, than comparable parcels sold by English auction. Following [Li \(2019\)](#), who attributes 57% of this gap to mispricing, we raise two-stage auction prices by 57% of the use-specific gap. Our results are robust to this adjustment (Appendix Table [A.3](#)), so we keep final transaction prices as the baseline.

Third, allocative efficiency depends on the discount for *marginal* parcels, whose use would change under a small reallocation. Reweighting toward such parcels (Appendix Section [B.4](#)) barely changes the aggregate industrial discount.

Fourth, unobserved parcel differences most likely bias the industrial discount upward: if parcels are zoned residential partly for unobserved features that raise residential value, industrial parcels lack them, so their predicted residential prices are overstated. Such a bias would only *strengthen* our conclusion that future industrial taxes are large relative to the discount. The bias is also likely small: the characteristics used in the hedonic prediction models explain about 50% of price variation, yet controlling for them changes the average discount by only about 10%. For unobservables to matter much, they would have to drive prices strongly and differ sharply across uses, as [Oster \(2019\)](#) argues.

Finally, state-owned enterprises (SOEs) and other politically connected firms may pay land prices that do not reflect their marginal willingness to pay. [Wang and Yang \(2021\)](#) find that SOE buyers pay a premium, whereas [Chen and Kung \(2019\)](#), [Chen et al. \(2023b\)](#), and [Chang et al. \(2026\)](#) find discounts for firms linked to politicians or to local government financing vehicles (LGFVs). Because these buyers account for small shares of transactions, however, the implied aggregate biases are modest: weighting each estimated premium or discount by the buyer group's transaction share yields about 1.3% for SOEs, −1.3% for LGFVs, and −1.0% for Politburo-linked firms. The aggregate mispricing is thus small and mixed in sign, and unlikely to affect our comparison materially.

4.2 Industrial Tax Estimation

We estimate the taxes generated by industrial land in two steps: a difference-in-differences (DID) design estimates the effect of land purchases on firms' sales, and we multiply the sales increase by the effective industrial tax rate.

4.2.1 The Effect of Land Purchase on Sales

Suppose firm j buys land of size Δ_j in event year v_j . We model its sales $S_{j,t}$ as

$$\frac{S_{j,t}}{S_{j,v_j-1}} = \begin{cases} \alpha_j + \eta_{p(j),I(j),t,v_j} + \varepsilon_{j,t} & t < v_j, \\ \alpha_j + \eta_{p(j),I(j),t,v_j} + \theta_{t-v_j+1} \cdot \frac{\Delta_j}{S_{j,v_j-1}} + \varepsilon_{j,t} & t \geq v_j. \end{cases} \quad (15)$$

Sales relative to the pre-purchase year depend on a firm fixed effect α_j , time-varying province-by-industry shocks $\eta_{p(j),I(j),t,v_j}$, and the land purchase Δ_j ; θ_{t-v_j+1} is the increase in annual sales (in RMB) per square meter of land purchased.

Treated firms have $\Delta_j > 0$ and control firms $\Delta_j = 0$. For cleaner identification, treated firms are those that bought land in only one year of the sample period, and control firms are those that bought no industrial land during the sample period.

The identification challenge is that land purchases may be correlated with post-purchase shocks $\varepsilon_{j,t}$, $t \geq v_j$, i.e., $E[\varepsilon_{j,t} \cdot \frac{\Delta_j}{S_{j,v_j-1}} | \alpha_j, \eta_{p(j),I(j),t,v_j}, v] \neq 0$. We decompose these shocks as

$$\varepsilon_{j,t} = f_t(p(x_{j,v_j-1})) + e_{j,t}, \quad t \geq v_j. \quad (16)$$

Here, f_t is an arbitrary function and $p(x_{j,v_j-1})$ is the firm's probability of purchasing land given pre-purchase observables x_{j,v_j-1} . Our identifying assumption is that $f_t(p(x_{j,v_j-1}))$ captures all correlation between land purchases and the shocks:

$$\mathbb{E}[e_{j,t} \mathbf{1}_{\Delta_j > 0} | \alpha_j, \eta_{p(j),I(j),t,v_j}, v] = 0, \quad \forall v. \quad (17)$$

That is, the residual shock $e_{j,t}$ is uncorrelated with the purchase decision. The assumption is partly testable through pretrends in sales between treated and control firms.

We therefore match treated and control firms on propensity scores for land purchase, computed from characteristics in year $v_j - 1$. Within strata defined by event year, province, and two-digit National Industries Classification code, we estimate $\hat{p}(x_{j,v_j-1})$ from three firm-level observables:

$$x_{j,v_j-1} = \left\{ \log(S_{j,v_j-1}), \log(S_{j,v_j-2}), \frac{\text{Profit}_{j,v_j-1}}{S_{j,v_j-1}} \right\}.$$

Here, $S_{j,t}$ is sales and $\text{Profit}_{j,t}/S_{j,t}$ is the profit margin; all three variables predict land purchases. Following the literature (Dehejia and Wahba, 1999; Blundell and Costa Dias, 2000; Smith and Todd, 2005), we match on two years of pre-treatment sales to obtain robust and consistent estimates of the treatment effect. After matching, a test of our identifying assumption is whether treated and control firms show parallel pre-purchase trends in sales; the event study fails to reject parallel trends for every purchase cohort.

We estimate θ_{t-v_j+1} by DID on the matched sample. Define the average treatment intensity among treated firms as

$$\frac{\bar{\Delta}}{\bar{S}_{(v,p,I)}} \equiv \mathbb{E} \left[\frac{\Delta_j}{S_{j,v_j-1}} \mid \Delta_j > 0, v_j = v, p(j) = p, I(j) = I \right]. \quad (18)$$

Eq. (15) then becomes

$$\frac{S_{j,t}}{S_{j,v_j-1}} = \alpha_j + \eta_{p(j),I(j),t,v_j} + \theta_{t-v_j+1} \cdot \mathbf{1}_{\Delta_j > 0} \cdot \frac{\bar{\Delta}}{\bar{S}_{(v,p,I)}} + \varepsilon'_{j,t}, \quad (19)$$

where we define

$$\varepsilon'_{j,t} \equiv \begin{cases} \varepsilon_{j,t}, & \Delta_j = 0; \\ \varepsilon_{j,t} + \theta_{t-v_j+1} \cdot \left(\frac{\Delta_j}{S_{j,v_j-1}} - \frac{\bar{\Delta}}{\bar{S}_{(v,p,I)}} \right), & \Delta_j > 0. \end{cases} \quad (20)$$

By construction,

$$\mathbb{E}[\varepsilon'_{j,t} \cdot \mathbf{1}_{\Delta_j > 0} \frac{\bar{\Delta}}{\bar{S}_{(v,p,I)}} \mid \alpha_j, \eta_{p(j),I(j),t}] = 0, \quad (21)$$

which follows from (17) and the definition of $\frac{\bar{\Delta}}{\bar{S}_{(v,p,I)}}$. Hence DID estimation of specification (19) consistently estimates θ_{t-v_j+1} .

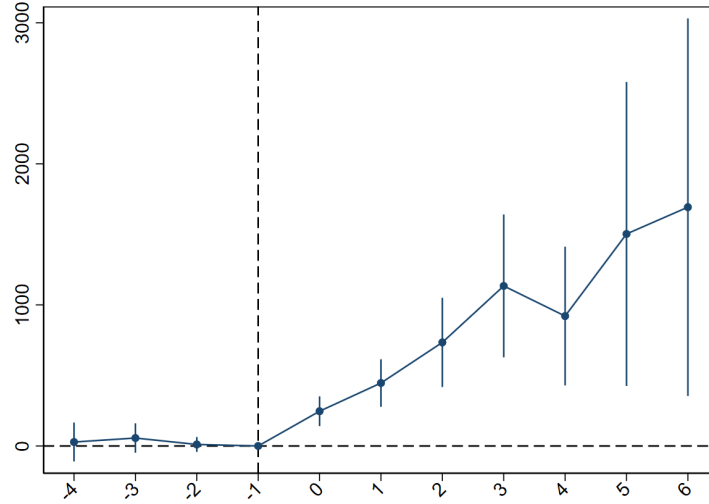


Figure 3: Dynamic Treatment Effect of Land Purchase on Sales

Note: This figure plots the 95% confidence interval for the event study coefficient estimates using Equation (19).

Figure 3 reports estimates of specification (19), pooling purchase years 2007–10.¹⁶ The sample starts in 2007, the first year of the land sale data, and ends in 2010, the last purchase year with at least three post-purchase years of firm data (2011–13) to estimate the long-run effect. For each purchase year v , the base year is $v - 1$, and we use data from $v - 4$ (few firms have earlier data) through 2013.

Figure 3 shows three patterns. First, the treatment effects are positive and economically and statistically significant. Second, they grow over time. Third, treated and control firms are statistically indistinguishable before the purchase. Matching guarantees parallel trends only from $t = v - 2$ to $t = v - 1$; that they also hold from $t = v - 4$ to $t = v - 2$ supports our identifying assumption.

Guided by these patterns, Table 2 summarizes the effects with two coefficients: a short-run effect for the first three years after purchase, which is smaller because firms are still making complementary investments (e.g., building new plants), and a long-run effect for the fourth and subsequent years. We denote the horizon k years after purchase by

¹⁶Table A.5 in the Online Appendix reports estimates for each purchase year.

$\omega(k)$, which equals “short” for $k \in \{0, 1, 2\}$ and “long” for $k > 2$. To avoid problems with staggered treatment in pooled regressions (De Chaisemartin and d’Haultfoeuille, 2020; Baker et al., 2022), we use a stacked DID with cohort-specific time fixed effects (Cengiz et al., 2019; Deshpande and Li, 2019).

Formally, we estimate

$$\frac{S_{j,t}}{S_{j,v_j-1}} = \alpha_j + \eta_{p(j),I(j),t,v_j} + \theta_{\omega(t-v_j)} \cdot \mathbf{1}_{\Delta_j > 0, t \geq v_j} \cdot \frac{\bar{\Delta}}{\bar{S}_{(v,p,I)}} + \varepsilon'_{j,t}, \quad (22)$$

where v is the event year shared by each treated firm and its matched controls; the time fixed effects vary with v_j , making this a stacked DID.

Columns (1)–(2) of Table 2 pool 2007–10 purchases, and the next four columns report each event year separately. On average, land purchases raise annual sales by 399.5 RMB/m² in the first three years and by 1027 RMB/m² thereafter.¹⁷

Even with parallel pretrends, assumption (17) would fail if firms bought land in response to a contemporaneous positive shock. We argue this is unlikely. Firms hit by an unexpected positive shock typically first expand on site; only when on-site expansion runs into significant diseconomies do they consider new plants, which require extensive market research and site selection (Schmenner, 2005). Firms are therefore unlikely to acquire new land in the same year a shock hits.¹⁸

Finally, the panel is unbalanced, partly because firms drop out when their sales fall below the survey’s inclusion threshold. We drop a matched treated-control pair whenever either firm’s data are missing. Online Appendix B.6 shows that imbalance mostly reflects idiosyncratic data-linkage problems, such as name changes or reporting inconsistencies; the modest part due to censoring makes our treatment-effect estimates conservative.

¹⁷Because 2010 data are missing, each cohort loses one year from either the short-run or the long-run window, depending on the purchase year v .

¹⁸We also test this argument. If purchases could respond to same-year shocks, purchases in the second half of the year would more likely reflect such shocks, so any upward bias would be larger for them. Column (2) of Table 2 does not support this: interacting the treatment effect with a dummy $H2$ for second-half purchases, we find similar effects in both halves of the year.

Table 2: Baseline Estimation of Marginal Output of Land

Event Year	2007–2010		2007	2008	2009	2010
Dep Var: Sale	(1)	(2)	(3)	(4)	(5)	(6)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t-v \in \{0,1,2\}}$	399.5*** (6.195)	363.9*** (4.816)	236.4*** (2.850)	285.0** (2.457)	277.6*** (3.956)	773.7*** (4.109)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t-v \geq 3}$	1,027*** (5.185)	1,096*** (4.489)	1,114** (2.291)	2,112*** (3.145)	551.7** (2.221)	1,253*** (3.324)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t-v \in \{0,1,2\}} \cdot \text{H2}$		77.78 (0.611)				
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t-v \geq 3} \cdot \text{H2}$		-144.3 (-0.385)				
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Province-Industry-Year FE			Yes	Yes	Yes	Yes
Event Year-Province-Industry-Year FE	Yes	Yes				
Observations	43,008	43,008	9,236	4,088	13,003	16,681
R-squared	0.662	0.662	0.673	0.673	0.656	0.660

Note: This table reports estimation results of Model (22) with the matched sample. We drop the matched pairs whenever the treated or the control firm exits the sample. The first estimate is for $\theta_{\text{short-run}}$ and the second is for $\theta_{\text{long-run}}$. For each treatment year $v \in \{2007, 2008, \dots, 2010\}$, the sample ranges from $v - 4$ to 2013 (but the data for 2010 are missing). The variable “sales” is in 1,000 RMB and $\bar{\Delta}$ is in 1,000m². Standard errors are clustered by firms. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.2.2 Firm Tax Estimation

Condition (5) values the marginal output of land by the total payment a land purchase gives rise to: the upfront price plus the taxes generated by the activity the parcel enables. A tax enters if it is caused by the purchase and borne by the purchaser or by parties whose payments are capitalized into its bid: the purchaser, its suppliers, and the buyers of what it produces. Who receives the tax is irrelevant, so central and local shares enter alike. Any tax is excluded if it would have been paid regardless of the purchase.¹⁹

We next convert the sales effect into tax payments. In the model of Section 3, additional land raises only the purchasing firm’s output and taxes. In practice, suppliers with idle capacity also expand when a downstream firm buys land, and by the principle above

¹⁹The principle likewise excludes the local government’s acquisition and compensation costs, which are costs of supplying land rather than payments for it. See the discussion following Proposition 1.

their taxes enter as well. The marginal output value of an industrial parcel is therefore the upfront land price plus the taxes paid by the purchasing firm and its suppliers.

Both main industrial taxes, the value-added tax (VAT) and the corporate income tax, are roughly linear in value added.²⁰ Since the combined value added of the purchasing firm and its suppliers equals the purchasing firm’s sales, the total increase in value added is the sales increase estimated above. What remains is the effective tax rate.

Using the annual firm sample, we regress the total VAT paid by a purchasing firm and its suppliers on their total value added, i.e., the purchasing firm’s sales. The relationship is close to linear, with an average VAT rate of about 12.10% that is stable across firm sizes. Adding income taxes and administrative fees, about 5.77% of value added, gives an average tax rate of 17.87% (details in Online Appendix B.8).

Applying this rate to the sales effects in Column (1) of Table 2, we obtain the annual tax effect of land purchases at horizon $\omega \in \{\text{short}, \text{long}\}$, denoted $\widehat{\text{Tax}}_\omega$: $\widehat{\text{Tax}}_{\text{short}} = 71.4$ RMB/m² in the first three years and $\widehat{\text{Tax}}_{\text{long}} = 183.5$ RMB/m² thereafter.²¹

To map these estimates into $\text{Tax}_{v,t}^I$ in Equation (6), which varies with both the tax year t and the vintage v , we assume that $\text{Tax}_{v,t}^I$ scales with economy-wide land productivity Z_t :

$$\text{Tax}_{v,t}^I \equiv \text{Tax}_{\omega(t-v)}^I \times Z_t, \quad (23)$$

where the subscript $\omega(t-v)$ equals “short” for $t-v \in \{0, 1, 2\}$ and “long” for $t-v > 2$, reflecting that firms build up operations in the first three years and reach full capacity thereafter. We proxy $\{Z_t\}$ using average long-run forecasts of real GDP growth and a constant long-run inflation assumption (Online Appendix B.9). Because $\widehat{\text{Tax}}_\omega$ is estimated from 2007–10 purchases and firm data through 2013, it is a weighted average of $\text{Tax}_\omega^I \times Z_t$ over the purchase-year–tax-year pairs at horizon ω in the estimation sample; we recover

²⁰For a detailed description of the system of firm taxation in China, see Online Appendix B.8.

²¹These estimates are of the same magnitude as two complementary benchmarks: the average VAT of 332.8 RMB/m² on industrial land in 2011 and the average minimum tax of 113.5 RMB/m² required by official guidance (Section B.10).

$(\text{Tax}_{\text{short}}^I, \text{Tax}_{\text{long}}^I)$ by setting this average, with the regression weights, equal to $\widehat{\text{Tax}}_{\omega}$.²² Finally, to be conservative, we truncate industrial tax payments at the 50-year statutory horizon.²³

4.2.3 City-level Estimates

Estimating industrial taxes city by city is difficult because many cities have few observations. Since IDR is roughly the ratio of the industrial tax to the industrial discount plus the residential tax, city-level IDR estimates are unbiased if errors in the industrial tax are uncorrelated with that sum. We therefore let the sales effect θ vary with the city's industrial discount plus residential tax at the time of purchase.

Formally, define $X_{c,v} \equiv \text{IndDisc}_{c,v} + \text{ResTax}_{c,v}$ where $\text{ResTax}_{c,v}$ is the residential tax per square meter of land in city c and year v , estimated in Section 4.3. We modify specification (15) as follows:

$$\frac{S_{j,t}}{S_{j,v_j-1}} = \alpha_j + \eta_{p(j),I(j),t,v_j} + (\theta_{\omega(t-v_j)}^0 + \theta_{\omega(t-v_j)}^1 \cdot X_{c(j),v_j}) \cdot \mathbf{1}_{t \geq v_j} \cdot \frac{\Delta_j}{S_{j,v_j-1}} + \varepsilon_{j,t}. \quad (24)$$

Define:
$$\frac{\overline{X \cdot \Delta}}{S}_{(v,p,I)} \equiv \mathbb{E} \left[\frac{X_{c(j),v_j} \cdot \Delta_j}{S_{j,v_j-1}} \mid \Delta_j > 0, v_j = v, p(j) = p, I(j) = I \right]. \quad (25)$$

Equation (24) can then be written as:

$$\frac{S_{j,t}}{S_{j,v_j-1}} = \alpha_j + \eta_{p(j),I(j),t,v_j} + \mathbf{1}_{\Delta_j > 0, t \geq v_j} \cdot \left(\theta_{\omega(t-v_j)}^0 \cdot \frac{\overline{\Delta}}{S}_{(v,p,I)} + \theta_{\omega(t-v_j)}^1 \cdot \frac{\overline{X \cdot \Delta}}{S}_{(v,p,I)} \right) + \varepsilon'_{j,t}, \quad (26)$$

where ε' is defined accordingly as in Equation (20). Similarly, we have

$$\mathbb{E}[\varepsilon'_{j,t} \cdot \mathbf{1}_{\Delta_j > 0} \cdot \frac{\overline{\Delta}}{S}_{(v,p,I)} \mid \alpha_j, \eta_{p(j),I(j),t}] = 0 \quad \text{and} \quad \mathbb{E}[\varepsilon'_{j,t} \cdot \mathbf{1}_{\Delta_j > 0} \cdot \frac{\overline{X \cdot \Delta}}{S}_{(v,p,I)} \mid \alpha_j, \eta_{p(j),I(j),t}] = 0.$$

DID estimation of specification (26) therefore consistently estimates θ . Multiplying by

²²Because $\widehat{\text{Tax}}_{\omega}$ is estimated from realized taxes, one could instead back out $(\text{Tax}_{\text{short}}^I, \text{Tax}_{\text{long}}^I)$ using realized rather than forecast Z_t over 2007–13. Doing so barely changes the estimates, because realized nominal growth closely tracks the average forecasts over 2011–13 (Figure A.6).

²³The results are quantitatively insensitive to this choice. At an 8% discount rate, a 50-year non-growing stream has $1 - 1.08^{-50} \approx 0.979$ of the present value of a perpetuity, and the difference between 50- and 70-year annuity factors is likewise small.

the average tax rate, the city-level increase in industrial tax is $(2.8 + 0.018 \cdot X_c)$ RMB/m² in the first three years after purchase and $(98.2 + 0.022 \cdot X_c)$ RMB/m² thereafter, where X_c is the 2007–10 average of $X_{c,v}$. As above, we map these estimates into city-level $\text{Tax}_{c,v,t}^I$:

$$\text{Tax}_{c,v,t}^I \equiv \text{Tax}_{c,\omega(t-v)}^I \times Z_t, \quad (27)$$

where $\text{Tax}_{c,\omega}^I$ is recovered from these city-level estimates in the same way as Tax_{ω}^I .

4.3 Residential Tax Estimation

Residential development generates taxes from developers, their suppliers, and home buyers, all of which enter under the principle above; buyers' taxes are capitalized into the developer's bid. We estimate a separate tax rate for developers, whose tax items differ from manufacturers', and apply the industrial rate to suppliers.²⁴

The residential taxes included in the baseline are paid once. Developers pay some (deed, stamp, and land use taxes) at acquisition and others (VAT and income taxes), along with buyers' deed taxes, at pre-sale, generally within three years; suppliers pay during construction. For simplicity, we assume all residential taxes are paid in the year after acquisition: $\text{Tax}_{c,v,t}^R = \mathbf{1}_{t=v+1} \times \text{ResTax}_{c,t}$, where $\text{ResTax}_{c,t}$ is the residential tax per square meter of land in city c and year t .²⁵

We calculate $\text{ResTax}_{c,t}$ as:

$$\text{ResTax}_{c,t} = (P_{c,t}^h \times (\text{DevTaxRate}_t + \text{DeedTaxRate}_t) + \text{Cost}_{c,t} \times \text{IndTaxRate}) \times \text{FAR}_c, \quad (28)$$

where $P_{c,t}^h$ is the average house price per square meter of livable space, DevTaxRate_t is the developer's tax rate on new-home sales, DeedTaxRate_t is the home buyer's deed tax rate, $\text{Cost}_{c,t}$ is the average construction cost per square meter of livable space, including

²⁴We exclude the income taxes of households moving into new units, which arise from labor income and would be paid wherever they lived. Post-sale taxes are not economically important: China has no residential property tax, owner-occupied housing is exempt from land use tax, and rental income tax is unenforced. For taxes on home resales, Online Appendix B.12 shows that under generous assumptions about these taxes, our baseline IDR estimate decreases by about 1.0 percentage point.

²⁵Section 4.4.2 shows that assuming a two-year lag instead does not affect our results.

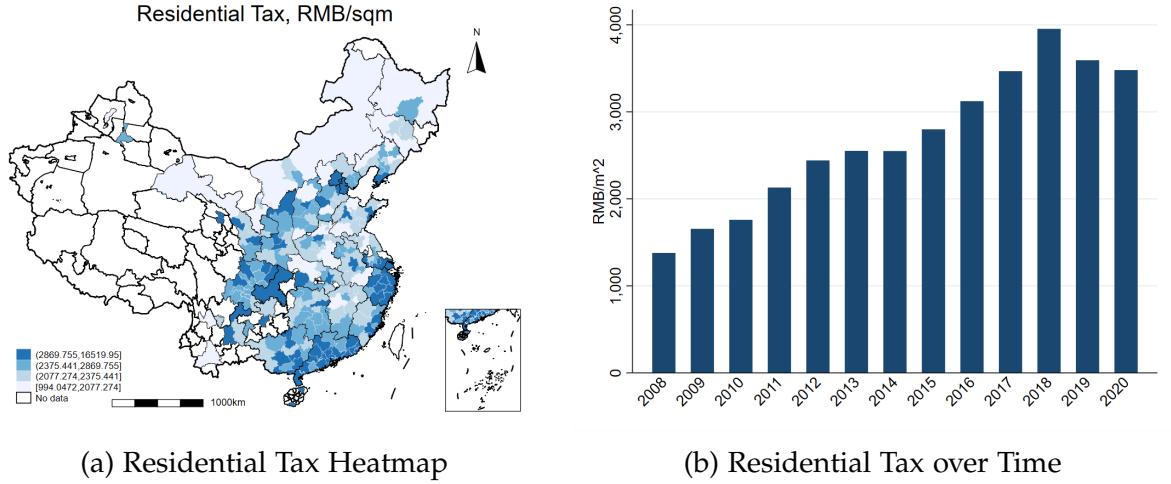


Figure 4: Residential Tax Estimates Summary.

Note: Panel (a) plots the average residential tax across prefecture cities during 2007–19. Panel (b) shows the average residential tax estimates across cities for each year from 2007 to 2019.

all intermediate inputs, IndTaxRate is the industrial tax rate from Section 4.2.2, and FAR_c is the average livable space built per square meter of land.

We compute $P_{c,t}^h$ as house sales revenue divided by livable area sold, and estimate DevTaxRate_t by regressing listed developers' annual taxes and fees on sales, year by year.²⁶ The fit is close to linear (Online Appendix Figure A.8), so the rate does not vary with developer size. We set the buyer's deed tax rate to 1.5%, take $\text{Cost}_{c,t}$ from developers' reports to the National Bureau of Statistics, and measure FAR_c as the size-weighted average floor ratio of residential parcels sold in city c during 2007–19, which varies little over time.

Residential taxes are higher in richer cities (correlation with GDP per capita of 0.63; Figure 4, Panel (a)) and have risen over time (Panel (b)).

²⁶Since May 1, 2016, developers have paid value-added taxes, which are not reported in their income statements. We estimate them as $(\text{Sales} - \text{COGS}) \times \text{the VAT rate}$ and add them to reported taxes.

Table 3: Industrial Discount, Tax and IDR

	IndDisc	Industrial Tax	Residential Tax	IDR
Baseline	1714.9	(71.4,183.5)	2206.0	7.4%
Exclude Five-Yr-Plan-targeted industries	1653.7	(65.2,133.8)	2134.5	5.9%
Full Tax Deduction	1714.9	(53.5,183.5)	2206.0	7.3%
Two-year gap of Developer Taxes	1714.9	(71.4,183.5)	2543.7	7.1%
Combination of three adjustments	1563.7	(48.9,133.8)	2478.4	5.6%

Note: This table shows the industrial discount estimates during 2007–10, the tax benefits, and the corresponding IDR. We aggregate the city-year level industrial discounts and residential tax payments to the national level, all weighted by the purchased land size of the treated firms in the estimation of industrial tax payment in Column (1) Table 2. We conduct robustness checks by excluding Five-Year Plan targeted industries (the second row), deducting the maximum tax rebates of 25% in the first five years (the third row), assuming the residential tax cash flow occurring two years after land acquisition (the fourth row), and the combination of the three adjustments (the last row). In Row 2 and 5, we set the weight to be purchased land size of treated firms in nontargeted industries to match the industrial tax estimation.

4.4 IDR and Land Allocation Efficiency

We now combine these estimates to compute IDR for 2007–10, the period covered by our industrial tax estimates. We compute it nationally and by city, translate it into quantities of misallocated land, and trace it over time.

4.4.1 National IDR during 2007–10

Table 3 summarizes the results. Weighted by the land purchases of treated firms in Column (1) of Table 2, the industrial discount $\text{IndDisc}_{c,v}$ and the residential tax $\text{Tax}_{c,v,v+1}^R$ average 1714.9 RMB/m² and 2206 RMB/m², respectively. Solving Equation (6) with these weighted averages gives a national $\text{IDR} = 7.4\%$.

We compare IDR with industrial firms' asset cost of capital, R_A , following the standard convention of discounting a project's operating cash flows at the asset cost of capital of comparable firms (Berk and DeMarzo, 2017). We treat the land purchase as an expansion of existing production and assume that the resulting tax cash flows have systematic risk

comparable to the operating cash flows of the industrial firms used to estimate R_A .²⁷ For listed industrial firms, the average R_A in 2007–10 is 8.0%, close to the 8.4% average perceived cost of capital that [Gormsen and Huber \(2025\)](#) report for listed firms.

The national calculation therefore indicates industrial oversupply. Contrary to the view that industrial land is heavily subsidized, however, the misallocation is modest nationwide, because long-run taxes make up a large part of what firms pay for industrial land. Section 4.4.4 quantifies misallocation across cities and shows that the average absolute deviation of industrial land shares from their efficient levels is modest.

4.4.2 Robustness Checks

We next check whether we overstate the importance of future taxes. First, firms in industries targeted by the 2006–15 Five-Year Plans ([Cen et al., 2021](#)) may have received subsidies that should be deducted from their payment for land, so we compute IDR separately for targeted and nontargeted industries.²⁸ IDR is modestly higher for targeted industries (8.2%) than for nontargeted ones (5.9%), but the latter is modestly below the baseline (second row of Table 3).²⁹

Second, local governments sometimes rebate taxes to new entrants, which should also be deducted. Even with 25% rebates in firms’ first five years, the most conservative case, IDR falls by 0.1 percentage point (third row of Table 3).

Third, if residential taxes arrive two years after purchase, the residential tax rises to 2543.7 RMB/m² and IDR falls slightly to 7.1% (fourth row).

Fourth, combining all three adjustments yields an IDR of 5.6% (last row).

²⁷ R_A is the natural benchmark because Tax_t^I is approximately linear in free cash flow and the interest tax shield, both of which carry the same risk and are both discounted at R_A under target leverage ([Berk and DeMarzo, 2017](#), Chapter 18). Appendix Section B.14 derives this decomposition, explains why the tax shield carries asset risk under target leverage, and details the estimation of R_A .

²⁸Online Appendix Table A.6 lists the targeted industries. Of the treated firms, 57.0% (43.0%) are in targeted (nontargeted) industries, accounting for 62.7% (37.3%) of matched industrial land.

²⁹If differential central-government subsidies are capitalized into land prices, our exercise assesses land allocation efficiency from the local jurisdiction’s perspective, conditional on these subsidies. This need not coincide with national efficiency, which also accounts for their fiscal cost.

Finally, we discuss the discount rate at which Condition (5) should be evaluated. Two distinct rates are involved. The first is the rate at which society values the cash flows generated by land, which is set by households' pricing kernel; since Condition (5) is an efficiency condition, it is the benchmark against which IDR is compared. The second is the rate at which firms discount when bidding for land; it does not enter Equation (6), which uses only land prices and tax cash flows, but it determines whether land prices reveal the true value of marginal cash flows. Our baseline uses the industrial cost of capital R_A for both. Gormsen and Huber (2025), however, document that firms' discount rates exceed their perceived cost of capital by 3.07 percentage points on average.

Following Gormsen and Huber (2025), we interpret this wedge as a friction on the firm side, such as financing constraints or managerial conservatism: firms bid at $\delta > R_A$ while the pricing kernel still values the cash flows at R_A . The benchmark is then unchanged, but land prices understate the value of marginal cash flows: a firm bidding at δ pays less for a given stream of output net of taxes than that stream is worth to society, and because industrial taxes are long-lived while residential taxes are paid once, the understatement is larger for industrial land. We therefore adjust our calculation in Online Appendix B.16 by recovering the marginal output streams from land prices at $\delta = R_A + 3.07\%$ before computing IDR. The adjustment raises our IDR estimates by at most 0.2 percentage point (Online Appendix Table A.7).³⁰

4.4.3 Geographic Variation in Land Misallocation

The national IDR masks substantial heterogeneity across cities. For each city c , we compute IDR_c for 2007–10 analogously, weighting by treated firms' local land purchases.

Figure 5 plots IDR_c against the city's average industrial discount (Panel (a)) and maps

³⁰One could instead interpret the wedge as genuine risk in these cash flows that R_A misses—for instance, because undeveloped land is riskier than an operating firm. Land prices would then reveal marginal values correctly and Equation (6) would need no correction, but the benchmark would rise to δ . Since any benchmark above our baseline IDR of 7.4% implies industrial oversupply under the national aggregation, this reading would reinforce the direction of our conclusion while enlarging the estimated oversupply.

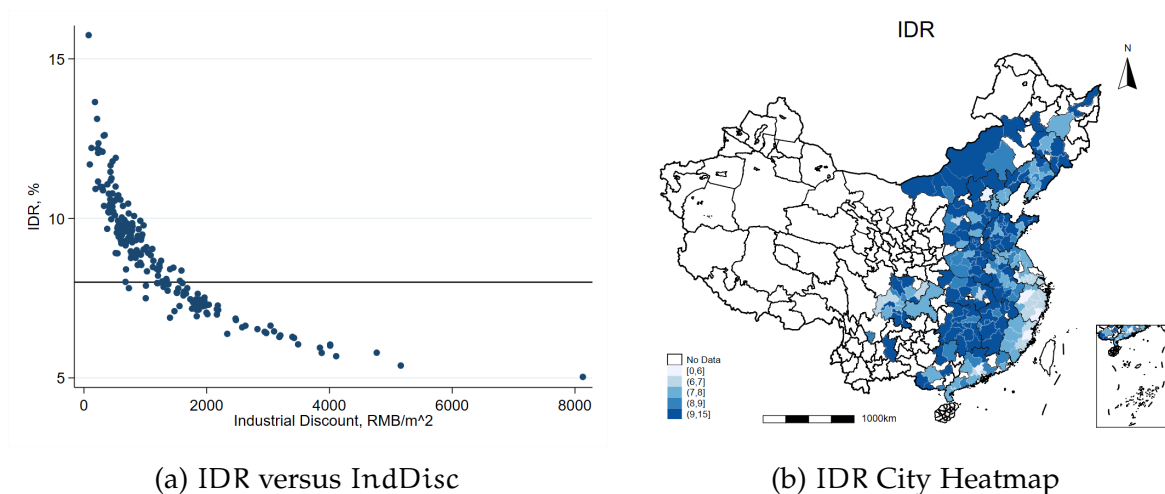


Figure 5: Geographic Distribution of Land Allocation Efficiency

Note: Panel (a) plots IDR against the city's average IndDisc_{ct} during 2007–10 across different prefecture cities; Panel (b) plots geographic heatmap of IDR for land allocation during 2007–10.

it (Panel (b)). Cities with higher industrial discounts also have higher industrial taxes, but their IDR_c is typically lower. IDR_c is lower in coastal and higher in inland regions; its correlation with 2007–10 GDP per capita is -0.39 .

Two takeaways emerge. First, although the national IDR is close to the cost of capital, many cities misallocate land. Across the 204 cities, the average IDR_c is 8.9%. In 70 cities, IDR_c is below 8.0%, indicating oversupply of industrial land; many are coastal cities with immigration and high house prices, which could gain by shifting land toward residential use. In the other 134 cities, IDR_c exceeds 8.0%, indicating undersupply of industrial land; these are typically interior cities with emigration and low house prices, which could gain by reducing residential land supply.

Second, misallocation is modest in many cities: 77 of the 204 cities have an IDR_c within 1 percentage point of 8.0%, and the average absolute gap between IDR_c and 8.0% is about 1.6 percentage points, suggesting that the efficiency loss from misallocation is unlikely to be large.

4.4.4 The Quantity of Land Misallocation

To measure misallocation in quantities, we compare the actual allocation with the counterfactual one that equalizes tax-inclusive marginal land values across uses. Public goods may adjust as land is reallocated; the counterfactual allocation satisfies the efficiency condition conditional on the public goods prevailing in the resulting equilibrium. We approximate this adjustment path using the responses of land prices and allocation to the tax-sharing shock in Section 5.1. Denote the industrial land share by $\ell_I = L_I / (L_I + L_R)$. The reduced-form semi-elasticities are:

$$\xi_1 \equiv \frac{d \ln(P_R)}{d \ell_I} \approx 5.15, \quad \xi_2 \equiv \frac{d \ln(P_I)}{d \ell_I} \approx -2.70 \quad (29)$$

These semi-elasticities incorporate the accompanying equilibrium responses of infrastructure and amenities, rather than holding public goods fixed. Online Appendix B.15 provides the estimation details.

Let V_s denote the tax-inclusive land price for use $s \in \{I, R\}$, with future taxes valued at R_A . Under the proportional-tax structure, V_s has the same semi-elasticity as P_s .³¹

Let Δ denote the change in the industrial land share. Approximating the equilibrium adjustment path with constant semi-elasticities gives

$$V'_R = \exp(\xi_1 \Delta) V_R, \quad V'_I = \exp(\xi_2 \Delta) V_I.$$

Equalizing these tax-inclusive prices yields the required reallocation,

$$\Delta^* = \frac{1}{\xi_1 - \xi_2} \ln \left(\frac{V_I}{V_R} \right).$$

Figure 6 plots Δ^* , the difference between efficient and observed industrial land shares

³¹Let Y_s denote the present value of marginal output from land in use s . With a fixed tax rate τ_s , competitive land demand implies $P_s = (1 - \tau_s)Y_s$, while the present value of marginal taxes is $\text{Tax}_s = \tau_s Y_s$. Thus, $V_s = P_s / (1 - \tau_s)$, so land prices and tax-inclusive prices have the same semi-elasticity along the equilibrium adjustment path.

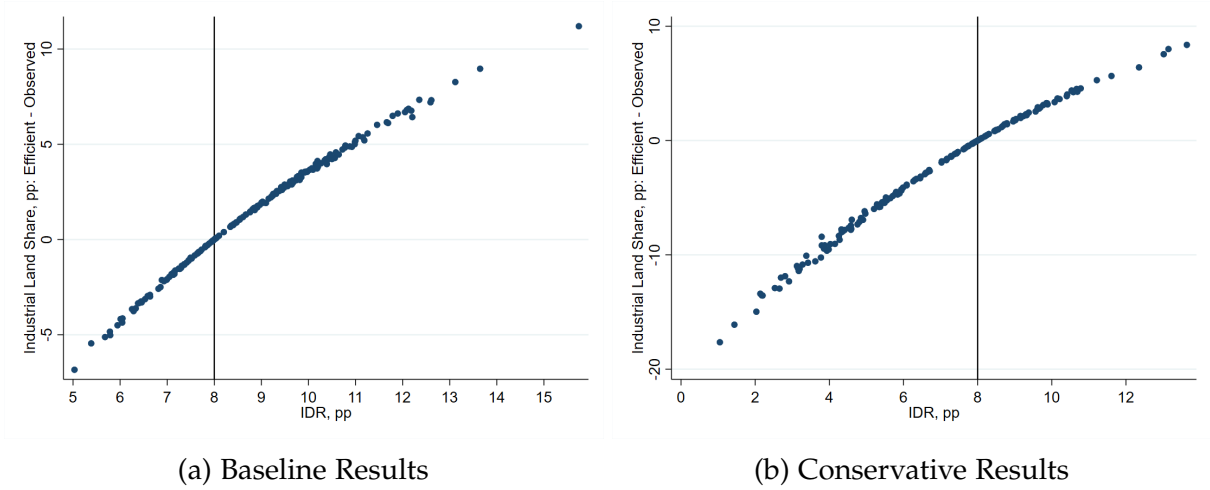


Figure 6: Land Misallocation and IDR

Note: The two graphs plot the difference between efficient and observed industrial land supply share against the IDR. Panel (a) plots the baseline results corresponding to the first row of Table 3, and Panel (b) the conservative results corresponding to the last row of Table 3.

against city-level IDR_c for 2007–10. In the baseline, the mean signed deviation is 0.77 percentage points, and the mean absolute deviation is 2.6, both weighted by the total residential and industrial land supply in each city during 2007–10.³² Under the most conservative specification (corresponding to last row of Table 3), these deviations are -3.7 and 5.2 percentage points, respectively. The quantity exercise therefore also indicates modest overall land misallocation.

4.4.5 Land Misallocation over Time

Our IDR estimates use 2007–10 transactions, the period with high-quality firm data. To trace allocative efficiency since then, we assume that Equation (23) also applies for $v > 2010$ and compute the national IDR_v for each year $v \geq 2007$.

In the baseline (Figure 7), IDR declines steadily, widening its gap below R_A and indicating a growing oversupply of industrial land; in the most conservative specification,

³²The positive mean signed deviation does not contradict the national IDR being below 8.0% because the two statistics aggregate cities differently: cities with higher residential land prices tend to have larger negative deviations and exert greater influence on the national IDR calculation.

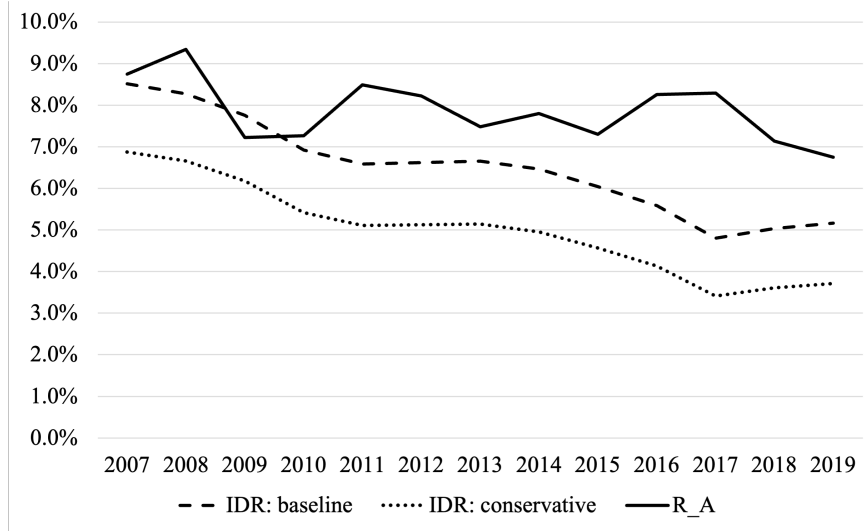


Figure 7: Time Series of IDR and Cost of Capital

Note: This figure plots the time series of IDR, under both the baseline specification (first row of Table 3) and the most conservative specification (last row of Table 3), as well as the average cost of capital for publicly listed industrial firms.

the gap is a further 1.5 percentage points wider. Together with the sharp rise in house prices since 2010, this suggests that shifting land from industrial to residential use, at least in some cities, would raise welfare.

5 Tax Benefits and Land Supply

Section 4 used demand-side prices to assess allocative efficiency; whether Condition (5) holds, however, depends on the government's supply decisions. We now test the supply-side predictions of Proposition 3: a higher retained share of industrial taxes and a lower government borrowing cost shift land toward industrial use and widen the residential-industrial price wedge. Because we lack reliable time-varying city-level estimates of IDR, we use the industrial discount, which is strongly correlated with IDR (Figure 5), as the outcome.

5.1 City Tax Shares

City governments retain most land-sale revenue but share value-added, corporate income, and business taxes with upper-level governments. The central government takes a uniform share of VAT, and each province splits the remainder with its cities, so city VAT shares vary across provinces.³³ Although cities may partly internalize taxes accruing to upper levels, they should weigh their own share most; Proposition 3 then predicts that a higher city VAT share raises the industrial discount and shifts land toward industrial use.

For identification, we exploit a 2016 change in tax sharing. Before May 1, 2016, the central government took 75% of VAT, leaving 25% to provincial and city governments. On that date, the “Business Tax to VAT” reform raised the local share from 25% to 50%.³⁴ Provinces split the additional 25% with their cities unevenly; this variation identifies the effect of tax sharing on industrial discounts.

Raw Data. Panel A of Figure 8 compares city VAT shares before and after 2016. Most cities’ shares rose, except in Guangdong, where they stayed at 25%. The increases vary substantially across cities. Panel B, a binned scatterplot, shows that the change in the industrial discount from 2015 to 2019 is strongly positively correlated with the 2016 change in city VAT share (excluding Guangdong), as predicted.

Guangdong cities are outliers in both panels: their VAT share did not change, yet their industrial discount rose substantially from 2015 to 2019. A likely explanation is that Guangdong alone adopted policies encouraging industrial land supply (Online Appendix C.1), so we drop Guangdong from the rest of this section.

Event Study. We estimate the event-study specification

$$y_{c,t} = \alpha_c + \gamma_t + \sum_{\tau \neq 2015} \beta_\tau \times \mathbf{1}_{t=\tau} \times \Delta \text{VATShare}_c + \varepsilon_{c,t}. \quad (30)$$

³³Wu and Zhou (2015) show that city VAT shares are higher when development varies less across the province’s cities, when the city’s industrial sector is more developed, and when the province controls fewer state-owned firms.

³⁴Local governments previously kept all business taxes. Once business taxes were replaced by the shared VAT, the central government raised local governments’ VAT share to keep their revenue stable.

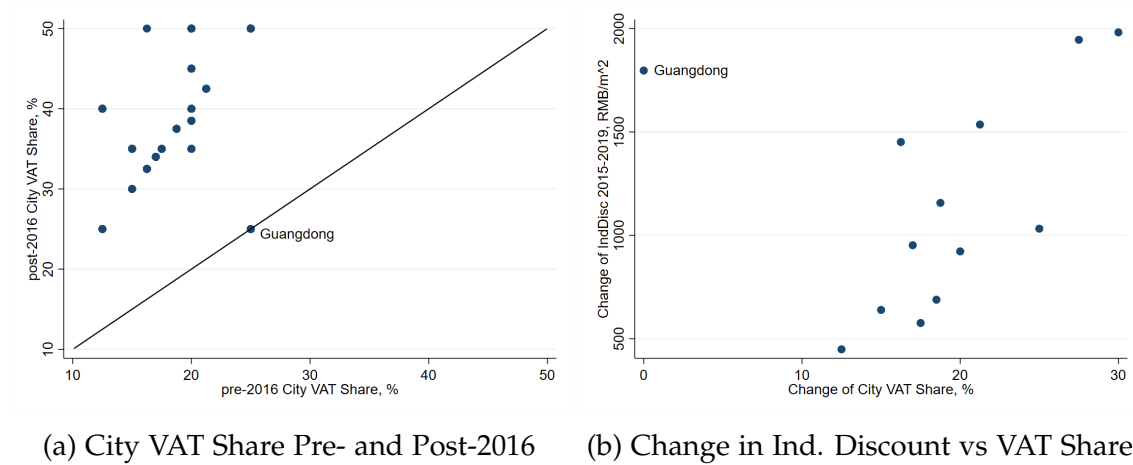


Figure 8: Change of City VAT Share and Industrial Land Discount

Notes: Panel (a) plots the city government's share of VAT before and after 2016. Panel (b) is a binscatter of the change in industrial land discount from 2015 to 2019 against the change in city VAT share across cities.

The base year is 2015, the year before the reform, and $\Delta \text{VATShare}_c$ is city c 's 2016 change in VAT share.

As predicted, Table 4 shows a significant positive effect on the industrial discount from 2016 onward and no significant differences before 2016, supporting parallel trends.

Consistent with the model, a larger retained share raises residential land prices and lowers industrial land prices (Columns (2)–(3)); the residential effect is larger, likely because residential prices are much higher.

Columns (4)–(6) turn to quantities, using land supply per capita as the dependent variable. A larger increase in the city's VAT share shifts land supply toward industrial use (Column (4)): cities immediately cut residential land supply and raise industrial supply over the following two years (Columns (5)–(6)).

The price evidence is stronger than the quantity evidence, for two reasons. First, industrial buyers who know that more of their future taxes will accrue to the local government may bargain for a larger discount, which requires no change in quantities. Second, and likely more important, planning constraints limit short-run quantity adjustment (Section 2), whereas prices of land, a durable asset, adjust immediately.

Table 4: City VAT Share and Industrial Land Discount

Dep Var:		Price			Quantity		
		IndDisc	P _R	P _I	(Ind-Res)/Pop	Res/Pop	Ind/Pop
		(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \text{VATShare} \times$							
Year=	2012	-1.844	-3.658	-1.814	1.599	0.123	-0.811
		(-0.138)	(-0.294)	(-0.888)	(1.470)	(0.197)	(-0.440)
	2013	-9.982	-10.72	-0.735	0.944	0.889	0.897
		(-1.004)	(-1.078)	(-0.682)	(0.914)	(1.370)	(0.702)
	2014	-10.64	-10.37	0.275	-0.297	0.337	-1.265
		(-0.852)	(-0.819)	(0.284)	(-0.388)	(0.894)	(-1.092)
	2016	19.57**	17.61*	-1.956***	0.0521	-0.647*	-0.759
		(2.096)	(1.873)	(-2.962)	(0.0754)	(-1.658)	(-1.002)
	2017	46.40***	44.43***	-1.974**	1.472*	0.805	2.424**
		(3.285)	(3.098)	(-2.329)	(1.766)	(1.464)	(2.350)
	2018	29.35*	27.40*	-1.950	3.961***	0.243	4.029***
		(1.812)	(1.674)	(-1.502)	(3.659)	(0.396)	(3.312)
	2019	50.84***	50.39***	-0.445	0.994	0.177	0.112
		(3.137)	(3.073)	(-0.321)	(1.005)	(0.331)	(0.0858)
Year FE		Yes	Yes	Yes	Yes	Yes	Yes
City FE		Yes	Yes	Yes	Yes	Yes	Yes
Observations		2,062	2,062	2,062	2,217	2,217	2,217
R-squared		0.836	0.847	0.825	0.705	0.650	0.664
#City		258	258	258	280	280	280

Note: This table shows how the change in city VAT share affects industrial land discounts and the industrial versus residential land supply. The sample consists of all the municipal cities (except those in Guangdong); the sample size in Column (1)–(3) is smaller because we need industrial discount estimates from 2012–19. The treatment variable, $\Delta \text{VATShare}$, is in percentage and the land supply is square meters per 100 people. Standard errors are clustered by cities. Robust t-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.2 Government Borrowing Rates

Proposition 3 predicts that governments with higher borrowing costs supply more residential and less industrial land, lowering IndDisc. We measure borrowing costs with yields on municipal corporate bonds (MCBs), the corporate bonds issued by city-level local government financing vehicles and known in the literature as LGFV or *chengtou* bonds, rather than municipal government bonds. The latter are issued by provinces, carry explicit provincial and implicit central guarantees, and are held mostly by banks,

so their yields reveal little about an individual city's credit and marginal borrowing cost. Although earlier pilot programs existed, issuance expanded substantially from 2015 onward, whereas MCBs are available throughout our 2012–19 sample. MCBs are bonds that the central government has repeatedly sought to detach from any government guarantee since the 2014 reform of local government debt (Chen et al., 2020); they are held mainly by securities firms, mutual funds, and insurance companies (Chen et al., 2023a), and their yields vary across cities with local fiscal fundamentals. Indeed, Geng et al. (2025) show that each central-government move to curtail implicit guarantees for financing vehicles—in 2014, 2018, and 2021–22—was followed by a sharp widening of MCB spreads between fiscally weak and fiscally strong cities, consistent with investors placing greater weight on local credit risk as expectations of government support weaken. MCB yields therefore contain information about city-level credit risk and financing conditions; even though expectations of higher-level government support may also affect their levels, such support does not prevent these yields from measuring the effective borrowing costs faced by local financing vehicles.³⁵

Because other forces may affect both MCB yields and industrial discounts, we build on Chen et al. (2020) and instrument MCB yields using the 2009 four-trillion-RMB stimulus. In response to the global financial crisis, the central government launched a four-trillion-RMB stimulus in 2009–10, and local governments' resulting infrastructure investment had lasting effects on their fiscal positions and hence on future bond yields. How much they invested depended on the tenure clock: Chen et al. (2020) show that cities in provinces whose governors were late in their terms invested more in 2009, plausibly because the incentive to comply with the center rises with the governor's tenure.³⁶

³⁵In Section 4.4.4, we use within-city tax-sharing shocks rather than cross-city variation in local government borrowing costs to estimate quantity adjustment. We make this choice because the tax-sharing changes apply only to the incremental tax base above the 2015 level, plausibly limiting their effect on overall fiscal capacity and public-good provision during 2016–2019; by contrast, differences in borrowing costs across cities during 2012–2019 likely have a larger effect on public-good provision.

³⁶This relates to the literature linking local officials' promotion incentives to growth over the course of their terms (Ru, 2018). City governments also have strong incentives to follow their provincial governor's agenda under China's "one-level-up" system, in which officials' promotions are largely determined by their

Following [Chen et al. \(2020\)](#), the instrument LateTerm_c equals one if city c 's provincial governor had been in office for at least three years at the start of 2009. LateTerm_c predicts lower MCB yields in subsequent years, especially 2012–19, consistent with 2009 infrastructure investment strengthening later fiscal positions—for example, through more valuable land inventory ready for sale or use as collateral. The first stage is strong, with an F-statistic of 33.65 for 2012–19.

The exclusion restriction is that these fiscal changes affect future industrial discounts only through MCB yields; in particular, the size of the land inventory, which LateTerm_c affects, must not directly affect the mix of land offered for sale.³⁷ In addition, [Chen et al. \(2020\)](#) show that, because of the anticorruption campaign launched in 2012, governor tenure in 2009 is barely correlated with tenure after 2012. We therefore use the sample from 2012 on, so that 2009 tenure does not affect later land allocation through later governor terms.

We estimate

$$\text{IndDisc}_{c,t} = \beta \times \text{MCBYield}_{c,t} + \sum_{\tau} \gamma'_{\tau} \cdot \mathbf{1}_{t=\tau} \cdot [X^1_{c,2008}, X^2_{c,t}] + \epsilon_{c,t}, \quad (31)$$

where $\text{MCBYield}_{c,t}$ is the issuance-weighted average yield of MCBs issued by city c in year t .³⁸ We estimate Eq. (31) on 2012–19 and control, with year-specific coefficients, for two sets of city conditions: ex ante measures $X^1_{c,2008}$ (GDP per capita, GDP growth, and the fiscal deficit relative to GDP, all in 2008) and ex post measures $X^2_{c,t}$ (growth of GDP, land prices, and industrial output from 2008 to t), which absorb channels through which LateTerm_c might affect the outcome and violate the exclusion restriction.

In Panel A of Table 5, the OLS estimates in Columns (1)–(3) show that industrial immediate superiors ([Chen and Kung, 2019](#)).

³⁷[Chen et al. \(2020\)](#) show that provinces with more stimulus bank loans in 2009 saw faster MCB growth and more shadow banking in 2012–15 because of refinancing. Their result concerns quantities; the effect on future MCB yields is ambiguous precisely because of the expanded land inventory.

³⁸The standard definition of MCBs comes from Wind ([Chen et al., 2020](#)), but its sample is limited before 2010. Our sample includes MCBs defined by Wind or ever included in the ChinaBond Urban Construction Investment Bond Yield-to-Maturity Curve.

Table 5: Industrial Discount and Municipal Corporate Bond Yield

Panel A: Effect on Industrial Land Discount

Specification	OLS	OLS	OLS	IV	IV	IV
Dep Var: IndDisc	(1)	(2)	(3)	(4)	(5)	(6)
MCBYield, %	-814.0*** (-9.486)	-456.2*** (-6.214)	-339.4*** (-5.398)	-2,683*** (-7.382)	-3,551*** (-3.057)	-3,612** (-2.568)
Ex-ante Controls	No	Yes	Yes	No	Yes	Yes
Ex-post Controls	No	No	Yes	No	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,540	1,536	1,534	1,540	1,536	1,534
#City	276	275	275	276	275	275
F statistic				33.65	9.026	7.730
AR test (p-value)				0.0000	0.0000	0.0004

Panel B: Effect on Industrial versus Residential Land Supply

Dep Var:	(Ind-Res)/Pop	Ind/Pop	Res/Pop
	(1)	(2)	(3)
MCBYield, %	-48.24** (-2.218)	-22.55 (-0.956)	25.69** (2.237)
Ex-ante Controls	Yes	Yes	Yes
Ex-post Controls	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	1,629	1,629	1,629
#City	298	298	298
F statistic	30.30	30.30	30.30
AR test (p-value)	0.0160	0.3291	0.0141

Note: This table shows the effect of City MCB yields on industrial land discount (Panel A) and the industrial relative to residential land supply in square meters per 100 people (Panel B). The sample period is from 2012–19. Standard errors are clustered by cities. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

discounts are negatively correlated with MCB yields. Instrumenting with LateTerm_c (Columns (4)–(5)), the effect remains negative and significant, and it barely changes when we add the ex post controls (Column (6)).³⁹

Panel B turns to *quantities*, replacing the dependent variable with land sold per capita. As predicted, higher MCB yields raise residential land sales and lower industrial land

³⁹Although the first-stage F-statistics in Columns (5) and (6) fall below the conventional Staiger–Stock threshold of 10, the weak-instrument-robust Anderson–Rubin test rejects a zero coefficient on MCBYield at the 1% level (Keane and Neal, 2024).

sales (though insignificantly): a 1 percentage point increase in MCB yields lowers annual industrial relative to residential land supply by 0.5 square meters per capita.

City governments' land allocations are thus tied to their financial strength, and because land allocation shapes the relative size of real estate and manufacturing, municipal finance policies can have knock-on effects on industrial structure.

6 Conclusion

Land is among the most important resources, and its allocation across uses has large welfare consequences. We show that assessing this allocation requires accounting for the taxes each use generates: because future taxes are capitalized into land prices, efficiency is judged by tax-inclusive, not upfront, prices. Once long-run industrial taxes are counted, the large residential–industrial price gap in China mostly reflects tax capitalization: land misallocation is modest overall. The direction of misallocation varies across cities, however: developed cities with high house prices would benefit from shifting land toward residential use, and less developed cities from the opposite reallocation.

On the supply side, fiscal considerations distort land allocation only when local governments lack flexible tax instruments, so that land sales take on a financing role. Consistent with this channel, cities retaining a smaller share of industrial taxes or facing higher borrowing costs supply more residential land and have smaller industrial discounts. Shocks to local public finances can therefore have lasting effects on land allocation and industrial structure. The central government can use tax sharing to counteract land-supply distortions arising from local governments' market power or nonpecuniary objectives.

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Online Appendix

A Model Appendix

Proof of Proposition 1 and 2.

Proof. For compactness, define the two tax-inclusive marginal land prices:

$$V_I = P_I + \sum_{t \geq 1} \frac{\tau}{(1+r)^{t-1}} \frac{\partial y_t}{\partial L_I}, \quad V_R = P_R + \tau P_h \frac{\partial y_h}{\partial L_R} \quad (32)$$

We have

$$u_{L_I} = \lambda_h \sum_{t \geq 1} \frac{1}{(1+r)^{t-1}} \frac{\partial y_t}{\partial L_I} = \lambda_h V_I, \quad u_{L_R} = \sum_{t \geq 1} \beta^{t-1} \cdot \frac{\partial u(c_t, h; A_t)}{\partial h} \phi = \lambda_h P_h \phi = \lambda_h V_R. \quad (33)$$

Given total land available $\bar{L}$, efficiency of land allocation requires

$$u_{L_I} = u_{L_R} \iff V_I = V_R, \quad (34)$$

which proves Proposition 1.

With $\{T_t^h\}$ capped at zero, the Lagrangian of the government optimization problem is:

$$\mathcal{L} = \mathcal{U}(X) + \lambda_g \mathcal{B}(X; T^h) + \mu(\bar{L} - L_I - L_R) - \sum_{t \geq 1} \mu_t T_t^h \quad (35)$$

The F.O.C with respect to L_I and L_R are:

$$u_{L_I} + \lambda_g \mathcal{B}_{L_I} - \mu = 0, \quad u_{L_R} + \lambda_g \mathcal{B}_{L_R} - \mu = 0 \quad (36)$$

Combine (33) and (36), we have

$$V_I + \frac{\lambda_g}{\lambda_h} \mathcal{B}_{L_I} = V_R + \frac{\lambda_g}{\lambda_h} \mathcal{B}_{L_R} \quad (37)$$

The F.O.C of T_t^h implies that

$$\lambda_g \frac{\partial \mathcal{B}}{\partial T_t^h} - \mu_t = \frac{\lambda_g}{(1+r)^{t-1}} - \mu_t = 0$$

When the constraint on T_t^h does not exist or is non-binding, $\mu_t = 0$ and hence $\lambda_g = 0$. Equation (37) then reduces to $V_I = V_R$, which proves part (i) of Proposition 2. When the constraint on T_t^h is binding, $\mu_t > 0$ and hence $\lambda_g > 0$. Equation (37) then gives

$V_I - V_R = \frac{\lambda_g}{\lambda_h} (\mathcal{B}_{L_R} - \mathcal{B}_{L_I})$ with $\lambda_g/\lambda_h > 0$, so the marginal output value of industrial land falls short of that of residential land—industrial land is oversupplied—if and only if $\mathcal{B}_{L_I} > \mathcal{B}_{L_R}$, which proves part (ii). $\square$

Proof of Proposition 3.

Proof. Part 1: Partial equilibrium.

The F.O.C. of the government problem is

$$\mathcal{U}_X + \lambda_g \mathcal{B}_X = 0 \quad (38)$$

We evaluate Condition (38) along the equilibrium path with endogenous T_t^g . With (λ_h, λ_g) fixed, take total differentiation of condition (38) with respect to s , we have

$$\begin{aligned} (\mathcal{U}_{XX} + \lambda_g \mathcal{B}_{XX}) \frac{dX}{ds} + (\lambda_h + \lambda_g) \begin{bmatrix} \tau Y_{L_I}^g \\ \sum_{t \geq 1} \frac{\tau}{(1+r^g)^{t-1}} \frac{\partial y_t}{\partial G} \\ 0 \end{bmatrix} &= 0 \\ \frac{dX}{ds} &= -(\mathcal{U}_{XX} + \lambda_g \mathcal{B}_{XX})^{-1} (\lambda_h + \lambda_g) \begin{bmatrix} \tau Y_{L_I}^g \\ \sum_{t \geq 1} \frac{\tau}{(1+r^g)^{t-1}} \frac{\partial y_t}{\partial G} \\ 0 \end{bmatrix} \end{aligned}$$

Similarly, take total differentiation with respect to r^g , we have

$$\frac{dX}{dr^g} = -(\mathcal{U}_{XX} + \lambda_g \mathcal{B}_{XX})^{-1} (\lambda_h + \lambda_g) \begin{bmatrix} \frac{\partial}{\partial r^g} \tau s Y_{L_I}^g \\ \frac{\partial}{\partial r^g} \left(\sum_{t \geq 1} \frac{\tau s}{(1+r^g)^{t-1}} \frac{\partial y_t}{\partial G} \right) \\ -\frac{\partial}{\partial r^g} \frac{1}{(1+r^g)^{t-1}} \end{bmatrix}$$

Denote $\mathcal{H} = \mathcal{U}_{XX} + \lambda_g \mathcal{B}_{XX}$ and assume $\mathcal{H}$ is non-singular. The F.O.C. with respect to A_t implies that $\lambda_h + \lambda_g > 0$. Also, $Y_{L_I}^g > 0$ and $\frac{\partial y_t}{\partial G} > 0$. Therefore, to show $\frac{dL_I}{ds} > 0$, it suffices to show that $\mathcal{H}^{-1}$ is entry-wise non-positive. For $\frac{dL_I}{dr^g}$, note that the F.O.C. of L_I does not involve A_t , and hence how the F.O.C. of A_t change with r^g should not impact L_I . In other words, $\mathcal{H}_{13}^{-1} = 0$. Therefore, to show $\frac{dL_I}{dr^g} < 0$, it suffices to show that $\mathcal{H}^{-1}$ is entry-wise non-positive. To this end, we apply the M-matrix theorem to $\mathcal{H}$.

First, at the optimal X , $\mathcal{H}$ must be negative semi-definite.

Second, we check the off-diagonal of $\mathcal{H}$ is entry-wise non-negative. With the utility function being separable and λ_h being constant, we have

$$\begin{aligned} \mathcal{U}_{L_I, A_t} &= 0, \mathcal{U}_{G, A_t} = 0, \mathcal{U}_{A_t, A_{t'}} = 0, \forall t \neq t' \\ \mathcal{B}_{L_I, A_t} &= 0, \mathcal{B}_{G, A_t} = 0, \mathcal{B}_{A_t, A_{t'}} = 0, \forall t \neq t' \end{aligned}$$

For the cross derivatives with respect to L_I and G :

$$\mathcal{U}_{L_I, G} + \lambda_g \mathcal{B}_{L_I, G} = \lambda_h(1 - \tau)Y_{L_I, G} + \lambda_h \tau s Y_{L_I, G}^g + \lambda_g \tau s Y_{L_I, G}^g + \lambda_g(1 - \tau)(Y_{L_I, G} + L_I Y_{L_I, L_I, G})$$

Assuming that the marginal industrial land sales revenue increases with G , we have

$$0 < Y_{L_I, G} + L_I Y_{L_I, L_I, G} < Y_{L_I, G}.$$

If $\lambda_g \geq 0$, then $\mathcal{U}_{L_I, G} + \lambda_g \mathcal{B}_{L_I, G} > 0$. If $\lambda_g < 0$, then

$$\begin{aligned} \mathcal{U}_{L_I, G} + \lambda_g \mathcal{B}_{L_I, G} &> \lambda_h(1 - \tau)Y_{L_I, G} + \lambda_h \tau s Y_{L_I, G}^g + \lambda_g \tau s Y_{L_I, G}^g + \lambda_g(1 - \tau)Y_{L_I, G} \\ &= (\lambda_h + \lambda_g)((1 - \tau)Y_{L_I, G} + \tau s Y_{L_I, G}^g) > 0. \end{aligned}$$

Therefore, apply the M-matrix theorem to $\mathcal{H}$ and $\mathcal{H}^{-1}$ is entry-wise non-positive.

Part 2: General equilibrium.

Assume the following functional forms:

$$\begin{aligned} u(c_t, h; A_t) &= \gamma \log(c_t) + (1 - \gamma) \log(h) + \kappa \log(A_t), \\ f(L_I, G) &= L_I^\alpha g^\varphi \text{ where } g = G + G_0, G_0 > 0. \end{aligned}$$

Given these assumptions, for each unit of industrial output, the government receives τs in tax payment, $(1 - \tau)\alpha$ in industrial land sales, and $(1 - \tau)(1 - \alpha)(1 - \gamma)$ in residential land sales. In total, the government receives $\pi(s) = (1 - \tau)(1 - \gamma + \alpha\gamma) + \tau s$ and household consumption of industrial goods increases by $1 - \pi$, where $\pi = \pi(1)$.

Intergovernmental Tax Sharing. Set $r^g = r$. Denote $\lambda'_g = \lambda_h + \lambda_g$. The F.O.C. for A_t and G are:

$$[A_t] \beta^{t-1} \frac{\kappa}{A_t} - \lambda'_g \frac{1}{(1 + r)^{t-1}} = 0 \quad (39)$$

$$[G] \sum_{t \geq 1} (\lambda_h(1 - \pi) + \lambda'_g \pi(s)) \frac{1}{(1 + r)^{t-1}} \frac{\partial y_t}{\partial G} - \lambda'_g = 0 \quad (40)$$

Substitute λ_h with the first-order condition for c_t , (40) can be rewritten as:

$$\frac{1}{\lambda'_g g^\varphi} = \frac{(1-\beta)}{\varphi\gamma} (g^{1-\varphi} - L_I^\alpha \varphi \pi(s) \frac{1+r}{r}) \quad (41)$$

Combine (39), (41), the government budget equation can be written as

$$g(1 + \frac{\kappa}{\varphi\gamma}) - G_0 = L_I^\alpha g^\varphi \frac{1+r}{r} \cdot \pi(s) \cdot (\frac{\kappa}{\gamma} + 1) + \sum_{t \geq 1} \frac{T_t^g}{(1+r)^{t-1}} \quad (42)$$

Substitute $\sum_{t \geq 1} \frac{T_t^g}{(1+r)^{t-1}} = \tau(1-s) \frac{1+r}{r} L_I^\alpha g^\varphi$ and divide both sides by g^φ , (42) becomes

$$g^{1-\varphi} (1 + \frac{\kappa}{\varphi\gamma}) - G_0 \cdot g^{-\varphi} = L_I^\alpha \frac{1+r}{r} \cdot (\pi(s) \cdot (\frac{\kappa}{\gamma} + 1) + \tau(1-s)) \quad (43)$$

By the envelope theorem, the optimal land allocation satisfies:

$$\frac{1-\gamma}{\alpha(\bar{L} - L_I)} = \frac{\gamma}{L_I} + \pi(s) \cdot (1-\beta) \lambda'_g \frac{1+r}{r} L_I^{\alpha-1} g^\varphi \quad (44)$$

(43) implies that g increases when s increases. To show that L_I increases with s , (44) implies that it is sufficient to show $\lambda'_g g^\varphi$ increases with s . Based on (41), it is equivalent to show that the RHS decreases with s . Fix L_I and differentiate (43), we have

$$\frac{\partial}{\partial s} (g^{1-\varphi} (1 + \frac{\kappa}{\varphi\gamma}) - G_0 \cdot g^{-\varphi}) = L_I^\alpha \frac{1+r}{r} \tau \frac{\kappa}{\gamma}$$

Change in the bracket term of the RHS of (41), multiplied by $1 + \frac{\kappa}{\varphi\gamma}$, is then:

$$(1 + \frac{\kappa}{\varphi\gamma}) \frac{\partial}{\partial s} (g^{1-\varphi} - L_I^\alpha \varphi \pi(s) \frac{1+r}{r}) = \frac{\partial}{\partial s} (G_0 g^{-\varphi}) - L_I^\alpha \tau \varphi \frac{1+r}{r} < 0$$

Further, let $Y \equiv \sum_{t \geq 1} \frac{y_t}{(1+r)^{t-1}} = \frac{1+r}{r} L_I^\alpha g^\varphi$ denote the present value of industrial output. The firm's first-order condition gives $P_I L_I = (1-\tau)\alpha Y$ and hence $\pi_I = (1-\tau)(1-\alpha)Y$; with log utility and $T_t^h = 0$, households spend the share $1-\gamma$ of π_I on housing, $P_h h = (1-\gamma)\pi_I$; and free entry of developers gives $P_R = (1-\tau)\phi P_h = (1-\tau)P_h h/L_R$. The price gap between residential and industrial land is therefore

$$\text{IndDisc} = P_R - P_I = (1-\tau)Y \left(\frac{(1-\tau)(1-\alpha)(1-\gamma)}{\bar{L} - L_I} - \frac{\alpha}{L_I} \right), \quad (45)$$

which increases as L_I and g increase.

Municipal Borrowing Costs. Set $s = 1$. The government budget equation is:

$$\sum_{t \geq 1} (1 - \tau)(1 - \gamma + \alpha\gamma) \frac{y_t}{(1 + r)^{t-1}} + \tau \frac{y_t}{(1 + r^g)^{t-1}} = \sum_{t \geq 1} \frac{A_t}{(1 + r^g)^{t-1}} + G, \quad (46)$$

The F.O.C for G and A_t are revised to:

$$\sum_{t \geq 1} \left(\lambda_h \frac{1 - \pi}{(1 + r)^{t-1}} + \lambda'_g \frac{(1 - \tau)(1 - \gamma + \alpha\gamma)}{(1 + r)^{t-1}} + \lambda'_g \frac{\tau}{(1 + r^g)^{t-1}} \right) \frac{\partial y_t}{\partial G} - \lambda'_g = 0 \quad (47)$$

$$\beta^{t-1} \frac{\kappa}{A_t} = \frac{\lambda'_g}{(1 + r^g)^{t-1}} \rightarrow \lambda'_g \sum_{t \geq 1} \frac{A_t}{(1 + r^g)^{t-1}} = \frac{\kappa}{1 - \beta} \quad (48)$$

The government's optimal land allocation satisfies

$$\frac{\bar{L} - L_I}{L_I} = \frac{(1 - \gamma)}{\alpha(\gamma + (1 - \beta)\lambda'_g \Theta)}, \quad (49)$$

where $\Theta = (1 - \tau)(1 - \gamma + \alpha\gamma)Y + \tau Y^g$.

Multiply (47) by G , we have

$$\lambda'_g G = \varphi \left(\lambda_h (1 - \pi)Y + \lambda'_g (1 - \tau)(1 - \gamma + \alpha\gamma)Y + \lambda'_g \tau Y^g \right) - \lambda'_g G_0. \quad (50)$$

Use (48) and (50) and the F.O.C. of c_t to replace λ_h , the government budget equation (46) can be written as:

$$\begin{aligned} \frac{\kappa}{1 - \beta} + \varphi \left(\frac{\gamma}{1 - \beta} + \lambda'_g \Theta \right) - \lambda'_g G_0 &= \lambda'_g \Theta \\ \Leftrightarrow \frac{\kappa + \varphi\gamma}{1 - \beta} &= (1 - \varphi)\lambda'_g \Theta + \lambda'_g G_0. \end{aligned} \quad (51)$$

A higher r^g lowers Θ for given (L_I, g) , but both adjust in equilibrium, so we solve for the equilibrium response. Write $\Theta = M(r^g)L_I^\alpha g^\varphi$ with $M(r^g) = (1 - \tau)(1 - \gamma + \alpha\gamma)\frac{1+r}{r} + \tau\frac{1+r^g}{r^g}$, so that $M'(r^g) = -\tau/(r^g)^2 < 0$. In (50), note that $\lambda_h(1 - \pi)Y = \frac{\gamma}{1 - \beta}$: the F.O.C. of c_t , $\beta^{t-1}\gamma/c_t = \lambda_h/(1 + r)^{t-1}$, gives $\lambda_h \sum_{t \geq 1} \frac{c_t}{(1 + r)^{t-1}} = \frac{\gamma}{1 - \beta}$, and the present value of consumption is $\pi_I - P_h h = \gamma\pi_I = \gamma(1 - \tau)(1 - \alpha)Y = (1 - \pi)Y$. Equations (49), (50), and (51) then express λ'_g , L_I , and g as functions of Θ alone:

$$\begin{aligned} \lambda'_g(\Theta) &= \frac{\kappa + \varphi\gamma}{(1 - \beta)[(1 - \varphi)\Theta + G_0]}, \\ L_I(\Theta) &= \frac{\bar{L} \alpha(\gamma + z)}{1 - \gamma + \alpha(\gamma + z)}, \quad z \equiv (1 - \beta)\lambda'_g \Theta = \frac{(\kappa + \varphi\gamma)\Theta}{(1 - \varphi)\Theta + G_0}, \\ g(\Theta) &= \frac{\varphi[(\kappa + \gamma)\Theta + \gamma G_0]}{\kappa + \varphi\gamma}. \end{aligned}$$

Both $L_I(\Theta)$ and $g(\Theta)$ are increasing, with elasticities

$$\varepsilon_L \equiv \frac{d \log L_I}{d \log \Theta} = \frac{1-\gamma}{1-\gamma+\alpha(\gamma+z)} \cdot \frac{z}{\gamma+z} \cdot \frac{G_0}{(1-\varphi)\Theta + G_0} \in (0,1),$$

$$\varepsilon_g \equiv \frac{d \log g}{d \log \Theta} = \frac{(\kappa+\gamma)\Theta}{(\kappa+\gamma)\Theta + \gamma G_0} \in (0,1).$$

Substituting into the definition of Θ gives one equation in Θ , $\log \Theta = \log M(r^g) + \alpha \log L_I(\Theta) + \varphi \log g(\Theta)$. Differentiating along an interior equilibrium ($0 < L_I < \bar{L}$, $G > 0$),

$$\frac{d \log \Theta}{dr^g} = \frac{M'(r^g)/M(r^g)}{1 - \alpha \varepsilon_L - \varphi \varepsilon_g} < 0,$$

where the denominator is positive because $1 - \alpha \varepsilon_L - \varphi \varepsilon_g > 1 - \alpha - \varphi > 0$ by strict concavity of f . Hence Θ falls with r^g , and so do $L_I(\Theta)$, $g(\Theta)$, and $Y = \frac{1+r}{r} L_I^\alpha g^\varphi$, while $\lambda'_g(\Theta)$ rises.

The price gap between residential and industrial land, which takes the same form as in (45),

$$\text{IndDisc} = P_R - P_I = (1-\tau)Y \left(\frac{(1-\tau)(1-\alpha)(1-\gamma)}{\bar{L} - L_I} - \frac{\alpha}{L_I} \right), \quad (52)$$

therefore decreases with r^g , as both Y and L_I decrease. $\square$

Land acquisition costs. Let C_I and C_R be the government's cost of acquiring a unit of land for industrial and residential use. Because compensation is paid to local households, it cancels in the aggregate resource constraint, so $\mathcal{U}(X)$ is unchanged, while the government budget becomes $\mathcal{B}(X) - C_I L_I - C_R L_R$. With $L_R = \bar{L} - L_I$, this adds $-(C_I - C_R)L_I - C_R \bar{L}$ to $\mathcal{B}$, so $\mathcal{B}_{L_I}$ falls by $\Delta C \equiv C_I - C_R$ and $\mathcal{B}_{XX}$ is unaffected. Holding (λ_h, λ_g) fixed and differentiating the F.O.C. (38) with respect to ΔC ,

$$\frac{dX}{d\Delta C} = \lambda_g \mathcal{H}^{-1} e_1, \quad \text{so} \quad \frac{dL_I}{d\Delta C} = \lambda_g \mathcal{H}_{11}^{-1} \leq 0,$$

where e_1 is the first unit vector, $\mathcal{H}^{-1}$ is entry-wise non-positive by the M-matrix argument in the proof of Proposition 3, and $\lambda_g > 0$ because the cap on T_t^h binds (Proposition 2). A higher cost of acquiring land for industrial relative to residential use therefore shifts land toward residential use. Since these linear terms do not alter $\mathcal{H}$, Proposition 3(i) holds for any fixed (C_I, C_R) .

B Supplementary Materials for Section 4

B.1 Data Cleaning

Land data. Our land sale data is from the Ministry of Natural Resources. We adopt the following procedures to remove outliers. First, the recorded size of a number of land parcels is above 10 million square meters, which are probably errors. We correct it by dividing the size by 10,000, the standard multiplier in Chinese unit systems. Second, the recorded price of some land parcels is over 100,000 yuan per square meter, which are also errors. Similarly, we scale the price down by 10,000.

We retrieve geographical coordinates of each land parcel by inputting their street addresses into the Gaode maps API. To verify the accuracy of the retrieved coordinates, we collect the Gaode address corresponding to the retrieved coordinates and compare it with the raw address in the land-sale data. We keep lands for which the Gaode address and the raw address are in the same town.

Firm data. Our firm data is from the ASIF database, collected by the Chinese National Bureau of Statistics. There is no consistent firm identifier in the ASIF database that is non-missing in all years. We thus rely on firm names to match firms across years. The database is censored from below, in the sense that one industrial firm will enter the database only in years when its annual sales exceeds a certain threshold, and if in the next year its annual sales fall below the threshold, it will not be in the database for that year. We can lose track of a firm in the ASIF database not only due to censoring, but also to other reasons such as the data collecting process or changing firm names. We discuss the potential bias of censoring in appendix B.6.

Merging. We merge the land-sale data with firm data by the name of land buyers. We merge not only land parcels directly bought by the firm, but also those bought by the firm's immediate controlling subsidiaries (ICS), and the ICSs of the firm's ICSs, and so forth. We define firm A as firm B's ICS if firm B has at least a 50% equity share in firm A. The ownership data come from firm registry information covering the universe of firms in China. Table A.1 shows how the merged sample compares to the full samples of land parcels and firms.

B.2 Constructing Urban Units

Cities are a relatively large unit of geography, and cities may have multiple clusters of developed land with different prices. To account for this possibility, we divide cities into "urban units." To do this, we use geographic data from Liu et al. (2018), who use Google Earth images to classify 30m×30m cells as urban or non-urban land, where

Table A.1: Summary Statistics of Industrial Lands and Land Buying Firms

	Obs	Mean	Std Dev	Obs	Mean	Std Dev
A. Industrial Lands Characteristics	Sample, 2007-2010			Population, 2007-2010		
Land price per square meter (yuan)	22,566	207.74	217.96	122,901	180.77	284.72
Area (1,000 m ²)	22,636	38.16	50.23	124,340	39.04	103.88
Distance to urban unit centers (km)	22,636	10.69	9.9	124,341	10.92	11.29
B. Firm Characteristics	Merged Firms, 2003-2013			All Firms, 2003-2013		
Sales revenue	70,466	260.4	1,206.591	2,151,097	178.87	1,626.65
Sales cost	70,464	222.75	1,085.41	2,150,925	151.88	2,141.12
Total assets	70,462	210.89	1,221.79	2,151,003	151.74	2,113.02
Gross value of industrial output	70,326	264.85	1,126.2	2,148,079	179.89	1,543.06
Enterprise income tax	60,334	2.75	36.92	1,969,737	1.9	38.38
Value-added tax	68,429	7.58	53.34	2,115,965	5.9	89.94
Sales tax and surtax	68,603	1.84	32.06	2,122,431	2.72	146.12
Total profit	70,345	16.71	91.4	2,149,174	11.91	269.09
Sales value	70,320	258.65	1,118.07	2,147,941	178.28	3,469.36
Average annual number of employees	69,288	363.05	1,437.91	2,124,366	287.57	7,841.25

Panel A is summary statistics of the sample and population of industrial land parcels sold during 2007-2010. Panel B is summary statistics of firm-year (2003-2013) observations in our sample of merged firms that purchased land during 2007-2010 and in the population of all ASIF firms. In total, there are 19,602 unique merged firms that purchased land during 2007-2010 and 711,023 unique ASIF firms between 2003-2013. All variables except the last one in Panel 2 are measured in one million yuan.

urban land refers to an impervious surface such as pavement, concrete, brick, stone and other man-made impenetrable cover types. We then cluster urban land into contiguous blocks, using the ArcGIS function `arcpy.AggregatePolygons_cartography`. Essentially, this function produces blocks of land, iteratively connecting blocks to form larger blocks, as long as they are within a specified distance of each other. The function has two parameter settings: the maximum permitted separation distance between units, which we set as one mile, and the maximum area of holes to fill, which we set as one square mile.

In Figure A.1, we first show the distribution of urban units throughout the country. A larger fraction of land is covered by these urban units in the more developed coastal areas, especially the Circum-Bohai Sea Region, the Yangtze River delta, and the Pearl River Delta. In Panel B we use Taizhou, a medium-sized city in Jiangsu, as an example to show the urban units. Each blue polygon with a black outline represents one urban unit.

There are 21,048 different urban units across the country. The median and mean of the total number of urban units in each prefecture city is 44 and 57, respectively. The median

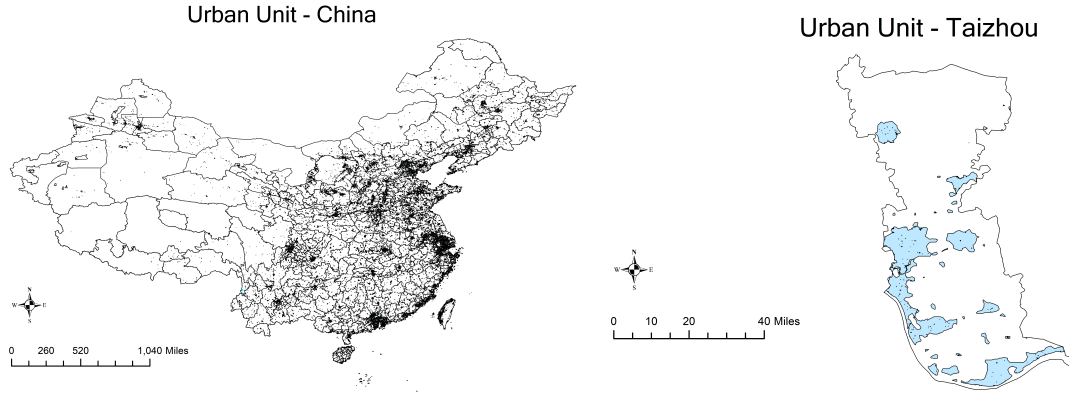


Figure A.1: Examples of Urban Units.

Note: Panel A is the distribution of all urban units in China. Panel B illustrates the urban units with the city of Taizhou. Each blue polygon with black outline represents one urban unit.

size of the urban units is 0.51 square kilometers and the mean is 8.39 square kilometers.

We extract the centroids of these urban units, and map each land parcel to the closest urban area centroid. In our estimation of industrial land discount, we use all the residential and industrial land parcels sold through auction during 2007-2019, and we impose an additional restriction to the sample size in terms of the number of land sales in each prefecture city. This leaves us with 3,837 different urban units, and the mean and median number of land parcels matched to these 3,837 urban units are 173 and 92, respectively. The mean and median size of these 3,837 urban units are 11.57 square kilometers and 0.52 square kilometers.

B.3 Land Characteristics: Industrial versus Residential

Figure A.2 shows the distribution of land characteristics for industrial and residential land. The Kolmogorov-Smirnov statistics reject the equality of distributions for land size and distance to urban center. Our identifying assumption, however, is not identical covariate distributions across uses but that the industrial parcels lie within the support of the residential hedonic characteristics and vice versa, so that the counterfactual predictions are based on interpolation rather than extrapolation. This is supported in Figure A.2.

Figure A.3 shows the distribution of the R-squared of the pricing functions (12) and its industrial counterpart across different city-period samples. The land characteristics included in the counterfactual prediction explain a reasonably large fraction of price variation.

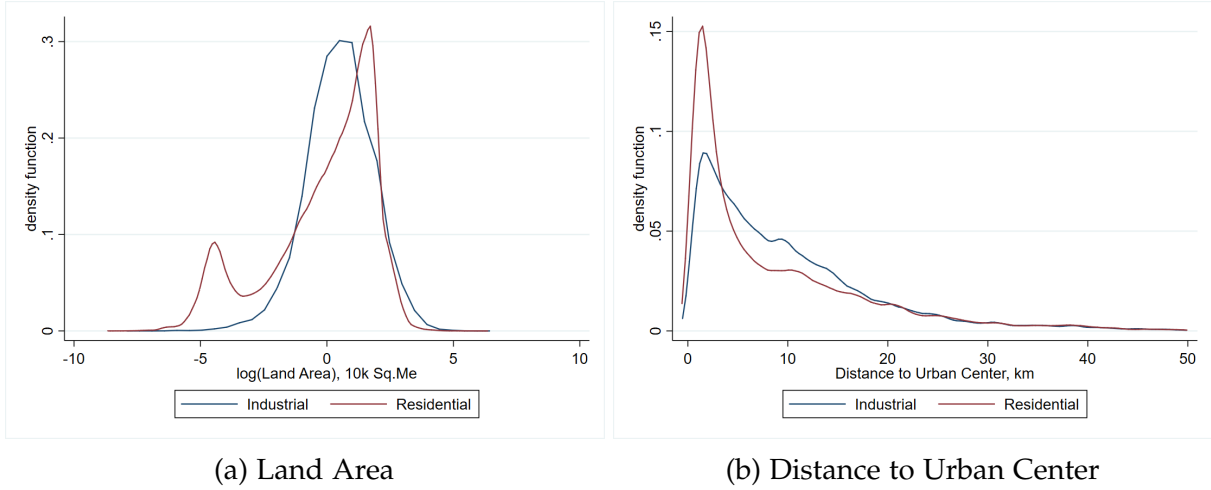


Figure A.2: Land Characteristics: Industrial versus Residential

Note: These two graphs show the distribution of land area (Panel (a)) and the distance of the land to the urban center (Panel (b)) for industrial and residential land parcels separately.

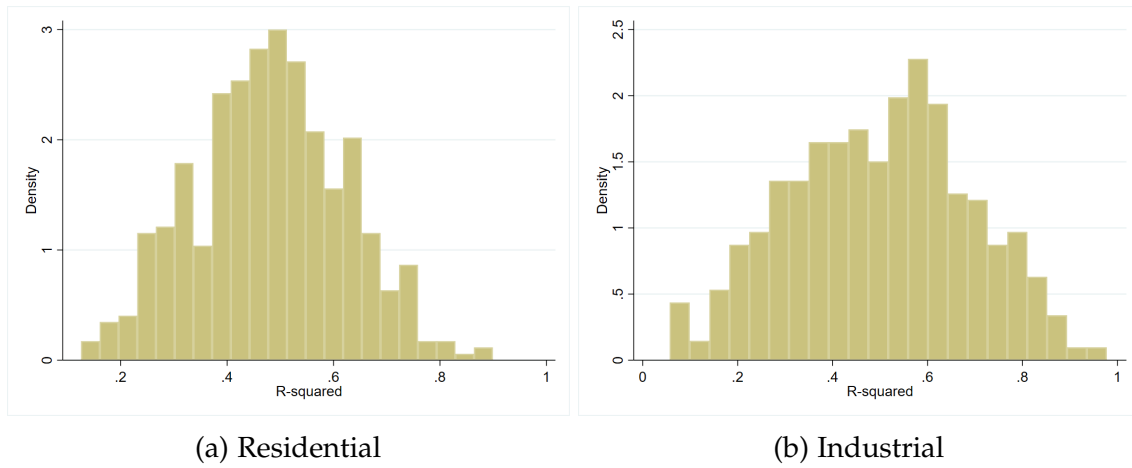


Figure A.3: Performance of the Land Pricing Model

Note: These two graphs show the distribution of R-squared of the two pricing functions, (12) and its industrial counterpart, across different samples defined by city-period combinations.

B.4 Marginal Land Zoning and Industrial Discounts

In the main text, we estimate the industrial land discount based on all incremental land supply in a given year. One concern is that, the government considers adjusting land use for a particular set of marginal land parcels, and it is for these marginal land parcels that we should compare industrial discount with the marginal future tax revenues. In this appendix, we identify marginal land parcels and calculate the city-level industrial discount that puts more weight on the marginal land parcels. The industrial firms' output

should be largely insensitive to which land parcel to operate, conditional on those sold in the same year by the same city government.

Suppose a local government considers selling a parcel i of land, in time t , as either residential or industrial. Let $U_{i,t}^{res}$ represent the government's difference in utility from selling the parcel as residential instead of industrial land; the government sells the parcel as residential if $U_{i,t}^{res} > 0$, and as industrial otherwise.

$$U_{i,t}^{res} = g(X_i) + \xi + \epsilon_{i,t}^{res} \quad (53)$$

In Eq. (53), $g(x_i)$ captures land i 's tendency to be used as residential, and ξ represents the government's overall tendency to sell residential land versus industrial land. Assume $\epsilon_{i,t}^{res}$ is i.i.d. and follows Type I extreme value distribution. The probability of a parcel with characteristics X_i being sold as residential is:

$$p(X_i, \xi) \equiv \frac{\exp(g(X_i) + \xi)}{1 + \exp(g(X_i) + \xi)} \quad (54)$$

Let $f(X)$ be the density function over land parcel characteristics. Given ξ , the expected total industrial land discount the total industrial land supply are:

$$\begin{aligned} ID(\xi) &= \int_X f(X) \cdot \text{Area}(X) \cdot (1 - p(X, \xi)) \cdot \text{IndDisc}(X) \cdot dX \\ IS(\xi) &= \int_X f(X) \cdot \text{Area}(X) \cdot (1 - p(X, \xi)) \cdot dX \end{aligned}$$

By shifting ξ , the local government can adjust the aggregate land allocation between residential and industrial uses. Imagine now the local government decreases ξ to increase industrial land supply, the cost that it will incur in the form of industrial land discount per square meter of land is

$$\frac{ID'(\xi)}{IS'(\xi)} = \frac{\int_X f(X) \cdot \text{Area}(X) \cdot p'(X, \xi) \cdot \text{IndDisc}(X) \cdot dX}{\int_X f(X) \cdot \text{Area}(X) \cdot p'(X, \xi) \cdot dX}$$

Now, by differentiating (54) and rearranging, we can find that:

$$\frac{\partial p(X, \xi)}{\partial \xi} = p(X, \xi) (1 - p(X, \xi)) \quad (55)$$

Hence, the marginal industrial land discount per square meter of land is essentially the average IndDisc weighted by:

$$\text{Area}(X) \cdot p(X, \xi) (1 - p(X, \xi)) \quad (56)$$

Table A.2: Estimating Industrial Discount With Marginal Land Zoning

Panel A: Model Predicted Residential Land Zoning

Model	Observed Land Zoning	
	industrial	residential
Logit	0.34	0.82
	0.23	0.24
	467,486	871,144
Nearest neighbor	0.24	0.87
	0.29	0.23
	470,920	874,175

Panel B: National Average Industrial Land Discount

Model	IndDisc
Simple Average	1714.9
Logit	1734.1
Nearest neighbor	1709.9

Note: Panel A shows the predicted probability of land zoning as residential versus industrial for the industrial and residential land separately, based on the local Logit model or the nearest neighbor model. Each cell reports the mean, standard deviation and number of observations. Panel B shows the national average of the city-level industrial land discounts during 2007-2010, using simple average and weighted by zoning probability predicted by local Logit model and the nearest neighbor model.

Expression (56) states that the marginal industrial land discount loads more on land parcels with higher $p(X, \xi) (1 - p(X, \xi))$. Intuitively, this term is $\frac{\partial p(X, \xi)}{\partial \xi}$, which captures how much small changes in the government's preference to sell residential land changes the *likelihood* of a given parcel i being sold as residential. The adjustment term is maximized when $p(X, \xi) = 0.5$, and is smaller when the probability of residential sales is very large or very small. This framework captures the intuition that parcels which have an intermediate likelihood of being sold as residential land are most "marginal". In contrast, when $p(X, \xi)$ is very close to 1 or 0, the government has a strong preference to sell the parcel as industrial or residential; small changes in ξ will not change the likelihood of selling the parcel as industrial versus residential substantially.

Implementation. To implement the estimation, we adopt two approaches to the estimation of $p(X, \xi)$. The first approach is to assume a linear Logit model, i.e., $g(X_i) = X_i\beta$, where X_i includes the second-order polynomial of log land area and distance to the urban center. As the geographic pattern of land use should be consistent over time, we

pool 2007-2019 together and estimate (β, ξ) for each urban unit separately.

The second approach is the nearest neighbor. This approach makes use of the fact that land parcels with the same use tend to cluster together. For each land parcel i in the urban unit u , we select all the land parcels within a distance of k_u and calculate the share of these neighbors being residential, $p_i(k_u)$, as an estimate of the probability of residential zoning for i . Then for all the land parcels in the urban unit u during 2007-2019, we choose k_u to maximize the log likelihood of the observed outcome:

$$k_u^* = \arg \max_{k_u} \mathcal{L}(k_u) = \sum_i \log \left(\mathbf{1}_i^{\text{res}} p_i(k_u) + \mathbf{1}_i^{\text{ind}} (1 - p_i(k_u)) \right)$$

The estimated probability of zoning as residential is then $\hat{p}_i = p_i(k_u^*)$.

The results are shown in Table A.2. Panel A shows the performance of the two models in predicting land uses. Both models do reasonably in predicting the land use, while the nearest neighbor model performs slightly better than the Logit model. Panel B shows national average industrial discounts in the baseline specification, as well as using the re-weightings from the Logit model and the nearest neighbor model. We find that the estimates of industrial discounts barely change with the re-weightings.

B.5 Mispricing in Two-Stage Auctions

We add a robustness check addressing potential underquoting of starting bids—and, more generally, potential mispricing of final transaction prices—in the land sale process. Prior work suggests that, relative to standard English auctions with on-site open bidding, two-stage auctions may be more vulnerable to corruption, collusion, or underpricing (Cai et al., 2013; Li, 2019). We conduct an additional robustness check by recovering the counterfactual price under English auctions. Conditional on parcel characteristics, residential and industrial parcels sold through two-stage auctions are respectively 41 and 7.7 log points cheaper than comparable parcels sold through English auctions. Li (2019) estimates that 57% of this price gap can be attributed to mechanism-related mispricing. We construct adjusted prices by increasing two-stage auctions prices by 57% of the use-specific two-stage auctions–English auctions log price gap. That is, we multiply residential two-stage auctions prices by $\exp(0.57 \times 0.41)$ and industrial two-stage auctions prices by $\exp(0.57 \times 0.077)$.

The main results are robust to this adjustment, as shown in Table A.3. This exercise directly addresses the concern that the sale mechanism may depress observed final prices, especially for residential land.

Table A.3: Robustness of Key Empirical Results with Land Mispricing Adjustment

	Paper Specification	Adjusting for mispricing
Correlation across city-year pairs		0.9952
Aggregate IndDisc and IDR	1714.9, 7.4%	2111.7, 6.8%
Mean absolute deviation of industrial land share (pp)	2.6	2.2
Regression of inddisc on vatchange -Table 4, Column (1)	-1.844, -9.982, -10.64, 19.57**, 46.40***, 29.35*, 50.84***	-2.257, -12.33, -10.07, 23.91**, 52.08***, 35.00*, 54.53***
IV Regression of inddisc on MCB yield -Table 5 Panel A, Column (6)	-3,612**	-4,310**

B.6 Firm Panel Imbalance

In this subsection we analyze the causes and consequences of panel imbalance in our difference-in-differences design. As noted in Section 2.2, firms enter and exit our panel due to data linkage issues, firm births and deaths, and sales falling below a threshold for inclusion in our data. While panel imbalance arising from data linkage issues is likely to be idiosyncratic, there is a concern that left-censoring due to sales falling below the threshold for inclusion could affect our estimate of the effect of land purchase. To assess the importance of censoring, we test whether panel imbalance (firm attrition) is more likely for firms close to the censoring boundary: to the extent that panel imbalance is idiosyncratic, we should not see differences in the distribution of sales for firms that do and do not attrite.

Figure A.4 shows the results of this test in the form of kernel densities of past-year sales, separately for firms that do and do not attrite in a given year. We see the two distributions are strikingly similar. If anything, firms near the 2011 censoring boundary (denoted by the second of the two vertical dashed lines in the figure) are disproportionately likely to be *not* censored. We are reassured that the role of censoring is likely modest in generating panel imbalance.

We also examine whether panel imbalance varies by treatment status (land purchase). Table A.4 shows the survival rates of the treated and matched control firms for each event year, i.e., the percentage of firms remaining in the sample. By construction, all the firms are observed in the two years before treatment. There is not much difference between the treated and control firms in $t = v - 3$ and $t = v - 4$ in terms of the survival rates, confirming that the matching generates a comparable control group for the treatment group. However, after the treatment year, the survival rate of the treatment group is higher than that of the control group. This is consistent with the firm's expansion on the

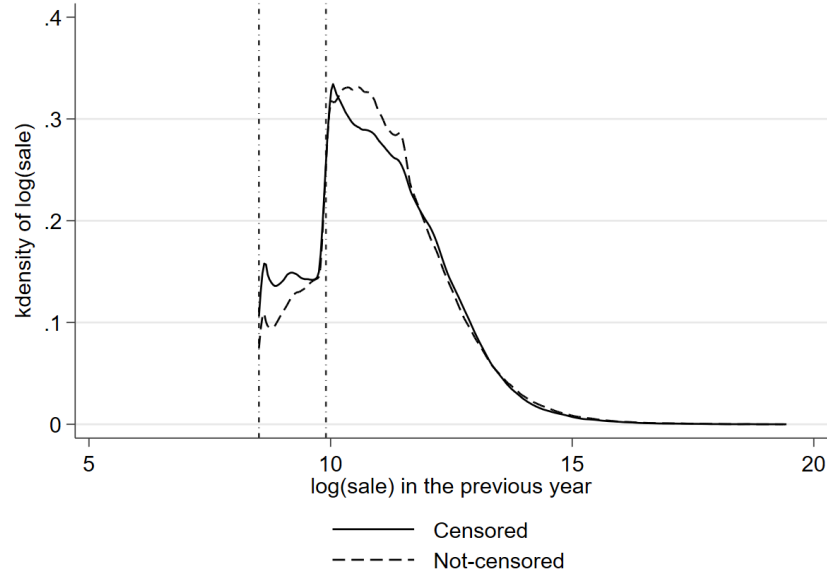


Figure A.4: Distribution of Log(Sale) in the Previous Year

Note: This figure reports the kernel densities of the past year $\log(\text{sale})$ for firms that do and do not exit in a given year separately. For 2011, the past year is 2009 as we do not have data for 2010. The two vertical dashed lines represent the censoring boundaries, which is 5 million RMB before 2011 and 20 million RMB after 2011.

Table A.4: Survival Rates of the Matched Sample

Event Year	2007		2008		2009		2010	
Treat	0	1	0	1	0	1	0	1
t=-4	37%	39%	59%	57%	64%	57%	56%	49%
t=-3	81%	78%	78%	73%	79%	75%	68%	64%
t=-2	100%	100%	100%	100%	100%	100%	100%	100%
t=-1	100%	100%	100%	100%	100%	100%	100%	100%
t=0	87%	100%	75%	100%	84%	100%		
t=1	68%	87%	59%	78%			63%	100%
t=2	55%	71%			50%	71%	59%	95%
t=3			36%	52%	46%	68%	54%	89%
t=4	32%	48%	32%	46%	40%	63%		
t=5	29%	44%	29%	42%				
t=6	26%	41%						

Note: This table reports the survival rates, i.e., the percentage of firms remaining in the sample in each year, for the treated and matched control firms for each event year. Note the rates are 100% for the two years with data before the event year by construction.

newly acquired land increasing sales and making the firm more likely to stay above the censoring threshold. While our evidence in Figure A.4 suggests the consequences of such censoring is likely to be modest, this does imply that our estimate of the treatment effect of land purchase is conservative: when the control firms exit the sample, dropping this observation removes a higher difference between the treated and control firms in sales, so dropping out these pairs will make the treatment effect estimates downward biased. This ultimately translates into a corresponding downward bias in our estimates of the effects of land sales on tax revenues, and hence a downward bias in our estimate of local governments' IDR from land sales.

B.7 Estimating Marginal Effect of Land Purchase on Sales

Table A.5 reports the estimates of specification (19) for each purchase year v from 2007 to 2010 separately.

B.8 Estimating Marginal Industrial Tax Rates

In this section, we explain how we estimate marginal industrial tax rates.

The main tax paid by industrial firms is the value-added tax (VAT). The VAT is based on the value added by the firm during each production stage. In practice, it is calculated using the firm's output times the VAT rate minus all the input times the VAT rate, which corresponds to the accumulative VAT paid by all upstream firms. As a result, the accumulative VAT paid until firm i equals firm i 's output value times the VAT rate. The VAT rate may differ across firms in different industries, and foreign exports are taxed at a lower rate than domestic sales. In the data, we observe the firm's output times VAT rate (Xiaoxiangshui in Chinese), and hence we can regress it on the firm's output value to calculate the average VAT rate.

To show that this method produces reasonable results, in Figure A.5, we show a scatterplot and a binned scatterplot of firms' accumulated tax against firms' output. The scatterplot shows that the ratio of accumulated tax to output differs nontrivially across firms: some firms pay a smaller share of output as accumulated tax than others. However, the binscatter shows that the relationship between accumulated tax and output across firms is well described by a straight line passing through 0, with slope 12.10%. This means that, on average, firms pay roughly 12.10% of output as taxes, and this does not vary substantially across firms of different sizes.

Besides value-added taxes, firms also pay income taxes and a variety of administrative fees, which we will collectively call $ITF_{j,t}$. Income taxes and fees are charged based on the firm's profit; we will assume these are homogeneous across industries. If we ignore

Table A.5: Dynamic Treatment Effect of Land Purchase on Sales

Event Year	2007	2008	2009	2010
Dep Var: sale change	(1)	(2)	(3)	(4)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v-4}$	2.926 (0.0200)	-17.28 (-0.205)	-16.84 (-0.229)	78.55 (0.491)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v-3}$	-30.64 (-0.417)	-35.27 (-0.436)	-66.02 (-1.086)	236.8* (1.813)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v-2}$	-56.99* (-1.669)	-6.641 (-0.114)	-48.77 (-1.056)	96.40 (1.603)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v}$	170.8*** (2.765)	226.3** (2.185)	124.5** (2.185)	
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v+1}$	213.7** (2.001)	355.5** (2.027)		730.0*** (4.320)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v+2}$	313.9* (1.879)		578.4*** (3.137)	1,007*** (3.215)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v+3}$		2,093*** (3.550)	658.2*** (2.659)	1,343*** (3.222)
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v+4}$	994.1** (2.395)	1,786*** (2.590)	430.3 (1.326)	
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v+5}$	928.9 (1.607)	2,641** (2.259)		
$\bar{\Delta}/\bar{S} \cdot \text{Treat} \cdot \mathbf{1}_{t=v+6}$	1,505** (2.190)			
Firm FE	Yes	Yes	Yes	Yes
Province-Industry-Year FE	Yes	Yes	Yes	Yes
Observations	9,236	4,088	13,003	16,681
R-squared	0.673	0.673	0.657	0.660

Note: This table reports estimation results of Model (19) with the matched sample. We drop matched pairs whenever the treated or the control firm exits the sample. For each treatment year $v \in \{2007, 2008, \dots, 2010\}$, the sample ranges from $v - 4$ to 2013. (Since 2010 data are missing, we do not have estimators for year at $t = 2010$.) The variable sales is in 1,000 RMB and $\bar{\Delta}$ is in 1,000 m². The year of $t = v - 1$ is used as the base year. Standard errors are clustered by firms. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

wages and predict the firm's profit with value-added ($S_{j,t} - \text{COGS}_{j,t}$), we can write:

$$\text{ITF}_{j,t} = (S_{j,t} - \text{COGS}_{j,t}) \cdot \psi_t$$

Following a similar logic to our calculations for value-added taxes, the accumulated income taxes and fees associated with firm j 's output, paid by j and its upstream suppliers, is $S_{j,t} \cdot \psi_t$. Since we do not observe accumulated income taxes and fees in the

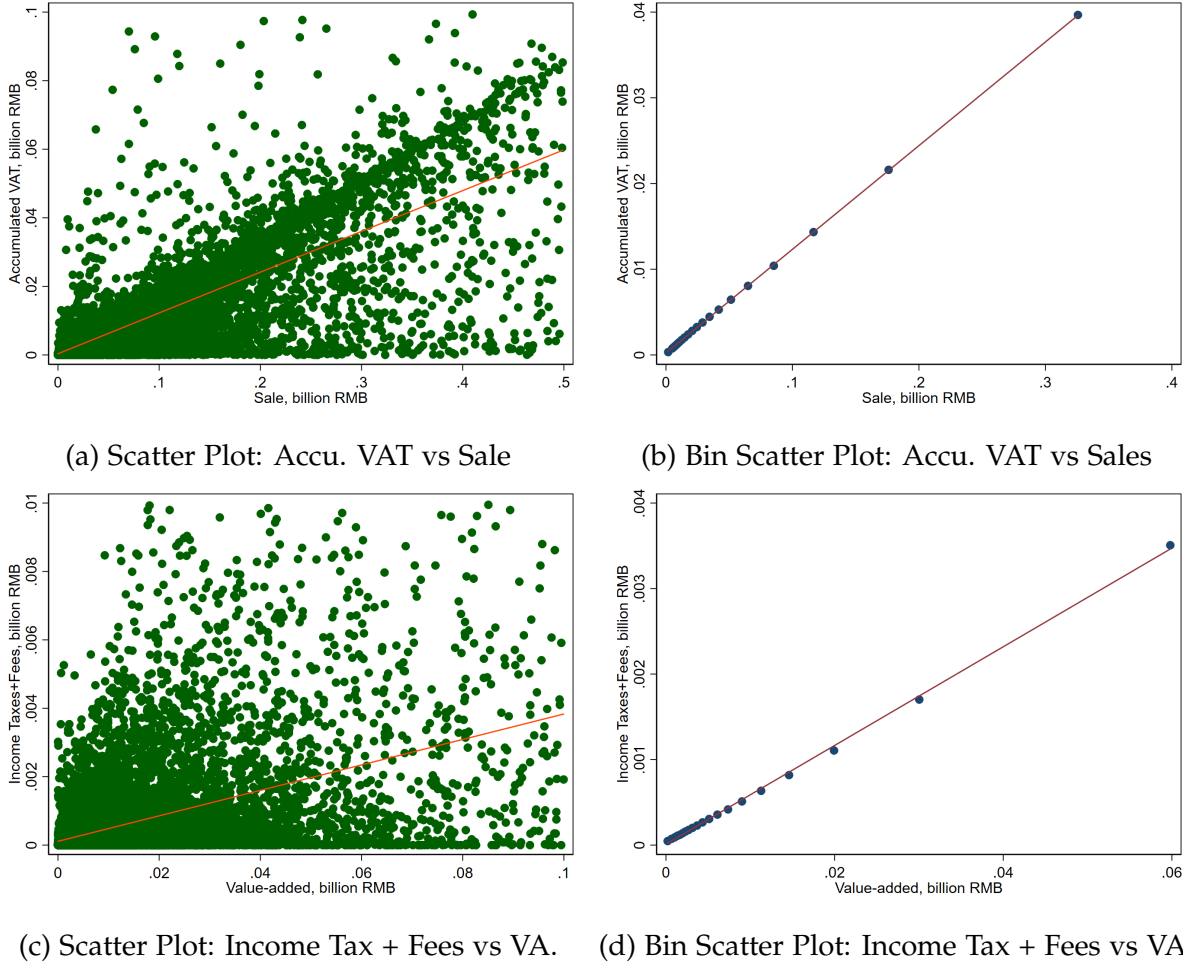


Figure A.5: Marginal VAT Rate and Income Tax and Fees Rate

Note: Panel (a) is the scatter of the "accumulated VAT" vs. sales based on a randomly chosen 1% of the sample and Panel (b) is the bin scatter of the two based on the full sample. Panel (c) is the scatter of corporate income tax plus fees vs. value-added (i.e., output minus input) based on a randomly chosen 1% of the sample and Panel (d) is the bin scatter of the two variables based on the full sample.

firm data, we instead estimate the rate ψ_t by regressing income taxes and fees, $ITF_{j,t}$, on firms' value-added, $S_{j,t} - COGS_{j,t}$. The estimate for the marginal rate is 5.77%, with a tight 95% confidence interval of [5.72%, 5.83%].

In the end, our estimate of the firm tax rate is $(12.10\% + 5.77\%) = 17.87\%$

B.9 Expected Growth of Industrial Tax Yield

Condition (5) calls for expected future tax payments at the time of land purchase. We approximate their long-run growth using external projections of China's economic growth, together with assumptions about inflation and the expansion of urban land.

We treat the 2007–2010 land-purchase years as a single estimation period and use realized nominal GDP growth within that period. For years after 2010, we use the average of five long-run projections of China’s real GDP growth: [Liu et al. \(2013, Table O.1\)](#) (World Bank), [Johansson et al. \(2013, Table 1\)](#) (OECD), [Fouré et al. \(2010, Figure 22\)](#) (CEPII), [Wilson and Purushothaman \(2006, Table 1.1\)](#) (Goldman Sachs), and [Hawksworth and Cookson \(2008, Figure 3\)](#) (PwC). Although the World Bank and OECD studies were published in 2013, their development began before 2010, making them informative about long-run growth expectations around the purchase period. As [Figure A.6](#) shows, the projections differ, particularly over shorter horizons; we use their average rather than select a single forecast. We convert projected real growth into nominal growth, assuming a constant annual inflation rate of 2.0%.

Because the relevant object is tax revenue per unit of land, we divide the resulting nominal GDP growth factors by the corresponding urban land-stock growth factors reported by the National Bureau of Statistics. We use observed land-stock growth through 2025 and assume a constant annual rate of 2.4% thereafter, equal to its 2025 value. Motivated by the role of long-term planning in urban land supply, we treat this land-stock path as predetermined and use it as a proxy for anticipated land expansion. Cumulating these growth factors gives our proxy for Z_t .

Specifically, let g_t denote projected real GDP growth and ℓ_t denote urban land-stock growth. For years after 2010, we construct nominal GDP growth per unit of urban land as

$$\frac{Z_t}{Z_{t-1}} = \frac{(1 + g_t)(1 + 0.02)}{1 + \ell_t}.$$

For 2008–2010, we instead divide the realized nominal GDP growth factor by the corresponding land-stock growth factor. Cumulating these growth factors yields our proxy for Z_t , up to an arbitrary normalization.

B.10 Complementary Evidence of Land Tax Yields

Two pieces of complementary evidence support our estimates of the taxes generated by industrial land. The first is the average VAT per square meter of industrial land: total VAT from the *China Tax Yearbook* divided by total industrial land area from the *China City Construction Yearbook*.⁴⁰ [Figure A.7a](#) shows this ratio by province in 2011, just after our 2007–10 estimation window. The cross-province average, 332.8 RMB/m², is of the same magnitude as, though somewhat larger than, our long-run marginal tax estimate of

⁴⁰We calculate the total VAT paid by firms in each province as the sum of the local governments’ and the central government’s VAT revenues.

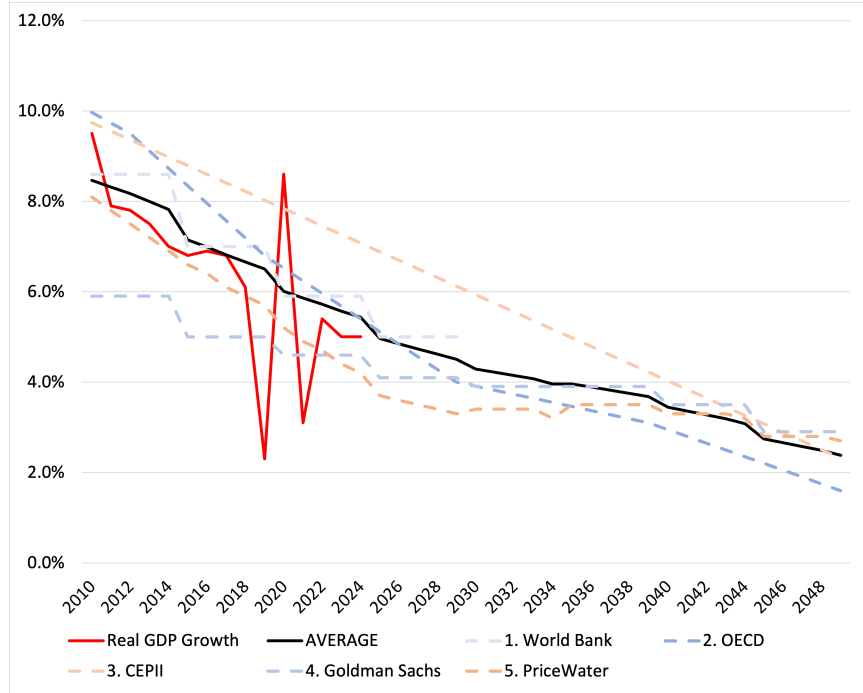


Figure A.6: Real GDP Growth: Realized versus Expected

Note: This figure plots the realized real GDP growth versus five forecasts (and their average) by different institutions made around 2007-2010.

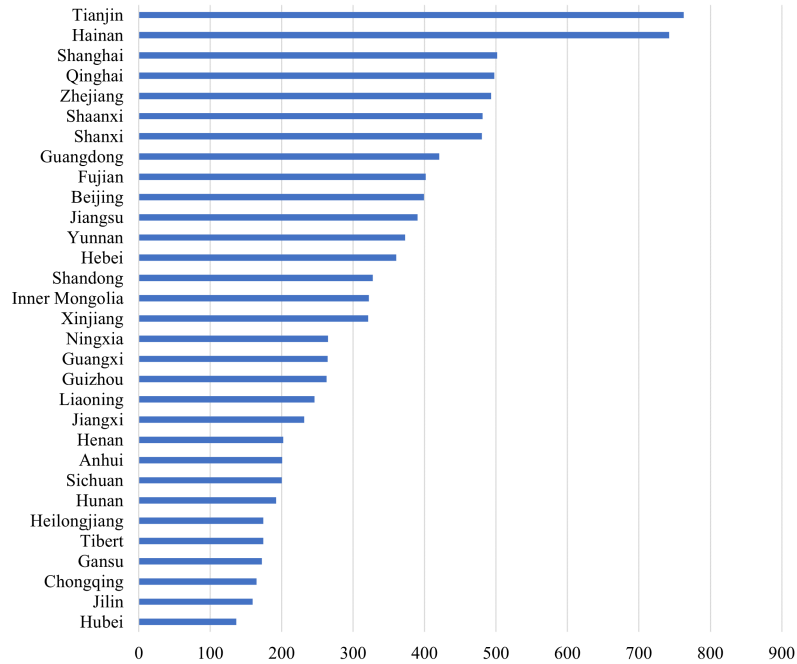
183.5 RMB/m².

The second is the official guidance on the minimum tax payment required of industrial land. In 2008, the Ministry of Land and Resources issued Guidelines on Land Supply to Industrial Projects, requiring local land bureaus to impose restrictions on industrial land supply.⁴¹ Some provinces added requirements on tax payments: Jiangsu was the first to impose an industry-specific minimum tax per unit of industrial land, in 2018, and others, such as Hunan, followed in 2020. Figure A.7b plots the industry-specific annual minimum tax set by Jiangsu and Hunan for manufacturing. For most industries it is around 100 RMB/m²; weighted by the industrial composition of 2007–10 land sales, the average is about 113.5 RMB/m². Our long-run marginal tax estimate of 183.5 RMB/m² is in line with these requirements.

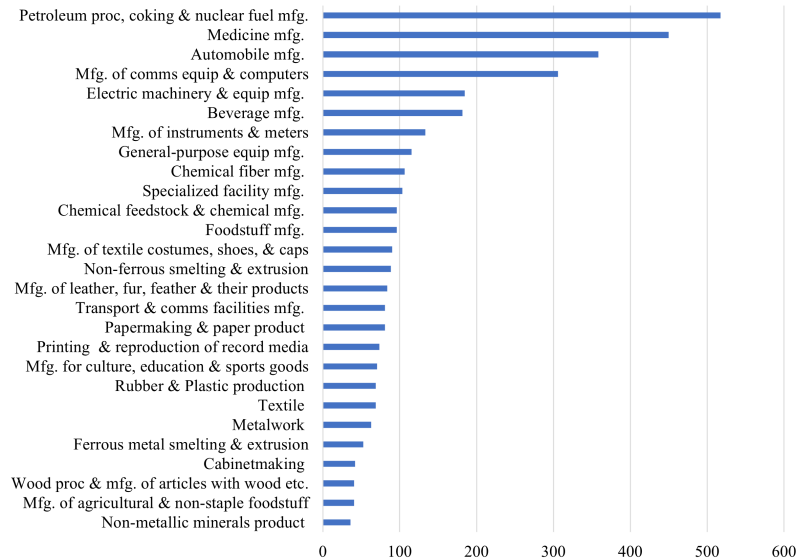
B.11 Estimating Marginal Residential Tax Rates

Figure A.8 shows a scatter plot and binned scatter plot of the listed home developers' annual taxes and sales during 2007-2021.

⁴¹These restrictions include the amount of fixed investment, floor ratio, the fraction of land for buildings and construction, and the fraction of land for offices and utilities.



(a) Total VAT Over Industrial Land for Each Province, 2011, RMB/m²



(b) Minimum Tax Requirement on Industrial Land, RMB/m²

Figure A.7: Supplementary Evidence on Land Tax Payment

Notes: Panel (a) plots the average VAT per square meter of industrial land across provinces in 2011. Panel (b) plots the industry-specific requirement on minimum firm tax payment on industrial land set by Jiangsu Province in 2018 and Hunan Province in 2020. Values are in RMB/m².

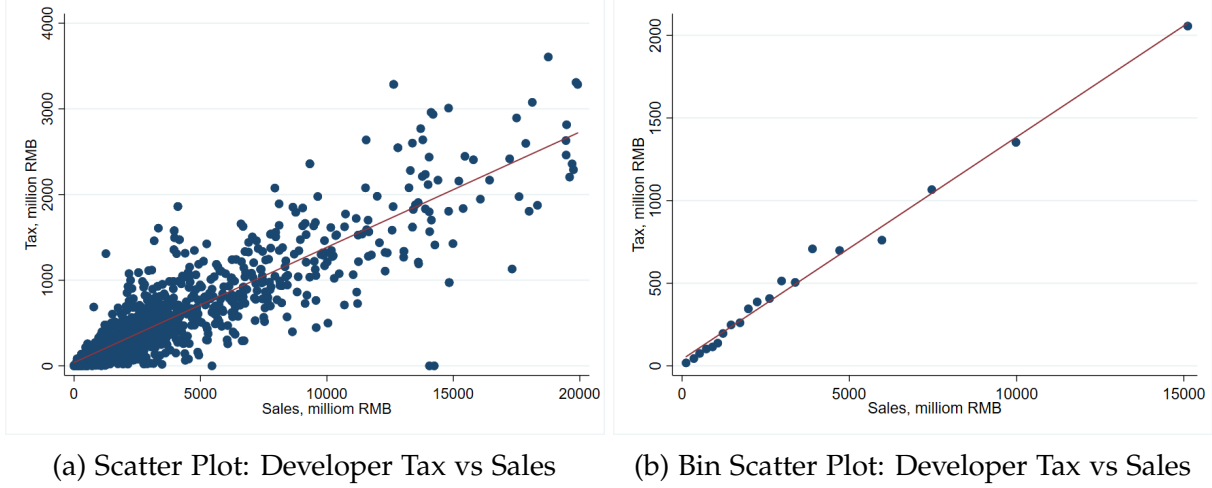


Figure A.8: Marginal Total Tax Rate of Home Developers

Note: Panel (a) is the scatter plot of the listed home developers' total annual taxes against their sales during 2007-2021 and Panel (b) is the bin scatter.

B.12 Transaction Taxes on Secondary-market Home Resales.

We assess the sensitivity of the national IDR to transaction taxes on secondary-market home resales. We assume an annual transaction rate of 6.3% of the urban housing stock, using the annual secondary-listing rate in the 2010–2012 CityRE data, relative to the urban housing stock in the 2010 Population Census, as a proxy. This is an assumed transaction rate rather than a directly observed rate of completed sales. Under a generous imputation that ignores the holding-period exemptions in the tax code and applies a 1.5 percent deed tax, a 20 percent income tax on price appreciation, and a 5 percent value-added tax on price appreciation, with average annual house-price growth of 4 percent (the average annual house price growth from 2011 to 2023 using CityRE data (He et al., 2026)), the annual secondary-transaction tax flow is

$$6.3\% \times (1.5\% + 20\% \times 4\% + 5\% \times 4\%) = 0.1575\%$$

of housing value. We assume long-run annual house-price growth of 4% and project resale-tax payments over a 70-year horizon. We discount these payments at a fixed rate of $\rho = 8\%$ to obtain PV^{resale} and add this present value to the residential side of the land-valuation comparison, expressing both components per square meter of land. The 8% discount rate used to value resale taxes is held fixed when we recompute the IDR.

Including these resale taxes reduces the national IDR from 7.4% to 6.4%, a decline of 1.0 percentage points. The national IDR remains below the 8% cost-of-capital benchmark.

B.13 Classification of Targeted Industries

Table A.6 shows the list of industries that were ever targeted by one or both of the Five-year Plans initiated in 2006 and 2011.

Table A.6: Targeted Industries of Five-Year Plan 2006 & 2011

Targeted Industries
Mfg. of agricultural and non-staple foodstuff
Chemical feedstock and chemical mfg.
Medicine mfg.
Non-ferrous smelting and extrusion
Specialized facility mfg.
Transport and comms facilities mfg.
Automobile mfg.
Electric machinery and equip mfg.
Mfg. of comms equip, computers and other electronic equip
Production and supply of electric power and heat power
Gas generation and supply
General-purpose equip mfg.
Exploitation of petroleum and natural gas
Chemical fiber mfg.
Coal mining and washing
Ferrous metal smelting and extrusion

Note: This table lists the industries that were ever targeted by one or both of the two Five-year Plans initiated in 2006 and 2011, which cover the period 2006-2015.

B.14 Firms' Cost of Capital

We use listed firms that are classified to be in the industrial sector by WIND from 2007-2024 to calculate firms' cost of capital. We first estimate their costs of equity with the capital asset pricing model (CAPM) as follows:

$$R_{j,e} = R_f + \beta_j \times (R_m - R_f),$$

where $R_{j,e}$ is the cost of equity of firm j , R_f is the risk-free rates, β_j is the market risk coefficient, and $R_m - R_f$ is the market return premium. We measure R_f with the return rate of the 10-year bonds issued by China Development Bank, a more liquid benchmark for risk-free rates. We calculate β_j using the weekly stock return during the past year.

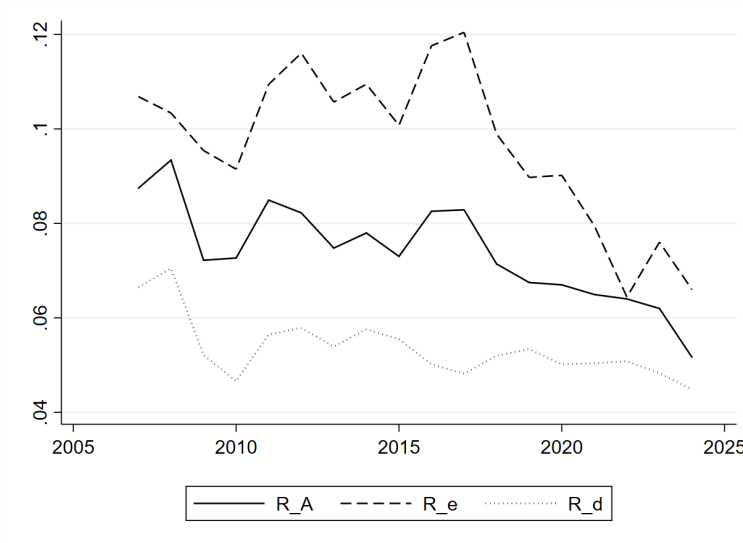


Figure A.9: Cost of Capital (R_A) of Listed Firms in the Industrial Sector

Note: This figure plots the cost of capital, i.e., the value weighted average of cost of equity and cost of debt, for the publicly listed firms that are classified in the industrial sector.

For market equity premium, we use the estimates developed by [Damodaran \(2025\)](#), who calculate the equity premium in developing countries using the equity risk premium in developed markets (i.e., the US) plus national risk premium that are indicated by Moody's rating-based default spread.

We then measure the firm's cost of capital as:

$$R_{j,A} = R_{j,e} \cdot \frac{E_j}{E_j + D_j} + R_{j,d} \cdot \frac{D_j}{E_j + D_j},$$

where $R_{j,d}$ is the cost of debt, E_j is the market value of equity and D_j is value of debt at the beginning of the year. We measure $R_{j,d}$ with the interest payment divided by the average interest-bearing debt at the beginning and the end of the year. Figure A.9 reports the average ($R_{j,A}$, $R_{j,e}$, $R_{j,d}$) over time.

To see why R_A is the natural benchmark, let X_t be EBIT, χX_t VAT revenue, and τ_c the corporate tax rate; then

$$\text{Tax}_t^I = \chi X_t + \tau_c (X_t - R_D D_t) = \frac{\chi + \tau_c}{1 - \tau_c} \underbrace{(1 - \tau_c) X_t}_{\text{FCF}_t} - \underbrace{\tau_c R_D D_t}_{\text{TS}_t},$$

where FCF_t is free cash flow and TS_t is the interest tax shield. Under target leverage, both carry the same risk and are discounted at R_A (see [Berk and DeMarzo, 2017](#), Chapter

18));⁴² we use R_A rather than the WACC because the tax shield appears explicitly in the cash flow.

B.15 Semi-elasticity of Land Price to Allocation

We run the following Difference-in-differences regression to obtain the average responses of land allocation and land prices to changes in city VAT share:

$$y_{c,t} = \alpha_c + \gamma_t + \beta \times \text{Post}_t \times \Delta \text{VatShare}_c + \varepsilon_{c,t}, \quad (57)$$

where $\text{Post}_t = 1$ if $t > 2015$ and 0 otherwise. The estimation delivers the following results:

$$\begin{aligned} \frac{d \ln(P_R)}{d \text{VatShare}} &= \frac{1}{E[P_R]} \frac{d P_R}{d \text{VatShare}} \approx 1.58\% \\ \frac{d \ln(P_I)}{d \text{VatShare}} &= \frac{1}{E[P_I]} \frac{d P_I}{d \text{VatShare}} \approx -0.83\% \\ \frac{d \ell_I}{d \text{VatShare}} &\approx 0.307\% \end{aligned}$$

We can then calculate the semi-elasticity of land prices to industrial land share as follows:

$$\xi_1 \equiv \frac{d \ln(P_R)}{d \ell_I} = \frac{d \ln(P_R)}{d \text{VatShare}} / \frac{d \ell_I}{d \text{VatShare}} \approx 5.15 \quad (58)$$

$$\xi_2 \equiv \frac{d \ln(P_I)}{d \ell_I} = \frac{d \ln(P_I)}{d \text{VatShare}} / \frac{d \ell_I}{d \text{VatShare}} \approx -2.70 \quad (59)$$

These semi-elasticities describe the joint equilibrium responses of land prices and allocation to changes in local VAT retention shares, including accompanying adjustments in public goods. Section 4.4.4 uses them to approximate an equilibrium reallocation path. Under the maintained proportional-tax structure, tax-inclusive land values have the same semi-elasticities as land prices, and the counterfactual endpoint equalizes marginal land values conditional on the public goods prevailing there.

B.16 Financial Cost of Capital versus Discount Rate

Let δ be the corporate discount rate and R_A the cost of capital. Let $V_{v,t}^I$ and $V_{v,t}^R$ be the marginal output value of industrial and residential land in year t after land purchase in year v . Competitive land demand implies that land prices plus the present value of future tax streams equal the present value of future marginal output streams, discounted at the

⁴²In the original Modigliani–Miller formulation, the debt level D is held fixed, so the interest tax shield $\tau_c R_D D$ is as safe as the debt itself and is discounted at R_D rather than R_A ; this is the case underlying the levered-beta formula of Hamada (1972). In practice, most firms target a leverage ratio rather than a debt level; D then moves with asset value, and the tax shield inherits the risk of the firm’s assets (Miles and Ezzell, 1980; Harris and Pringle, 1985).

Table A.7: Corporate Discount Rate, Cost of Capital and IDR

	IDR	IDR (Gormsen and Huber, 2025)
Baseline	7.4%	7.5%
Exclude Five-Yr-Plan-targeted industries	5.9%	6.1%
Full Tax Deduction	7.3%	7.4%
Two-year gap of Developer Taxes	7.1%	7.1%
Combination of three adjustments	5.6%	5.7%

Note: This table shows the IDR when corporate discount rate equals cost of capital (first numerical column) and when corporate discount rate exceeds cost of capital by 3.07 percentage points (second numerical column).

corporate discount rate δ :

$$\sum_{t \geq v} \frac{V_{v,t}^s}{(1 + \delta)^{t-v+1}} = P_v^s + \sum_{t \geq v} \frac{\text{Tax}_{v,t}^s}{(1 + \delta)^{t-v+1}}, \quad s \in \{I, R\} \quad (60)$$

Social optimality, in contrast, requires equalizing the present value of future marginal output streams across uses discounted at the cost of capital:

$$\sum_{t \geq v} \frac{V_{v,t}^I}{(1 + R_A)^{t-v+1}} = \sum_{t \geq v} \frac{V_{v,t}^R}{(1 + R_A)^{t-v+1}} \quad (61)$$

The optimality condition (5) holds when $\delta = R_A$. However, [Gormsen and Huber \(2025\)](#) document that corporate discount rates exceed their cost of capital by 3.07 percentage points on average. To gauge the sensitivity of our IDR estimates to this wedge, we assume

$$V_{v,t}^s = \kappa^s \times \text{Tax}_{v,t}^s \quad (s \in \{I, R\}), \quad \delta - R_A = 3.07\%.$$

Using $\delta = R_A + 3.07\% = 11.07\%$, we recover κ^I and κ^R from (60). We then solve for IDR as the discount rate ρ that equalizes the two streams from year v onward:

$$\text{IDR}_v \equiv \left\{ \rho : \sum_{t \geq v} \frac{\kappa^I \times \text{Tax}_{v,t}^I}{(1 + \rho)^{t-v+1}} = \sum_{t \geq v} \frac{\kappa^R \times \text{Tax}_{v,t}^R}{(1 + \rho)^{t-v+1}} \right\}. \quad (62)$$

Table A.7 reports the resulting estimates of IDR, which are at most 0.2 percentage point higher than those in Table 3.

C Supplementary Materials for Section 5

C.1 Guangdong Policy Changes in 2016

The main policy change that most provinces made in 2016 was to change the share of VAT taxes accruing to city governments. However, Guangdong is an outlier: it did not change the city government VAT tax share, but implemented a number of other policies to encourage city governments to allocate more industrial land. These policies thus confound our analysis of the effect of VAT tax changes on industrial land sales. When we include cities in Guangdong when estimating Equation (30), there are no significant results from dynamic treatment effect analysis (the results are available upon request).

Guangdong made the following policy changes in 2016. All cities within the province were required to specify a region within which all land had to be sold as industrial, not residential land. Cities were also broadly required to guarantee “sufficient” industrial land supply to advanced manufacturing industries. Incentives to do so included, for example, policies stating that industrial land allocated to major investment projects would not count towards land quotas, that is, the maximal amount of land that cities could sell within a certain period of time.

These policies were imposed upon city governments and supervised by the provincial government. Cities which experienced higher growth in manufacturing were to be rewarded with larger quotas for future land sales. To verify in the data that this policy encouraged more industrial land sales, we regress an indicator for whether a city received a reward of higher land quotas in 2019, on the share of land sold as industrial in the year 2017. The results are shown in Table A.8: as predicted, cities allocating more industrial land were substantially more likely to be rewarded.

The majority of these policies were applied only in the Guangdong province.⁴³ These policies are likely to have contributed to Guangdong increasing industrial land supply, despite the fact that the city government VAT share in Guangdong stayed constant in 2016. Thus, we drop Guangdong from our event study analysis.

⁴³Two exceptions are that the policy of rewarding cities with higher manufacturing growth with larger land quotas was also implemented in Guangxi in 2017, and Sichuan in 2019.

Table A.8: Industrial Land Supply and Reward in Guangdong

Dep Var: Reward	(1)	(2)	(3)
Share of industrial land supply	0.380* (1.689)	1.963* (1.843)	1.215* (1.931)
Observations	121	118	118
R ²	0.138	0.0776	0.0788
Spec	OLS	Logit	Probit
City FE	Yes	Yes	Yes

Note: This table reports the correlation between the share of industrial land supply in 2017 and whether the district/county received reward in 2019 across the 118 districts/counties in Guangdong. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$