Pro-Manufacturing Land Policies of Competing Local Governments: A Quantitative Analysis of China*

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Abstract

Local government policies can correct market inefficiencies but are also shaped by spatial political economy considerations. We study the rationale and impact of local land policies in China, where local governments have a de facto monopoly in regional urban land markets and exhibit a pronounced pro-manufacturing land allocation across sectors. We develop a multi-sector quantitative spatial equilibrium model where local governments compete non-cooperatively through local land policies. Calibrating and simulating the model, we find that the observed policies are, on average, comparable to the Nash policy when local governments maximize manufacturing output. This result reveals a manufacturing bias in the observed land policies. When local governments instead prioritize maximizing local real income per capita, we find that the land allocation to manufacturing still considerably exceeds that in a competitive market. However, this pro-manufacturing policy results in higher local real income per capita across regions. Finally, when considering the goal of maximizing national average real income per capita, we find that the non-cooperative outcome is nearly as effective as the cooperative equilibrium.

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1 Introduction

The policies by local governments play an important role in resource allocation, but the rationale and welfare consequences of their policies have not been fully understood. On the one hand, local governments can potentially use local policies to mitigate inefficiencies arising from various forms of externalities in the competitive equilibrium. On the other hand, when local governments compete non-cooperatively or have local objectives that deviate from local welfare (e.g., bias toward a particular sector), local government policies may conflict with national welfare, contributing to the misallocation of resources across regions and sectors.

This paper studies the rationale and welfare implications of local government policies in China both empirically and theoretically using a quantitative spatial model with non-cooperative competition between local governments via local land policies.[1] China offers a distinct case for this study due to its unique urban land policies. Specifically, the local government of each region in China is de facto monopoly in the urban land markets within the region. It allocates its total land supply between different uses–including manufacturing, residential, and services, in which the total land supply is restricted by the central government for each region. The local government's urban land policies, as we stated above, can potentially mitigate or aggravate the misallocation of resources, depending on the objectives of local governments and the competition between them. Our quantitative investigation aims to unveil the local governments' objectives and discern which of the counteracting forces prevail in the economy.

Empirically, we document a "manufacturing bias" in the observed allocation of urban land across regions in China. By analyzing land transaction data from 2008 to 2015, we estimate price differentials across land uses, including manufacturing, residential, and services sectors. We find that, on average, land prices for residential and services uses are more than twice as high as land prices for manufacturing in the same region, even after adjusting for observable characteristics of transacted land. Notably, the estimated price gaps show variation across provinces. Specifically, regions that allocate a higher proportion of land to manufacturing use tend to have lower land prices for manufacturing use relative to other land uses, with differences of up to 9 times greater.

Moreover, we find that provinces that have a higher land price discount for manufacturing uses tend to also have a relatively larger number of manufacturing firms/workers than service firms/workers. The local government's allocation of a larger share of land to manufacturing activities lowers regional land input prices and reduces production costs for manufacturing firms. As a result, the region becomes more attractive to manufacturing firms. Conversely, this leads to higher land costs for residential and services sectors. These differential changes in input costs by sector

[1] Competition among local governments for firms and investment has been a salient feature of the Chinese economy over the past few decades, which is widely recognized as a key driver behind China's rapid economic growth (Qian and Roland, 1998; Li and Zhou, 2005; Xu, 2011; Xiong, 2018).

may lead to the observed association between land policy and the distribution pattern of firms.

Importantly, our findings also show that provinces with greater land discounts for manufacturing tend to exhibit lower relative labor productivity (sales per worker) in manufacturing compared to services. This suggests that regions allocating more land to manufacturing may not necessarily possess a comparative advantage in this sector, and their land policy might be contributing to further misallocation of resources across regions and sectors, potentially exacerbating inefficiencies in the economy.

To understand the observed patterns and evaluate their welfare implications, we construct a multi-sector, multi-region quantitative spatial equilibrium model. In each region, there are two areas: urban and rural. Workers are assigned a specific region and area at birth ("hukou") and have the option to migrate to other regions or areas, incurring migration costs. The urban area comprises three sectors — manufacturing, services, and housing — while the rural area includes agriculture and housing.

The manufacturing (vs. services) sector of the urban area is endowed with a continuum of firms that can freely enter the sector of a region by paying an entry cost. Upon entering the specific market, they engage in monopolistic competition and produce using labor, capital, intermediate inputs, and the land allocated for the use of this specific sector. The entry of new firms generates not only positive externalities – stemming from the increased variety of goods for consumption and intermediate use – but also agglomeration/congestion effects arising from the increased supply of sectoral labor and the increased demand for land for production and residential purposes. Local policies have the potential to balance these two counteracting forces and increase aggregate welfare relative to what the economy could achieve in the competitive equilibrium.

We calibrate the fundamentals and structural parameters of the model using data from China in 2012 (or the nearest available years), considering the local land policies as given in the data. Additionally, by utilizing the inverted productivity of the region after accounting for variety effects, we estimate the agglomeration effect of sectoral labor on sectoral productivity. Our findings reveal negative agglomeration (congestion) effects in both manufacturing and services sectors. However, these effects are outweighed by the greater variety effects resulting from more firms entering the market along with the increased labor supply. It is crucial for local governments to consider variety effects and congestion effects stemming from labor and land supply limitations when formulating their policies.

Subsequently, using the calibrated fundamentals, we conduct a counterfactual analysis wherein local governments lose their authority to control urban land allocation, allowing the market to determine allocation (i.e., competitive land market allocation) in each region. Our findings indicate a substantial reduction in the share of land allocated to manufacturing in most regions, with observed reductions of up to 50 percentage points. Furthermore, we find that the prevalent biased land allocation towards manufacturing in the data, as opposed to the competitive land market allocation, is associated with significant losses in real income for the (more advanced) coastal regions in China, up to almost 15%, and significant gains in real income for the (less advanced) inland regions.

To gain a deeper understanding of the rationale behind the distribution of urban land across different sectors, we enhance our model by incorporating the endogenous land policies implemented by local governments. This inclusion takes the form of a non-cooperative game, inspired by the methodology employed in the study by Ferrari and Ossa (2023). Each region's local government possesses the authority to make decisions regarding the allocation of urban land for various purposes. They strategically utilize their land policies as a competitive tool to attract more firms or workers and to align them between sectors in order to maximize their objectives.

We begin by considering scenarios where the objective of local governments is to maximize either local real income or local manufacturing output. We find that the level of land allocation implied by the data is, on average, comparable to that implied by the case when local governments compete to maximize local manufacturing output. Comparing these two scenarios to the competitive land market case, we observe a higher proportion of land allocated to manufacturing across the majority of regions, up to 20 percentage points for several regions for real income maximization scenario and 70 percentage points for a few regions for manufacturing output maximization scenario. These findings suggest that competition among local governments plays a significant role in explaining the observed land allocation patterns across sectors.

Although implied local land policies are pro-manufacturing, we find that real income is higher than the competitive market equilibrium case for all but one region when local governments maximize local real income, suggesting that local government land policies can potentially improve welfare. Moreover, when we compare this scenario to the land policies observed in the data, we find that most regions would experience significant real income gains, suggesting the possibility of welfare gains for the country from shifting local government objectives.

Finally, the cooperative equilibrium, where a national social planner chooses local land shares to maximize national real income, yields slightly lower manufacturing land shares and slightly higher local real income per capita than the case where local governments maximize local real income. Two notable exceptions are Beijing and Shanghai, where the social planner adopts higher manufacturing land shares that lead to lower local real income per capita.

Related literature. This paper is related to the growing literature that utilizes quantitative spatial equilibrium models to examine how the spatial misallocation of production factors affects aggregate productivity and welfare (e.g., Herkenhoff et al., 2018; Tombe and Zhu, 2019; Fan, 2019; Bryan and Morten, 2019; Hsieh and Moretti, 2019; Hao et al., 2020). In line with this literature, our research extends the analysis by investigating the political economy factors that drive spatial misallocation.

Specifically, we explore the endogenous land policies adopted by local governments, contributing to a deeper understanding of the underlying mechanisms and implications of spatial misallocation.

The role of competition among local governments in resource allocation across regions has been a central topic in public economics since at least Tiebout (1956). Reviews by Mieszkowski and Zodrow (1989) and Agrawal et al. (2022) provide comprehensive insights on this topic. While recent studies such as Suárez Serrato and Zidar (2016) and Fajgelbaum et al. (2019) have utilized quantitative spatial equilibrium analysis to assess the welfare implications of various local policies, these studies typically treat the policies as exogenous. Notable exceptions are Ferrari and Ossa (2023) and Deng et al. (2023). Ferrari and Ossa (2023) use a quantitative spatial model to examine the endogenous competition for subsidies among U.S. states, while Deng et al. (2023) investigate the implications of the foreign multinationals on regional tax policies in China. In contrast to those papers, our paper focuses on examining the urban land policies of local governments in China, and we specifically explore the interplay between factor mobility and these local policies.

The urban land policy in China has garnered significant attention from both academic and policy circles in recent years. While many studies have adopted a reduced-form approach, there are notable recent contributions that employ structural analysis. For instance, Yu (2019) develops a quantitative spatial equilibrium model to examine the impact of the Farmland Red Line Policy on economic development and welfare in China. Similarly, Fang et al. (2022) investigates the aggregate effects of land quota allocation across regions. These papers primarily focus on the overall land supply in a region, considering the given policy framework. In contrast, our paper concentrates on the endogenous allocation of land across different usages within a region. Another relevant study by Henderson et al. (2022) explores the misallocation that arises from the political manipulation of land markets by local governments. While their analysis considers local governments as small "price-takers," and the heterogeneous land policies as the result of heterogeneous preferences of local governments, our paper highlights the strategic interactions that occur between these entities.

The remainder of the paper is structured as follows. Section 2 outlines the construction of the data and presents the empirical evidence. Section 3 develops the multi-region, multi-sector spatial with local policies by non-cooperative local governments. Section 4 describes the calibration strategy. Section 5 presents the quantitative results. Section 6 concludes.

2 Data and Empirical Evidence

In this section, we first discuss data sources concerning firms, workers, and the stock and price of land for different uses at the regional level in China. Subsequently, we use this data to present three novel facts regarding the "manufacturing bias" evident in local land policies and firm distributions.

2.1 Data

We mainly combine three data sources to construct our dataset of regional firms, labor, and land stock and price. The first source is the China Statistical Yearbook (CSY), from which we obtain the number of establishments and population at the province level from 2010 to 2015. The second source is the "Summary and Analysis Report of National Urban Land Use," from which we construct prefecture- and province-level stocks of land for manufacturing, services, and residential uses. The last source is the online dataset of land transactions in China, from which we estimate province-level land price gaps between manufacturing and services or residential sectors.[2]

2.2 Urban Land Policy and Local Government Competition in China

To gain a thorough understanding of the potential misallocation of firms and workers in China and the role of local government land policies in shaping this issue, it is essential to introduce two key institutional backgrounds: the urban land policies implemented by local governments and the competition among these local governments. This subsection aims to provide insights into each of these backgrounds.

Urban land policy by local governments. In China, all urban land is constitutionally owned by the national government. However, since the 1980s, a market for urban land use rights has gradually emerged and expanded. In this process, local governments have assumed the exclusive role of regional legal owners and suppliers of urban land, effectively becoming monopolies. While the total supply of newly developed urban land in each city is largely determined through a cooperative effort involving higher-level governments, local governments have the discretion to allocate the total supply among various categories of use, including manufacturing, services, residential, and public utility.[3] Given the importance of the manufacturing, services, and residential sectors to the region's GDP growth, we focus on the allocation of land to these three types of uses. Among these three types of use, the observed land price for residential and services uses are close and much more expensive than that for manufacturing use.

While the central government provides general guidelines regarding the distribution of land usage types within a city, these guidelines are typically loosely formulated and do not necessarily impose binding obligations on local governments. This arrangement has empowered local governments to act as intermediaries, managing the transactions and distribution of urban land use rights within their respective regions. As the de facto monopolists in local land markets who can allocate

[2] http://www.landchina.com.

[3] Land use for public utility includes education, health, transportation, and related purposes. For manufacturing, we include construction and minerals.

urban land across different usage categories at their own will, local governments can influence the relative prices of various land types to serve their own objectives.[4]

Competition among local governments via land policies. Competition among local governments for firms and investment has been a salient feature of the Chinese economy over the past few decades. The literature has proposed two key reasons underlying this competition. Firstly, within the framework of federalism in China, local governments engage in competition to attract firms in order to expand their tax bases. This aspect has been discussed in depth by Jin et al. (2005) and Han and Kung (2015). Secondly, a ”GDP tournament” among local government officials has been identified in the literature, as highlighted by studies such as Li and Zhou (2005) and Xiong (2018). This tournament refers to the competition among officials, where the probability of their promotion is influenced by the economic performance of their respective regions.

These factors drive the competition observed among local governments in China, influencing their policies and strategies as they strive for economic growth and development. Among them, the extent to which they allocate land for industrial use, i.e., *the land share for manufacturing use*, is an important one. Back in 2016, a list of major Chinese cities, including Shanghai, Suzhou, Guangzhou, and Qingdao, participated in the competition for the first Tesla Gigafactory in China.[5] In 2018, Shanghai won and became the location of Gigafactory Shanghai with a basket of favorable policies, the most important policy of which was around 214 acres of manufacturing land provided to Tesla at a low price of 14 US dollars per square feet.[6] Apparently, the case of Tesla is only one of the numerous cases that happen in China.

2.3 “Manufacturing Biases” in the Local Land Market

This subsection introduces three key observations crucial for motivating our subsequent model: the prevailing ”manufacturing bias” in the land market across regions in China, its association with firm and worker distributions in the sector, and lower relative labor productivity of manufacturing in regions with larger “manufacturing biases”.

Fact 1: Higher price discounts for manufacturing uses are associated with more land allocation for manufacturing

Table 1 displays the estimated land price gaps among different land uses: services, residential, and manufacturing (industrial) uses, with manufacturing land price used as the benchmark. The

[4] For more details on the institutional background of the urban land market in China, readers are also referred to Chen and Kung (2019), Gyourko et al. (2022), He et al. (2023), and Fang et al. (2022).

[5] https://tech.sina.cn/csj/2020-02-04/doc-iimxxste8649080.d.html.

[6] https://auto.ifeng.com/qichezixun/20190723/1312187.shtml.

estimation is based on plot-level land transaction data spanning from 2008 to 2015, utilizing the following equation:

$$\log\left(P_{l,t}\right) = Residential_{n(l)} + Services_{n(l)} + \boldsymbol{X}'_{l,t}\boldsymbol{\beta} + \chi_{p(l)} + \chi_{y(t)} + \eta_{p(l)}y(t) + \varepsilon_{l,t}. \quad (1)$$

Here, $P_{l,t}$ represents the price of plot l at time period t. $Residential_{n(l)}$ and $Services_{n(l)}$ denote the fixed effects used to estimate the price gap for residential or other services uses compared to land for manufacturing purposes. The estimation of the price gaps is conducted at the province-level regions, denoted as $n(l)$. $\boldsymbol{X}_{l,t}$ is a vector comprising characteristics of land and transaction types that could influence the transaction price. [7] To account for potential underlying variations across regions, prefecture fixed effects $\chi_{p(l)}$ and year trends by prefecture are controlled for. Additionally, year fixed effects are included to address macro-level shocks on land transactions.

Table 1 illustrates the estimated land price gaps experienced by services and residential land uses in comparison to manufacturing uses within the land market. On average at the national level, the price for these uses exceed twice the price of manufacturing utilization. Moreover, their price differentials relative to manufacturing use do not exhibit significant distinctions. This finding is further validated by the estimation results in the second column, which exclusively focuses on land transactions for services and residential uses, using services use as the benchmark. Motivated by this data fact, our model will encompass two distinct land markets: one is for manufacturing uses and the other is for either services or residential uses.

Notably, the estimated gaps vary across provinces. As detailed in Section 2.2, local governments, functioning as de facto monopolists, hold the authority to determine the supply of land for various uses. To assess the potential impact of their land policies on the price gap, we illustrate in Figure 1 the relationship between the price gap for manufacturing use and services uses (services and residential) and the share of manufacturing land use among the three types across provinces in China. Figure 1 presents that a larger land share for manufacturing use is associated with a lower land price for manufacturing use relative to that for residential use. Therefore, heterogeneous land price discounts are likely the result of different local government land policies across regions in China rather than heterogeneous demand for different land uses. In addition, it is noteworthy that all provinces in China discount manufacturing land use relative to service land use, suggesting that all provinces have a manufacturing bias in the land market.[8]

[7]Specifically, following Henderson et al. (2022), we incorporate controls for the logarithm of the land area of the transaction, the logarithm of the total area of land transactions in the prefecture for the year, separately for manufacturing and services, the logarithm of the distance to the city center, its interaction with the logarithm of the land area, the maximum floor-to-area ratio, and the auction format.

[8]Figure B.1 shows the price differentials between manufacturing uses and services and residential uses, separately. In almost all provinces, the price gap between service uses and manufacturing uses is comparable to the gap between residential uses and manufacturing uses, aligning with the national average results.

Table 1: Land Price Gaps between Different Uses

Dep. Variable	Log Land Price	
	All	No Manufacturing
Residential	1.335***	0.064
	(0.057)	(0.039)
Services	1.293***	
	(0.039)	
Prefecture FE	Yes	Yes
Year FE	Yes	Yes
Prefecture FE * Year Trend	Yes	Yes
Controls	Yes	Yes
Observations	383599	260871
R^2	0.733	0.748

Note: This table shows the land price differences between manufacturing, services, and residential uses in China, based on plot-level land transaction data from 2008 to 2015. Column 2 (”All”) compares the land prices of services and residential uses, respectively, relative to manufacturing use. Column 3 (”No Manufacturing”) compares the land prices of residential uses relative to services use. Control variables include land area, maximum floor-to-area ratio, auction format, total area of manufacturing land transactions, total area of services land transactions, and distance to city center and its interaction with land area. Robust standard errors are in parentheses.

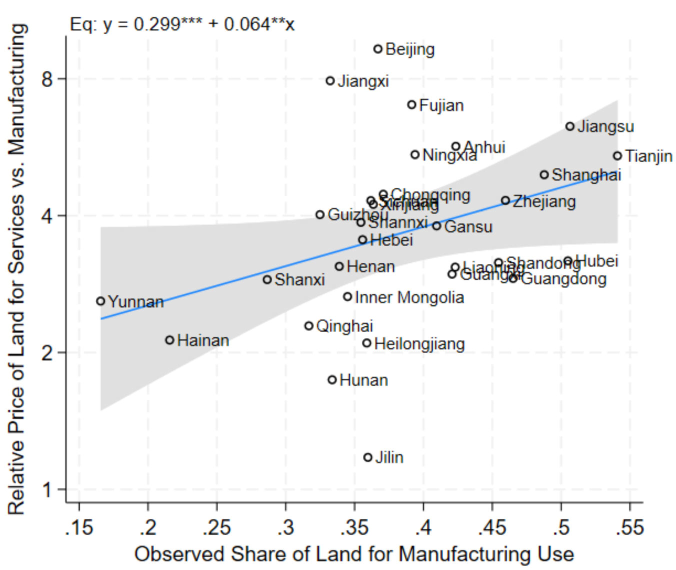
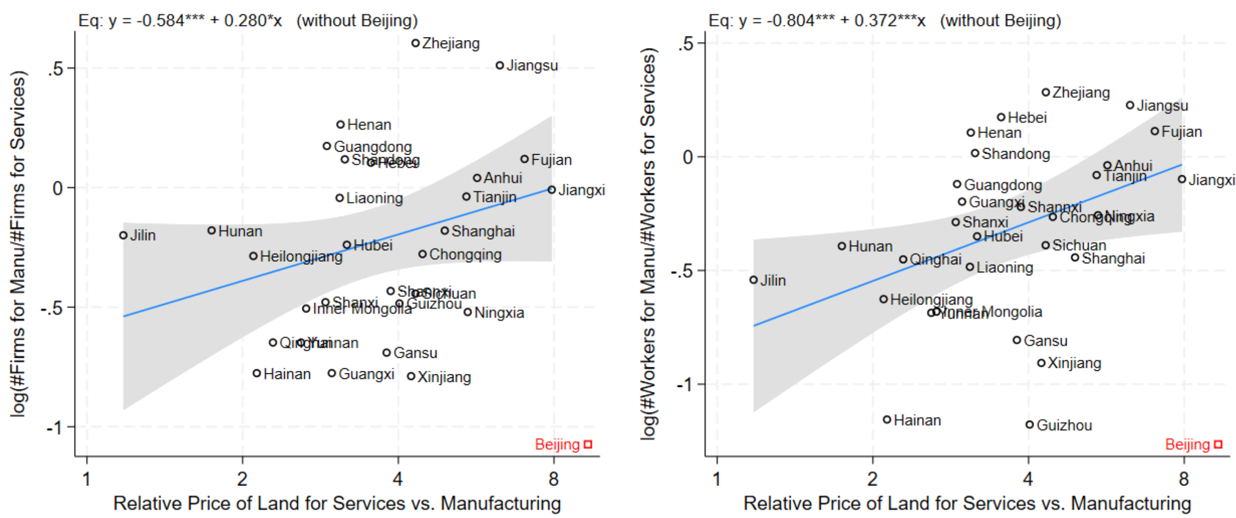


Figure 1: Manufacturing land price and the land share for manufacturing uses in different provinces

Note: The figure shows the relationship between the price ratio of manufacturing land prices to residential land prices and the share of manufacturing land in each province in China. The price ratio is estimated using micro data. See text for the details on the estimation. The blue line represents the fitted line, along with the 95% CI indicated by the gray shadow area.

Fact 2: Higher price discounts for manufacturing uses are associated with more manufacturing firms and workers

A lower manufacturing land price has the potential to reduce the marginal cost of production for manufacturing firms, thereby making the region more attractive for their establishment. Additionally, the resulting decrease in manufacturing land price, driven by a larger share of manufacturing land, leads to a higher land cost for services sector. This, in turn, elevates the marginal cost of production for the sector, potentially prompting service firms to consider relocating from the region. These potential effects suggest a conceivable association between land allocation for manufacturing and the disparity in firm distribution between manufacturing and services.



(a) Firm (b) Worker

Figure 2: Land price discounts for manufacturing and factor distribution disparity between manufacturing and services

Note: The panel (a) shows the relationship between the land price discounts for manufacturing uses and the relative ratio of manufacturing to service firms in each province in China. The ratio of manufacturing to service firms is defined as the ratio between the fraction of manufacturing firms distributed to the province and the fraction of service firms distributed to the province. The panel (b) shows the relationship between the land price discounts for manufacturing uses and the ratio of workers between manufacturing and service in each province in China. The price discount is estimated using micro data. See text for the details on the estimation. The blue lines represent the fitted line, along with the 95% CI indicated by the gray shadow area.

We confirm this association in the data, as illustrated by Figure 2a. With probably the exception of Beijing, provinces that have higher price discounts for manufacturing land attract a relatively more manufacturing firms than they do for service firms, measured by the ratio between the fraction of manufacturing firms distributed to the province and the fraction of service firms distributed to the province. Similarly, in Figure 2b we see that provinces with higher price discounts for manufacturing land also have a higher ratio of manufacturing workers to service workers.

Fact 3: Relative labor productivity of manufacturing to services is lower in provinces with higher land discounts for manufacturing

Lastly, we demonstrate that provinces with higher land discounts for manufacturing tend to have lower relative labor productivity of manufacturing to services. This relationship is depicted in Figure 3, in which the x-axis is the province-level relative price of land for services and manufacturing—defined as the ratio of land prices for residential and other services uses to the manufacturing land price, and the y-axis is the labor productivity—defined as sales per worker. This suggests that regions that allocate more land for manufacturing do not seem to have a comparative advantage in the manufacturing sector.

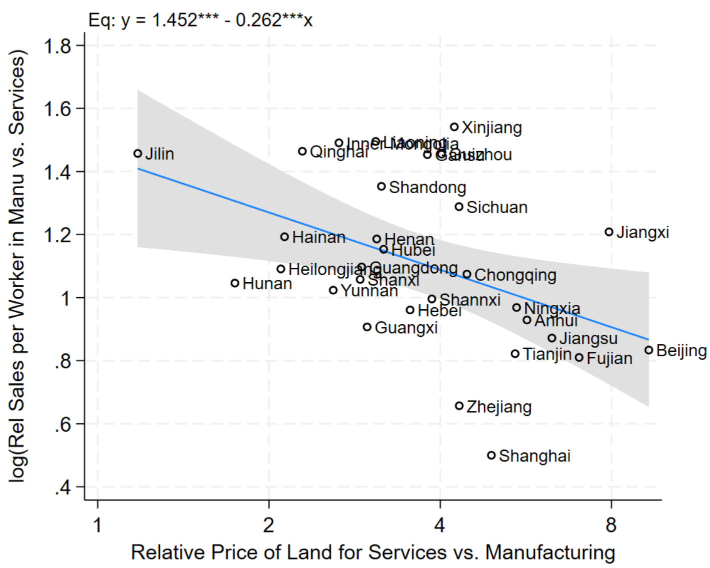


Figure 3: Land price discounts for manufacturing and relative labor productivity of manufacturing to services

Note: The figure shows the relationship between the land price discounts for manufacturing uses and relative labor productivity of manufacturing to services in each province in China. The price discount is estimated using micro data. See text for the details on the estimation. The labor productivity is defined as sales per worker. The blue line represents the fitted line, along with the 95% CI indicated by the gray shadow area.

As discussed, manufacturing biases are evident in China's land market, with provinces that allocate more land to manufacturing experiencing discounted land prices relative to services. These land policies correlate with the observed disparities in the distribution of firms and workers in manufacturing and services, suggesting that pro-manufacturing land policies effectively attract them to the sector.

However, provinces with higher land discounts for manufacturing tend to have lower relative labor productivity of manufacturing to services. The critical question is whether these policies are welfare-enhancing or distorting. Increased land allocation for manufacturing may limit land availability for residential uses, potentially leading to higher living costs. This, in turn, could discourage workers from relocating to these regions or prompt local workers to move out, resulting in a potentially inefficient allocation of workers and firms across regions. However, this might not necessarily be the case. China is undergoing a structural change in its economy and may possess a comparative advantage in the manufacturing sector as a whole. If so, the estimated and observed "manufacturing biases" could enhance the country's competitiveness and facilitate a more efficient allocation of workers and firms across regions and sectors. Achieving this efficiency might not be possible through a competitive land market when externalities are present. In the next section, we construct a quantitative spatial model to explore the implications of observed land policies. Subsequently, we delve into the role of interregional competition among local governments in the following section.

3 Model

In this section, we develop a spatial general equilibrium model that incorporates the location choices of workers and free entry of firms in a multi-sector environment. Our model builds on Tombe and Zhu (2019) to represent China's hukou system within a spatial framework. It is important to note that this section, along with the subsequent quantitative analysis, operates under the assumption of fixed land allocation. Subsequently, we will introduce the concept of non-cooperative competition among local governments, following Ferrari and Ossa (2023). These local governments aim to maximize their respective local objectives through land policies, specifically in terms of allocation for manufacturing or services uses.

There are $N+1$ regions representing China's N provinces plus the rest of the world, indexed by $n, i \in \{1, \ldots, N+1\}$. Each region has two areas: urban and rural, denoted by $j, k \in \{U, R\}$. The urban area has three sectors, manufacturing, services, and residential services, denoted by $s \in \{M, S, H\}$ respectively. The rural area, instead, has two sectors, agriculture and residential services, denoted by $s \in \{A, H\}$ respectively. In the manufacturing and service sectors of region-urban area nU, a continuum of M^s_{nU} firms entering the market by paying entry costs and play monopolistic competition. In the agriculture and residential service sectors, we assume that the market is perfectly competitive.

Firms in the agriculture, manufacturing, and service goods sectors use labor, land, capital, and intermediate inputs from each sector for production, $s \in \{A, M, S\}$. Firms in the residential service sectors use capital and land for production. The agriculture, manufacturing, and service goods are tradable, while the residential services are non-tradable. We assume that capital is freely mobile across regions, areas, and sectors, and use it as a numeraire in the economy.

In each sector $s \in \{A, M, S\}$ of region-area (n, j), competitive final good producers combine goods and services purchased from local and other firms via trade and produce the local final good Q^s_{nj}. Final goods are used for consumption or used as intermediate inputs by local firms in sectors $s \in \{A, M, S\}$. Firms in the residential service sector use only capital and land for production.

Workers are born with a specific region-area (i, k), which is called their hukou origin. Workers may choose a region-area to work and can migrate from their hukou origin (i, k) to another region-area (n, j). Conditional on migrating into entering an urban area (U) of the region n, workers then choose which sectors of manufacturing and service to work in.[9] The labor market of each region-area-sector (n, j, s) is competitive. Workers inelastically supply their labor and earn competitive labor income from the respective sector they work. Workers use the labor income and consume four types of goods and services.

In terms of land, in the urban area of region n, there exists the allocation share of total land T_{nU} for manufacturing use, θ_n, and services or residential land use, $1 - \theta_n$, which is pre-determined by the local government of the region and taken as given. We assume that the land market for services and residential uses is competitive, motivated by the fact that the land for industrial use is equally discounted compared to services and residential uses, in China. In the rural area of region n, the agriculture land used by the agricultural firms and the residential service land used by the residential service firms are exogenous and fixed at $\bar{T}^A_{nR}$ and $\bar{T}^H_{nR}$, respectively.

The rest of the world is introduced to rationalize the country's aggregate trade imbalance across sectors. Therefore, we do not consider the entry of firms for the rest of the world and assume that they price their goods and services competitively. We also fix the supply of labor and the use of land for each sector.

3.1 Worker Location-Sector Choice

Each worker makes a discrete choice of a region-area to live and a sector to work for. A worker is born with her *hukou* (i, k). If a worker chooses to live in the urban area, the area has two sectors to work for, $\mathcal{S}_U = \{M, S\}$. She can choose to work for either of them, and the labor income may vary between the sectors. If a worker chooses to live in the agriculture area, the area has only agricultural sector to work, $\mathcal{S}_R = \{A\}$, and she will work for the sector. In addition to the labor income, she receives a transfer from the region, the amount of which may vary depending on whether or not the region in which she lives is the same as her hukou. These different transfers by the region-area

[9] Note that the housing sector does not use labor, and agriculture sector is the only sector that uses labor in the rural area.

by their hukou origin and different labor income by sector lead to different income $v^s_{nj,ik}$ by their choice and origin.

When moving, workers have to pay the utility costs, $\delta_{nj,ik}$. These migration costs reflect the amenities a worker may enjoy or the disutilities that may arise from cultural and climatic differences between the place of origin and the potential place of work. We also allow workers to have preferences about the sector in which they work. This matters for workers in the urban area, where they can choose to work in either manufacturing or services. We normalize the value to one for services so that the sector preference for manufacturing, ξ^M_n, is relative to working in services.

Workers have a Cobb-Douglas utility function, and consume agricultural goods, manufacturing goods, services, and housing. The region-area consumer price index $\mathcal{P}_{nj}$ summarizes the prices of agriculture, manufacturing, services, and housing in the region.

$$\mathcal{P}_{nj} = \left(P^H_{nj}\right)^{\alpha^H} \prod_{s\in\{A,M,S\}} \left(P^s_n\right)^{\alpha^s}, \tag{2}$$

where $\sum_{s\in\{A,M,S\}} \alpha^s = 1 - \alpha^H$.

Workers decide the region-area and sector to work, by maximizing the following indirect utility:

$$u^s_{nj,ik} = \varepsilon^s_{nj,ik} \left(\frac{\xi^s_n}{\delta_{nj,ik}}\right)\left(\frac{v^s_{nj,ik}}{\mathcal{P}_{nj}}\right), \tag{3}$$

where $\varepsilon^s_{nj,ik}$ is idiosyncratic preferences. We assume that $\varepsilon^s_{nj,ik}$ are drawn iid from a generalized extreme value (GEV) distribution.

$$G(\varepsilon^s_{nj,ik}) = \exp\left(-\sum_{n\in N}\left(\sum_{s\in\mathcal{S}_j}(\varepsilon^s_{nj,ik})^{-\rho}\right)^{\frac{\kappa}{\rho}}\right), \tag{4}$$

with $\kappa \leq \rho$. We can derive the choice probability for workers with hukou in (j,k) to work for any sector in region-area (n,j) as

$$m_{nj,ik} = \frac{\left(V_{nj,ik}/\delta_{nj,ik}\mathcal{P}_{nj}\right)^{\kappa}}{\sum_{n'\in N}\sum_{j'\in\{U,R\}}\left(V_{n'j',ik}/\delta_{n'j',ik}\mathcal{P}_{n'j'}\right)^{\kappa}}, \tag{5}$$

where

$$V_{nj,ik} = \left(\sum_{s'\in\mathcal{S}_j}\left(\xi^{s'}_n v^{s'}_{nj,ik}\right)^{\rho}\right)^{\frac{1}{\rho}} \tag{6}$$

and the share of workers from (i,k) choosing to work for sector s in region-area (n,j) as

$$m^s_{ik|nj} = \frac{\left(\xi^s_n v^s_{nj,ik}\right)^\rho}{\sum_{s' \in \mathcal{S}_j} \left(\xi^{s'}_n v^{s'}_{nj,ik}\right)^\rho}. \tag{7}$$

We can calculate the number of workers in each region-area as

$$L_{nj} = \sum_{s \in \mathcal{S}_j} L^s_{nj} = \sum_{s \in \mathcal{S}_j} \sum_{i \in N} \sum_{k \in \{U,R\}} L^s_{nj,ik} = \sum_{s \in \mathcal{S}_j} \sum_{i \in N} \sum_{k \in \{U,R\}} m^s_{ik|nj} m_{nj,ik} \bar{L}_{ik}, \tag{8}$$

where $\bar{L}_{ik}$ is the population of workers with hukou origin in (i,k).

The income of a worker born in region-area (i,k) and work for sector s in region-area (n,j), $v^s_{nj,ik}$, is composed of three parts: the wage w^s_n, the universal lump-sum transfer (social welfare) from the local government of region n, τ_{nj}, and lump-sum transfer available only for workers who remain in the region-area corresponding to their hukou, τ^h_{nj}.

$$v^s_{nj,ik} = \begin{cases} w^s_n + \tau_{nj} + \tau^h_{nj} & \text{if } n = i \text{ and } j = k \\ w^s_n + \tau_{nj} & \text{if } n \neq i \text{ or } j \neq k. \end{cases} \tag{9}$$

We define the average income of the region and the average income of the hukou-destination market pair as

$$v_{nj} = \sum_{i \in N} \sum_{k \in \{U,R\}} \sum_{s \in \mathcal{S}_j} \left(\frac{L^s_{nj,ik}}{L_{nj}}\right) v^s_{nj,ik}, \tag{10}$$

$$v_{nj,ik} = \sum_{s \in \mathcal{S}_j} \left(\frac{L^s_{nj,ik}}{L_{nj,ik}}\right) v^s_{nj,ik}, \tag{11}$$

where $L_{nj,ik} \equiv \sum_{s' \in \mathcal{S}_j} L^{s'}_{nj,ik}$.

3.2 Firm Entry in Urban Areas and Trade for Manufacturing and Services

For sector $s = M$ (manufacturing) or S (services), firms enter the market freely by paying entry costs, produce differentiated goods or services, and engage in monopolistic competition. Only urban areas have these sectors, so we omit the area notation to make the expressions concise.

Firms pay entry costs f^s_n by the input of production. Assuming that firms access the same Cobb-Douglas technology in the region, we have per firm production q^s_n and input for production

z_n^s as

$$q_n^s = \varphi_n^s (z_n^s - f_n^s), \tag{12}$$

$$z_n^s = \frac{1}{\mathcal{M}_n^s} \left(\frac{1}{\gamma^s} \left(\frac{L_n^s}{\beta_L^s} \right)^{\beta_L^s} \left(\frac{K_n^s}{\beta_K^s} \right)^{\beta_K^s} \left(\frac{T_n^s}{\beta_T^s} \right)^{\beta_T^s} \right)^{\gamma^s} \prod_{s' \in \{A,M,S\}} \left(\frac{C_n^{s's}}{\gamma_{s'}^s} \right)^{\gamma_{s'}^s}, \tag{13}$$

where $\beta_L^s + \beta_K^s + \beta_T^s = 1$ and $\gamma^s + \sum_{s' \in \{A,M,S\}} \gamma_{s'}^s = 1$.

Differentiated varieties from each region are aggregated into a final good or service, which is consumed by households and used by firms as an intermediate input. The quantity of the aggregate sector s final goods in region n is

$$Q_n^s = \left(\sum_{i=1}^{N} \int_0^{\mathcal{M}_i^s} q_{ni}^s(\omega)^{\frac{\sigma^s - 1}{\sigma^s}} d\omega \right)^{\frac{\sigma^s}{\sigma^s - 1}}, \tag{14}$$

where $q_{ni}^s(\omega)$ is the quantity region n purchasing from region i for sector s for a variety ω.

With the monopolistic competition assumption, the price of the good or service is

$$p_n^s = \frac{\sigma^s}{\sigma^s - 1} \frac{c_n^s}{\varphi_n^s}, \tag{15}$$

where the unit cost of input for production c_n^s is:

$$c_n^s = \left((w_n^s)^{\beta_L^s} (r_n^s)^{\beta_T^s} \right)^{\gamma^s} \prod_{s' \in \{A,M,S\}} \left(P_n^{s'} \right)^{\gamma_{s'}^s}. \tag{16}$$

Here, capital rental rates are omitted from the equation, as we use the freely traded capital as the numeraire (i.e., $r^K = 1$ for all sectors).

Firms enter the market until the profits are zero, and this free entry condition is summarized as $z_n^s/(\sigma^s - 1) = f_n^s$.[10] Applying the property of the Cobb-Douglas function, we have

$$\mathcal{M}_n^s = \frac{1}{\sigma^s - 1} \frac{R_n^s}{c_n^s f_n^s} = \frac{1}{\gamma^s \beta_L^s (\sigma^s - 1)} \frac{w_n^s L_n^s}{c_n^s f_n^s}. \tag{18}$$

[10]We can derive the profits of the firms as

$$\frac{1}{\sigma^s} p_n^s \varphi_n^s z_n^s - c_n^s f_n^s = c_n^s \left(\frac{1}{\sigma^s - 1} z_n^s - f_n^s \right). \tag{17}$$

The final (and intermediate input) good price is

$$P_n^s = \left(\sum_{i=1}^{N} \mathcal{M}_i^s \left(\frac{\sigma^s}{\sigma^s - 1} \frac{d_{ni}^s c_i^s}{\varphi_i^s} \right)^{1-\sigma^s} \right)^{\frac{1}{1-\sigma^s}} . \tag{19}$$

and the trade share for sector s is

$$\lambda_{ni}^s = \frac{\mathcal{M}_i^s \left(d_{ni}^s c_i^s / \varphi_i^s \right)^{1-\sigma^s}}{\sum_{i'=1}^{N} \mathcal{M}_{i'}^s \left(d_{ni'}^s c_{i'}^s / \varphi_{i'}^s \right)^{1-\sigma^s}}. \tag{20}$$

Lastly, we consider a possibility of agglomeration effect from the sectoral labor.

$$\varphi_i^s = \bar{\varphi}_i^s \left(L_i^s \right)^{\zeta^s} . \tag{21}$$

3.3 Agricultural Production in Rural Areas and Trade

For agriculture sector, we assume that the model structure is a standard Eaton-Kortum model. We follow the same production structure for agriculture as in manufacturing and service sectors. But agriculture sector is perfectly competitive and is only in rural areas.

The unit cost of production is

$$c_n^A = \left(\left(w_{nR} \right)^{\beta_L^A} \left(r_n^A \right)^{\beta_T^A} \right)^{\gamma^A} \prod_{s' \in \{A,M,S\}} \left(P_n^{s'} \right)^{\gamma_{s'}^A} , \tag{22}$$

where φ_i^A is the total factor productivity (including the Gamma function) and the price index is

$$P_n^A = \left(\sum_{i=1}^{N} \left(\frac{d_{ni}^A c_i^A}{\varphi_i^A} \right)^{1-\sigma^A} \right)^{\frac{1}{1-\sigma^A}} . \tag{23}$$

and the trade share is

$$\lambda_{ni}^A = \frac{\left(d_{ni}^A c_i^A / \varphi_i^A \right)^{1-\sigma^A}}{\sum_{i'=1}^{N} \left(d_{ni'}^s c_{i'}^s / \varphi_{i'}^s \right)^{1-\sigma^A}}. \tag{24}$$

3.4 Residential Service Production

We assume in the residential services sector is competitive. Competitive firms in the residential services sector use capital and land for production, with the following Cobb-Douglas production technology,

$$H_{nj} = \varphi_{nj}^{H} \left(\frac{K_{nj}^{H}}{\beta_K^H} \right)^{\beta_K^H} \left(\frac{T_{nj}^{H}}{\beta_T^H} \right)^{\beta_T^H}, \tag{25}$$

where φ_{nj}^{H} is productivity and $\beta_L^H + \beta_T^H = 1$. Note that, in urban areas, the land available for residential and services uses is endogenous and determined by the land policy. Residential services are not tradable. Therefore, combined by the perfectly competitive market, the residential service price in (n, j) equals

$$P_{nj}^{H} = \left(\varphi_{nj}^{H}\right)^{-1} \left(r_{nj}^{H}\right)^{\beta_T^H}, \tag{26}$$

where r_{nj}^{H} is the land price for residential use.

3.5 Market Clearing Conditions

Define X_n^s as the total expenditure on the good or service of sector s in n. The regional market clearing condition for sector $s \in \{A, M, S\}$ in region n is

$$X_n^s = \sum_{s' \in \{A,M,S\}} \gamma_s^{s'} R_n^{s'} + \alpha^s \sum_{j \in R,U} v_{nj} L_{nj} + \frac{\alpha^s}{1-\alpha^H} \Upsilon_n, \tag{27}$$

where R_n^s is the sales of region n for sector s

$$R_n^s = \sum_{i=1}^{N} \lambda_{in}^s X_i^s. \tag{28}$$

In equation (27), the first term of the RHS represents the expenditure for the intermediate input use, while the second and last terms represent the final consumption by workers and due to the global portfolio, respectively. We assume that the income from the global portfolio is spent only on tradable goods and services, so that the residential sector is excluded for its consumption, i.e., $\sum_{s \in \{A,M,S\}} \frac{\alpha^s}{1-\alpha^H} = 1$.

The global portfolio comprises capital revenue, with each region owning its fixed share ι_n.[11] With capital market clearing condition, we have

$$\Upsilon_n = \iota_n \left(\sum_{s \in \{A,M,S\}} \gamma^s \beta_K^s \sum_i R_i^s + \alpha^H (1 - \beta_T^H) \sum_n \sum_{j \in R,U} v_{nj} L_{nj} \right) = \iota_n \bar{K}, \tag{29}$$

[11] Note that firm profits are zero due to the free entry condition.

where $\bar{K}$ represents the total capital in the economy.

The labor market clearing condition for each location-sector is

$$w_n^s L_n^s = \gamma^s \beta_L^s R_n^s, \quad \forall\, s \in \{A, M, S\}\,. \tag{30}$$

In each area (urban, rural), we have two types of land markets. In urban areas, θ_n of land is allocated for manufacturing use, and the rest is allocated for services or residential uses. The land market clearing condition for manufacturing use is

$$r_n^M \theta_n T_{nU} = \gamma^M \beta_T^M R_n^M, \tag{31}$$

and the land market clearing condition for services is

$$r_{nU}^H (1-\theta_n) T_{nU} = r_n^S (1-\theta_n) T_{nU} = \gamma^S \beta_T^S R_n^S + \beta_T^H \alpha^H v_{nU} L_{nU}. \tag{32}$$

In rural areas $j = R$, we assume that the land supply for agriculture and residential services is given and fixed at $\bar{T}_{nR}^A$ and $\bar{T}_{nR}^H$, respectively. Then, we have the market clearing condition for rural agricultural land is

$$r_n^A \bar{T}_n^A = \gamma^A \beta_T^A R_n^A, \tag{33}$$

and the market clearing condition for rural residential service land is

$$r_{nR}^H \bar{T}_{nR}^H = \beta_T^H \alpha^H v_{nR} L_{nR}. \tag{34}$$

3.6 Land Ownership of Native Hukou Holders

Workers who stay in their hukou region-area can claim their land ownership and receive a lump sum transfer, τ_{nj}^h. Specifically, we assume as follows. For urban hukou holders who stay in their hukou region-area, they receive the transfer equivalent to the land value they consume indirectly through residential services.

Thus, the transfer for urban ($j = U$) hukou holders staying in their region-area is

$$\tau_{nU}^h = \beta_T^H \alpha^H v_{nU,nU} = \sum_{s \in \{M,S\}} \gamma^s \beta_T^s R_n^s. \tag{35}$$

For rural ($j = R$) hukou holders who stay in their hukou region-area, they receive the transfer of all land income shared among them.

$$\tau^h_{nR} = \frac{r^A_{nR}\bar{T}^A_{nR} + r^H_{nR}\bar{T}^H_{nR}}{L_{nR,nR}}. \tag{36}$$

The remaining part of the land revenue coming from the urban area is collected by the local government. The local government of each region has the authority to determine the share of *urban* land allocated for manufacturing use (θ_n) or service use ($1-\theta_n$) that is for services or residential uses. Given the allocation of urban land, the local government collects relevant land revenues and redistributes them to their residents in the urban area.

$$\tau^\ell_{nU} L_{nU} = r^M_n \theta_n T_{nU} + r^H_{nU}(1-\theta_n)T_{nU} - \beta^H_T \alpha^H v_{nU,nU} L_{nU,nU}. \tag{37}$$

3.7 Equilibrium

Following Ferrari and Ossa (2023), we first characterize the equilibrium for given land policies. In this equilibrium, workers and firms make location choices to maximize utility and profits, respectively, and all the markets clear.

Definition 1 *Taking land policies as given, an equilibrium is a set of* $\left(L_{njs}, M_{njs}, w_{njs}, r^s_n, r^h_n, P_{nj}\right)$ *that solves worker location choice problems* (11), (5), (30), (7),(8), *location-level firm entry problems* (16), (18), *trade share and price conditions for agriculture, manufacturing, and services* (19), (20), (22), (23), (24), *residential service price* (26), *the market clearing conditions for agriculture, manufacturing, services, capital, labor, and land for each use* (27), (29), (30), (31), (32), (33), (34), *and the government budget constraint* (37).

4 Calibration

In this section, we outline our approach to calibrating the model's fundamentals using observed data and the values of structural parameters for subsequent simulation.

To simulate the model, we need to calibrate exogenous fundamentals such as exogenous part of the productivity ($\bar{\varphi}i^s$), firm entry costs (f^s_n), trade costs (d^s_{ni}), migration costs ($\delta_{nj,ik}$), and sectoral preferences of workers (ξ^M_n). Trade costs and migration costs are calibrated using standard methods found in the literature, following the approaches by Head and Ries (2001) and Tombe and Zhu (2019), respectively. Workers' sectoral preferences are calibrated to match the distribution of employment across sectors. For productivity, we describe the ideas of our calibration methods below. Appendix A provides further details on the procedures.

For the majority of structural parameters, we determine their values through calibration, by matching relevant data moments from China, or by adopting commonly used values from existing literature. However, for the agglomeration elasticity in production (ζ^s), we estimate these values by using calibrated productivity levels across provinces and observed sectoral labor supply. To address endogeneity concerns, we use lagged employment data for the sector and region as an instrument.

4.1 Inversion of Productivity

Inversion of productivity by sector involves several steps. First, we invert trade costs across regions by sector using the regional input output table for China and employ the commonly used approach by Head and Ries (2001). Subsequently, we invert the "competitiveness" of the region for the sector. We invert the "competitiveness" so that we can fit the sales and expenditure distribution across regions, considering the effects of trade costs they face into account. For instance, if two regions face similar trade costs with other regions, yet one region demonstrates higher sales than the other, this indicates a higher competitiveness of the former region for that sector market.

The inverted "competitiveness" include the effect of productivity, unit cost of production, and love of variety effects from the firms. We use the observed firm distribution to separate the variety effects from the other two. The unit cost of production stems from wage rate for the sector, land rental rate for the sector, and intermediate input prices in the region. For the wage rate, we use the labor market clearing condition and observed employment in the sector. For land rental rate, we first calibrate the land allocation between manufacturing and services or housing by using the estimated land price gap and land market clearing conditions.

The inverted "competitiveness" encompasses the combined effects of productivity, unit production costs, and love of variety effects from firm entry. To distinguish the variety effects from the other components, we use the observed firm distribution across provinces. Unit production costs are determined by the wage rate for the sector, land rental rate for the sector, and intermediate input prices in the region. To determine the wage rate, we use the labor market clearing condition and observed employment in the sector. For the land rental rate, we first calibrate the allocation of land between manufacturing and services by substituting the estimated land price gap into the land market clearing conditions.

$$\frac{r_n^S}{r_n^M} = \frac{\theta_n}{1-\theta_n} \frac{\gamma^M \beta_T^M R_n^M}{\gamma^S \beta_T^S R_n^S + \alpha^H \beta_T^H v_{nU} L_{nU}}. \tag{38}$$

As detailed in Appendix A, the term $v_{nU} L_{nU}$ is determined by the sales of the region in manufacturing and services. Therefore, given the parameter values, we can invert the model implied land allocation share using the estimated land price gap and sales across sectors. The final component, intermediate input prices in the region, can be computed by leveraging the competitiveness and trade costs across regions.

Finally, firm entry costs are determined by the calibrated unit cost of production, along with observed sales and the number of firms for the sector in the region, by using the free entry condition (18).

4.2 Structural Parameters

In this subsection, we discuss how we estimate the key structural parameters of the model and the values of the other parameter values we use from the literature. Table 2 summarizes the parameter values and their sources.

Table 2: Structural Parameters

Parameters	Description	Values	Sources
$(\alpha^A, \alpha^M, \alpha^S, \alpha^H)$	Consumption share	(0.03, 0.47, 0.27, 0.23)	Calibration
κ	Migration elasticity	1.5	Tombe and Zhu (2019)
$\sigma - 1$	Trade elasticity	4.5	
$(\gamma^A, \gamma^M, \gamma^S)$	Value added share in industrial production	(0.58, 0.22, 0.55)	Calibration
$(\beta_L^A, \beta_L^M, \beta_L^S)$	Labor share in production	(0.6, 0.39, 0.45)	Calibration
$(\beta_T^A, \beta_T^M, \beta_T^S)$	Land share in production	(0.19, 0.12, 0.15)	See text
β_T^H	Land share in housing production	0.35	See text
(ξ^M, ξ^S)	Agglomeration effect from sectoral labor	(-0.17, -0.14)	See text

For land share in production β_T^s, we select a value of $(\beta_T^A, \beta_T^M, \beta_T^S) = (0.19, 0.12, 0.15)$, which is in the range of the literature. Hsieh and Moretti (2019) assume a value of 0.1 for the US, while Brinkman et al. (2015) estimate a slightly lower value of 0.09. Caselli and Coleman II (2001) set values of 0.19 and 0.06 for agriculture and manufacturing in the US. Adsera (2000) estimates a range of values from 0.12 to 0.19 for various sectors in the US, including manufacturing, durable goods, non-durable goods, and finance. Dekle and Eaton (1999) find estimates of 0.12 and 0.28 for manufacturing and financial services in Japan, respectively.

We set the land share in residential production at 0.35, in line with findings from Tan et al. (2020). They report a share between 0.31 and 0.39 for housing construction in China. Additionally, Combes et al. (2021) estimate the capital elasticity in housing production using French data and their estimate implies a land share of 0.35 under the Cobb-Douglas production function.

For the agglomeration effect of sectoral labor, we estimate it for the manufacturing and services sectors, yielding $\zeta^M = -0.16$ and $\zeta^M = -0.13$ as shown in Tables 3 and 4.[12] Negative

[12]Hubei is excluded from the analysis due to its outlier status in calibrated productivity for services. The regional input-output data used for estimating trade costs suggests an unusually small share of service trade for the province (0.01%), contrasting with significantly larger figures in other years (e.g., over 10% in 2017). Data cleaning efforts are ongoing to address the impact of such outlier years.

agglomeration effects are rationalized, for example, by the inelastic supply of specific production factors for the sector within the region, leading to congestion effects with increased labor supply. However, despite these negative impacts, the overall effect of increased labor supply is expected to be positive. As Equation (18) illustrates, given the production cost and wage rate of the region, a greater supply of labor implies more firm entry, thereby generating greater variety effects on the region's productivity. With a trade elasticity of $\sigma^s - 1 = 4.5$, the implied variety effects have an elasticity of $1/4.5 = 0.22$, which is significantly greater than the estimated congestion effect from the sectoral labor. In column (4), we estimate the agglomeration effect in the model without having firm entry and its variety effects. Consistent with our discussion and estimates, the estimated effects are significantly positive and greater for services than manufacturing, falling within the range of values found in the literature.

For the other parameters, we calibrate with Chinese data or use the values conventionally used in the literature.

Table 3: Labor Agglomeration Effects in Manufacturing

VARIABLES	(1) OLS $\ln \varphi_i^M$	(2) IV $\ln \varphi_i^M$	(3) IV $\ln \varphi_i^M$ (No Firm)	(4) IV $\ln f_i^M$
$\ln L_i^M$	-0.162*** (0.022)	-0.168*** (0.022)	0.090*** (0.021)	-0.001 (0.037)
Observations	30	30	30	30
Fixed Effect	East Coast	East Coast	East Coast	East Coast
IV		$\ln L_i^M$ in 1997	$\ln L_i^M$ in 1997	$\ln L_i^M$ in 1997
Kleibergen-Paap F		375.2	375.2	375.2

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Labor Agglomeration Effects in Services

VARIABLES	(1) OLS $\ln \varphi_i^S$	(2) IV $\ln \varphi_i^S$	(3) IV $\ln \varphi_i^S$ (No Firm)	(4) IV $\ln f_i^S$
$\ln L_i^S$	-0.120*** (0.043)	-0.138*** (0.048)	0.116** (0.052)	-0.007 (0.076)
Observations	30	30	30	30
Fixed Effect	East Coast	East Coast	East Coast	East Coast
IV		$\ln L_i^M$ in 1997	$\ln L_i^M$ in 1997	$\ln L_i^M$ in 1997
Kleibergen-Paap F		213.1	213.1	213.1

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3 Model Calibrated Land Allocation vs. Observed Allocation

In calibrating the fundamentals of our model, we use the estimated land price gap between services and manufacturing rather than relying on the observed land allocation share for each sector. Using the observed land share will treat every unit of land equally and overlooks heterogeneity in land such as land quality and floor-to-area ratio. By incorporating the estimated land price gap, which controls for the differences in the characteristics of transacted land, we can capture a representation of the price gap between services and manufacturing for homogeneous land in the model.

Therefore, calibrated land allocation from our model with the estimated land price gap does not necessary match with the observed land allocation in the data. Consequently, we employ this untargeted moment for model validation. Figure 4 shows a reasonable match in the allocation pattern for manufacturing across regions between the calibrated and observed land allocation share, with a correlation coefficient of 0.49.

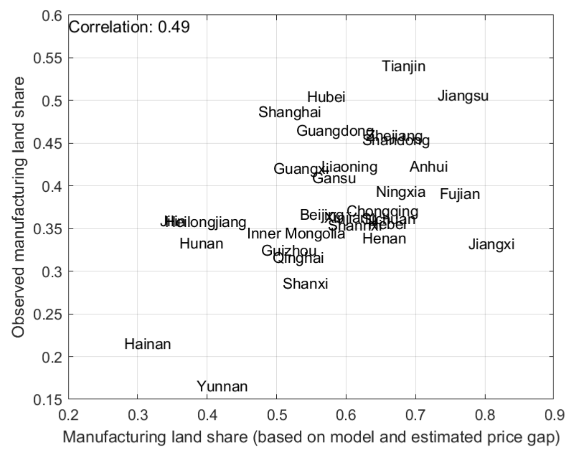


Figure 4: Calibrated land share vs. observed land share

5 Quantitative Analysis

5.1 Quantitative Analysis with Observed Relative Land Prices

We begin our quantitative analysis with the observed relative land prices of services to manufacturing in the data. In our model, firm entry not only creates positive externalities in the economy due to love-for-variety effects in consumption and intermediate use but also brings agglomeration/congestion effects due to the increased labor in each sector, rendering the competitive equilibrium inefficient. Therefore, the observed policy in terms of allocating urban land among different uses—which local governments in China have full authority in and determine the service-to-manufacturing relative land price—could potentially mitigate or amplify the inefficiencies.

Before specifying the possible objectives of the local government that can rationalize the observed land policy patterns, we first compare the outcomes of the observed land policies with the outcomes in the (regional) competitive land market economy, where land price and allocation are determined in the competitive land markets of each region. Figure 5 compares the observed relative land prices of service to manufacturing in the data (i.e., blue dots) with the relative land prices in a competitive land market (i.e., black stars) for each province in China. Province-level regions are ordered by GDP per capita, with Guizhou representing the least developed and Shanghai representing the most developed region based on this metric.

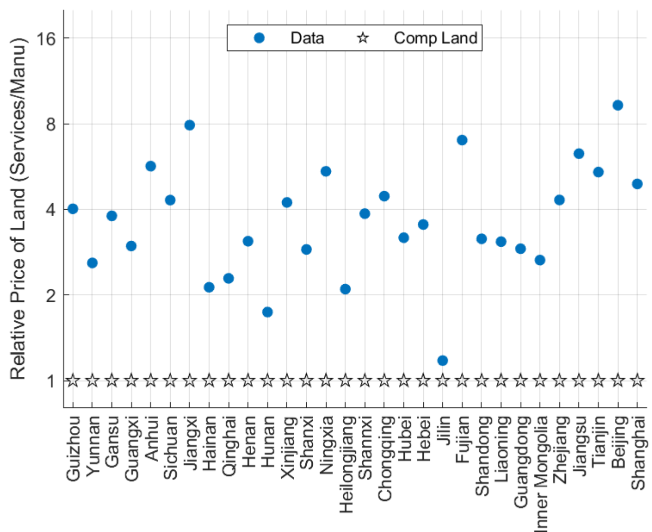


Figure 5: Data vs. competitive land market economy: relative price of service to manu. land

Note: The figure compares the relative land price of service to manufacturing land in the observed data and the relative land price in the counterfactual competitive land market economy for each province of China.

Figure 5 shows that in the competitive land market economy, by definition, the relative land prices of service and manufacturing are equal to one for all regions. In contrast, in the data, there is a substantial reduction in the share of land allocated to manufacturing by local governments of most regions, evinced by a high relative land price with an average of about 4 in the observed data. Then, in Figure 6, we further compare the percentage deviations in the regional real income per capita of the competitive land market economy from the data. We find that the prevalent biased land allocation towards manufacturing in the data—as opposed to the competitive land market allocation—is associated with significant losses in the regional real income for (more advanced) coastal regions in China, such as Shanghai, Jiangsu, and Fujian, but significant gains for (less advanced) inland regions, such as Guizhou and Inner Mongolia.

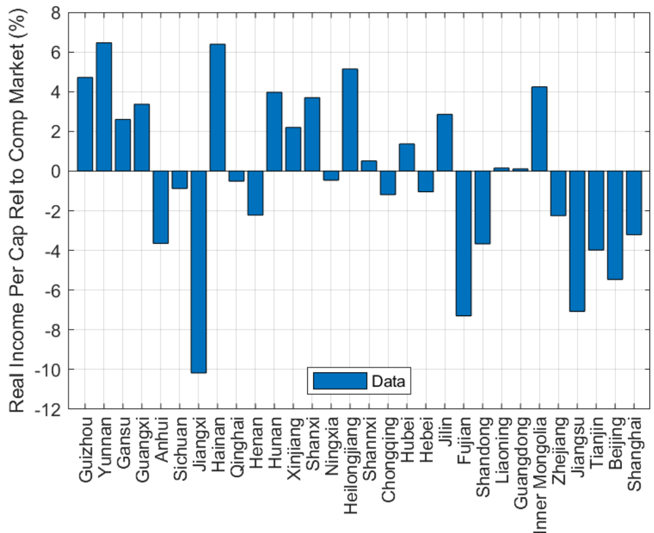


Figure 6: Competitive land market economy relative to data: Regional real income per cap.

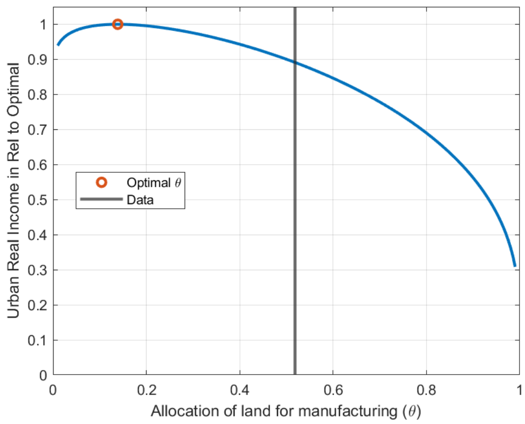
Note: The figure shows the percentage deviation in the regional real income per capita of the competitive land market economy to the observed data for each province of China.

5.2 Local Government Objectives

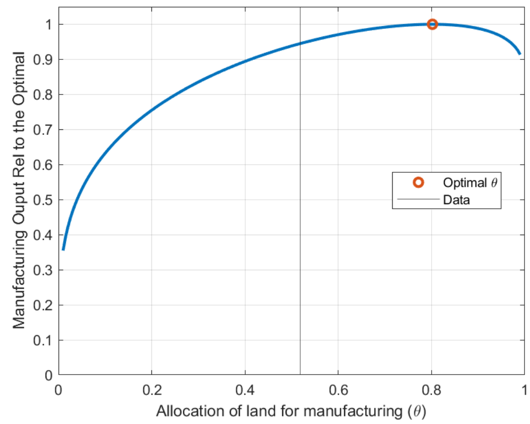
Despite the potential of local policies in efficiency restoration, the observed regional land allocation revealed by the service-to-manufacturing relative land price appears to introduce additional distortions and underperforms a competitive land market economy, particularly in more developed regions. In this section, we delve into the potential sources of these distortions.

To analyze this, we follow Ferrari and Ossa (2023) and assume that local governments engage in non-cooperative policy decision-making. As discussed in Section 2.3, local government competition has been a prominent feature of the Chinese economy in recent decades, and their policy choices are likely to be non-cooperative. Furthermore, given the observed bias towards manufacturing in land allocation (i.e., relative land price), we investigate whether this bias stems from the non-cooperative nature of land policy decisions or is a consequence of their preference for manufacturing in their objectives, which may contribute to distortions in land allocation and real urban income across regions and sectors.

We start our analysis of local government objectives by focusing on the exampling case of Shanghai and illustrating how its local real urban income and manufacturing output change with its land policy, with other local governments choose their land allocation as in the data. Figure 7 plots the urban real income (y-axis of Panel a) and the manufacturing output (y-axis of Panel b) as a share of their counterparts in the *optimal* land allocation, respectively, against the share of manufacturing land in Shanghai (x-axis in both panels). The optimal land allocation maximizes the respective



(a) Maximize real urban income



(b) Maximize manu. output

Figure 7: Max. real urban income vs. max.manu. output by Shanghai government

Note: The figure shows the optimal land allocation (in terms of regional share of manufacturing land) by the local government in Shanghai for the cases where local government maximizes local real urban income and manufacturing output, respectively. The vertical line is the land allocation in the data. The optimal share of manufacturing land is labeled by the red circle at the peak of each blue curve in each panel.

objective in each panel, labeled by the red circle at the peak of each blue curve. Notably, in both cases, the value of the objective (i.e., local real urban income and manufacturing output) exhibits an inverted U-shaped relationship with the local share of manufacturing land, which implies the uniqueness of the optimal response of local government land policy to other regions' policies. Moreover, the optimal allocation of land for manufacturing use in the case of real urban income maximization is significantly smaller than in the case of manufacturing output maximization. In particular, the allocation of manufacturing land in the data is in the middle of those in the two cases, implying that the local government objective is between maximizing real urban income and manufacturing output, which is consistent with our later results in multi-regional Nash equilibrium.

In what follows, we study the general case in which all local governments compete non-cooperatively in the sense of Nash equilibrium, and focus on three distinct cases: first, local governments maximize local real income per capita; second, local government maximize local manufacturing output; third, all local governments play a cooperative game aiming to maximize the national real income per capita. Figure 8 displays the service-to-manufacturing relative land price in different cases for each province. Figure 11 displays the percentage deviations in the regional real income per capita in different cases relative to those in the competitive land market economy for each province.

Local government maximizes local real income per capita. We begin with the case where the objective of local governments is to maximize local real income per capita. Figure 8 shows that compared to the competitive land market economy where relative land prices are one across all regions (consistent with Figure 5), maximization of real income per capita by local governments yields a relative land price of around two for most of the provinces. This finding suggests that under local government competition, even if local governments aim to maximize real income per capita rather than manufacturing output directly, they still tend to allocate more land to manufacturing use (than in the competitive land market economy), evincing the critical role of regional interaction and competition in increasing local real income and in explaining the observed data. Further investigating the welfare in Figure 11, we find that real income per capita is higher for all regions when local governments maximize local real income than in the competitive land market economy, suggesting that land policy by local governments can potentially improve welfare.

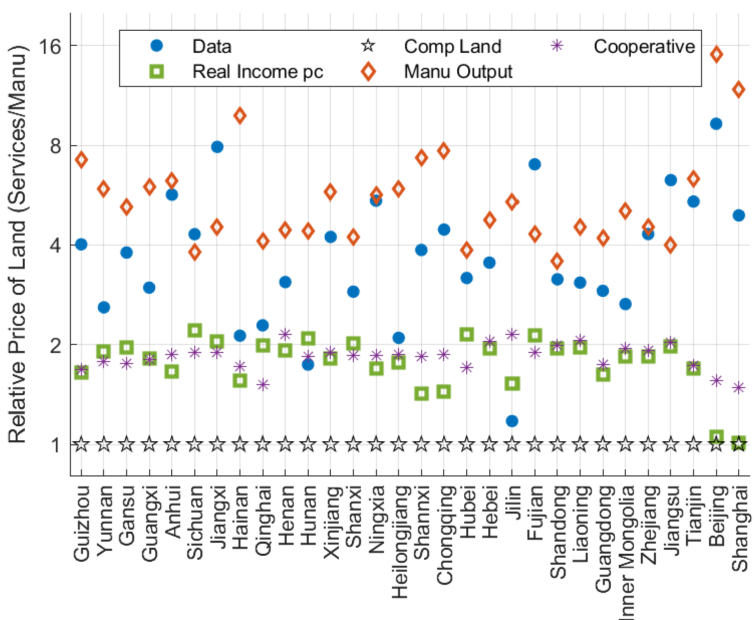


Figure 8: Relative land prices of service to manufacturing in different cases

Note: This figure shows the relative land prices of service to manufacturing in each province in different cases: 1) the data; 2) local governments maximize local manufacturing output; 3) local governments maximize local real income; 4) competitive land market economy; 5) cooperative equilibrium that maximizes national real income per capita.

In addition, Figure 11 also shows that local governments maximizing real income per capita yields significantly higher real income compared to the observed land policy in the data for most regions. However, for both relative land prices and real income per capita, maximization of real income per capita by local governments can explain around half of the manufacturing bias of those in the real-world data. In other words, direct manufacturing bias in local governments' objectives

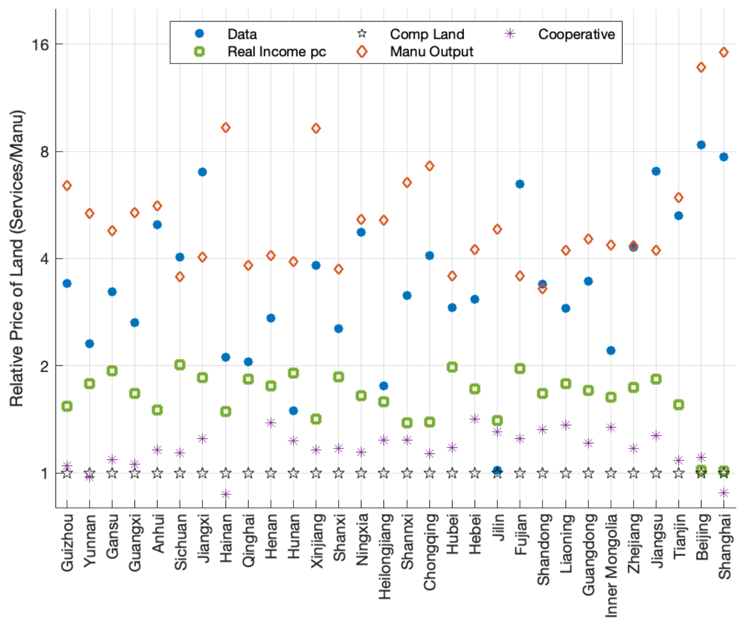


Figure 9: Relative land prices of service to manufacturing in different cases (Without international trade)

Note: This figure shows the relative land prices of service to manufacturing in each province in different cases: 1) the data; 2) local governments maximize local manufacturing output; 3) local governments maximize local real income; 4) competitive land market economy; 5) cooperative equilibrium that maximizes national real income per capita.

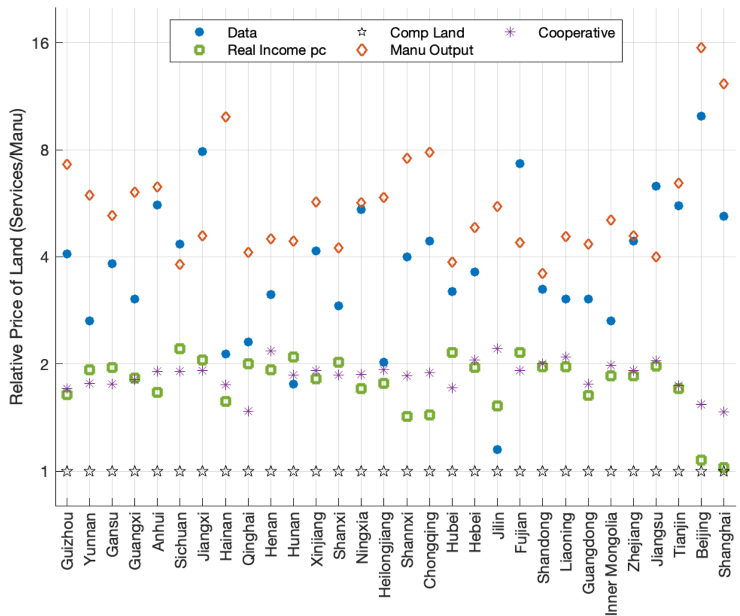


Figure 10: Relative land prices of service to manufacturing in different cases (Half migration costs)

Note: This figure shows the relative land prices of service to manufacturing in each province in different cases: 1) the data; 2) local governments maximize local manufacturing output; 3) local governments maximize local real income; 4) competitive land market economy; 5) cooperative equilibrium that maximizes national real income per capita.

is still needed to explain the data, which we discuss in the next paragraph.

Local government maximizes local manufacturing output. Then, we consider the case where the objective of local governments is to maximize local manufacturing output. Figure 8 shows that the relative land prices in the case of local governments maximizing manufacturing output is close to the data on average, except for a few regions such as Beijing and Shanghai. This result suggests that the manufacturing bias in the preferences of local governments in China is crucial to understand the observed bias towards manufacturing in land allocation and relative land prices of service to manufacturing, which require better understanding.[13]

Cooperative equilibrium that maximizes national real income per capita. Finally, we consider the case where all local governments play a cooperative game rather than the non-cooperative Nash game in previous cases, and each local government choose its land allocation to maximize the national real income per capita. Figure 8 shows that the relative land prices in the cooperative equilibrium is slightly lower than yet close to the case where local governments maximize local

[13]The preference for manufacturing may be driven by ideological or fiscal reasons. We plan to explore this more in future studies.

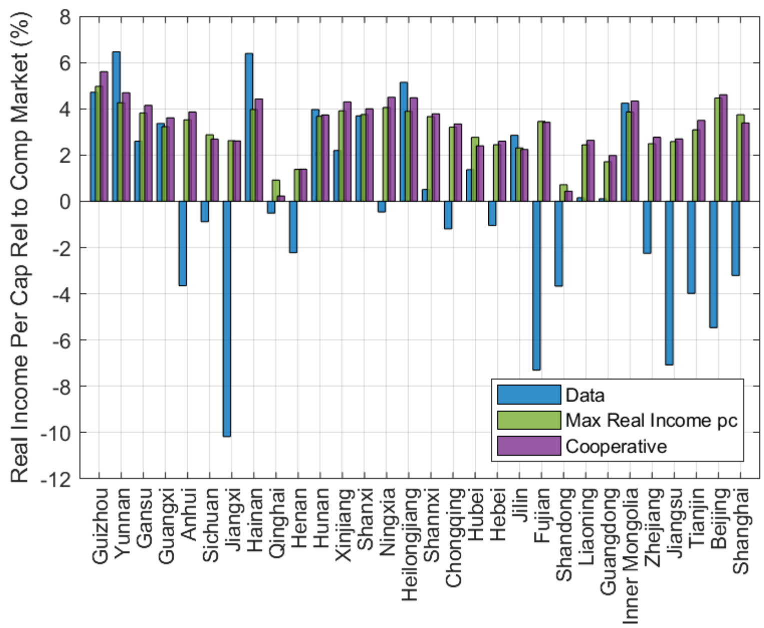


Figure 11: % deviation in real income per cap. of different cases from comp. land market economy

Note: The figure shows the percentage deviation in local real income per capita from the case of competitive land market economy for each province.

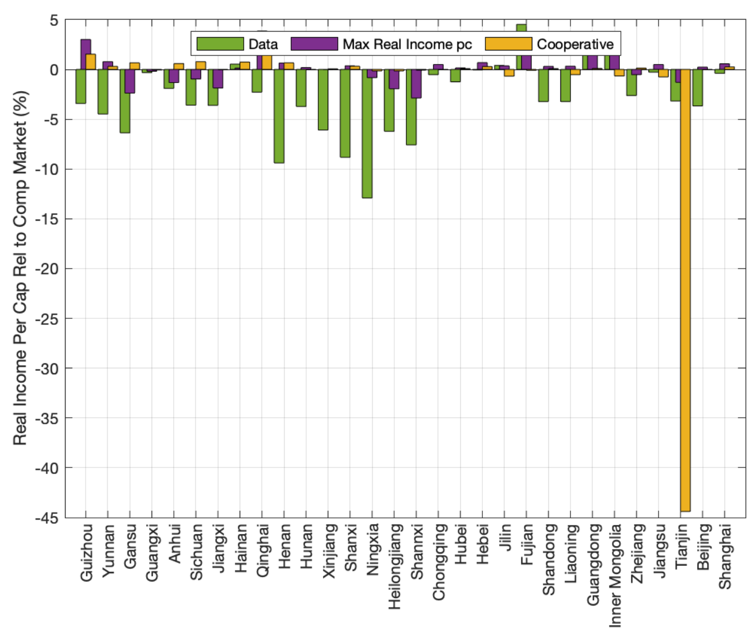


Figure 12: % deviation in real income per cap. of different cases from comp. land market economy (Without international trade)

Note: The figure shows the percentage deviation in local real income per capita from the case of competitive land market economy for each province.

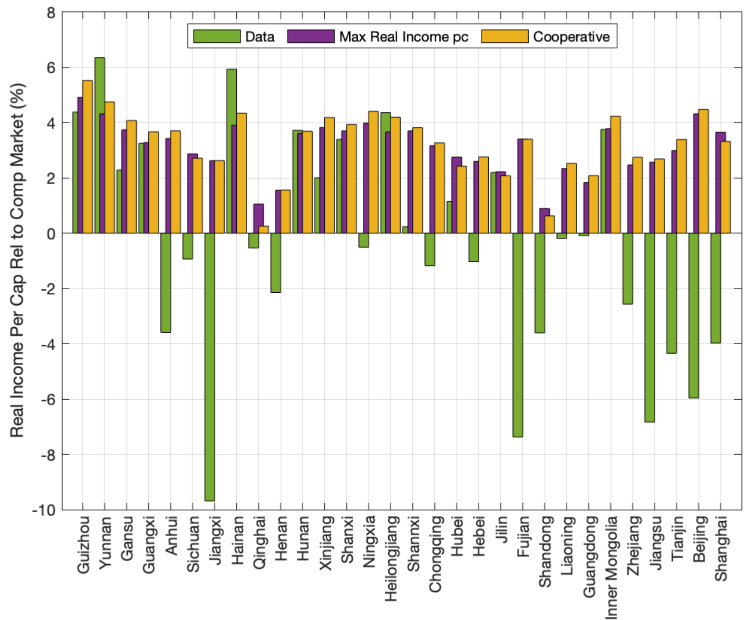


Figure 13: % deviation in real income per cap. of different cases from comp. land market economy (Half migration cost)

Note: The figure shows the percentage deviation in local real income per capita from the case of competitive land market economy for each province.

real income per capita for most of the regions, leading to similar real income per capita in the two cases, evinced by Figure 11.

Two notable exceptions are Beijing and Shanghai, in which the cooperative equilibrium embeds higher service-to-manufacturing relative land prices than the case where local governments maximize local real income, leading to slightly lower real income per capita for these two regions in the cooperative equilibrium.

National income per capita and manufacturing export-to-value-added ratio. Table 7 displays the percentage deviation in real national income per capita of different cases from the competitive land market economy. It show that the cooperative equilibrium yields national real income per capita that is quite close to the case where local governments maximize local real income per capita, which are 4.65% and 4.45% higher than that in competitive land market economy, respectively. This again implies that even with local government competition, as long as local governments are maximizing local real income per capita, their land allocation policies is welfare enhancing and can be close to the optimal one for the nation as a whole.

In contrast, if local governments have strong manufacturing bias and maximize local manufacturing output, the national real income per capita is significantly lower than in the competitive land market economy by as much as 4.2%, which are therefore lower than the case of local governments' maximizing local real income per capita by a even larger extent of 6.8%. The national real income per capita in the data, consistent with our findings of regional real income per capita in Figure 11, is between the cases of maximizing local real income per capita and manufacturing output and lower than in the competitive land market economy by 1.9%.

In addition to the national real income per capita, Table 7 also displays the national-wise export-to-value-added ratio of the manufacturing sector in different cases, which reveals the crucial role of local government competition and their objectives in explaining the large trade surplus (particularly from the manufacturing sector). When local governments maximize local manufacturing output, the export-to-value-added ratio of the manufacturing sector is 0.428, which is very close to the 0.423 in the data. In contrast, in both cases of cooperative equilibrium and the non-cooperative Nash equilibrium with local governments maximizing local real income per capita, the manufacturing export-to-value-added ratio are much lower at 0.403 and 0.399, respectively. Therefore, we conclude that local government competition with manufacturing bias in the objectives of local governments are critical to explain the large manufacturing trade surplus in China.

Table 5: National real income per capita and manufacturing export-to-value-added ratio

	Real national income PC (% dev. from comp. land mrkt.)	Manu export-to-VA ratio
Cooperative equilibrium	2.7	0.403
Nash equil.: local gov max. real income pc	2.6	0.399
Local land policies in the data	-1.9	0.423
Nash equil.: local gov max. manu. output	-4.2	0.428
Experiments with alternative ways of local gov interactions		
local max real income pc *with belief that* other gov. choose data policies	2.4	0.397
local max manu. *with belief that* other gov. choose data policies	-4.7	0.428
local max manu. *with belief that* other gov. max real income pc	-5.6	0.429

5.3 Role of Local Government Competition

In previous analyses, local government competition is always associated with specific objectives of local governments that maximize either local real income per capita or local manufacturing output. In this subsection, we follow Ferrari and Ossa (2023) to carry out counterfactural analyses from which we infer the contribution of local government competition to the relative land prices.

More specifically, we consider three cases: first, each local government maximizes local real income per capita *with the belief* that other local governments choose data land allocation (Figure 14); second, each local government maximizes local manufacturing output *with the belief* that other

Table 6: National real income per capita and manufacturing export-to-value-added ratio (Half migration cost)

	Real national income PC (% dev. from comp. land mrkt.)	Manu export-to-VA ratio
Cooperative equilibrium	2.7	0.393
Nash equil.: local gov max. real income pc	2.6	0.389
Local land policies in the data	-2.1	0.415
Nash equil.: local gov max. manu. output	-4.4	0.420
Experiments with alternative ways of local gov interactions		
local max real income pc *with belief that* other gov. choose data policies		
local max manu. *with belief that* other gov. choose data policies		
local max manu. *with belief that* other gov. max real income pc		

Table 7: National real income per capita and manufacturing export-to-value-added ratio (No International Trade)

	Real national income PC (% dev. from comp. land mrkt.)	Manu export-to-VA ratio
Cooperative equilibrium	0.2	0
Nash equil.: local gov max. real income pc	-0.2	0
Local land policies in the data	-4.3	0
Nash equil.: local gov max. manu. output	-5.8	0

local governments choose data land allocation (Figure 15); third, each local government maximizes local manufacturing output *with the belief* that other local governments maximize local real income per capita (Figure 16).

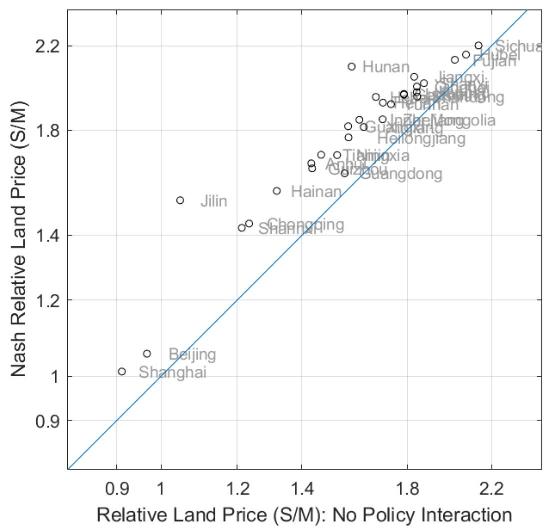


Figure 14: Role of local gov competition: real income per cap. max. vs. data

Note: x-axis: Each local government maximizes local real income per capita *with the belief* that other local governments choose land allocation in the data. y-axis: Nash equilibrium where all local governments maximize local real income per capita.

Figure 14 compares the service-to-manufacturing relative land price in the case where each local government maximizes local real income per capita *with the belief* that other local governments choose land allocation in the data (x-axis), to the case of Nash equilibrium where local governments maximize local real income per capita (y-axis). The figure shows that knowing that other local governments maximize local real income per capita leads to higher relative land price than in the case where local governments are agnostic of other governments decisions of maximizing local real income per capita, evinced by the dots higher than the 45 degree line for most provinces. In other words, the interaction forces from other local governments real income per capita maximization behavior *attenuate* my local governments' pursue of real income per capita maximization, consistent with the retaliation explanation by Ferrari and Ossa (2023).

Figure 15 compares the service-to-manufacturing relative land price in the case where each local government maximizes local manufacturing output *with the belief* that other local governments choose land allocation in the data (x-axis), to the case of Nash equilibrium where local governments maximize local manufacturing output (y-axis). The figure shows that knowing that other local governments maximize local manufacturing output leads to lower relative land price than in the case where local governments are agnostic of other governments decisions of maximizing lo-

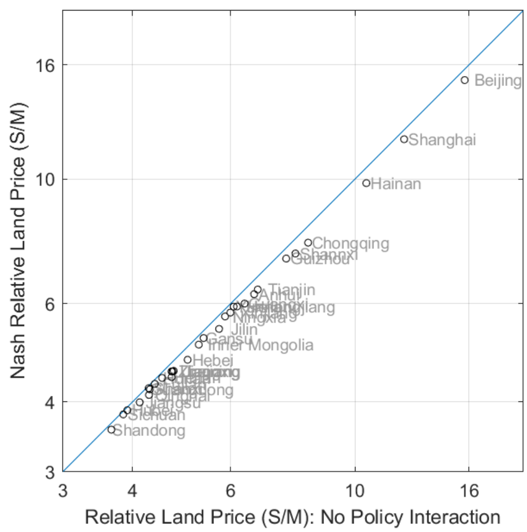


Figure 15: Role of local gov competition: manu. output max. vs. data

Note: x-axis: Each local government maximizes local manufacturing output *with the belief* that other local governments choose data land allocation. y-axis: Nash equilibrium where all local governments maximize local manufacturing output.

cal manufacturing output, evinced by the dots lower than the 45 degree line for most provinces. In other words, the interaction forces from other local governments manufacturing output maximization behavior *attenuate* my local governments' pursue of manufacturing output maximization, again consistent with the retaliation explanation by Ferrari and Ossa (2023). In particular, because the data is close to the case of local governments maximizing local manufacturing output, the deviations of dots from the 45 degree line in Figure 15 are smaller than those in Figure 14.

Finally, Figure 16 compares the service-to-manufacturing relative land price in the case where each local government maximizes local manufacturing output *with the belief* that other local governments maximize local real income per capita (x-axis), to the case of Nash equilibrium where local governments maximize local manufacturing output (y-axis). The figure shows that knowing that other local governments maximize local manufacturing output rather than real income per capita leads to lower relative land price than in the case where local governments have the wrong beliefs that other governments maximize local real income per capita, evinced by the dots lower than the 45 degree line for most provinces. In other words, the interaction forces from other local governments manufacturing output maximization behavior *attenuate* my local governments' pursue of manufacturing output maximization, again consistent with Figure 15 and the retaliation explanation by Ferrari and Ossa (2023).

In conclusion, our analyses reveal that the major role of local government competition is to attenuate local governments' policy choices from their original goals, whether they are maximizing

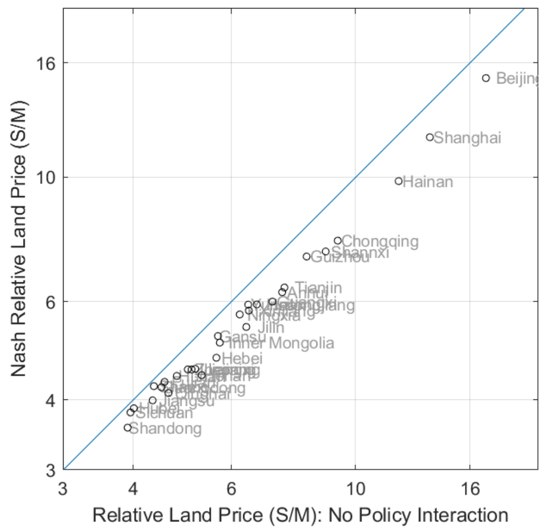


Figure 16: Role of local gov competition: manu. output max. vs. real income per cap. max.

Note: x-axis: Each local government maximizes local manufacturing output *with the belief* that other local governments maximize local real income per capita. y-axis: Nash equilibrium where all local governments maximize local manufacturing output.

local real income per capita or local real manufacturing output.

Table 7 conclude with the national real income and manufacturing export-to-value-added ratios in the above three cases. All three cases indicate that without "retaliation" threats from other local governments (i.e., with the wrong belief that other local governments do not pursue the same goal as mine), local governments' land policies are too aggressive and lead to lower real national income per capita to the corresponding cases of Nash equilibria, evinced by -4.7% and -5.6% lower than -4/2% and 2.4% lower than 2.6%. The impacts of local government competition on the manufacturing export-to-value-added ratios, though, are limited, evinced by the very close numbers in these cases to those in the corresponding cases of Nash equilibria.

6 Conclusion

In this study, we aim to unravel the welfare implications of local land policies in China. Our research uncovers a pronounced "manufacturing bias" that is pervasive across the country and particularly in regions with lower relative labor productivity of manufacturing to services.

We develop a multi-sector quantitative spatial equilibrium model where local governments compete non-cooperatively through local land policies, and find that a transition to a competitive land market would substantially decrease the land allocation to manufacturing in most provinces, while raising local real income in coastal regions. The observed policies are, on average, comparable to the Nash policy when local governments maximize manufacturing output. When local governments maximize local real income, the land allocation to manufacturing is still substantially higher than in a competitive land market, but this leads to higher local real income almost everywhere.

Looking ahead, our research agenda includes studying the interaction between local land policies and other government policies, such as changes in hukou policies.

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Online Appendix for "Local Government Competition and Spatial Mismatch between Workers and Firms"

Ming Lu, Yuta Suzuki, Xican Xi, Le Xu, and Yuejun Zhong

March 2024

A Calibration of Fundamentals

A.1 Trade Costs

We calibrate trade costs by applying the method by Head and Ries (2001). We assume that trade costs are symmetric and normalize them by the within region trade costs (i.e., $d_{nn} = 1$). Using equation for trade share (20), we have

$$d_{ni}^{s} = \left(\frac{\lambda_{in}^{s}}{\lambda_{nn}^{s}}\frac{\lambda_{ni}^{s}}{\lambda_{ii}^{s}}\right)^{-\frac{1}{2(\sigma^{s}-1)}}. \tag{A.1}$$

A.2 Global Portfolio Share and Expenditure Share of the Rest of the World

We calibrate the global portfolio share $\{\iota_n\}$ using equation (27). Summing this over sectors, we have

$$\sum_{s\in\{A,M,S\}} X_n^s = \sum_{s\in\{A,M,S\}} (1-\gamma^s) R_n^s + \left(1-\alpha^H\right) \sum_{j\in\{U,R\}} v_{nj} L_{nj} + \Upsilon_n \tag{A.2}$$

The aggregate income of workers is the following, which can be calculated using the regional sales data.

$$\sum_{j\in\{U,R\}} v_{nj} L_{nj} = \sum_{s\in\{A,M,S\}} \frac{\gamma^s (1-\beta_K^s)}{1-\alpha^H \beta_T^H} R_n^s, \tag{A.3}$$

Substitute this into the previous equation, we have

$$\sum_{s\in\{A,M,S\}} X_n^s = \sum_{s\in\{A,M,S\}} (1-\gamma^s) R_n^s + \sum_{s\in\{A,M,S\}} \frac{\gamma^s \left(1-\alpha^H\right)(1-\beta_K^s)}{1-\alpha^H \beta_T^H} R_n^s + \Upsilon_n, \tag{A.4}$$

$$= \sum_{s\in\{A,M,S\}} \left(1-\gamma^s + \frac{\gamma^s \left(1-\alpha^H\right)(1-\beta_K^s)}{1-\alpha^H \beta_T^H}\right) R_n^s + \Upsilon_n \tag{A.5}$$

This implies

$$\Upsilon_n = \sum_{s\in\{A,M,S\}} \left(X_n^s - \left(1-\gamma^s + \frac{\gamma^s \left(1-\alpha^H\right)(1-\beta_K^s)}{1-\alpha^H \beta_T^H}\right) R_n^s\right) \tag{A.6}$$

Similarly, substitute the aggregate income into the global portfolio equation (29), we have

$$\Upsilon_n = \iota_n \left(\sum_{s\in\{A,M,S\}} \gamma^s \beta_K^s \sum_i R_i^s + \alpha^H (1-\beta_T^H) \sum_i \sum_{s\in\{A,M,S\}} \frac{\gamma^s (1-\beta_K^s)}{1-\alpha^H \beta_T^H} R_i^s \right), \tag{A.7}$$

$$= \iota_n \left(\sum_{s\in\{A,M,S\}} \sum_i \left(\gamma^s \beta_K^s + \alpha^H (1-\beta_T^H) \frac{\gamma^s (1-\beta_K^s)}{1-\alpha^H \beta_T^H} \right) R_i^s \right), \tag{A.8}$$

Using the previous two equations, we have

$$\iota_n = \frac{\sum_{s\in\{A,M,S\}} \left(X_n^s - \left(1 - \gamma^s + \frac{\gamma^s (1-\alpha^H)(1-\beta_K^s)}{1-\alpha^H \beta_T^H}\right) R_n^s \right)}{\sum_{s\in\{A,M,S\}} \sum_i \left(\gamma^s \beta_K^s + \alpha^H (1-\beta_T^H) \frac{\gamma^s (1-\beta_K^s)}{1-\alpha^H \beta_T^H} \right) R_i^s}. \tag{A.9}$$

In order to match the trade imbalance at the sector level, we calibrate the consumption share of the rest of the world for agriculture, manufacturing, and services.

$$\alpha_{RoW}^s = \left(X_{RoW}^s - \sum_{s'\in\{A,M,S\}} \gamma_s^{s'} R_{RoW}^{s'} \right) / \left(\sum_{j\in R,U} \upsilon_{RoW,j} L_{RoW,j} + \Upsilon_{RoW}/(1-\alpha^H) \right). \tag{A.10}$$

A.3 Productivity

We calibrate the productivity for each sector in the following steps.

1. Calculate the unit cost per productivity by using the observed expenditure $\{X_i^s\}$, sales $\{R_n^s\}$, the number of firms $\{M_n^s\}$, and calibrated trade costs.
2. Calculate the price index (up to scale)
3. Calculate the unit cost of production (up to scale) using the observed labor allocation $\{L_{nj}\}$, overall land supply $\{T_n\}$, land price gap, and sales $\{R_n^s\}$
4. Calculate φ_n^s (up to scale)

A.3.1 Step 1: Inversion of the Unit Cost per Productivity

For the estimation and the imputation, we apply the following lemma in Eckert (2019) with trade data and trade share equation (20).

Lemma 1 *Consider a mapping of the form:*

$$R_n^s = \sum_i^{N+1} \frac{\omega_n^s D_{in}^s}{\sum_m^{N+1} \omega_m^s D_{im}^s} X_i^s, \ \forall i = 1, \ldots, N+1. \tag{A.11}$$

For any strictly positive vectors $\{R_n^s\} \gg 0$ and $\{X_n^s\} \gg 0$, such that $\sum_n^{N+1} R_n^s = \sum_n^{N+1} X_n^s$, and any strictly positive matrix $\mathbf{D} \gg 0$, there exists a unique (to scale) strictly positive vector $\{\omega_n\}$.

Note that trade share equation is

$$\lambda_{in}^s = \frac{M_n^s \left(d_{in}^s c_n^s / \varphi_n^s\right)^{1-\sigma^s}}{\sum_{n'=1}^N M_{n'}^s \left(d_{in'}^s c_{n'}^s / \varphi_{n'}^s\right)^{1-\sigma^s}}. \tag{A.12}$$

Thus, each variable in the trade share in the lemma corresponds to the variables in our model as follows

$$\omega_n^s \equiv M_n^s \left(c_n^s / \varphi_n^s\right)^{1-\sigma^s}, \tag{A.13}$$

$$D_{in}^s \equiv \left(d_{in}\right)^{1-\sigma^s}. \tag{A.14}$$

After calibrating ω_n^s, we can calibrate c_n^s/φ_n^s as follows

$$c_n^s / \varphi_n^s = \left(\omega_n^s / M_n^s\right)^{-\frac{1}{\sigma^s - 1}}. \tag{A.15}$$

Note that we can obtain the unit cost per productivity uniquely to scale. Thus, we need a normalization here. This normalization does not matter for the calibration of the relative productivity.

A.3.2 Step 2: Price Index

Equations (19) and (23) show that

$$P_n^s \propto \left(\sum_m^{N+1} \omega_m^s D_{im}^s\right)^{\frac{1}{1-\sigma^s}}. \tag{A.16}$$

We use the equation and calibrate $\tilde{P}_n^s$ with equality.

A.3.3 Step 3: Unit Cost of Production

From equation (16), we have

$$c_n^s \propto \left(\left(w_{nj}\right)^{\beta_L^s} \left(r_n^s\right)^{\beta_T^s}\right)^{\gamma^s} \prod_{s' \in \{A,M,S\}} \left(\tilde{P}_n^{s'}\right)^{\gamma_{s'}^s} \tag{A.17}$$

We can calculate the wage rate and land price using the observed land stock, labor allocation, and sales. We let $\tilde{c}_n^s$ be the calibrated value with the equation above holds with equality.

A.3.4 Step 4: Calibration of Productivity

We can calculate the relative productivity as

$$\varphi_n^s = \tilde{c}_n^s \left(\omega_n^s / M_n^s\right)^{\frac{1}{\sigma^s - 1}}. \tag{A.18}$$

After the calculation, we would like to normalize productivity.

A.3.5 Firm Entry Costs

Using equation (18) with the calibrated unit cost, we have

$$f_n^s = \frac{1}{\sigma^s - 1} \frac{R_n^s}{\tilde{c}_n^s M_n^s} \tag{A.19}$$

A.4 Sector Preference of Workers

From the data, we have the number of workers migrating from (i, k) to (n, j). Using equation (7), we can calculate the number of workers in manufacturing in region n as

$$L_{nj}^M = \sum_{i=1}^N \sum_{k \in \{U,R\}} m_{ik|nj}^s L_{nj,ik}, \tag{A.20}$$

$$= \sum_{i=1}^N \sum_{k \in \{U,R\}} \frac{\left(\xi_n^M v_{nj,ik}^M\right)^\rho}{\left(\xi_n^M v_{nj,ik}^M\right)^\rho + \left(v_{nj,ik}^S\right)^\rho} L_{nj,ik}, \tag{A.21}$$

We can calculate the income from the data. Since the RHS is monotonically increasing in ξ_n^M, we can uniquely derive the value quantitatively.

A.5 Migration Costs

We calibrate migration costs by applying the same strategy as Tombe and Zhu (2019). We normalize them by the staying costs (i.e., $\delta_{nj,nj} = 1$). Also, we normalize $\xi_n^s = 1$ for $s = S$ (and A) and $\varphi_{nj}^H = 1$. We cannot identify utility costs of migration separately from productivity in the residential service production. As a result, the calibrated migration costs include relative difference in amenity and residential production productivity of migrants in comparison to that of the workers who have their hukou in the location. Using the migration share (5) and the relative expected income (6), we have for $(n, j) \neq (i, k)$

$$\delta_{nj,ik} = \frac{V_{nj,ik}}{V_{ik,ik}} \frac{\mathcal{P}_{ik}}{\mathcal{P}_{nj}} \left(\frac{m_{nj,ik}}{m_{ik,ik}} \right)^{-\frac{1}{\kappa}}.$$

Given the observed allocation of factors and calibrated productivity and trade costs, we can solve for the real income ratio. Combined with the observed migration shares, we can calibrate the bilateral asymmetric migration costs from this equation.

B Other Figures

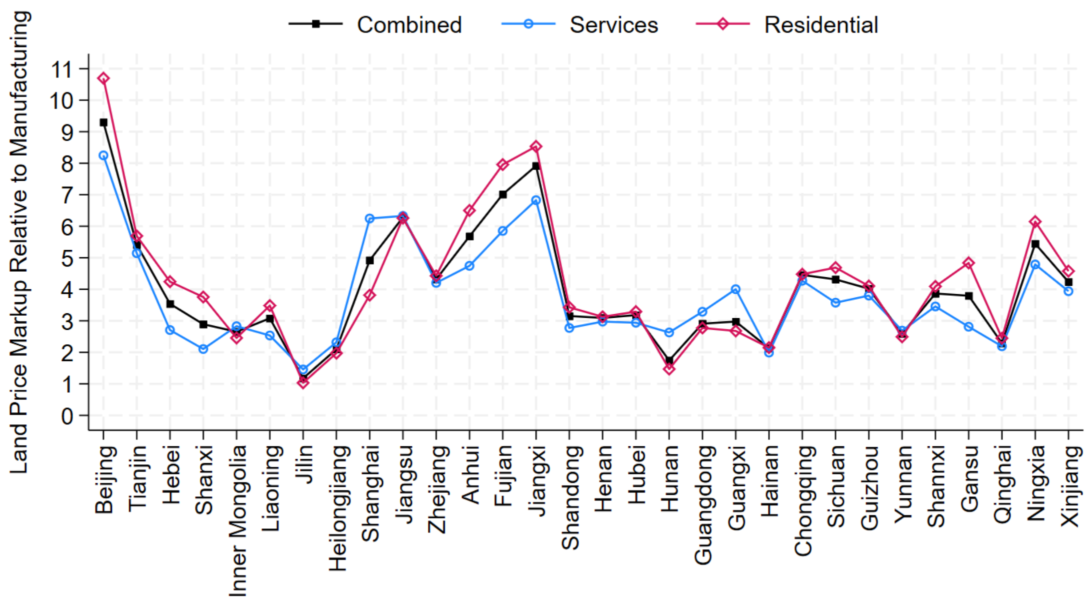

Figure B.1: Land Price Differentials across Regions