Bidding for Firms or Bidding for People? Urban Land Allocation in China

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Abstract

In China, local government allocates a given quota of total land to different usages, mainly industrial and residential. We find a huge and geographically dispersed gap between the prices of residential land and industrial land, suggesting that Chinese local governments are oversupplying industrial land and the degree of misallocation varies across regions. We build up a parsimonious spatial economics model with migration and local governments that manipulate land allocation to maximize local output. We propose a new algorithm to compute the Nash equilibrium and calibrate the model, and show that the observations could be well accounted by the model. We show that even partial reforms to change the incentives of local governments or lift migration barrier could reduce the average industrial land space share in China from about 40% to 10-20%. The presence of endogenous local government also magnifies the effects of place-based policy in decreasing spatial inequality and increasing welfare.

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1 Introduction

Local government policies play an important role in shaping the spatial allocation of resources in one country. And the misalignment between local and national incentives could lead to severe misallocation. This is particularly true in China, where local government is believed to be the engine of its spectacular growth in the past decades (Xu 2011). The well-known "growth tournament" hypothesis suggests that local government officials are motivated to leverage policy tools to increase local GDP growth for a better opportunity of promotion within the top-down political system (Li and Zhou 2005). However, such output-prioritized incentives can lead to significant distortion. In this paper, we examine one of the most critical manifestations of these distortions: the misallocation of land use by Chinese local governments.

In China, local government has no discretion on setting tax rate and dispose tax revenue, but it enjoys discretion in determining the proportion of different land uses subject to an aggregate land quota imposed by higher government. It could sell the long term use right of land to land developers with pre-specified usages that should be strictly observed. In this paper, we focus on two most important uses of land: residential and industrial. We show that in a classical Rosen-Roback model, the optimal equilibrium features equalization between their prices. However, when we examine the land transaction data in China through the lens of hedonic regression, we see a stark disparity between the prices of industrial and residential land, as the former is much lower. We further show that the price gap is positively associated with the industrial land space share across Chinese cities, suggesting oversupply of the industrial land. Moreover, in more developed region that is closer to the coastline, the price gap and industrial land space share is larger, suggesting an unequal distribution of the distortion and more severe distortion in more developed area.

Motivated by these facts, we build a parsimonious spatial economics model with inter-regional migration and local government splits a fixed land space between industrial land and residential land to maximize local output. Each local government takes other places' conditions and land use allocation as given, leading to a Nash equilibrium. In the model, the local government needs to strike a balance between supplying more industrial land for production and supplying more residential land to attain workers who may otherwise walk away. We show, both theoretically under simplifying assumptions and numerically under reasonable parameterization, that the local government with higher local productivity tends to allocate a higher proportion of land to industrial usage, which agrees with our empirical observation. Moreover, while we allow local government to take other governments' decision as given, the model predicts very weak response of local industrial land share to the change of land use in other places. This suggests that the model equilibrium features "atomistic competition" (Agrawal et al. 2022) among local governments.

To quantitatively analyze the model, we proposed a tractable algorithm to compute the Nash equilibrium and calculate the model. Building on the mathematical program with equilibrium constraints (MPEC) approach of previous literature, we leverage on the simple structure of our model to compute the values of first order partial derivatives of outcome with respect to policy tools at any given equilibrium, and then use gradient descent algorithm to approach the Nash equilibrium. The algorithm allows us to track the marginal effect of land use allocation all the time and makes it convenient to match the Nash equilibrium to the data. We calibrate the model to a panel of 200 Chinese cities, and find that to match the severe and geographically dispersed industrial land oversupply in China, there must be high cost of workers' inter-regional migration. Starting from Tiebout (1956), literature of local government policy emphasizes the ability of residents to discipline the local government by walking away from places of bad policy ("voting by foot"). And this study suggests the mechanism working on the other side where cultural and institutional migration barrier (essentially, the household registration system, or *hukou*) allows local government to pursue local output by oversupplying industrial land at the cost of resident welfare.

We assess the impacts of several counterfactual policy reforms with the model. Firstly, we show that if all the local governments' incentives are changed from maximizing local output to maximizing the welfare of local residents, the industrial land space share will be decreased to be homogeneous and the Pareto optimum is obtained. Secondly, we show that even when we do not change the incentive of local government, lifting internal migration barrier and restoring labor mobility could also greatly reduce the industrial land space share and bring the land use allocation closed to, though not fully overlapped with, the Pareto optimum. Finally, we evaluate the effects of place-based policies, demonstrating that while the existence of local government policy exacerbated spatial inequality, it could also amplify the effects of place-based policies that are designed to decrease the inequality.

Literature This paper contributes to four strands of literature. Firstly, we contribute to the literature on resource misallocation e.g. Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Brandt et al. (2013), Liu (2019). In this literature, misallocation is caused by a wedge between prices of the same resource perceived by different enterprises, sectors, and regions. We borrow their idea in our empirical analysis to infer misallocation from price gaps between different types of land in transaction data. While our paper differs in two dimensions: firstly, we build a model to endogenize the wedge and study how changes in economic environment and policies could alleviate it. Secondly, previous literature studies the allocation of resources among different productive usages and its implication on aggregate productivity, while in our paper the land allocation is between a productive usage (industrial) and a welfare-enhancing usage (residential), and we study its implication on welfare.

Secondly, this paper is also a part of the recent literature on local government policy choices, as is reviewed in Agrawal et al. (2022). Brueckner and Neumark (2014) and Diamond (2017) demonstrated how geographical characteristics impact the rent extraction capacity of local governments in US, which is in the same line of our study where Chinese local governments set different industrial land space share under different local conditions. Parkhomenko (2020) studied the zoning policy in US, where residential development level is determined in a voting model with lobbying to maximize local real estate owner's utility, while we studied similar policies in a different context where land use is determined by a top-down local government to maximize local output. Slattery (2018) studied the subsidy competition among local governments in US to bid for firms with data of bid records. Fajgelbaum et al. (2019) and Ferrari and Ossa (2023) studied the impact of state tax and subsidy reform in US with spatial economics models. We contribute to the literature with a case study of a different local policy tool in another important economy, and highlight how political economy motivations distort the economy in this special context.

Thirdly, we propose a novel and comprehensive theory to explain the urban land misallocation in China. Previous literature offers several explanations for the phenomenon, including corruption (Cai et al., 2013), fiscal revenue maximization (He et al., 2022), and spatial competition to bid for firms and promote local economic growth (Tao et al., 2010). However, most of these studies are based on reduced-form evidence with micro-level data, and these micro-level explanations do not perfectly align with macro-level outcomes. For instance, while subsidizing industrial land may indeed attract firms, it could lead to the undersupply of residential land, discouraging residential settlement and, in turn, hindering the very economic activity it aims to foster. To account for this seeming paradox, Henderson et al. (2022) attributed the geographical dispersion of land use allocation to the dispersion in local government's preference over utility and output. While in this paper we show that the current land allocation pattern could be supported, both qualitatively and quantitatively, by a combination of two reasonable assumptions: "growth tournament" hypothesis and weak labor mobility in China, and quantify the impact of counterfactual reforms with the structural model.

Lastly, our framework aligns with the recent development in the literature of quantitative economic geography (e.g. Redding 2016) in two aspects. Firstly, we model the policy making of each location and compute the resultant Nash equilibrium in a spatial economy. Starting from Ossa (2014), similar approach has been applied to the study of local government subsidy (Ferrari and Ossa 2023), tax on multinational corporation (Wang 2020), and imposing international trade sanctions (De Souza et al. 2024). While this literature offers new insights in spatial interaction and enables us to study optimal policy in a spatial economy, computing the equilibrium is always a challenging task. In our paper, we leverage on the simple structure of our model and propose an algorithm that computes the values of first order partial derivative of objective variable with respect to the policy variable and uses the result to compute the equilibrium. Our algorithm has two advantages: firstly, it is more transparent than directly using optimization routines as we can keep track of the partial derivatives that measure the marginal impact of policy all the time. Secondly, it makes calibration much easier. Previously we need to calculate Nash equilibrium for any set of parameters and figure out which parameter value yields the best fit. Now instead we could plug in the policy variable values from data, and find the set of parameter values that equalize the partial derivatives to zero, and computing partial derivatives is much easier than computing a Nash equilibrium.

We also add to the recent literature that study Chinese economy through the lens of spatial economics models, including Tombe and Zhu (2019), Fan (2019), Yu (2019), Zi (2020), Fang et al. (2022), and Henderson et al. (2022), and Wu and You (2023). Yu (2019) and Fang et al. (2022) studied the impact of central government policies that restrict the aggregate urban land expansion in China, which is complementary to our study of the local government policies that determine the composition of land taking a total land quota as given. We are closest to Henderson et al. (2022), which similarly proposed a full-fledged spatial economic framework. However, a deliberate assumption in their model posits that local governments are making land allocations without recognition of the geographical spillovers among others. While this assumption helps them to reach a closed-form solution and a clear-cut (one-to-one) mapping from land allocation to the local government's objective function, their modeling choice also muted the interesting interplay among locations, and failed to explore the impacts of national regulation on local policy choices[1] In contrast to their approach, we build on the techniques of Ossa (2014) to compute a Nash equilibrium among local governments to highlight those channels. By doing so, we are able to explore the interactions among local governments under different national institutions.

Layout The paper is organized as follows: in the next section, we introduce the institutional background of China's urban land use policy and the dataset we use. Next, we follow with an analysis of land transaction records over the past decade to highlight three stylized facts from the land transaction data, which, aided by transaction prices, suggest the urban land misallocation in China. Drawing on these empirical insights, we construct a spatial equilibrium model that incorporates migration dynamics and endogenous urban land allocation mechanisms. Finally, we employ this model to explore the outcomes under various counterfactual scenarios.

[1]For example, consider a national policy designed to enhance labor mobility. In response, local governments would allocate more land for housing due to their increased pressure from the potential for workers to "vote by foot". However, in the model of Henderson et al. (2022), as local governments are considered to ignore such effects, the allocations would be the same.

2 Institutional Background and Datasets

2.1 Policy Background on Urban Land Allocation in China

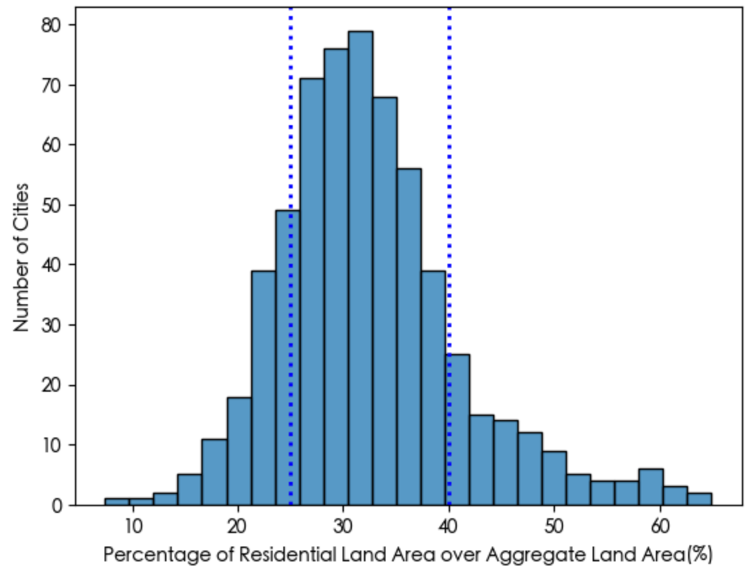
In China, a de jure socialist nation, all land is publicly owned. There are two main types of ownership: rural (agricultural) land, held by local collectives of farmers (communes), and urban land, which, according to Article 10 of China's Constitution, is owned by the government. The local government primarily manages urban land allocation, a process governed by the Law of the People's Republic of China on Land Administration, 1988. This law enables local authorities to expropriate agricultural land from collectives of farmers and convert it into urban land. Subsequently, local governments allocate their newly urbanized land for various uses by long-term leases with developers. This is called "New Construction Sites". Local governments also have the authority to requisition urban land from developers and reallocate it to different uses and developers, which is called "Existing Construction Sites". While there is no legal ban of direct transfer of land between private land developers, such secondary transaction is rare to observe. In the following context, we define the process of converting rural land to urban land as "urban land expansion", and the subsequent distribution of urban land to different usages and developers as "urban land allocation".

Urban Land Expansion and Quota Restriction Over the past decades, there has been significant growth in urban land areas as local governments have actively transformed suburban rural land into urban territories, extending urban boundaries (see Figure A.1). However, local governments are not free to expand urban land at will but subject to quotas assigned by the central government for each prefecture. These quotas are stringent, as the central government are concerned about the reduction of farmland (Yu, 2019) and the excessive expansion of cities. The importance of quota restrictions intensified after 2004 when the central committee of the Chinese Communist Party emphasized the need to enhance the role of land supply policy in macroeconomic management (Fang et al., 2022).

Urban Land Usage Allocation While subject to quota restriction on urban land expansion, local governments still afford large discretion on the subsequent land usage allocation. In a series of fiscal reforms in the 1990s, local governments' discretion on fiscal policy and claims to fiscal income were handed to central government, while they were still left responsible for most local public expenditure. As an ad hoc compensation, the central government acquiesced local government's manipulation of urban land allocation, and claims to land sales revenue, while this process was gradually formalized. Once the government has prepared the land parcels, they can transfer the land usage through various methods, including negotiation, bidding, auction, and listing. Since 2002, all commercial and residential land use has been required to be transferred through the latter three methods; and in 2007, all urban industrial lands were mandated to be sold through public auctions.

A typical land transaction takes the following form: the local government first prepares the land parcel from either newly expanded or existing urban land and assigns a specific usage and term of lease (usually 50 years for industrial land, and 70 years for residential land) for the land. Then potential land developers could bid for the land with a clear plan of developing the land for the designated usage. After the transaction, if the development plan is not carried out as scheduled, the local government could take back the land parcel (and resell it) at no cost. Therefore, it is reasonable to assert that local governments have control and are not subject to substantial central government control over the ratios of urban land area allocated to different usages. We further provide suggestive evidence for this assertion in the following graph: in Figure 2.1, we plot the histogram for residential land area share of total urban land for all the Chinese cities in the year 2019. We also draw two vertical dotted line denoting the lower and upper bound (25% and 40%) of residential land area share that is "recommended" by the central government in its national land use and planning standards (GB 50137-2011). We do not observe a bunching of residential land shares along the two boundaries, but instead, a substantial proportion (33%) of cities are outside of this range.

Figure 2.1: Distribution of Residential Land Area Share in 2019 Across Cities



Notes: The data was obtained from the Urban Construction Statistical Yearbook of China (2007 to 2019) and was published by the Ministry of Housing and Urban-Rural Development of China.

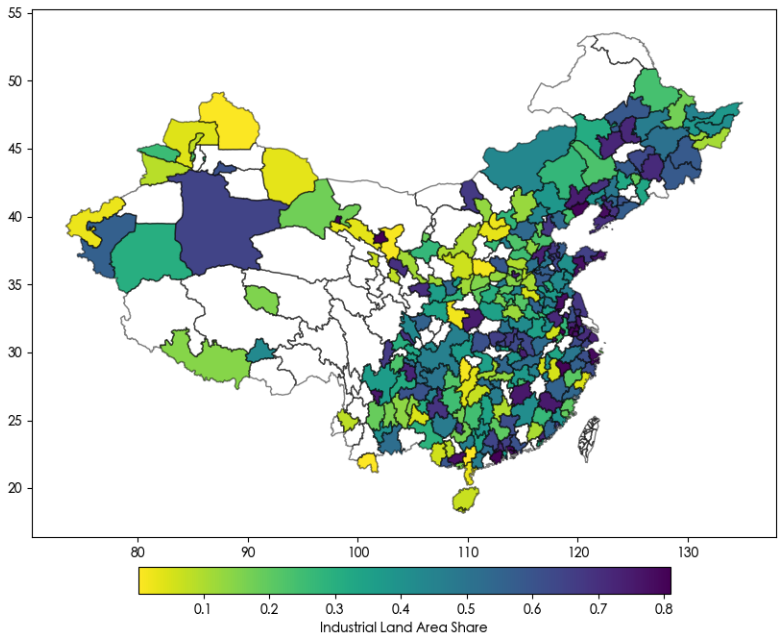
To investigate urban land allocation in China, we employ two datasets. The first dataset, derived from the statistical yearbook data on China's urban land use, represents the annual "stock" of urban land and helps illustrate the aggregate pattern and quantify the model. The second dataset, used in the empirical analysis section, consists of web-scraped data on urban land transactions over the past decade and represents the "flow" of urban land. This dataset is crucial for identifying empirical evidence of urban land misallocation. We provide a brief overview of these two datasets in this subsection.

2.2 Datasets

To study the urban land allocation in China, we employ two datasets. Firstly, to demonstrate the aggregate pattern and quantify the model, we use the statistical yearbook data on China's urban land use, which could be thought of as the annual "stock" of urban land. Secondly, in the following section of empirical analysis, to find empirical evidence on urban land misallocation, we use a dataset of web-scrapped urban land transactions in the past decade, which could be thought of as the "flow" of urban land. We briefly introduce the two datasets in this subsection.

Stock Data From Yearbook Every year, the Ministry of Housing and Urban-Rural Development of China publishes China's Urban Construction Statistical Yearbook, which can be downloaded from its website. It covers basic statistics like urban population, land area, and a series of amenity measures (e.g. energy use, public transportation) at various disaggregate levels (regional/provincial/city). Essential for our purpose, it includes a table of urban land areas of different usages at the city level. After merging the data from 2007 to 2021, we obtain a consecutive panel for more than 600 cities in China. Our primary interest is in industrial and residential land spaces, as they are the two most important land usages, as is demonstrated in Figure A.2, where the space share of industrial land and residential land has the largest mean and variance across cities when compared to other usages like commercial and public service. Their summary statistics is demonstrated in Table A.1. We also plot the quantiles of land area and industrial land area ratio across different periods in Figure A.3. Besides the urban expansion process described before, the change in urban land area across periods in the dataset could also be due to the change in administrative boundary (e.g. annexing or ceding small towns near its original boundary) and the change in statistical criteria. For example, there is a kink along the growing trends of industrial land area in 2012 in Figure A.3, which is possibly due to the adoption of new national land use and planning standards (GB 50137-2011) in that year. We also merge the yearbook data with prefecture units in China and plot their industrial land area ratio in Figure 2.2, where deeper color denotes an area with higher industrial land ratio, which concentrates near the coastline of China and occupies the most developed area in China.

Figure 2.2: Geographical Distribution of Industrial Land Area Ratio in 2019



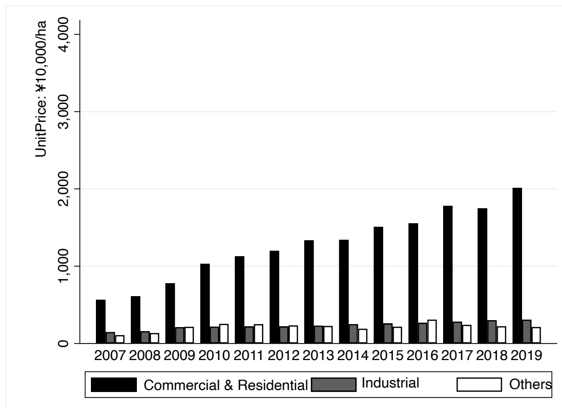
Notes: Data source is the Ministry of Housing and Urban-Rural Development of China, Urban Construction Statistical Yearbook 2019. Industrial Land Ratio is calculated as the ratio between industrial land area and the summation of industrial land area and residential land area. Map is colored at the prefecture level.

Flow Data From Transaction Records Since 2007, all industrial urban land transactions in China have been required to be auctioned and all transaction records made public. We collected public land transaction records from the Ministry of Land and Resources via web scraping. The dataset covers from the year 2007 to 2019. This dataset contains 2,243,010 land transactions, including 501,289 industrial and 1,115,517 residential-commercial land sales. Each transaction record details the characteristics of the land parcels, such as their quality (government-evaluated and categorized into several ranks before auction), area, source (whether the land is newly acquired urban land or existing urban land), and location (calculated as the distance from the land parcel to the city government and the geographical center of the county-level administrative district). It also includes information on transaction methods, prices, and pre-determined land usage. The summary statistics of the dataset are presented in Tables Table A.2 and Table A.3. The price of the land transactions will be the key focus of our empirical analysis in the next section. In Figure Figure 2.3, we plot the unit price of different types of land across years in our dataset. There is a striking discrepancy between the price of residential and commercial land and that of industrial land. While one may think that this huge price gap is not driven by their different usages, but by other factors. For example, industrial land may tend to be located further to the center of the city and hence associated with a lower price. To isolate the price gap between residential and industrial land from those other factors, we dig in in the next section.

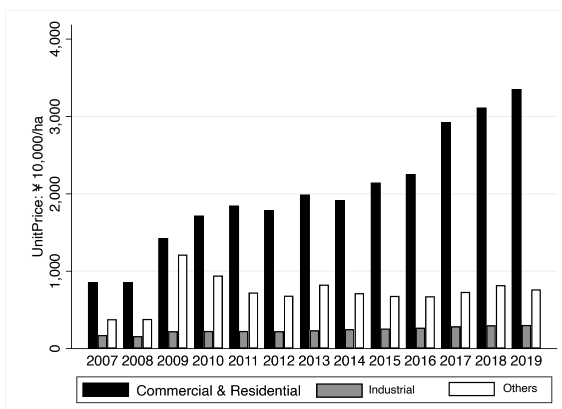
3 Empirical Analysis

In this section, we present three stylized facts about urban land prices in China. Firstly, we show that even after we control land characteristics, there is still a huge gap between the industrial and residential land in China, which is also a widely acknowledged consensus in literature. The second fact, which has received less attention in previous literature, highlights the geographical dispersion of the price gap, demonstrating that the price gap is greater in more developed cities closer to the coastline. Finally, we connect the transaction data with the aggregate allocation data, and demonstrate a positive correlation between a region's price gap and its industrial land area ratio. We end this section with a discussion of our results. Essentially, we do not attempt to fully decompose the price gap or pinpoint the exact impact

Figure 2.3: Unit Price of Industrial Land and Commercial & Residential Land



(a) Price of all land parcels



(b) Prices of land sold in auctions

Notes. The figures display the price gap between industrial land and commercial residential land. "Others" contains public service land, transportation land, water facilities land, etc. Figure (a) uses the transaction information of all land parcels for the years 2007-2019, and figure (b) uses the subsamples of land sales via public auctions.

of quantity supply on price differences, instead, we treat these findings as indicative evidence of land use misallocation in China. This misallocation is notably more severe in developed areas, thus motivating our study into the causes and consequences of urban land use allocation in China.

3.1 Stylized Fact 1: Price Gap Between Industrial and Residential Land

To investigate the price difference between lands of different usages, we run the following hedonic regression that is standard in the literature (e.g. Nichols et al. 2013, Kok et al. 2014, Albouy et al. 2018, and Henderson et al. 2022):

$$log(P_{ict}) = \beta_0 + \beta_1 IndD_{ict} + \beta_2 IndD_{ict} \times Dist_c + \beta_3 X_{ict} + \alpha_{ct} + \varepsilon_{ict} \quad (1)$$

where $log(P_{ict})$ is the unit price ($RMB10,000/ha.$) of the land parcel i in city c and year t, and $IndD_{ict}$ is a dummy variable shows whether the land is zoned for industrial usage. X_{ict} is a vector of parcel characteristics for each land sale, including the area of land, the rank of land quality [2], floor-area ratio (FAR) restrictions [3], the format of transactions(including government allocation, English auction, sealed-bid auction, and two-stage auction, with negotiation as a comparison), the source of land (new construction land, new construction land from the stock pool, and existing construction land), the distance to the city center, as well as the distance to the urban district center or rural county center. Specifically, we use the location of the government office building as the center of each city and county. We also control for the fixed effect of city-year, and set standard errors clustered at the level of

[2]City governments categorize the urban land into different tiers based on the amenity quality of land, which is an indicator of the quality of the land.

[3]Floor-area ratio (FAR) refers to the building capacity per unit area of land, i.e. the ratio of building area to site area. Local government makes restrictions on both the upper and lower bound of FAR when leasing the land.

city-year. To address the concern on the impact of development density and time length of lease, we also use the unit price per floor space and per year as dependent variables by dividing the price with FAR and terms of lease. The estimation result is demonstrated in column (1) - (3) in Table 3.1. We also conducted a series of robustness check to consider only auction subsample as is reported in Table A.4.

The coefficient of industrial dummy variable is negative and statistically significant under all specifications. Take the coefficient in column (1) in Table 3.1 as an example, the unit price of industrial land is on average (exp(-1.510)=) 22.10% of the price of the residential land with similar properties. Even when we take the mild estimates, the industrial land price is still only (exp(-0.755)=) 47.0% after accounting for the development density. In short, there is a huge price gap between residential and industrial land that is simply caused by its usage assignment.

3.2 Stylized Fact 2: Price Gap is Wider in More Developed Region

To explore the spatial distribution of the price gap, in this reduced-form part, we use the city's distance to the nearest port $Dist_c$ as a proxy for the productivity level of a city, and interact it with the industrial dummy in specification Equation 1. A natural reason of this choice is that after joining WTO in 2000, China's rapid growth was mainly driven by the reduction of external costs, and the effects of globalization are uneven among regions due to their proximity to the coast. For example, the comparative-advantage industries tend to locate closer to international gates, and large-scale workers move toward fast-growing coastal regions (Cosar and Fajgelbaum 2016; WorldBank 2009). Therefore, the distribution of local productivity is highly correlated with the spatial advantage to engage in trade liberalization.

Columns (4)-(6) in Table 3.1 report the regression result that includes the interaction term. The coefficients are positive and highly significant in

Table 3.1: Unit Price of Land on the Parcel Characteristics

VARIABLES	(1) $log(P_{ict})$	(2) $log(P_{ict}/floor)$	(3) $log(P_{ict}/time)$	(4) $log(P_{ict})$	(5) $log(P_{ict}/floor)$	(6) $log(P_{ict}/time)$
$IndDummy_{ict}$	-1.510***	-0.755***	-1.091***	-2.655***	-2.190***	-2.526***
	(-45.589)	(-26.714)	(-38.622)	(-10.255)	(-8.058)	(-9.296)
$IndDummy_{ict} \times log(Dist_c)$				0.093***	0.117***	0.117***
				(4.449)	(5.460)	(5.460)
$log(dcity_{ict})$	-0.177***	-0.165***	-0.165***	-0.176***	-0.164***	-0.164***
	(-19.207)	(-22.664)	(-22.664)	(-18.804)	(-22.291)	(-22.291)
$log(area_{ict})$	0.007	0.023***	0.023***	0.006	0.021***	0.021***
	(1.266)	(3.748)	(3.748)	(0.946)	(3.353)	(3.353)
$[log(area_{ict})]^2$	-0.002	0.005*	0.005*	-0.003	0.004*	0.004*
	(-0.937)	(1.918)	(1.918)	(-1.300)	(1.662)	(1.662)
tansway_Allocation	-1.326***	-0.981***	-0.981***	-1.334***	-0.990***	-0.990***
	(-8.442)	(-6.558)	(-6.558)	(-8.471)	(-6.611)	(-6.611)
tansway_English	1.476***	1.616***	1.616***	1.493***	1.639***	1.639***
	(23.077)	(23.928)	(23.928)	(23.221)	(24.521)	(24.521)
tansway_Sealedbid	0.966***	1.193***	1.193***	0.958***	1.189***	1.189***
	(8.757)	(12.096)	(12.096)	(8.561)	(11.911)	(11.911)
tansway_Twostage	1.032***	1.211***	1.211***	1.034***	1.216***	1.216***
	(17.345)	(20.016)	(20.016)	(17.299)	(20.113)	(20.113)
FAR_lowbound	0.052***			0.052***		
	(3.836)			(3.842)		
FAR_upbound	0.144***			0.149***		
	(11.229)			(11.350)		
source_newD	-0.148***	-0.225***	-0.225***	-0.152***	-0.233***	-0.233***
	(-7.797)	(-7.058)	(-7.058)	(-8.020)	(-7.336)	(-7.336)
source_newstockD	-0.339***	-0.612***	-0.612***	-0.341***	-0.614***	-0.614***
	(-7.061)	(-7.489)	(-7.489)	(-7.113)	(-7.520)	(-7.520)
landrank	-0.029***	-0.034***	-0.034***	-0.029***	-0.034***	-0.034***
	(-7.274)	(-8.235)	(-8.235)	(-7.422)	(-8.435)	(-8.435)
City-Year FE	Y	Y	Y	Y	Y	Y
Observations	206,788	287,101	287,101	206,788	287,101	287,101
R-squared	0.661	0.618	0.620	0.662	0.619	0.621

Notes. This table displays the price gap between industrial land and commercial-residential land, controlling the information of each land parcel. Transaction records in urban areas from 2007 to 2019 are used. Column (2) takes the unit price of residential lands over the upper bound of FAR and compares it with the unit price of industrial land. Column (3) further takes the unit price of lands over the leasing time for each type. $Dist_c$ is expressed in unit of meter.

all specifications, which means that moving the city inland leads to a smaller price gap. To give a sense of the economic importance of the results, we use the interaction coefficient of 0.117 in column (5) as an example. Moving inland from the place of 1% shortest distance to the port to the place of the median distance (which is 463 km), the ratio between industrial land and residential land will jump from 21.96% to 49.94% after adjustment of development density. The price gap narrows by half.

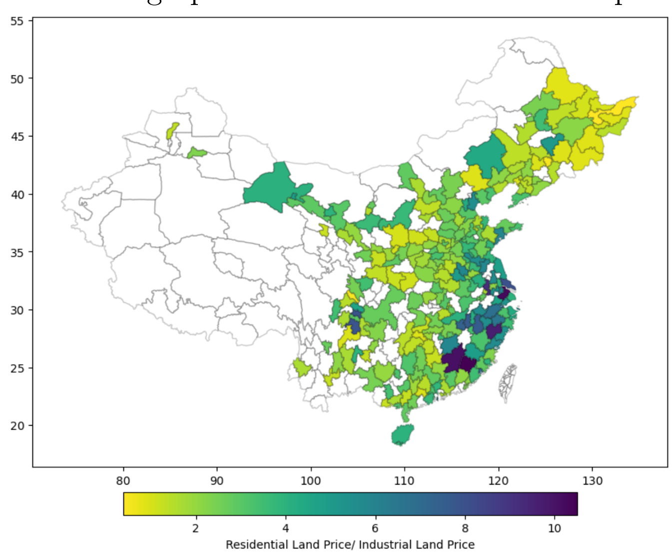
Besides regression over individual land transactions, we also run regression Equation 1 (without interaction term of distance and industrial dummy) for a subsample of land transactions in each city, to obtain the estimate of β_1, the industrial land discount, for each city. Then we can recover the ratio between residential land price and industrial land price in each city by ratio $= 1/e^{\beta_1}$. Figure 3.1 demonstrates the spatial distribution of the price gap across cities in China. From the map, we see that the eastern regions display a larger discount in the industrial land price, which fades out along the inner land.

Moreover, after obtaining location-specific β's under several specifications, we regress these city-level price gap measures on the industrial land area share and the logarithm of the distance to the coastline. The result is demonstrated in Table 3.2. There is a significant positive coefficient log distance to the coast on the city's price gap. Note that these β's are all negative, and a smaller (or larger in absolute value) denotes a wider price gap, thus the regression result also shows that as the city becomes more distant from the coast, it has a smaller price gap between residential and industrial lands.

3.3 Stylized Fact 3: Location with High Price Gap Also Tends to Have Higher Industrial Land Ratio

Finally, we establish a connection between the observed price gap and the ratio of the supplied quantity (area). Our main result is also reported in Table

Figure 3.1: Geographical Distribution of Price Gap in China



Notes. This map demonstrates the spatial distribution of the industrial discount of land prices across cities in China. We run regressions according to Equation 1 for each city and display the inverse exponential of the coefficient of industrial dummy $1/e^{\beta_1}$ in the map.

Table 3.2: Land Area Share v.s Industrial Discounts

	Whole Sample			**Auction Samples**		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	β_{IndD}	β_{IndD}^{FAR}	$\beta_{IndD}^{FAR\&time}$	β_{IndD}	β_{IndD}^{FAR}	$\beta_{IndD}^{FAR\&time}$
Panel A: 2019						
IndustrialLandRatio2019	-0.348	-0.578**	-0.578**	-0.356	-0.539*	-0.539*
	(-1.369)	(-2.241)	(-2.240)	(-1.278)	(-1.857)	(-1.856)
log(DistanceCoast)	0.107***	0.117***	0.117***	0.130***	0.143***	0.143***
	(4.094)	(4.383)	(4.382)	(4.529)	(4.779)	(4.780)
Observations	273	273	273	274	274	274
R-squared	0.076	0.100	0.100	0.087	0.105	0.105
Panel B: 2008						
IndustrialLandRatio2008	-0.487*	-0.459	-0.459	-0.271	-0.325	-0.325
	(-1.775)	(-1.635)	(-1.636)	(-0.899)	(-1.031)	(-1.031)
log(DistanceCoast)	0.107***	0.122***	0.122***	0.133***	0.149***	0.149***
	(4.106)	(4.586)	(4.585)	(4.655)	(4.993)	(4.993)
Observations	273	273	273	274	274	274
R-squared	0.080	0.092	0.092	0.084	0.097	0.097

Notes. This table shows the relationship between the share of industrial land in the base year (2008) and subsequent industrial land discounts from 2008 to 2019. We run regressions based on Equation 1 and Table 1 for each city to estimate β for each city. The dependent variable in columns (1) and (3), β_{IndD}, shows the price gap between industrial and residential lands, adjusting for the attributes of each land parcel as Table 1. The dependent variable in columns (2) and (4), β_{IndD}^{FAR}, is obtained by taking the unit price of residential lands over the upper bound of FAR and comparing it with the unit price of industrial land. The dependent variable in columns (3) and (6) considers the disparity in the official lease duration for these land types: 70 years for residential and 50 years for industrial land. Panel A displays the results for all observations, while Panel B shows the findings from transactions via public auctions, including auctions, listings, and bidding processes.

Table 3.2. Even after controlling the distance to the coast, we still observe a negative impact of the industrial land area ratio on β's, the industrial land price gap. This indicates that at least, we could regard distorting industrial land oversupply as one of the many factors that contribute to such a huge price gap.

3.4 Discussions

As is mentioned earlier, the purpose of this section is to demonstrate the huge and geographically dispersed price gap, and suggest that the local government supplying too much industrial land over residential land could be a contributing factor. In the case of distributing a resource to various productive activities, it is straightforward that a gap in its marginal product (price) in different usages indicates misallocation. But it is less obvious in our case where the land is distributed between one productive usage and the other non-productive usage, as some may argue that the optimal land allocation should feature a price gap. To address these concerns, we firstly build a simple Rosen-Roback model in Appendix B, showing that the optimal allocation (i.e. the allocation that maximizes local welfare) features equal price between the two usages.

Comparison to the Land Market in the US Another straightforward way to demonstrate that the current price pattern indicates inefficiency in land use allocation is to make international comparison with other countries where the land market is less intervened by government. While we do not have available data on other countries yet, we can compare our results with some existing research. Kok et al. (2014) uses the sample of land transactions in the San Francisco Bay Area and runs a regression of unit price on characteristics of land quality, locations, and indicators of different usages. In their benchmark result (Table 2 of their paper), they omit single-family apartments and find the coefficient of industrial land to be 0.044 or -0.012 in different specifications, and both estimates are not statistically significant from 0. This is clearly and substantially different from our result, where the estimated coefficient of the industrial dummy variable is significantly smaller than 0 and large in magnitude. They did obtain some statistically significant coefficient of commercial land (0.310) and multi-family land (0.428). However, firstly, these numbers are also smaller than our results on China. Secondly, these expensive land uses are also those most strictly zoned by San Francisco municipality government, which corresponds to out topic that government intervention leads to price gap. Moreover, we also look at the time series data in Nichols et al. (2013)[4], which includes the average land price from 1995 to 2012 in 23 US metropolitan statistical area (MSA). It is obtained by averaging all the transactions taking place within the half year, and aggregated to two usages: residential and commercial (which includes both business and industrial usages). In Figure A.4 we plot the ratio of time average price between residential land and commercial land in each city, and the result ranges from 0.4 - 1.4. Note that this is obtained from the observational data before stripping away the effects of land characteristics, and not a direct comparison between industrial and residential land. But given the limited information, it still suggests that the price gap in China is significantly larger than that in the US.

Corruption Another popular account for abnormal land prices in China is that the price could be distorted by corruption in the land market. For example, Chen and Kung (2019) showed that the firms with a link to top political officials (what they call "princeling firms") tend to enjoy a discount when purchasing land from local governments. However, as is demonstrated in Table IV of their paper, princeling firms tend to have even higher discounts for residential land. While corruption could have a substantial impact on land price, there is neither notable evidence nor intuition on how it contributes to systematic price gaps between industrial and residential land.

[4]We are grateful for Joseph Nichols for sharing the data

4 Model

In this section, we build a parsimonious spatial economics model to study how local governments make decisions on urban land allocation given the local and national economic condition. We lay out the setup of the model, define the equilibrium, and demonstrate the properties of the equilibrium under simplifying assumption and under numerical exercises. In the model, local government strikes a balance between providing more industrial land to directly increase local output and providing residential land to attract more workers and indirectly increase local output. Essentially, the local government could take advantage of the impaired mobility of workers to push the balance towards more industrial land, and it turns out that such ability of taking advantage is stronger for places with higher fundamental values (i.e. higher productivity or higher quality-of-life amenity), resulting in a positive correlation between local development and industrial land space share, which is in the same line as our empirical observation.

4.1 Setup

We consider an economy with N places, denoted by subscript $j = 1, 2, 3, ..., N$. Each place j has a total land endowment $\bar{X}_j$ that the local government could allocate to industrial and residential usage. We use K_j and H_j to denote the amount of industrial and residential land, and let the share $s_j = \frac{K_j}{\bar{X}_j}$ denote the land allocation decision made by local government. We simplify the production side to have only one homogeneous consumption good, which is produced using local industrial land, imperfectly mobile labor, and perfectly mobile capital, traded frictionlessly across regions and we denote the price as numeraire. Initially, each place j inhabits a population $\bar{L}_j$ of workers who will decide where they work and live, resulting in an equilibrium with population L_j migrating from all the places. Detailed setup is as follows.

Production In each place, representative firms use the following Cobb-Douglas technology to produce numeraire goods from labor L_j, industrial land K_j, and capital I_j:

$$Y_j = A_j(K_j^\alpha L_j^{1-\alpha})^{1-\gamma} I_j^\gamma$$

where Y_j is the total output and A_j is the place-specific TFP level. In a competitive labor market, the wage (W_j) and industrial land price (P_j^k) will equal to their marginal production, and the firm earns 0 profit:

$$P_j^k = (1-\gamma)\alpha A_j K_j^{\alpha(1-\gamma)-1} L_j^{(1-\alpha)(1-\gamma)} I_j^\gamma \tag{2}$$

$$W_j = (1-\gamma)(1-\alpha) A_j K_j^{\alpha(1-\gamma)} L_j^{(1-\alpha)(1-\gamma)-1} I_j^\gamma \tag{3}$$

$$r = \gamma A_j (\frac{K_j^\alpha L_j^{1-\alpha}}{I_j})^{1-\gamma} \tag{4}$$

Moreover, we assume that firms from all the locations compete for the footloose capital that has a fixed amount $\bar{I}$, leading to an economy-wide interest rate r such that

$$\sum_{j=1}^{N} I_j = \bar{I} \tag{5}$$

Workers For an individual worker o who settles in location j, her utility function is given below

$$U_j^o = \varepsilon_j^o B_j (\frac{h_j}{\beta})^\beta (\frac{c_j}{1-\beta})^{1-\beta}$$

where ε_j^o is the idiosyncratic preference shock, B_j is the location-specific quality-of-life amenity, h_j and c_j denote the consumption of residential land (housing) and numeraire good, respectively. After settling down in location j, the worker inelastically supplies her unit of labor, receiving wage payment W_j as income, and spends it on residential land and numeraire goods, whose prices are respectively P_j^h and one. Therefore, the indirect utility function of workers in j is:

$$V_j = B_j \frac{W_j}{(P_j^h)^\beta} \tag{6}$$

An individual worker makes their migration decision by comparing the combination of their idiosyncratic shock and V_j's for all locations. As is standard in the literature, we assume that ε_j^o is i.i.d. and follows a Frechet distribution with scale parameter ϵ. We also take into consideration the migration cost, which is measured by $d_{ij} \in (0, 1]$ to denote that the migrants from location i to location j will only obtain d_{ij} proportion of the utility in the destination. Let L_{ij} denote the population of migrants from i to j, then we have:

$$\pi_{ij} = \frac{L_{ij}}{\bar{L}_i} = \frac{(d_{ij}V_j)^\epsilon}{\sum_{k=1}^N (d_{ik}V_k)^\epsilon} \tag{7}$$

$$L_j = \sum_{i=1}^N \pi_{ij}\bar{L}_i \tag{8}$$

Land and Government Local government of place j will decide on the land allocation rule s_j such that $K_j = s_j\bar{X}_j$ and $H_j = (1 - s_j)\bar{X}_j$. Note that given the preference of workers, we have the following market clearing conditions for residential land:

$$\beta W_j L_j = P_j^h H_j \tag{9}$$

In the endogenous policy equilibrium, we assume that each local government has full information of the environment, and manipulates s_j to maximize the local output.

4.2 Definitions of Equilibrium

Given the setup of the model, we could define the equilibrium with exogenous urban land allocations given by $\{s_j\}_{j=1}^N$, as well as the Nash equilibrium where each government manipulates the policy to maximize the local output, taking others' action as given. Definitions are as follows:

Exogenous Equilibrium Given a set of parameters $\{\alpha, \beta, \epsilon, \gamma\}$ and regional fundamentals $\left\{A_j, B_j, \bar{X}_j, \bar{L}_j\right\}_{j=1}^N$, an equilibrium with exogenous policy $\{s_j\}_{j=1}^N$ is defined as a set of variables $\left\{K_j, H_j, L_j, W_j, P_j^h, I_j, V_j\right\}_{j=1}^N$ such that:

1. Land is allocated based on decision rule: $K_j = s_j \bar{X}_j$ and $H_j = (1 - s_j)\bar{X}_j$
2. Local wage, price of industrial land, and return to capital all equal to their marginal product Wage in place j equals its marginal product in every place as in 3, 4, and 2.
3. Local residential land market is cleared by its price as in Equation 9.
4. Local workers optimize their utility as in Equation 6.
5. Workers migrate based on their idiosyncratic shocks and rational expectation of destination utility as Equation 7
6. Economy-wide interest rate is set to clear the aggregate capital market as in 5.

Endogenous Equilibrium An equilibrium with endogenous policy is defined as a set of variables $\left\{K_j, H_j, L_j, W_j, P_j^h, I_j, V_j\right\}$ and a set of land allocation policies $\left\{s_j^*\right\}_{j=1}^N$ such that:

1. Equations 2 - 9 hold
2. s_j is chosen to maximize local output subject to equilibrium conditions and land allocation policies of all the other places $\{s_k\}_{k \neq j}$.

$$\max_{s_j} \quad Y_j$$
$$\text{subject to} \quad 2-9$$
$$s_i = s_i^*, \quad \forall i \neq j$$

4.3 Anatomy of Equilibrium

In this subsection, we firstly prove the uniqueness of exogenous equilibrium, and analyze the equilibrium to get intuition on how government manipulates their policy. Combining equation 5 and 4, we have:

$$I_j = (\frac{\gamma A_j}{r})^{\frac{1}{1-\gamma}} K_j^{\alpha} L_j^{1-\alpha}$$
$$r = \gamma[\frac{\sum_{j=1}^{N} A_j^{\frac{1}{1-\gamma}} K_j^{\alpha} L_j^{1-\alpha}}{\bar{I}}]^{1-\gamma}$$

Let $\tilde{Y}_j = A_j^{\frac{1}{1-\gamma}} K_j^{\alpha} L_j^{1-\alpha}$, we have

$$I_j = (\frac{\gamma}{r})^{\frac{1}{1-\gamma}} \tilde{Y}_j$$
$$r = \gamma(\frac{\sum_{j=1}^{N} \tilde{Y}_j}{\bar{I}})^{1-\gamma}$$

Take them into 3, we have

$$W_j = (1-\gamma)(1-\alpha)(\frac{\gamma}{r})^{\frac{\gamma}{1-\gamma}} A_j^{\frac{1}{1-\gamma}} K_j^{\alpha} L_j^{-\alpha} \tag{10}$$

Then combining 9 and 6 we have:

$$V_j = B_j \frac{W_j}{(\frac{\beta W_j L_j}{H_j})^{\beta}} = \frac{B_j H_j^{\beta}}{\beta^{\beta}} \frac{W_j^{1-\beta}}{L_j^{\beta}}$$

Take 10 to the equation above, we can write L_j as a function of W_j:

$$L_j = \underbrace{[\frac{((1-\gamma)(1-\alpha))^{1-\beta}}{\beta^\beta}(\frac{\gamma}{r})^{\frac{\gamma(1-\beta)}{1-\gamma}}]^{\frac{1}{\alpha(1-\beta)+\beta}}}_{\bar{M}}[\frac{B_j H_j^\beta K_j^{\alpha(1-\beta)} A_j^{\frac{1-\beta}{1-\gamma}}}{V_j}]^{\frac{1}{\alpha(1-\beta)+\beta}}$$

For simplicity, we denote $U_j = V_j^\epsilon$, and substitute L_j in 7 with the equation above

$$U_j = \bar{M}^{\frac{\epsilon[\alpha(1-\beta)+\beta]}{\epsilon[\alpha(1-\beta)+\beta]+1}}[B_j \bar{X}_j^{\alpha(1-\beta)+\beta} A_j^{\frac{1-\beta}{1-\gamma}} s_j^{\alpha(1-\beta)}(1-s_j)^\beta]^{\frac{\epsilon}{\epsilon[\alpha(1-\beta)+\beta]+1}} \left\{\sum_{i=1}^N \frac{d_{ij}^\epsilon \bar{L}_i}{\sum_{k=1}^N d_{ik}^\epsilon U_k}\right\}^{-\frac{\epsilon[\alpha(1-\beta)+\beta]}{\epsilon[\alpha(1-\beta)+\beta]+1}} \tag{11}$$

We can think this as a definition of operator T defined on R^N. Similar to Redding (2016)[5], it is easy to verify that this operator has only one fixed point which could be obtained by iterative procedures, from which we can further recover other regional variables and hence the equilibrium.

Given this property of equilibrium with exogenous land policies, we can use a brutal force method to compute for a Nash equilibrium by running a brutal force search over a grid of $\{s_j\}_{j=1}^N$ to select the Nash equilibrium.

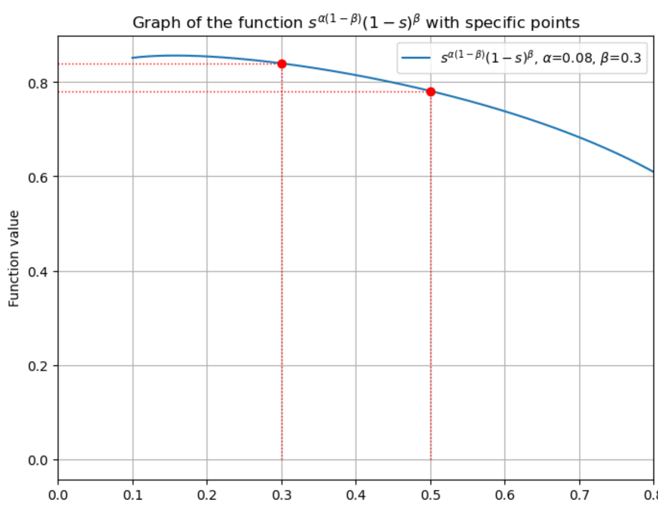
From Equation 11, we can see that the composite term $[B_j \bar{X}_j^{\alpha(1-\beta)+\beta} A_j^{\frac{1-\beta}{1-\gamma}} s_j^{\alpha(1-\beta)}(1-s_j)^\beta]$ is a sufficient statistics for population distribution. Intuitively, we think of this term as a measure of "the strength to attract workers", as the higher its value is, the higher proportion of worker population will end up locating at the corresponding location. The term is maximized when setting $s^0 = \frac{\alpha(1-\beta)}{\alpha(1-\beta)+\beta}$, which is the optimal land allocation to maximize local worker population. However, as in our model the government is aimed at maximizing output instead of population, the endogenous industrial land share will always be higher s^0, such that the government strikes a balance between the benefit of increasing output (as well as attracting more capital to invest

[5]Proposition 1 in https://www.princeton.edu/~reddings/papers/quantspatial_appendix_4May2016.pdf

through increasing local marginal product of capital) through industrial land supply (as the marginal product of land will always be positive) and the loss of worker population due to shrinkage in residential land (as L_j will be decreasing in s_j at Nash equilibrium).

Moreover, we can also tell that the strategic consideration i.e. the impact of other governments' land allocation on local policy decision will be numerically small. To see this, we plot the value of function $s_j^{\alpha(1-\beta)}(1-s_j)^{\beta}$ under reasonable parameterization in the following graph. We can see that the variation of this function value is small. Think of, for example, an increase of other government's industrial land share from 30% to 50%, the value of function will only decay from 0.84 to 0.78, only a decline of 7% of the whole term. Nevertheless, from the following comparative statics we can see that the local urban land allocation is still significantly impacted by the change in the " strength to attract workers" of other locations through general equilibrium effects.

Figure 4.1: Graph of Function



4.4 Comparative Statics: Theoretical Result under Special Assumptions

We firstly theoretically prove the positive relationship between local productivity A_j and the output-maximizing industrial land shares s_j by imposing some additional conditions on local government:

Proposition 1 If $\gamma = 0$, $\forall i, j, d_{ij} = 1$, and local government manipulates s_j to maximize local output Y_j taking the utility of other places as given, it will set a higher industrial land ratio when it has higher productivity A_j

Proof Under the given conditions, the local government's planning problem is as follows:

$$\max_{s_j} A_j K_j^{\alpha} L_j^{1-\alpha}$$

$$\text{subject to} 2-6, 9, \text{ and}$$

$$L_j = \frac{V_j^{\epsilon}}{V_j^{\epsilon} + \underbrace{\sum_{i \neq j} V_i^{\epsilon}}_{\bar{V}}} \bar{L}$$

where $\bar{V}$ and $\bar{L}$ are treated as constants. This is similar to the "bounded rationality" case in Henderson et al. (2022). And solving this problem we arrive at the following condition:

$$1 + \frac{1}{f} + \frac{1}{f}\frac{V_j^{\epsilon}}{\bar{V}} = \frac{1-\alpha}{\alpha}\left[\frac{\beta}{\alpha(1-\beta)+\beta}\frac{1}{1-s_j} - 1\right]$$

where f is a constant of α, β, ϵ. Note that V_j on the LHS is also a function, and the optimum that satisfies this equation is obtained on the range of s_j where V_j in decreasing in s_j. It is easy to verify that $\frac{\partial V_j}{\partial s_j} > 0$, and therefore the optimal s_j is increasing in A_j.

This result is an intuitive one. We show that if the government takes into consideration the impact of its decision on the local population, even an output-maximizing government will "succumb" to its residents and distribute some land to residential usage, instead of going to a corner solution as in Henderson et al. (2022). However, the capacity of local government is stronger when local productivity is higher. This is quite similar to the case in Liu and Su (2023) where the US state government has a stronger rent-seeking ability given a higher local productivity.

4.5 Comparative Statics: Numerical Result

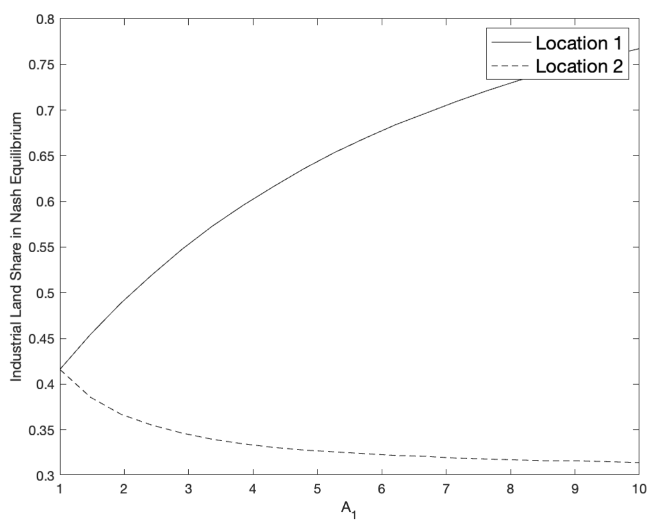
Given the model and the algorithm, we can also compute the equilibrium numerically and see the change in equilibrium outcome in response to the change in parameter and regional fundamental values. Here we adopt the simplest symmetric two-location parameterization as the following table and report two of the most intuitive and interesting results of comparative statics.

Table 4.1: Parameter and Fundamental Values for Comparative Statics

Parameter	Value	Description
Parameters		
α	0.08	Land intensity of production (relative to labor)
β	0.3	Expenditure share on housing
η	2	Elasticity of migration
γ	1/3	Capital intensity of production
Regional Fundamentals		
A_j	$5\forall j$	Productivity
d_{ij}	$d_{ij} = 1$	Migration Cost
B_j	$1\forall j$	Quality-of-life amenity
$\bar{X}_j$	$1\forall j$	Total land endowment
$\bar{L}_j$	$1\forall j$	Initial Population

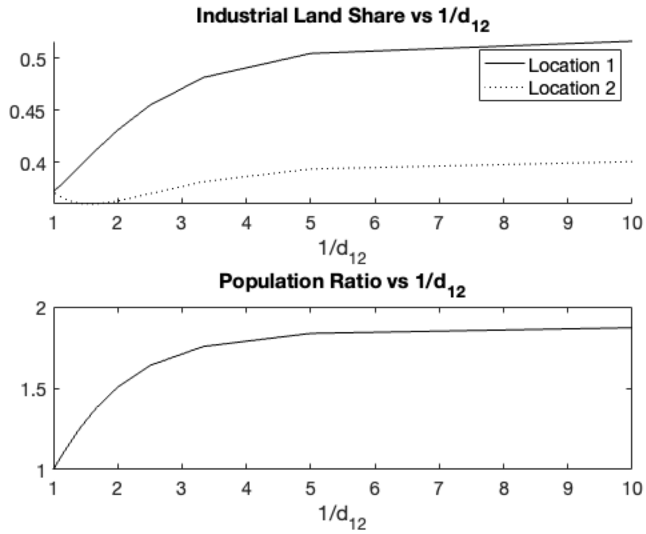
Firstly, it is easy to see from the model that a uniform change in productivity of all the locations will have no impact on equilibrium land allocation or population distribution. Only relative productivity change will tweak the equilibrium. This is captured in the following Figure 4.2, where we calculate Nash equilibrium with varying productivity in the 1st location. It shows that the increase in productivity in one location will increase the industrial land ratio in one location, but decrease the industrial land ratio in the other location. This result highlights the interaction between different locations through spatial linkages and strategic consideration of local governments.

Figure 4.2: Comparative Statics: Impact of Productivity



Secondly, in the current model, labor mobility is crucial in determining the industrial land share. In the following Figure 4.3, we show the impact of increasing one-way migration cost, from location 1 to location 2, on the equilibrium outcome. Generally speaking, both governments react to it by increasing the industrial land shares, and intuitively, the government at location 1 will set a higher industrial land share as its citizens are tied to their birthplace and weaker in their ability to walk away. Also intuitively, as the immigration cost from location 1 to location 2 increases while the opposite keeps the same, location 1 will tend to have a higher population, albeit the high industrial land shares, in the equilibrium.

Figure 4.3: Comparative Statics: Impact of Migration Cost



4.6 Discussion

In this simplified model we abstract from the use of land sales revenue. One may think the local government just wastes the income or spends it on purchasing numeraire goods (corruption). A standard treatment of factor income in the spatial economy is to redistribute it to local residents (e.g. Redding 2016), which will scale up local resident income by a constant factor and will not impact the result of this model besides scaling up the welfare in all the places with the same factor. Caliendo et al. (2018) and Ferrari and Ossa (2023) impose another exogenous rule on the distribution of factor income to generate trade imbalance, which is not used here for tractability. Finally, Henderson et al. (2022) and Fajgelbaum et al. (2019) assume local government uses its revenue to boost local TFP or amenity, which could be an interesting extension of the current model.

We neither discuss the claim and use of return to capital in the model. The treatment of this factor income varies in the papers listed above. Mostly it is used as an instrument to support inter-regional trade imbalance. In the current model, the introduction of the perfectly mobile capital fans out the productivity distribution compared to a model without the capital. Intuitively, capital magnifies the productivity advantage or disadvantage held by local governments, leading to a higher geographical dispersion of their policy making.

5 Quantification

In this section, we firstly illustrate the algorithm we use to either 1) calculate the equilibrium given a set of parameters or 2) calibrate the parameters given equilibrium outcome provided in the data. Then, we utilize the algorithm to match the land use allocation pattern in 2019 with the Nash equilibrium and calibrate local fundamental values and labor mobility costs, and verify the validity of these results.

5.1 Algorithm

Let the bold letter $\boldsymbol{x}$ denote the vector of $[x_1, x_2, ..., x_N]^T$. As is shown in the above section, the equilibrium could be boiled down to a system of N equations that define $\boldsymbol{U}$ as an implicit function of $\boldsymbol{s}$, and all the other equilibrium outcomes could be sequentially solved. Essentially, the key equations could be denoted as $\boldsymbol{\Omega} = 0$, where Ω_j is defined as:

$$\Omega_j = U_j - \bar{M}^{\frac{\epsilon[\alpha(1-\beta)+\beta]}{\epsilon[\alpha(1-\beta)+\beta]+1}} [B_j \bar{X}_j^{\alpha(1-\beta)+\beta} A_j^{\frac{1-\beta}{1-\gamma}} s_j^{\alpha(1-\beta)} (1-s_j)^{\beta}]^{\frac{\epsilon}{\epsilon[\alpha(1-\beta)+\beta]+1}} \left\{ \sum_{i=1}^{N} \frac{d_{ij}^{\epsilon} \bar{L}_i}{\sum_{k=1}^{N} d_{ik}^{\epsilon} U_k} \right\}^{-\frac{\epsilon[\alpha(1-\beta)+}{\epsilon[\alpha(1-\beta)+\beta]}}$$

Then, from implicit function theorem, we immediately obtain the $N \times N$ Jacobian matrix of $\boldsymbol{U}$ w.r.t. $\boldsymbol{s}$ as

$$\frac{\partial \boldsymbol{U}}{\partial \boldsymbol{s}} = -[\frac{\partial \boldsymbol{\Omega}}{\partial \boldsymbol{s}}]^{-1} \frac{\partial \boldsymbol{\Omega}}{\partial \boldsymbol{U}}$$

where $\frac{\partial \boldsymbol{\Omega}}{\partial \boldsymbol{s}}$ and $\frac{\partial \boldsymbol{\Omega}}{\partial \boldsymbol{U}}$ are the corresponding $N \times N$ Jacobian matrix, whose $j, k-$th element could be derived as follows:

$$\frac{\partial \Omega_j}{\partial s_k} = \begin{cases} 0 & \text{if } j \neq k \\ -\frac{\epsilon}{\epsilon[\alpha(1-\beta)+\beta]+1} U_j (\frac{\alpha(1-\beta)}{s_j} - \frac{\beta}{1-s_j}) & \text{if } j = k \end{cases}$$

$$\frac{\partial \Omega_j}{\partial U_k} = I\{j = k\}$$

$$- \frac{\epsilon[\alpha(1-\beta)+\beta]}{\epsilon[\alpha(1-\beta)+\beta]+1} U_j \left\{ \sum_{i=1}^{N} \frac{d_{ij}^{\epsilon} \bar{L}_i}{\sum_{k=1}^{N} d_{ik}^{\epsilon} U_k} \right\}^{-1} \left\{ \sum_{i=1}^{N} \frac{d_{ij}^{\epsilon} d_{ik}^{\epsilon} \bar{L}_i}{(\sum_{k=1}^{N} d_{ik}^{\epsilon} U_k)^2} \right\}$$

Note that when the equilibrium outcome for a given $\boldsymbol{s}$ is calculated, we are able to calculate the numerical values of these Jacobians. Then, sequentially, we could apply the chain rule to calculate the numerical value of the implicit function $\frac{\partial Y_j}{\partial s_j}$ for a given $\boldsymbol{s}$. Let $\frac{dY}{ds}$ denote the vector of $[\frac{\partial Y_1}{\partial s_1}, \frac{\partial Y_2}{\partial s_2}, ..., \frac{\partial Y_N}{\partial s_N}]$. Then we can keep updating $\boldsymbol{s}$ at the $(i+1)$-th iteration, $\boldsymbol{s}^{(i+1)}$ based on $\boldsymbol{s}^{(i)}$ with the following rule:

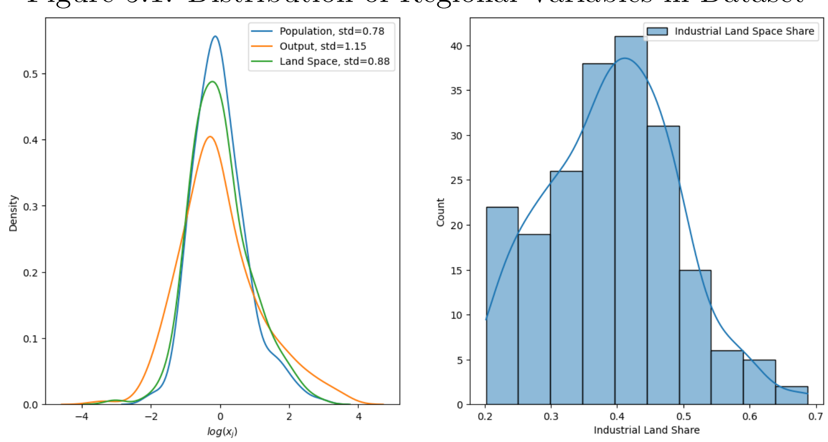
$$\boldsymbol{s}^{(i+1)} = \boldsymbol{s}^{(i)} + step \cdot \frac{dY}{ds}$$

until $\frac{dY}{ds}$ approaches zero, where *step* is a small positive number. The intuition of this algorithm is simple: if $\frac{dY_j}{ds_j} > 0$, the local government j could increase local output by increasing its industrial land share, so we update it with a small increment. This algorithm is thus transparent and could utilize the vectorized calculation features of many software (e.g. Matlab) when compared to a brute force grid search method. While the uniqueness of Nash equilibrium with endogenous land allocation is not guaranteed, we can try out different initial values to check the multiplicity of the equilibrium.

5.2 Calibration

We then take the model to the disaggregate city-level data. We assemble a dataset of city's industrial and residential land area, population, and output in the year of 2019. After excluding those with too small industrial land area ratio (mostly tourism cities), our dataset consists of 205 cities. The distribution of their industrial land space ratio, population, and output is demonstrated in Figure 5.1, where we plot the de-meaned logarithms of the last three variables to get rid of the impact of the absolute scale. In the calibration, we firstly choose a set of parameters $\{\alpha, \beta, \eta, \gamma\}$ from the literature. Then, we internally calibrate the regional productivities ($\{A_j\}_{j=1}^{N}$), quality-of-life amenities ($\{B_j\}_{j=1}^{N}$), initial population (($\left\{\bar{L}_j\right\}_{j=1}^{N}$)) and migration cost ($\{d_{ij}\}_{i,j=1}^{N}$) to match Nash equilibrium to the moments. We end calibration with a set of model fit exercises to show that our internal calibration result is consistent with reality.

Figure 5.1: Distribution of Regional Variables in Dataset



External Calibration Firstly, we choose some key parameter values from the literature, which is demonstrated in Table 5.1. For α, the land intensity of production function, we use a similar value as in Henderson et al. (2022). All the other three parameters take the values commonly used in the literature.

Internal Calibration We internally calibrate the other fundamental values of the model: $\left\{\bar{L}_i, d_{ij}, A_i, B_i\right\}$ to match three moments in 2019 data with

Table 5.1: Externally Calibrated Parameter Values

Parameter	Value	Description	Source
α	0.07	Land intensity of production (relative to labor)	Henderson et al. (2022)
β	0.3	Expenditure share on housing	
η	3	Elasticity of migration	Fan (2019)
γ	1/3	Capital intensity of production	

Nash equilibrium of the model: 1) output distribution, 2) population distribution. and finally 3) industrial land area ratio. We firstly impose the restrictions on parameters such that the entry cost of one place is the same for workers from any other locations i.e. $d_{ij} \equiv \tilde{d}_j, \forall i \neq j$. This corresponds to the household registration system (*hukou*) in China where different places have different requirements for emigration to receive local public service like education and medical service. Then, we calibrate the values of these fundamentals with the following procedures:

1. Use bisection method to adjust the values of A_j and $\tilde{d}_j$ for each place to match its partial derivative $\frac{dY_j}{ds_j}$ value to 0 when $\{s_j\}$ takes the values in data.

2. Use the A_j and $\tilde{d}_j$ to calculate a Nash equilibrium and obtain the simulated industrial land area ratio denoted by $\left\{s_j^0\right\}$.

3. Use bisection method to adjust the values of $\bar{L}_j$ to match the population distribution under $\left\{s_j^0\right\}$.

4. Repeat the above three steps until the result is close to data.

5. Finally, adjust the value of A_j to match the output distribution. Everytime we adjust A_j, we also adjust B_j such that the composite term $A_j^{\frac{1-\beta}{1-\gamma}} B_j$ stays the same value, and therefore keep Nash equilibrium land allocation uncahnged.

One thing worth discussion is our choice of internally calibrating $\bar{L}_i$ instead of directly using population of city in 2000 as an input. Increasing one dimension of variables to manipulate certainly helps improve the performance of matching, and on the other hand, this is a convenient way to accommodate the model assumption of unchanged total population to the fact that the aggregate urban population has substantially grown in the past decade.[6].The model calibrated result and the data are well fitted, as is demonstrated in the following Figure 5.2, where we plot the targeted data against the equilibrium outcome in the model, as well as our calibrated initial population and the population of each city in the year 2000.

It turns out that the migration cost, denoted by $\{d_{ij}\}$ plays a crucial role in matching the model to data. This is intuitive: on the one extreme, fully restoring labor mobility by setting $d_{ij} = 1$ (as is presented in counterfactual analysis) will push local governments to set industrial land share to a low level, while on the other hand, zero labor mobility ($d_{ij} = 0$) will allow local government to distribute all the land to industrial usage. Therefore, the intermediate value theorem guarantees that we could obtain a calibrated migration cost to match the land use allocation pattern in the data. We plot our calibrated d_j's on the left panel of Figure 5.3, which ranges from almost zero to 0.4. On the right panel of the graph, we show that the log of entry cost, measured by the inverse of d_j, is positively correlated with the population of the city in 2019. This agrees with our observation that in China, larger city has stricter *hukou* restrictions that make people difficult to migrate in.

6 Counterfactual Analysis

Equipped with calibrated model, we conduct a series of counterfactual analysis in this section. Firstly, as our setup features a special assumption on

[6] In other words, to obtain a good matching of population distribution, we could also instead add an auxiliary location denoting rural area in China and manipulate its utility in the equilibrium as an exogenous input

Figure 5.2: Model Fit of Equilibrium Outcome and Calibrated Initial Population

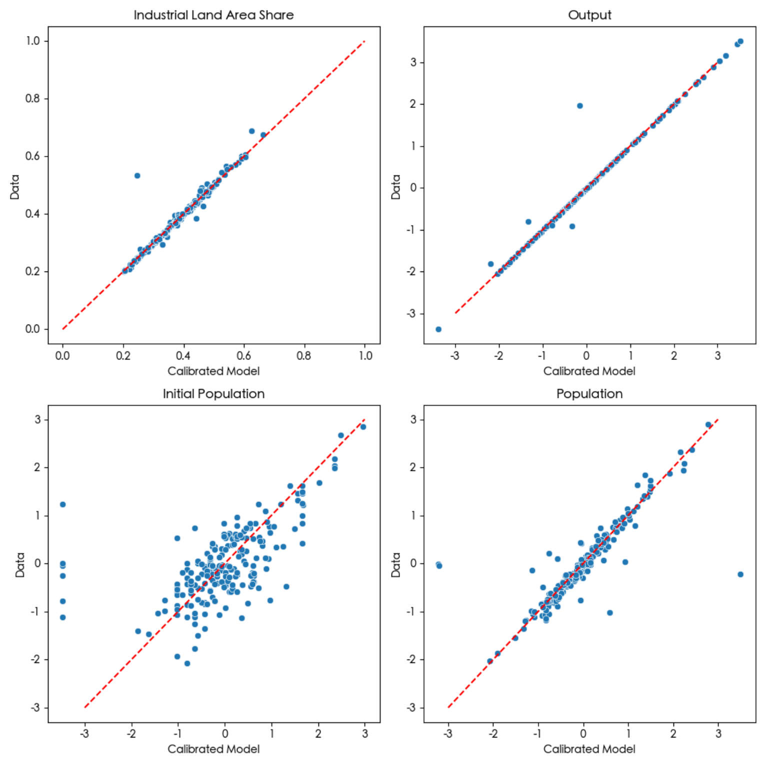
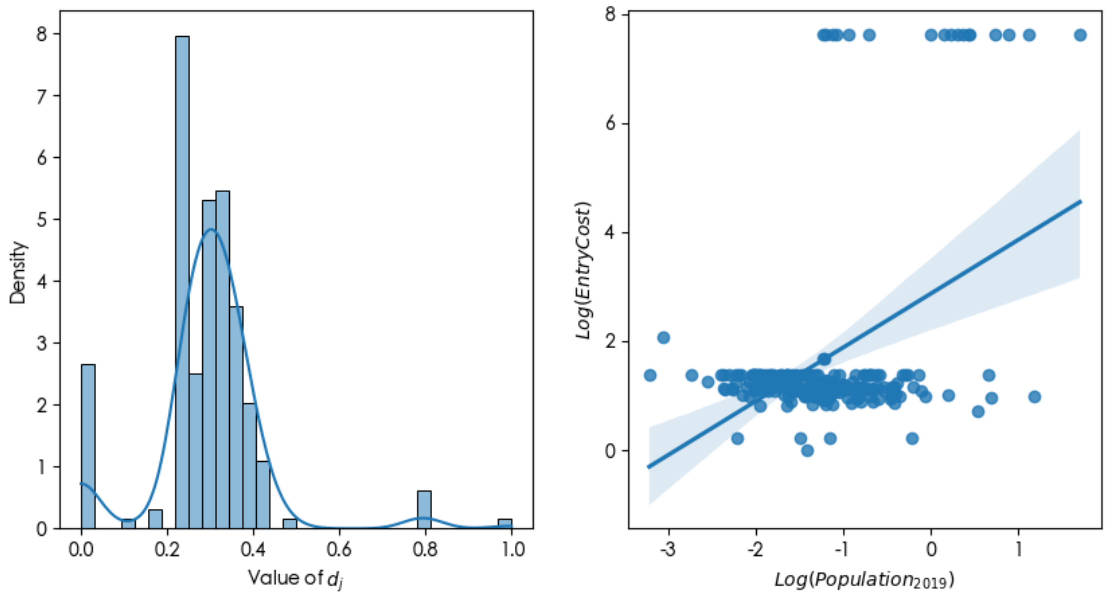


Figure 5.3: Calibrated Entry Cost



local government's incentive, it is natural to explore the impact of alternative political incentives on urban land use allocation. Secondly, in the spirit of Tiebout (1956), we demonstrate how lowering migration barrier could help nudge local governments to adjust land use allocation. Finally, we design and evaluate the effects of place-based policies in the presence of local government policy response.

6.1 Counterfactual I: Alternative Incentives of Local Government

In recent studies on Chinese local governments (e.g. Xiong 2018; Henderson et al. 2022), the objective function of local government is set as a weighted combination of different factors including local output, utility, and fiscal revenue. In our model, we could accommodate this by modifying the objective function of local government to take the following form similar in

Henderson et al. (2022):

$$Y_j^{w_j} V_j^{1-w_j}$$

where V_j denotes utility of local workers, and $w_j \in [0, 1]$ denotes the government preference on output over local welfare. As is shown in our analysis of the model, government with $w_j = 0$ i.e. only cares about local welfare, will set the industrial space share to a constant consisting of parameters i.e. $s^* = \frac{\alpha(1-\beta)}{\alpha(1-\beta)+\beta}$. To evaluate the effects of reforms that change the incentive of local government officials on the economy, we consider the following scenarios:

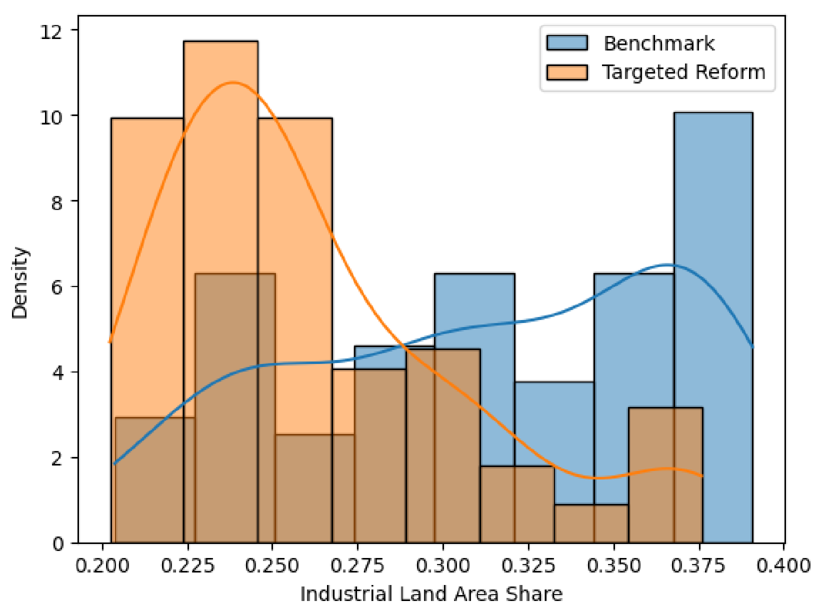
1. **Benevolent Government:** Let all local governments set $w_j = 0$;
2. **Half-half:** Let all local governments set $w_j = 0.5$;
3. **Targeted Reform:** Let local governments in the locations where the current industrial land share is above the median level set $w_j = 0$, while keeping the other governments' objectives unchanged.

The results are reported in Table 6.1. The equilibrium with benevolent local governments will greatly increased utility at the cost of lower output. By changing targets from output to utility, the regional inequality in output will decrease while the regional inequality in utility will increase. The other two reform effects stand in between, with targeted reform i.e. changing half of local governments completely has a slightly smaller effects compared to the case of half-half, where we change all local governments incentives by half. Finally and interestingly, we see that in the targeted reform case, even those local governments whose incentives are unchanged will also adapt to accommodate the change in economic environment due to the reform taking place elsewhere. Specifically, we plot the industrial land area share of the untargeted locations in **??**. And we can see that they also demonstrate similar pattern as their peers: the mean and variation of industrial land area ratio both decrease.

Table 6.1: Counterfactual w/ Different Local Government Incentives

Variable	(1) Benchmark	(2) Benevolent Government	(3) Half-half	(4) Targeted Reform
Population Mean	0.15	0.15	0.15	0.15
Population SD	0.28	0.27	0.27	0.27
Utility Mean	3.35	3.70	3.68	3.63
Utility Mean Weighted by Population	2.89	3.21	3.19	3.13
Utility SD	1.45	1.60	1.59	1.56
Output Mean	0.47	0.45	0.45	0.45
Output SD	0.92	0.87	0.88	0.89
Industrial Land Area Ratio Mean	0.39	0.11	0.14	0.18
Industrial Land Area Ratio SD	0.10	0.00	0.00	0.08

Figure 6.1: Distribution of Industrial Land Area Share Among Untargeted Area



6.2 Counterfactual II: Higher Labor Mobility

As weak labor mobility is key to support the current inefficient land use pattern, we consider the counterfactual scenario where the migration barrier is lifted while the local government incentives remain the same. Specifically, in the following table Table 6.2 we document two counterfactual outcome: firstly, we simply set all $d_{ij} = 1$ to fully restore labor mobility. Secondly, we consider a moderate reform by changing the values of d_{ij} to $max\{d_{ij}, 0.5\}$. We can see that as labor mobility increases, the (population-weighted) average utility increases while the output decreases. Moreover, labor mobility will greatly decrease spatial inequality as well as pushing local governments to move towards a more efficient and homogeneous policy choice.

Table 6.2: Counterfactual w/ Higher Labor Mobility

Variable	(1) Benchmark	(2) No Migration Cost	(3) Moderate Migration Reform
Population Mean	0.15	0.15	0.15
Population SD	0.28	0.09	0.19
Utility Mean	3.35	3.09	3.22
Utility Mean Weighted by Population	2.89	3.45	3.31
Utility SD	1.45	0.64	0.79
Output Mean	0.47	0.45	0.46
Output SD	0.92	0.60	0.76
Industrial Land Area Ratio Mean	0.39	0.20	0.22
Industrial Land Area Ratio SD	0.10	0.00	0.01

6.3 Counterfactual III: Inter-regional Transfer

Finally, we experiment a set of inter-regional policies imposed by central government. There is a recent discussion on the effects of place-based policy enacted by central government. For example, Fajgelbaum and Gaubert (2020) argue that in the presence of spillover, spatial transfer could be Pareto improving. The context of this papers open new avenues to analyze the impact of place-based policies: firstly, the inefficiency caused by local government policy may be corrected by central government's place-based policy. Secondly, ignoring the local government's policy response to the central government could be misleading in gauging the general equilibrium impact of the place-based policy. In this section, we consider the impact of two different place-based policy: firstly, we consider central government adding new land quota to local governments; secondly, we consider central government imposing a city specific income tax or subsidy on workers.

Allocating New Land Quota The recent decades witnessed rapid urban expansion in China where the land quota assigned to local government grows at a fast but uneven pace. For example, Fang et al. (2022) argued that the central government gave too much land quota to hinterland cities and caused spatial misallocation. While in their model, the land use allocation is simply determined by price equalization. Intuitively, incorporating the role of local government in land use allocation may alter their conclusion, as favoring less developed cities in land quota will encourage developed cities to allocate more land to residential usage, helping decrease spatial inequality. To quantitatively evaluate the effects, we consider a scenario where central government has a new land quota with the total size of 100% of the existing national land space to allocate, and consider two different rules to assign quota:

1. **Rule 1.** The central government simply increases aggregate land space in all the locations by the same proportion.
2. **Rule 2.** The central government evenly distributes the land quota to each city. Note that this will lead to a higher growth rate of land space in places with smaller initial land space.

The counterfactual results are displayed in the following Table 6.3. Firstly, it turns out that the increase in land quota has a numerically small effects on equilibrium outcome or local government policies, as the current result is obtained by double the total urban land area. Other key takeaway from the table is that an equal increase in land space tends to increase utility and decrease inequality at the cost of decrease in output.

Table 6.3: Counterfactual w/ New Land Quota

Variable	(1) Proportional Increase	(2) Equal Increase - Direct	(3) Equal Increase - GE
Population Mean	0.15	0.15	0.15
Population SD	0.28	0.29	0.29
Utility Mean	4.31	4.90	4.91
Utility Mean Weighted by Population	3.71	3.85	3.88
Utility SD	1.86	2.22	2.24
Output Mean	0.48	0.46	0.46
Output SD	0.94	0.84	0.84
Industrial Land Area Ratio Mean	0.39	0.39	0.38
Industrial Land Area Ratio SD	0.10	0.10	0.10

Inter-regional Transfer Finally, we consider the effect of a simple inter-regional transfer policy in the economy. Specifically, we consider the central government sets an income tax/subsidy rate ($\{t_j\}_{j=1}^N$) for workers in location j such that the final income of workers in location j is ($(1+t_j)W_j$). Setting t_j equal everywhere (e.g. rebating the land sales revenue evenly to local workers by setting $t_j = \frac{\alpha+(1-\alpha)\beta}{(1-\alpha)(1-\beta)}$) will scale up national welfare with no distributional impact. The interesting case arises when we consider a place-based rule to vary $\{t_j\}_{j=1}^N$. In the following table, we consider the following three rules:

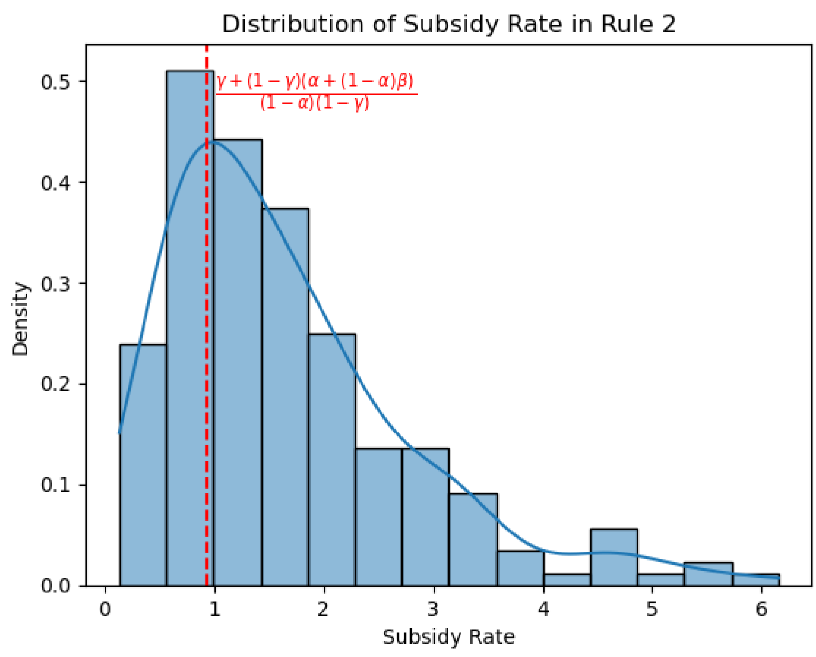
1. **Rule 1.** Central government sets a homogeneous subsidy rate to labor to distribute the income from land and capital i.e. setting $t_j =$

$\frac{\gamma+(1-\gamma)(\alpha+(1-\alpha)\beta)}{(1-\alpha)(1-\gamma)}$

2. **Rule 2.** Central government sets the subsidy rate under which it could distribute capital income evenly to all labors regardless of their location.

Note that to calculate the outcome of Rule 2 we go through two steps: firstly, we calculate the regional subsidy rate from the initial equilibrium, then we take these rates as given and calculate respectively the outcome when land use allocation remains the same and the case when local government manipulates land use in response. The distribution of calculated Rule 2 subsidy rate is plotted in Figure 6.2, with red vertical line denoting the homogeneous Rule 1 subsidy rate. Due to the spatial inequality in the initial equilibrium, the subsidy rate varies and a large proportion of the locations have Rule 2 subsidy rate higher than Rule 1.

Figure 6.2: Distribution of Subsidy Rate in Rule 2



The counterfactual equilibrium outcome is reported in Table 6.4. In the first column, we can see that an equal subsidy rate does nothing other than scaling up the utility (and hence standard deviation), serving as a benchmark in the comparison. In the second column, we present the outcome when we adopt the Rule 2 subsidy rate without changing land allocation. Another significant change is that its adoption fans out the distribution of utility and population. This is because the current subsidy rate is designed based on income (i.e. the comparison between wages) instead of real income or utility. Interestingly, however, the presence of endogenous land use allocation could help alleviate it. Think of a location with high industrial space ratio at the benchmark equilibrium: such place features a high wage and hence receives a lower subsidy rate. Such subsidy rate will then push local governments to supply more residential land to retain local population. This mechanism shows that other side of local government policy: while the local government tends to set a higher industrial land space share at more productive place and hence increase inequality, it will also act the opposite way when local advantage shrinks. In other words, there is a supplier effects on reducing spatial inequality when accounting for endogenous local government policies. This can be directly demonstrated as in Figure 6.3. On the left panel, we plot the distribution of industrial land space share in benchmark case versus the case of Rule 2 subsidy, and on the right panel we plot the industrial share for the same city in counterfactual case against its benchmark level. Clearly, the local government response to the policy results in a more efficient and more homogeneous policy pattern.

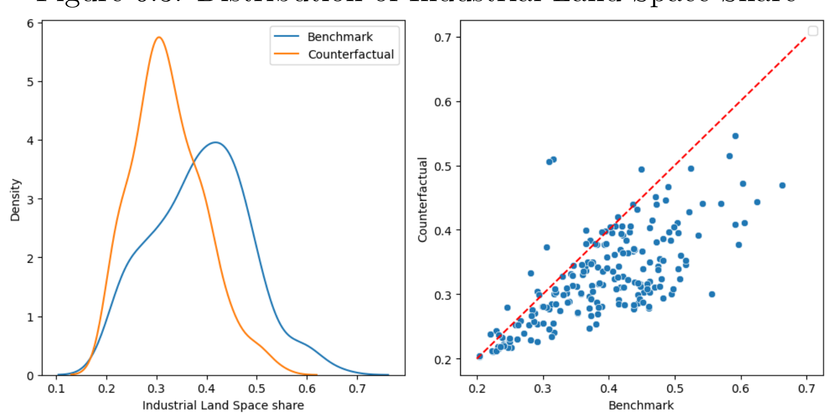
7 Conclusion

In this paper, we provide a case study of local government policies by looking at the urban land use allocation policy in China. There are two popular perceptions of this topic: firstly, local government uses all means to maximize local output, and secondly, they tend to discount industrial land. We examine these popular perceptions rigorously by first demonstrating the

Table 6.4: Counterfactual w/ Regional Transfer

Variable	(1) Equal Subsidy	(2) Even Distribution - Direct	(3) Even Distribution - GE
Population Mean	0.15	0.15	0.15
Population SD	0.28	0.54	0.52
Utility Mean	5.20	6.72	6.88
Utility Mean Weighted by Population	4.48	5.50	5.66
Utility SD	2.25	2.65	2.63
Output Mean	0.47	0.40	0.40
Output SD	0.92	0.74	0.75
Industrial Land Area Ratio Mean	0.39	0.39	0.32
Industrial Land Area Ratio SD	0.10	0.10	0.07

Figure 6.3: Distribution of Industrial Land Space Share



potential oversupply of industrial land indicated by the huge price gap in our empirical analysis. Then we build up a spatial model and let local governments endogenously determine their land use allocation and form a Nash equilibrium.

We also developed an algorithm to compute and calibrate the model, and in the two-location case, we are able to match the observed land allocation pattern with our model. In the counterfactual analysis, we show that even a partial reform on local government official's incentives could greatly decrease the industrial land supply and harmonize industrial land ratios. We also show that in line with the classical Tiebout model, increasing the mobility of workers could also help alleviate industrial land oversupply. Finally, we show that the presence of endogenous local government policy brings general equilibrium effects to central government's place-based policy. On the one hand, the existence of local government policy creates distortion that central government could target. On the other hand, the policy that tackles spatial inequality will also help discipline local government policies towards efficiency and homogeneity, revealing one potential benefits of place-based policies.

References

Agrawal, D. R., Hoyt, W. H., and Wilson, J. D. (2022). Local policy choice: theory and empirics. *Journal of Economic Literature*, 60(4):1378–1455.

Albouy, D., Ehrlich, G., and Shin, M. (2018). Metropolitan land values. *Review of Economics and Statistics*, 100(3):454–466.

Brandt, L., Tombe, T., and Zhu, X. (2013). Factor market distortions across time, space and sectors in china. *Review of Economic Dynamics*, 16(1):39–58.

Brueckner, J. K. and Neumark, D. (2014). Beaches, sunshine, and public sector pay: theory and evidence on amenities and rent extraction by government workers. *American Economic Journal: Economic Policy*, 6(2):198–230.

Cai, H., Henderson, J. V., and Zhang, Q. (2013). China's land market auctions: evidence of corruption? *The Rand journal of economics*, 44(3):488–521.

Caliendo, L., Dvorkin, M., and Parro, F. (2019). Trade and labor market dynamics: General equilibrium analysis of the china trade shock. *Econometrica*, 87(3):741–835.

Caliendo, L., Parro, F., Rossi-Hansberg, E., and Sarte, P.-D. (2018). The impact of regional and sectoral productivity changes on the us economy. *The Review of economic studies*, 85(4):2042–2096.

Chen, T. and Kung, J. K.-s. (2019). Busting the "princelings": The campaign against corruption in china's primary land market. *The Quarterly Journal of Economics*, 134(1):185–226.

Cosar, A. K. and Fajgelbaum, P. D. (2016). Internal geography, international trade, and regional specialization. *American Economic Journal: Microeconomics*, 8(1):24–56.

De Souza, G., Hu, N., Li, H., and Mei, Y. (2024). (trade) war and peace: How to impose international trade sanctions. *Journal of Monetary Economics*, page 103572.

Diamond, R. (2017). Housing supply elasticity and rent extraction by state and local governments. *American Economic Journal: Economic Policy*, 9(1):74–111.

Fajgelbaum, P. D. and Gaubert, C. (2020). Optimal spatial policies, geography, and sorting. *The Quarterly Journal of Economics*, 135(2):959–1036.

Fajgelbaum, P. D., Morales, E., Suárez Serrato, J. C., and Zidar, O. (2019). State taxes and spatial misallocation. *The Review of Economic Studies*, 86(1):333–376.

Fan, J. (2019). Internal geography, labor mobility, and the distributional impacts of trade. *American Economic Journal: Macroeconomics*, 11(3):252–288.

Fang, M., Han, L., Huang, Z., Lu, M., and Zhang, L. (2022). Place-based land policy and spatial misallocation: Theory and evidence from china.

Available at SSRN 3846313.

Ferrari, A. and Ossa, R. (2023). A quantitative analysis of subsidy competition in the us. *Journal of Public Economics*, 224:104919.

He, Z., Nelson, S. T., Su, Y., Zhang, A. L., and Zhang, F. (2022). *Industrial land discount in China: a public finance perspective*. National Bureau of Economic Research.

Henderson, J. V., Su, D., Zhang, Q., and Zheng, S. (2022). Political manipulation of urban land markets: Evidence from China. *Journal of Public Economics*, 214(C).

Hsieh, C.-T. and Klenow, P. J. (2009). Misallocation and manufacturing tfp in china and india. *The Quarterly journal of economics*, 124(4):1403–1448.

Kok, N., Monkkonen, P., and Quigley, J. M. (2014). Land use regulations and the value of land and housing: An intra-metropolitan analysis. *Journal of Urban Economics*, 81:136–148.

Li, H. and Zhou, L.-A. (2005). Political turnover and economic performance: the incentive role of personnel control in china. *Journal of public economics*, 89(9-10):1743–1762.

Liu, E. (2019). Industrial policies in production networks. *The Quarterly Journal of Economics*, 134(4):1883–1948.

Liu, S. and Su, Y. (2023). Spatial productivity differences and government rent-seeking. *Available at SSRN*.

Lucas, R. E. and Rossi-Hansberg, E. (2002). On the internal structure of cities. *Econometrica*, 70(4):1445–1476.

Nichols, J. B., Oliner, S. D., and Mulhall, M. R. (2013). Swings in commercial and residential land prices in the united states. *Journal of Urban Economics*, 73(1):57–76.

Ossa, R. (2014). Trade wars and trade talks with data. *American Economic Review*, 104(12):4104–4146.

Parkhomenko, A. (2020). Local causes and aggregate implications of land use regulation. *Available at SSRN 3739183*.

Redding, S. J. (2016). Goods trade, factor mobility and welfare. *Journal of*

International Economics, 101:148–167.

Restuccia, D. and Rogerson, R. (2008). Policy distortions and aggregate productivity with heterogeneous establishments. *Review of Economic dynamics*, 11(4):707–720.

Slattery, C. (2018). Bidding for firms: Subsidy competition in the us. *Available at SSRN 3250356*.

Tao, R., Su, F., Liu, M., and Cao, G. (2010). Land leasing and local public finance in china's regional development: Evidence from prefecture-level cities. *Urban studies*, 47(10):2217–2236.

Tiebout, C. M. (1956). A pure theory of local expenditures. *Journal of political economy*, 64(5):416–424.

Tombe, T. and Zhu, X. (2019). Trade, migration, and productivity: A quantitative analysis of china. *American Economic Review*, 109(5):1843–1872.

Wang, Z. (2020). Multinational production and corporate taxes: A quantitative assessment. *Journal of International Economics*, 126:103353.

WorldBank (2009). World development report: reshaping economic geography. Technical report.

Wu, W. and You, W. (2023). Should governments increase or decrease the degree of urbanization? a quantitative analysis of the internal migration restrictions in china. *A Quantitative Analysis of the Internal Migration Restrictions in China (March 5, 2023)*.

Xiong, W. (2018). The mandarin model of growth. Technical report, National Bureau of Economic Research.

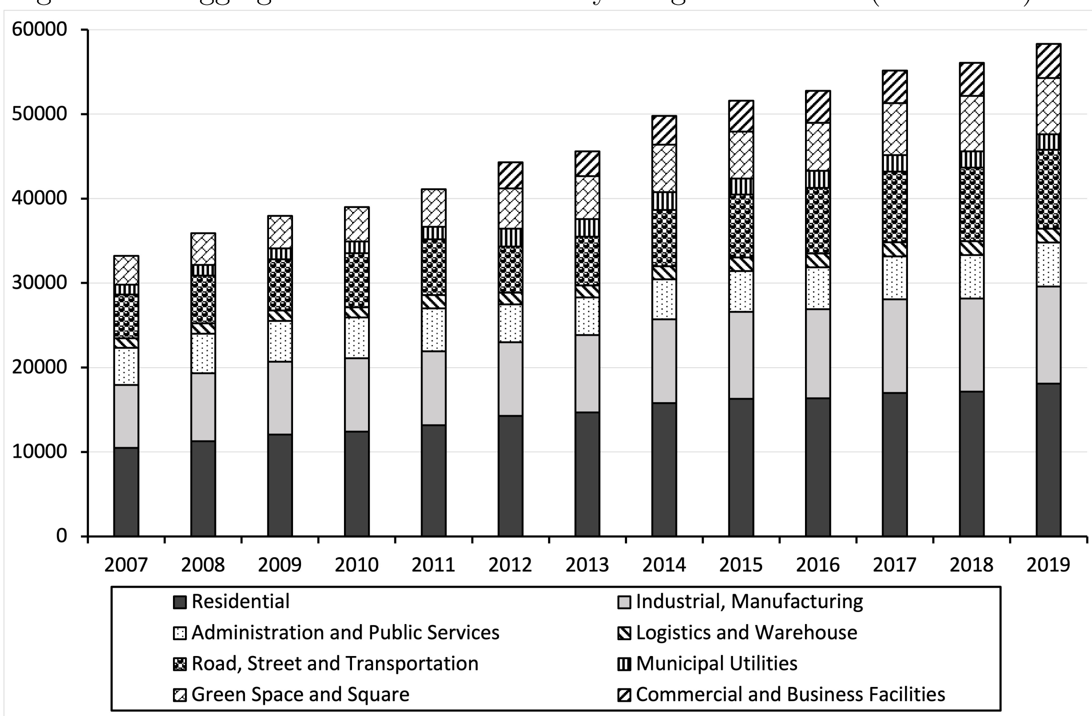
Xu, C. (2011). The fundamental institutions of china's reforms and development. *Journal of economic literature*, 49(4):1076–1151.

Yu, Y. (2019). Land-use regulation and economic development: Evidence from the farmland red line policy in china. *Job Market Paper*.

Zi, Y. (2020). Trade liberalization and the great labor reallocation.

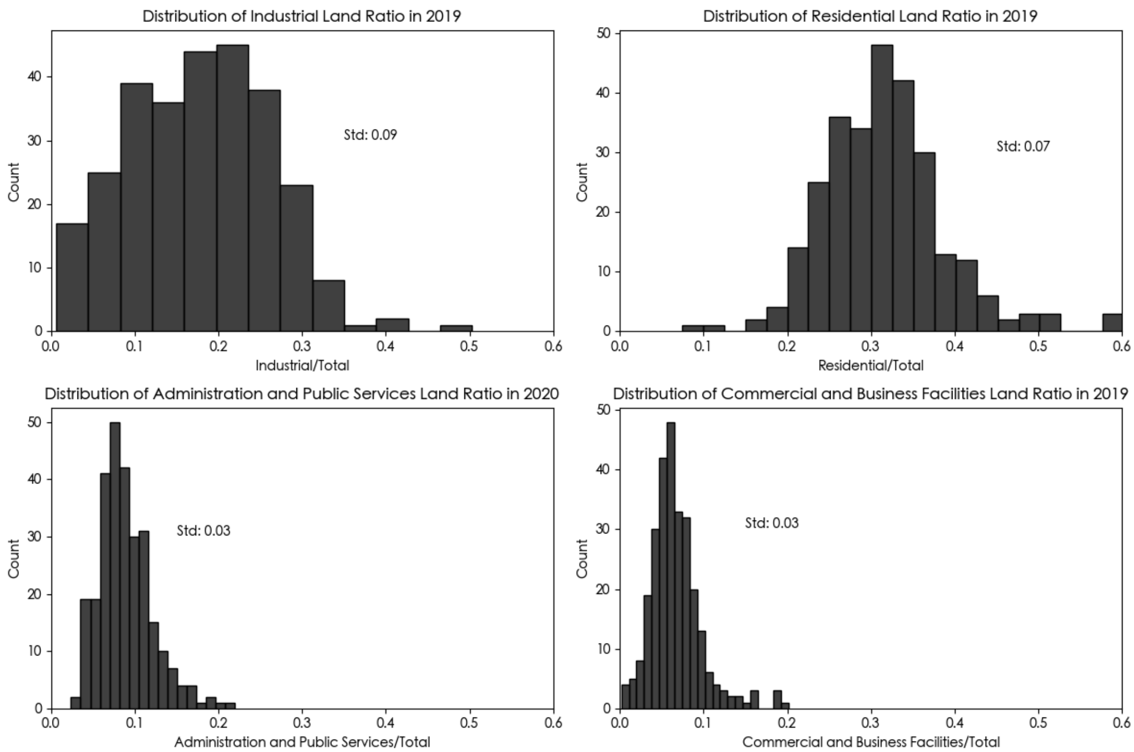
Appendix A Figures and Tables

Figure A.1: Aggregate Urban Land Area by Usages and Years (Unit: km^2)



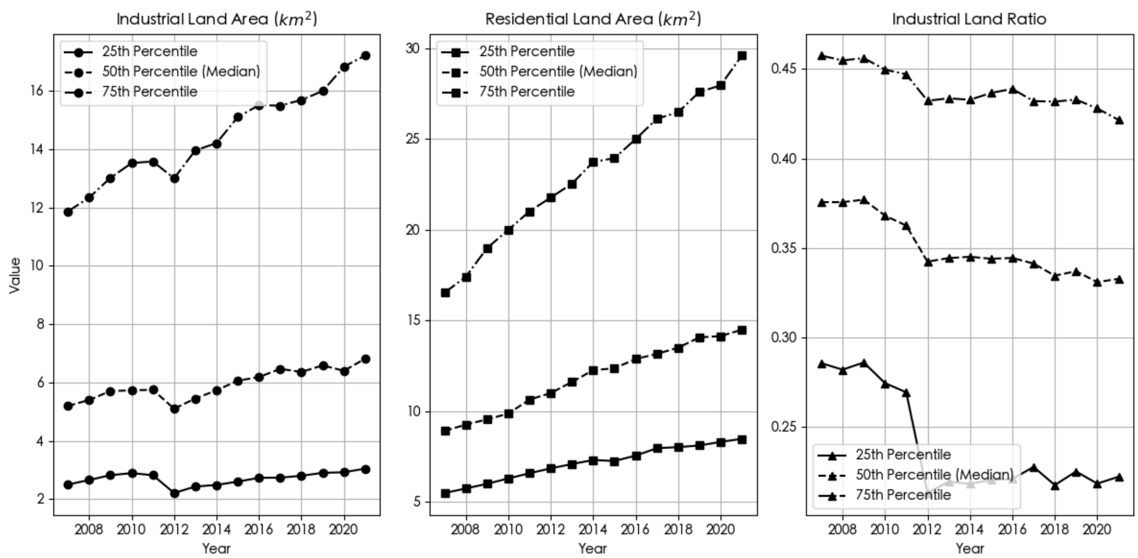
Notes: The data was obtained from the Urban Construction Statistical Yearbook of China (2007 to 2019) and was published by the Ministry of Housing and Urban-Rural Development of China.

Figure A.2: Distribution of Land Area Share in 2019 Across Cities



Notes: The data was obtained from the Urban Construction Statistical Yearbook of China (2007 to 2019) and was published by the Ministry of Housing and Urban-Rural Development of China.

Figure A.3: Evolution of Land Area and Ratio in Yearbook Data



Notes: Data source is the Ministry of Housing and Urban-Rural Development of China, Urban Construction Statistical Yearbook (2007 - 2019). Industrial Land Ratio is calculated as the ratio between industrial land area and the summation of industrial land area and residential land area.

Figure A.4: Price Ratio Between Residential and Commercial Land

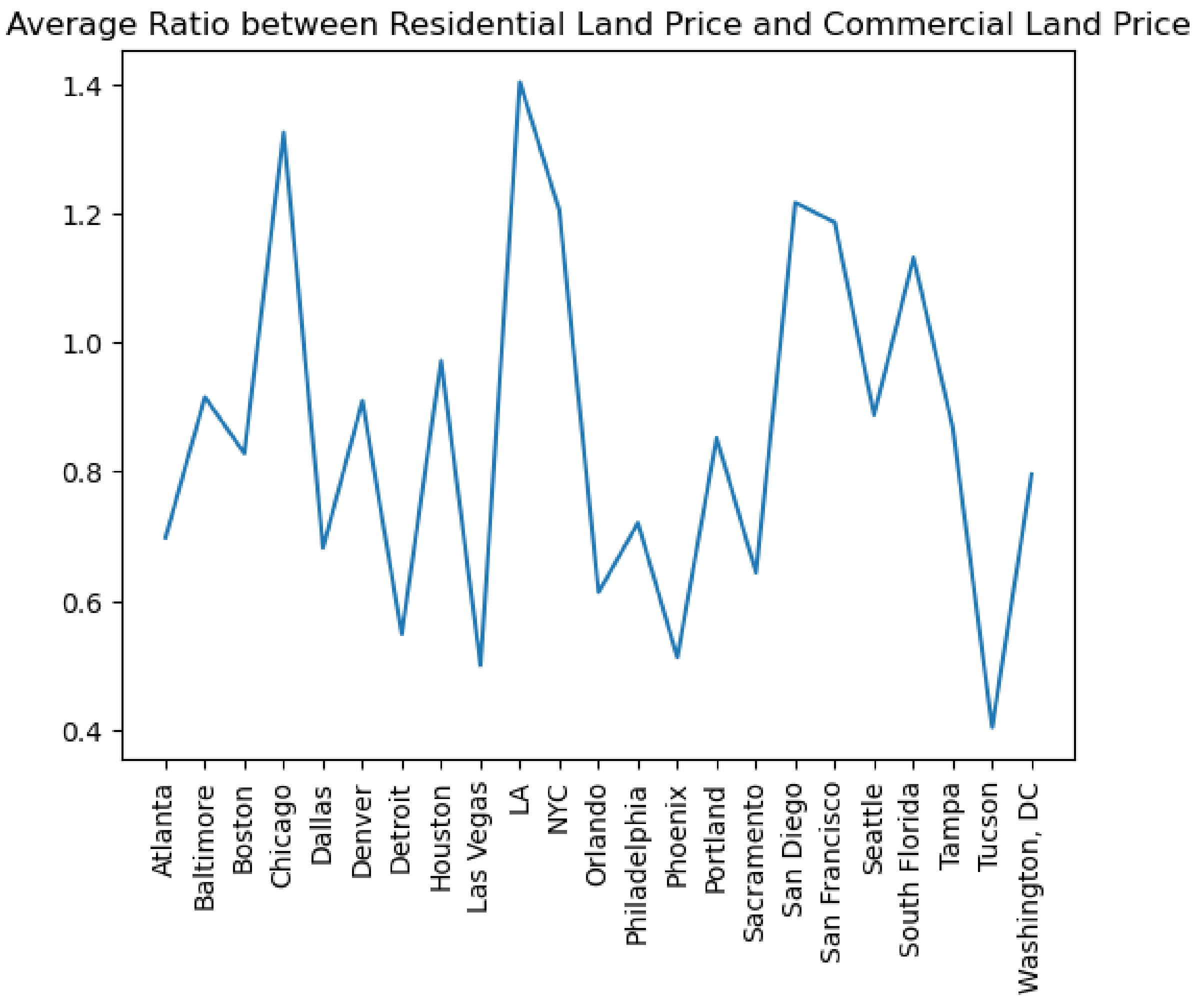


Table A.1: Summary Statistics of Statistics Yearbook Data

	Industrial Land Area		Residential Land Area		Industrial Land Ratio		Number of
Year	Mean	SD	Mean	SD	Mean	SD($\times$100)	Observations
2007	15.182	3.639	22.698	6.399	0.370	0.542	610
2008	16.170	3.716	24.681	7.144	0.368	0.541	611
2009	17.999	4.656	26.084	7.371	0.369	0.539	612
2010	18.816	5.361	26.770	7.459	0.362	0.536	610
2011	19.353	5.883	28.519	8.018	0.356	0.539	609
2012	19.866	5.468	31.643	8.155	0.324	0.629	607
2013	20.864	5.747	32.651	8.538	0.329	0.598	608
2014	22.444	6.249	34.910	9.227	0.328	0.588	615
2015	23.421	6.655	36.251	9.791	0.331	0.596	616
2016	23.818	6.745	36.064	9.862	0.333	0.599	616
2017	25.116	6.739	37.937	9.963	0.332	0.582	614
2018	24.817	6.931	38.058	10.587	0.327	0.582	613
2019	25.713	7.166	39.888	10.979	0.327	0.579	614
2020	26.392	8.081	39.965	11.112	0.326	0.599	613
2021	26.367	8.511	41.122	11.709	0.323	0.574	612

Notes: Data source is the Ministry of Housing and Urban-Rural Development of China, Urban Construction Statistical Yearbook (2007 - 2019). Industrial Land Ratio is calculated as the ratio between industrial land area and the summation of industrial land area and residential land area.

Table A.2: Summary Statistics of Land Transaction Database

		Freq.	Percent	
Number of Transactions	Urban	802,864	35.79	
	Rural	1,440,146	64.21	
Urban Land Transactions				
Land source	New Construction Sites	344,598	42.92	
	New Construction Sites (from Stock Pool)	98,137	12.22	
	Existing Construction Sites	360,129	44.86	
Transaction Saleway	Allocation	251,004	31.26	
	Negotiation	247,625	30.84	
	Auction	38,247	4.76	
	Bidding	4,036	0.5	
	Listing	261,952	32.63	
Land Type	Residential Land	275,432	34.57	
	Industrial Land	161,898	20.32	
	Commercial Land	103,022	12.93	
	Transportation Land	84,569	10.61	
	Public Admin & Service Land	127,048	15.95	
	Other Types	44,782	5.62	
Other Characteristics	**Mean**	**Std.**	**Min**	**Max**
Area of Land Parcel	4.167	80.320	0	42559
Total Price of Land Parcel	16,123.450	5,943,619	0	3.62E+09
Unit Price Per Hectares	1,136.755	2,324.461	0	12750.02
FAR Lower Bound	0.831	0.790	0	5
FAR Upper Bound	1.731	1.473	0	7
Distance to City Center	40.360	153.878	0	2941.959

Table A.3: Summary Statistics of Land Transaction Database 2

	New Construction Sites		New Sites from Stock Pool		New Construction Sites	
Transaction Saleway	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Allocation	151,556	43.98	36,812	37.51	62,636	17.39
Negotiation	20,549	5.96	24,701	25.17	202,375	56.2
Auction	19,303	5.6	5,515	5.62	13,429	3.73
Bidding	1,818	0.53	475	0.48	1,743	0.48
Listing	151,372	43.93	30,634	31.22	79,946	22.2
	New Construction Sites		**New Sites from Stock Pool**		**New Construction Sites**	
Land Usage	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Residential Land	53,528	15.56	35,758	36.44	186,146	52.5
Industrial Land	103,028	29.94	14,571	14.85	44,299	12.49
Commercial Land	35,624	10.35	11,281	11.5	56,117	15.83
Transportation Land	58,760	17.08	13,053	13.3	12,756	3.6
Public Admin & Service Land	73,731	21.43	16,446	16.76	36,871	10.4
Water Facilities Land	1,700	0.49	361	0.37	471	0.13
Public Rental Housing Land	1,536	0.45	347	0.35	1,478	0.42
Low-Rent Housing Land	1,855	0.54	925	0.94	1,512	0.43
Affordable Housing Land	9,985	2.9	4,759	4.85	12,657	3.57
	Residential Land		**Industrial Land**		**Commercial Land**	
Transaction Saleway	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Allocation	15,158	5.5	3,371	2.08	2,259	2.19
Negotiation	157,296	57.11	30,610	18.91	37,705	36.6
Auction	21,793	7.91	6,574	4.06	8,679	8.42
Bidding	1,728	0.63	1,082	0.67	1,068	1.04
Listing	79,457	28.85	120,261	74.28	53,311	51.75
	Residential Land		**Industrial Land**		**Commercial Land**	
Land Source	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
New Construction Sites	53,528	19.43	103,028	63.64	35,624	34.58
New Sites from Stock Pool	35,758	12.98	14,571	9	11,281	10.95
Existing Construction Sites	186,146	67.58	44,299	27.36	56,117	54.47

Table A.4: Unit Price of Land on the Parcel Characteristics

VARIABLES	(1) $log(P_{ict}/floor)$	(2) $log(P_{ict}/floor)$	(3) $log(P_{ict})$	(4) $log(P_{ict}/floor)$	(5) $log(P_{ict}/floor)$	(6) $log(P_{ict})$
Panel A: Subsamples of industrial land and residential-commercial land						
$IndDummy_{ict}$	-0.896***	-0.820***	-1.480***	-2.302***	-2.624***	-3.194***
	(-49.432)	(-44.024)	(-76.268)	(-13.426)	(-14.932)	(-17.810)
$IndDummy_{ict} \times Dist_c$				0.115***	0.148***	0.142***
				(8.212)	(10.175)	(9.910)
$log(dcity_{ict})$	-0.206***	-0.199***	-0.206***	-0.207***	-0.200***	-0.207***
	(-34.773)	(-33.137)	(-33.262)	(-34.304)	(-32.812)	(-32.870)
$log(dcounty_{ict})$	-0.028***	-0.025***	-0.059***	-0.030***	-0.027***	-0.060***
	(-5.490)	(-4.862)	(-13.477)	(-5.716)	(-5.101)	(-13.457)
$log(area_{ict})$	-0.001	0.006*	0.003	-0.007**	-0.001	-0.003
	(-0.432)	(1.892)	(0.728)	(-2.222)	(-0.343)	(-0.677)
$log^2(area_{ict})$	-0.002	0.000	0.006***	-0.002	-0.000	0.006***
	(-1.179)	(0.029)	(3.221)	(-1.340)	(-0.235)	(3.043)
Observations	652,778	615,583	465,467	624,739	590,146	447,606
R-squared	0.519	0.500	0.616	0.516	0.498	0.612
City - Year FE	Y	Y	Y	Y	Y	Y
Panel B: Subsamples of two lands and transactions via public auctions						
$IndDummy_{ict}$	-1.051***	-0.946***	-1.542***	-2.272***	-2.438***	-3.150***
	(-86.777)	(-67.375)	(-95.123)	(-18.612)	(-17.465)	(-21.398)
$IndDummy_{ict} \times Dist_c$				0.100***	0.123***	0.133***
				(10.297)	(10.984)	(11.190)
$log(dcity_{ict})$	-0.185***	-0.180***	-0.191***	-0.185***	-0.180***	-0.191***
	(-51.078)	(-48.853)	(-46.556)	(-50.456)	(-48.200)	(-46.144)
$log(dcounty_{ict})$	-0.040***	-0.038***	-0.068***	-0.042***	-0.040***	-0.069***
	(-15.724)	(-14.496)	(-23.310)	(-16.698)	(-15.408)	(-23.439)
$log(area_{ict})$	-0.012***	-0.006**	-0.001	-0.018***	-0.012***	-0.006**
	(-4.568)	(-2.097)	(-0.249)	(-6.579)	(-4.307)	(-2.068)
$log^2(area_{ict})$	-0.000	0.001	0.007***	-0.001	0.001	0.007***
	(-0.282)	(1.292)	(5.724)	(-0.632)	(0.797)	(5.370)
City - Year FE	Y	Y	Y	Y	Y	Y
Observations	495,066	476,129	351,770	472,975	455,085	337,042
R-squared	0.566	0.510	0.711	0.561	0.505	0.708

Notes. This table keeps the subsamples of industrial land and residential-commercial land transactions, and panel B excludes all transactions via negotiation or allocation. Control variables in each regression contain the format of transactions, the maximum floor area ratio, land quality rank, and the source of land. All standard errors are clustered into the level of city-year.

Appendix B A Simple Model of Land Price and Allocation

To understand the relationship between the quantity (area) and price of different types of land. We consider a canonical Rosen-Roback model with homogeneous and fixed amount of land distributed between industrial and residential usage.

Consider a city with fixed total land $\bar{X}$ divided between industrial land K and housing land H. Local representative firm uses industrial land and labor to produce a numeraire consumption good sold in world market (without trade cost) and pay back land and labor at competitive return rates. Local workers inelastically supply one unit of homogeneous labor and spend all the income on consumption good and local residential land. Let Y denote the total output, U denote the utility of a representative local resident, we have

$$Y = Y(K, L)$$
$$U = U(c, h)$$

where c and h are respectively consumption good and residential land consumed by the worker. Then, we have the following general characterization of land prices under efficient allocation:

Proposition 1. *If all the land sales revenues are evenly rebated to local workers, the price will be equalized between residential land and industrial land under efficient land allocation i.e. the allocation that maximize local resident's utility.*

The intuition of this proposition is also simple. Note that if all the land sales revenue is rebated to local workers, all the output will be consumed by local workers. Therefore, we could write the indirect utility function V of worker as

$$V(K, H) = U(\frac{Y(K, L)}{L}, \frac{H}{L})$$

Under optimal land allocation, the marginal contribution of two lands to utility should be equalized i.e.

$$\frac{\partial U}{\partial C}\frac{\partial Y}{\partial K} = \frac{\partial U}{\partial H}$$

Meanwhile, from the firm's optimization problem we know that the price of industrial land equals its marginal product:

$$P_K = P_c \frac{\partial Y}{\partial K}$$

and from worker's optimization problem, we know that the price of residential land is determined by marginal utility ratio

$$\frac{P_H}{P_c} = \frac{\partial U/\partial H}{\partial U/\partial C}$$

Combine the two equations we can see that when the two prices are equal, we exactly equalize the marginal contribution of residential land and industrial land to worker utility, which finishes the proof.

While in the above proof, we implicitly assume that the local labor population L is constant, it turns out that the same result holds when labor is mobile and react to local utility, as is shown in the following proposition

Proposition 2. *The result of Proposition 1 still hold when local population L is a function of local utility i.e. $L = \mathcal{L}(U)$.*

The proposition also holds for all the common functional forms of production function Y and worker preference U. Specifically, when we consider Cobb-Douglas function, we have the following neat characterization of efficient land allocation:

Proposition 3. *If we assume that both the production function and worker* *preference take the following Cobb-Douglas form:*

$$Y = AK^{\alpha}L^{1-\alpha}$$
$$U = Bh^{\beta}c^{1-\beta}$$

where A and B are respectively local productivity and quality-of-life amenity. Then the efficient (worker welfare maximizing) land allocation is given by:

$$K = \frac{\alpha(1-\beta)}{\alpha(1-\beta)+\beta}\bar{X}; \quad H = \frac{\beta}{\alpha(1-\beta)+\beta}\bar{X}$$

This is an intuitive result, as optimal residential land share is increasing in β, which measures its importance in worker welfare, while the optimal industrial land share is contingent on $\alpha(1-\beta)$: how industrial land increases workers' good consumption (whose importance is measured by $(1-\beta)$) through increasing output (where the importance of industrial land is measured by α).

Another thing worth noting in the model is that we assume that all the revenue of land sales is evenly rebated to local residents. Previous literature has several different treatment on the disposal of the local factor income. It is either evenly rebated to local workers for tractability (e.g. in the benchmark model in Redding (2016)), or distributed across space to generate trade imbalance (e.g. Caliendo et al. 2019). In the context of China, Tombe and Zhu (2019) assume that it is evenly distributed among people who stay in their original place to characterize the impact of hukou system. While little attention is paid to its implication on land allocation efficiency.

Proposition 4. *If a constant share t of the output is taken away from local worker (either through transfer of land revenue or a linear tax without lump sum rebate), the efficient land allocation does not coincide with the market equilibrium where land allocation is determined by price equalization. Instead, the efficient equilibrium features a higher proportion of land for residential land usage.*

This proposition could be easily seen by writing out the indirect utility function:

$$V(K,H) = U(\frac{(1-t)Y(K,L)}{L}, \frac{H}{L})$$

Then, when following the same procedures in the proof of proposition 1, we can see that $(1-t) \in (0,1)$ downplays the contribution of industrial land to utility, leading to a smaller share of industrial land. This indicates that in some scenarios of the literature listed above, subsidy to residential land could be a welfare-enhancing policy. While in our context, it turns out that such distortion exactly serves the purpose of output maximization:

Proposition 5. *If we assume that the production function and worker preference take the Cobb-Douglas functional form as in proposition 3, we have the following results:*

1. *If we assume that local population takes the following functional form of local utility with constant elasticity:*

$$L = U^{\varepsilon}$$

then the local output maximizing land allocation is given by:

$$K = \frac{\alpha(1+\frac{1}{\varepsilon})}{\alpha(1+\frac{1}{\varepsilon}) + \beta(1-\alpha)}\bar{X}; H = \frac{\beta(1-\alpha)}{\alpha(1+\frac{1}{\varepsilon}) + \beta(1-\alpha)}\bar{X}$$

2. *If we assume that local government takes out a constant share t of the output away from local worker, the land allocation under price equalization is given by:*

$$K = \frac{\alpha(1-\beta)}{\alpha(1-\beta) + \beta(1-t)}\bar{X}; H = \frac{\beta(1-t)}{\alpha(1-\beta) + \beta(1-t)}\bar{X}$$

Specifically, if we assume that local government takes away all the land sales revenue without rebate and does not impose any direct tax, we *have $t = \alpha + (1-\alpha)\beta$, under which the market equilibrium of land allocation coincides with the output-maximizing land allocation when labor is perfectly mobile i.e. $\varepsilon \to \infty$.*

Different from the efficient allocation where government subsidizes residential land, in the case of output maximizing government, it is good from government's perspective to subsidize industrial land either through directly manipulating land allocation or indirectly taxing local worker. Another interesting implication is that even when government is not self-interested Leviathan as in Diamond (2017), it may still be ideal for them to extract rent from local resident to help deviate land allocation away from efficient equilibrium but closer to the output-maximizing outcome. Moreover, it is also straightforward to see the role of labor mobility, characterized by migration elasticity ε, in determining the output-maximizing land allocation: if $\epsilon = 0$ i.e. the local labor is perfectly immobile, the local government will distribute all the land to industrial usage. On the contrary, increasing the value of ϵ i.e. allowing workers to be more responsive to change in local conditions will help alleviate, though not fully addressing, the problem of industrial land oversupply. This result is also in the spirit of Tiebout (1956) where mobile residents could help discipline local government and nudge the equilibrium towards an efficient one. Or, put it differently, when labor mobility increases, even output maximizing local government is pressured to supply more residential land to bid for workers.

A final note: throughout the discussion of this session, we only focus on the quantity (area) of the land, and abstract away from the heterogeneity of urban land in terms of location, amenity etc., and how the different land usages sort into different land, which is the focus of another strand of urban economics literature e.g. Lucas and Rossi-Hansberg (2002). While the sorting could lead to substantial price gap, the impact of land characteristics could be stripped away by a hedonic regression in empirical study, and price ratio we obtained in this simple model corresponds to the the "inherent" price ratio between different types of land revealed in the empirical study, which is the topic of the next section.