

Place-based Land Policy and Spatial Misallocation: Theory and Evidence from China *

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Abstract

Place-based policies may create spatial misallocation. We investigate a major policy in China that aims to reduce regional development gaps by distributing more urban land quotas to underdeveloped inland regions. We show empirical evidence that this policy decreased productivity in more developed eastern regions relative to inland regions. We then build a prefecture-level spatial equilibrium model with migration, land constraints, and agglomeration. The model reveals that this policy led to substantial output and productivity losses by distorting both labor and production across regions. Regional output gaps shrank, but workers from underdeveloped regions reduced their migration to developed regions and earned less. Counterfactuals show that national output would have been 1.8% higher in 2010 if the policy had not been implemented, and workers from underdeveloped regions would have earned 7% more income. Instead, regional monetary transfer policies could reduce regional inequality without significantly increasing spatial misallocation.

Keywords: Place-based Policy; Land Policy; Spatial Misallocation; Migration; Labor Mobility; Regional Inequality; China; **JEL Classification Numbers:** O18, R58, E24, J61, R52;

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1 Introduction

Many countries regulate urban land allocation using place-based policies. These regulations commonly target underdeveloped regions to promote balanced national development (Neumark and Simpson, 2015). However, promoting balanced development may come at the cost of generating spatial misallocation, especially in the presence of spatial frictions. In this paper, we empirically and quantitatively study the consequences of a major place-based land allocation policy on both spatial misallocation and regional development in China. Specifically, we investigate a sudden shift in China’s land supply policy in 2003, which transitioned from a demand-driven approach to a development-promoting approach commonly called the inland-favoring land policy.

Unlike most countries, the state owns all urban land in China. The central government sets a strict quota on how much land can be used for construction in each prefecture each year. Since the 1978 reforms, the Chinese government has distributed quotas based on each prefecture’s demand, which favored rapidly growing eastern coastal regions. However, entering the 2000s, the continuing divergence of economic development across regions became a primary concern as eastern regions substantially outpaced the rest of the country. As a result, in 2003 the demand-driven approach was dramatically shifted to a development-promoting approach by reallocating land supply quota from eastern to inland regions, hence an ‘inland-favoring’ land supply policy. This policy has since remained in place.

This place-based policy distorted both urban floor space supply and labor markets and generated severe spatial misallocation of labor and production. Urban space constraints in more productive regions increased prices for residential and production floor space. Such changes in floor space prices led to spatial misallocation and reduced output via three channels. First, more expensive production floor space directly constrained production in more productive regions. Second, labor demand and supply in more productive regions were further constrained by more expensive production and residential floor space, hindering migration inflows. Finally, the decline in migration inflows into more productive regions further reduced agglomeration effects in these regions. All three channels shifted the spatial allocation of production and labor towards less productive regions and caused national labor productivity to stay relatively low.¹

But has China successfully promoted balanced development despite such spatial misallocation costs? The answer depends on the measure. The policy shrank productivity and output gaps between developed eastern and underdeveloped inland regions at the cost of lowering the incomes of workers from underdeveloped regions since they became less likely to migrate to developed regions that offer higher wages. This is consistent with recent literature (Tombe and Zhu, 2019; Lagakos et al., 2020; Lagakos, 2020; Lagakos, Mobarak, and Waugh, 2023; Wu and You, 2023;

¹All the spatial (mis)allocation of production and labor discussed here is relative to the national Chinese growth trend. With underlying structural transmission, productivity growth, population growth, total construction land, and total urban workers are still growing despite the potential spatial (mis)allocation.

Huynh, 2023) finding that reducing internal migration costs is particularly beneficial to workers in underdeveloped regions, especially rural areas where returns to migration opportunities are high. Overall national welfare was reduced while the effects on workers from poorer and rural areas are *mixed*. Thus, this policy successfully promoted geographically balanced development. However, it did not necessarily benefit workers from underdeveloped regions. We find that by replacing the policy with regional transfers, China could increase both national output and the incomes and welfare of workers from underdeveloped regions.

We analyze the effects of this place-based land policy in three steps. First, we show empirically how the policy changes measured productivity across regions. Second, we develop a spatial equilibrium model to explain the mechanism and quantify the impact of the policy. Third, we conduct several counterfactual exercises to compare the current policy to other alternatives.

In the first step, we investigate the effect of the inland-favoring policy on the prefecture average firm productivity gap between eastern and inland regions. Employing prefecture-level Difference-in-Differences regression, we find that the inland-favoring policy reduced the prefecture average firm productivity gap between the eastern and inland prefectures by 5-8%, depending on the productivity measure. The results remain consistent across various robustness exercises. Moreover, we do not observe significant productivity improvements among inland firms. We further present empirical analyses showing that the policy increased relative land and housing prices and reduced relative wages and migration inflows in eastern regions. Our empirical analysis demonstrates that the inland-favoring policy narrowed the productivity gap between eastern and inland regions by potentially increasing the spatial misallocation of labor and production.

In the second step, we construct a spatial general equilibrium model to illustrate the mechanism of policy distortion and quantify the aggregate effects. The model features several degrees of heterogeneity (multi-prefecture, multi-skill, and multi-area), migration with costs, urban production with agglomeration, and floor space constraints in both residence and production. In the model, place-based land policy may affect national productivity in three ways. First, reducing land supply in more developed prefectures directly reduces national productivity as productive firms in developed prefectures face tighter production floor space constraints. Second, it reduces migration to developed prefectures as workers face higher housing costs due to tighter residential floor space constraints and lower wages due to tighter production floor space constraints. Finally, it reduces agglomeration effects in more developed prefectures due to fewer migration inflows.

Using microdata from the Chinese Population Census, the City Statistical Yearbooks of 225 Chinese prefectures, the Urban Statistical Yearbook of China, and other supplementary databases in 2005 and 2010, we solve and quantify the model. We then estimate the agglomeration parameter by combining our empirical analysis and the structural model using indirect inference. Finally, we show quantitative equilibrium results that measured productivity is much higher, but the land constraint is much more severe in more developed eastern prefectures.

In the final step, we implement three counterfactuals. In the first, we examine what would happen if the pre-2003 land supply policy was maintained. Naturally, this increases land supply in eastern prefectures and decreases floor space prices. More migrants are attracted to these prefectures, resulting in a 1.5% (1.8%) increase in national output in 2005 (2010). We also find that the productivity loss due to the inland-favoring policy was enormous. If we remove the policy, national productivity increases by 5.9% in 2005 and by 8.1% in 2010. The removal of the policy would reduce output and productivity in underdeveloped inland prefectures and cause a larger regional output gap. However, since workers from these underdeveloped inland prefectures have better access to developed prefectures, their incomes would be higher due to more migration. Thus, removing the inland-favoring policy increases incomes for almost all workers. The inland-favoring land supply policy did promote geographical convergence but did not necessarily increase the incomes of workers from underdeveloped regions.

In the second counterfactual, we propose a direct regional transfer as an alternative regional balancing policy to replace the place-based land policy. Instead of distributing more land to less developed regions, the central government could directly tax the additional benefits from more land in developed regions and transfer the proceeds to underdeveloped regions. Without loss of generality, we show that a direct regional monetary transfer could increase the incomes and welfare of workers from underdeveloped regions with minimal spatial misallocation.

Finally, in the third, we show the effects of alleviating all land supply distortions by equalizing floor space prices both cross-prefecture and within-prefecture. We compare this optimal policy in terms of production to the current equilibrium allocation to evaluate the overall magnitude of Chinese spatial misallocation. We have three main findings. First, the policy creates a positive correlation between land supply and productivity, which is the opposite of the negative correlation in the current equilibrium. Second, it significantly increases productivity, urban output, income, and welfare. Third, by comparing to the optimal policy in terms of production, we find that the inland-favoring land policy contributes significantly to Chinese spatial misallocation, accounting for 11% in 2005 and 31% in 2010 of the productivity misallocation.

Literature Review Evaluating the effects of place-based policies or land-use regulations in emerging markets is particularly challenging. Firstly, a clean causal identification of the effects of land-use regulations is usually hard to find. Secondly, empirically identified causal effects are usually local and cannot be easily aggregated, while aggregated quantitative studies usually overlook the distributional effects. Finally, limitations in data availability usually confine the analyses to a few developed prefectures. In this paper, we attempt to address all three issues simultaneously.

First, we draw on direct causal evidence for the effects of place-based land-use regulations. Earlier literature has studied the impacts of land-use regulations on housing and welfare both theoretically (Hamilton, 1978; Wallace, 1988; Brueckner, 1995; Helsley and Strange, 1995; Hilber

and Robert-Nicoud, 2013) and empirically (Glaeser, Gyourko, and Saks, 2005; Glaeser and Ward, 2009; Gyourko and Molloy, 2015), focusing mainly on the housing market in a few developed U.S. prefectures due to data availability. Meanwhile, addressing the endogeneity of the effects of land-use regulations remains a challenge (Quigley and Rosenthal, 2005). To tackle this challenge, recent literature has adopted DID strategies (Cunningham, 2007; Kahn, Vaughn, and Zasloff, 2010; Yu, 2019) around policy shifts. We leverage the sudden policy change in 2003 and the DID approach to establish the causal impact of the policy in China.

Second, we develop a comprehensive quantitative spatial equilibrium model to capture the aggregate and distributional effects. Recent literature has investigated various frictions and place-based policies² that result in spatial misallocation or welfare losses, including (urban-rural) migration frictions (Tombe and Zhu, 2019; Lagakos et al., 2020; Lagakos, 2020; Lagakos, Mobarak, and Waugh, 2023; Wu and You, 2023), housing constraints (Hsieh and Moretti, 2019), urban land expansion frictions (Yu, 2019; Fu, Xu, and Zhang, 2021), political manipulation (Henderson et al., 2022), and combinations of several of the frictions above (Li, Ma, and Tang, 2021; Deng et al., 2020; Chen et al., 2019). Among these, the most related study is Yu (2019), which investigates the effect of the "Farmland Red Line Policy" on economic development in China.³ We comprehensively build our quantitative model to capture the aggregate effects by including urban-rural-skill-specific migration and housing frictions on the household side and production space frictions and agglomeration effects in density on the firm side. Additionally, the rich prefecture-urban-rural-skill structure allows us to analyze distributional effects more carefully.

Third, we take our model to comprehensive individual-level, firm-level, and prefecture-level datasets to seriously address data limitations common in emerging markets. Much literature has studied migration and regional development in China and other developing countries. In the context of China, scholars have investigated the Hukou restriction and regional trade barriers (Tombe and Zhu, 2019; Hao et al., 2020), international trade and labor mobility (Ma and Tang, 2020; Tian, 2018; Fan, 2019; Zi, 2020), housing constraints (Fang and Huang, 2022), air quality (Khanna et al., 2021), and local public services for migrants (Sieg, Yoon, and Zhang, 2021; Huang, 2020).⁴ We take our model to the most granular level possible by combining the Chinese Population Census, various Statistical Yearbooks, the Land Parcel Trade Dataset, and other supplements to ensure the credibility of our aggregate and distributional quantitative results.

²These papers include enterprise zones (Neumark and Kolko, 2010; Freedman, 2013; Ham et al., 2011; Busso, Gregory, and Kline, 2013), discretionary grants (Crozet, Mayer, and Mucchielli, 2004; Devereux, Griffith, and Simpson, 2007), infrastructure investment (Kline and Moretti, 2014; Glaeser and Gottlieb, 2008; Becker, Egger, and Von Ehrlich, 2010), special economic zones (Wang, 2013; Lu, Wang, and Zhu, 2019), and community development (Eriksen and Rosenthal, 2010; Accetturo and De Blasio, 2012; Romero, 2009), among others.

³Yu (2019) finds that this restriction on converting rural farmland to urban construction land leads to severe spatial misallocation in land and labor, lowers GDP, and reduces welfare, consistent with our findings.

⁴Studies of other developing countries include Malaysia (Bertaud and Malpezzi, 2001), Indonesia (Bryan and Morten, 2019; Civelli et al., 2022), Brazil (Pellegrina, 2022), Columbia (Tsivanidis, 2019), Mexico (Monras, 2020), and India (Imbert and Papp, 2020), among others.

In summary, our study contributes to the literature by empirically, theoretically, and quantitatively examining the effect of place-based land-use regulations on China’s aggregate and regional economies. We address several issues common to this literature, such as endogeneity and data limitations. By combining comprehensive individual-level, firm-level, and prefecture-level datasets, we provide a detailed analysis of the impact of place-based land policies on various aspects of the Chinese economy.

Layout This paper is organized as follows. Section 2 provides the institutional background and describes the datasets. Section 3 provides empirical evidence that the inland-favoring land policy decreased productivity in more developed eastern regions relative to inland regions. Sections 4 and 5 develop and estimate a spatial equilibrium model and solve it using microdata. Section 6 conducts a counterfactual analysis of eliminating the place-based land policy. Section 7 evaluates a counterfactual when all land frictions are removed. Section 8 provides model sensitivity checks and further discussion. Section 9 concludes.

2 Background and Data

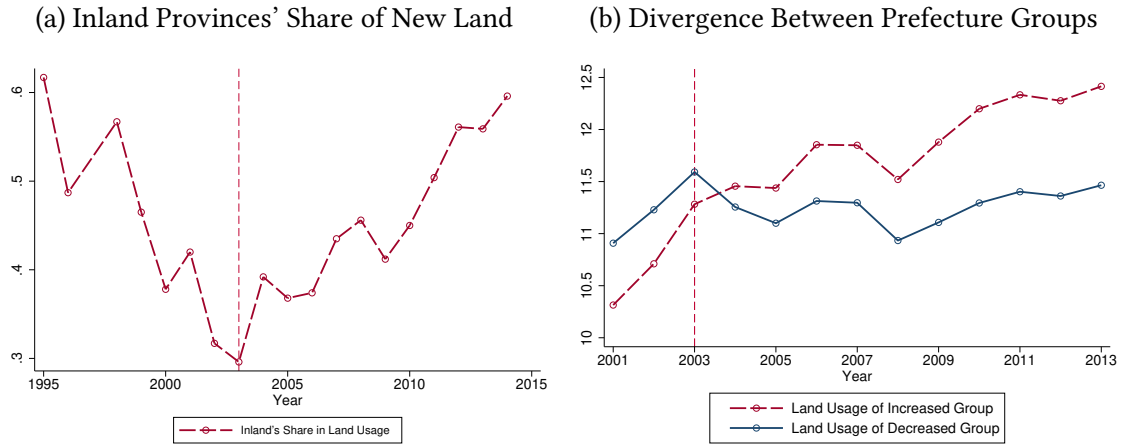
2.1 Institutional Background

Land Ownership In China, there is no private land ownership. A village collectively owns agricultural land, while urban land is state-owned. Agricultural land is transferred to the state through land expropriation before being used for urban construction. Construction companies must buy "use rights" from the local government to develop urban land. The central government strictly controls urban expansion to ensure enough agricultural land for domestic food supply security (Yu, 2019). Each prefecture is assigned a quota of new urban construction land each year. Before 2003, the quota was mainly based on each prefecture’s demand.

The 2003 Reform Allocation of construction land quotas has been used as a place-based policy since 2003. Before 2003, developed areas with higher land demand were usually assigned more land quota. However, after Jintao Hu and Jiabao Wen’s new administration took office in 2003, the central government started to focus on balancing economic development by allocating more land quota to underdeveloped inland provinces.⁵ In 2004, the central committee of the Chinese Communist Party made it clear that it is necessary to strengthen the role of land supply policy

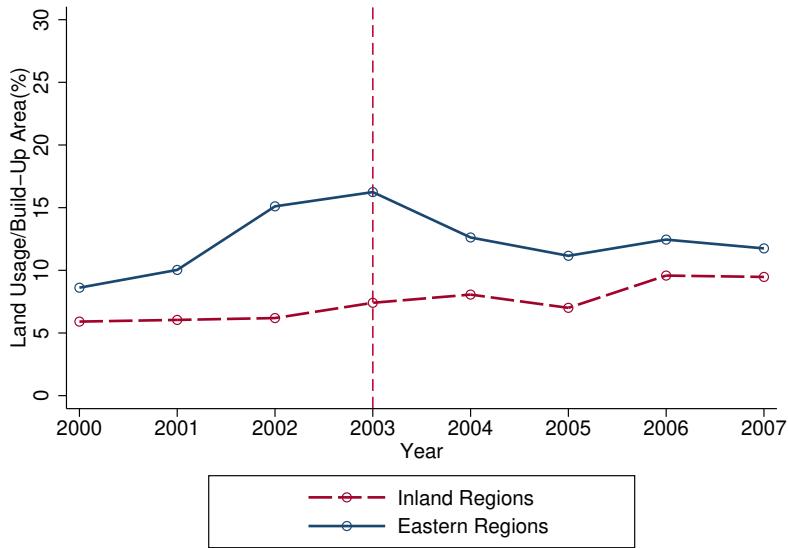
⁵Some studies have documented this significant change, see e.g. Lu and Xiang (2016), Han and Lu (2017), Liang, Lu, and Zhang (2016), or Fu, Xu, and Zhang (2021). Another part of the policy was that 70% of development zones, also known as special economic zones, that subsidize land usage, were closed in 2003–2004. The planned urban construction land supply for these closed development zones was also cut. Most of these closed development zones were located in eastern regions, and many newly opened development zones have since been established inland to support local economic development (Lu and Xiang, 2016; Chen et al., 2019).

Figure 1: New Urban Land Usage Before and After 2003



Notes: Figure shows changes in use of new urban land each year. Data sources are the National Bureau of Statistics of China, Statistical Yearbook of China's Land and Resources (2000–2016), and Yearbook of China's Land (1996–1999). The unit of subfigure (b) is the log of hectares.

Figure 2: Changes in New Land and Total Built Area

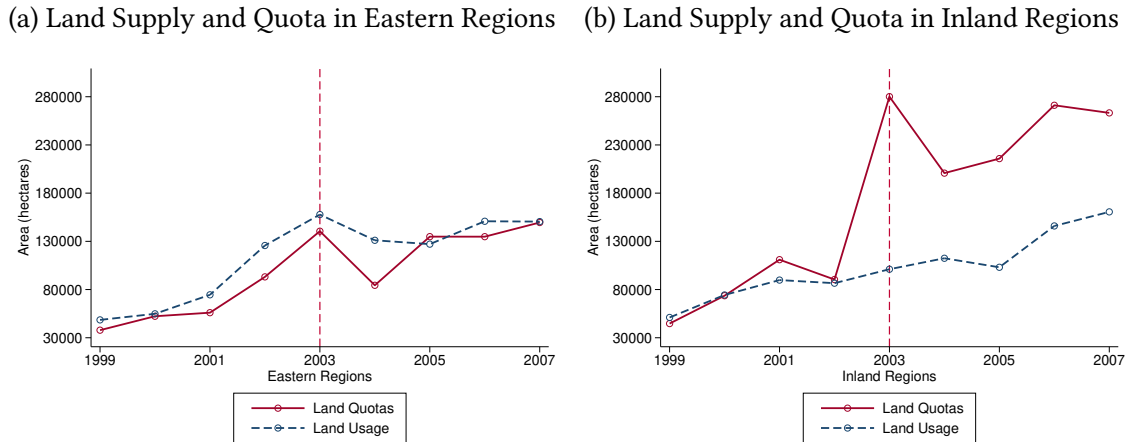


Notes: Figure shows time trends of the ratio between new urban land and total built area. The blue solid line is annual new urban land in the developed eastern region, and the red dashed line is annual new urban land in the inland region. The dashed vertical line indicates the implementation of the inland-favoring land policy.

in macroeconomic management.⁶ Additionally, the National Master Land Use Plan (2006–2020) issued in 2005 officially stated that construction land use in eastern areas would be strictly con-

⁶Decision of the State Council on deepening the reform of strict land management, issued on 12/21/2004 ([link](#)).

Figure 3: Urban Land Usage and Quota Before and After 2003



Notes: Figure compares allocated quota of urban land to land actually incorporated into cities in each year. Data sources are the National Bureau of Statistics of China, Statistical Yearbook of China’s Land and Resources (1999–2007), and Yearbook of China’s Land (1999–2007).

trolled, and land-use quotas in inland areas would be increased.⁷

Changes in Usage We first measure actual new land usage across regions in each year. Figure 1 panel (a) shows the inland provinces’ share of national new urban construction land from 1999 to 2007. This is distinct from land quota. Quota defines how much new land may be converted to urban land each year, whereas we refer to new land usage as the amount of quota actually used to convert formerly agricultural land into new urban land each year. Relative inland urban land growth declined rapidly during the east’s rapid economic growth from 1995–2003 before reversing from less than 30% in 2003 to 60% in 2015. The turning point was clearly in 2003. The trend generated by this inland-favoring policy becomes even more apparent at the prefecture level. Figure 1 panel (b) divides Chinese prefectures into two groups: prefectures whose new land usage shares increased after 2003 and prefectures whose new land usage shares shrank after 2003. Land usage in the first group was lower before 2003, but jumped and surpassed the second group after 2003, with the gap growing over time. Han and Lu (2017) also shows that a prefecture’s land usage share was more likely to shrink after 2003 if it had a larger share of land usage before 2003. Most of these were more developed eastern prefectures. Figure 2 shows the time trend of the proportion of new urban land usage each year over the total built area (total used urban land). It illustrates that the proportion was at 10–15% per year in eastern areas relative to 5–10% in inland areas. We also find a significant turning point in the year of 2003, after which the proportion of new urban land was reduced in eastern areas.

Changes in Quotas Another indicator is changes in new urban land quota — more specifi-

⁷The National Master Land Use Plan (2006–2020) is published by Xinhua Press in Chinese ([link](#)).

cally, changes in the amount of additional land designated for urban construction approved by the central government each year. This metric, while closely aligned with actual new land usage, may diverge due to local governments reserving land for future sale. Unfortunately, quota data at the prefecture-level is confidential, restricting our analysis to province-level urban land quotas. Figure 3 depicts the variations in land quota and land usage within eastern regions in Panel (a) and inland regions in Panel (b). We have two main observations. First, the land quota constraint is binding in eastern regions, as indicated by the close movement between the quota and actual land usage lines. In certain early years, land usage was observed to be marginally higher, a phenomenon potentially attributable to the recycling of pre-existing construction land.⁸ Conversely, this constraint appears less stringent in inland regions. In particular, the growth rate of land usage in inland regions was not as fast as that of land quotas after 2003. Land usage started to increase rapidly with a lag of about two years. Second, a pivotal shift in both land usage and quota post-2003 is evident. While eastern regions saw a reduction in quotas, inland quota surged. Overall, this period marked a cessation of land usage and quota growth in eastern areas, juxtaposed with encouraging such growth inland.

2.2 Datasets

2.2.1 Data for the Empirical Analysis

The main data we use is the *National Industrial Enterprise Database (NIED)*, published by the National Bureau of Statistics. It covers all enterprises “above scale” (main business revenue greater than 5 million RMB). This dataset accounts for over 90% of all industrial production in China.⁹ The dataset contains rich enterprise-level information, such as firm name, industry category, incorporation year, number of employees, total salary, and total fixed assets.¹⁰ Table 1 shows the descriptive statistics of the enterprise data. Variables in Panel A are calculated at the firm-level. Variables in Panel B are averaged at the prefecture-level, weighted by firm employment. Our main productivity calculation is based on the OP (Olley and Pakes, 1992) estimation method. We also calculate productivity using the LP (Levinsohn and Petrin, 2003) and the ACF (Ackerberg, Caves, and Frazer, 2015) methods in Appendix A, which yield similar results. Furthermore, we investigate other outcome variables, including prefecture-level wages, land prices, housing prices, and migration, to validate the mechanism using additional datasets. Additional descriptions and results are in Appendix A.7.

⁸For instance, when an old manufacturing facility is demolished, and the land is repurposed for new commercial development, such usage is included in the annual new land usage statistics, but not in the land quota for that year.

⁹Since there is a major missing data issue after 2007, we only use data from 2001 to 2007.

¹⁰For unknown reasons, some companies provide missing or erroneous information. Some data cleaning and a 1% censoring process were applied to avoid abnormal observations.

Table 1: Summary Statistics

Variable	Description	Observations	Mean	Std. dev.	Min	Median	Max
Panel A. Firm-level Variables							
Ln(tfp_op)	Firm TFP (OP)	877383	3.25	1.02	-0.04	3.27	5.63
Ln(tfp_lp)	Firm TFP (LP)	877383	6.36	1.09	3.08	6.32	9.02
Ln(tfp_acf)	Firm TFP (ACF)	877383	4.72	1.46	1.03	4.71	8.03
Ln(output)	Ln(1k yuan)	877383	8.62	1.29	5.31	8.51	12.22
Ln(wage)	Ln(1k yuan yearly)	876147	2.39	0.63	0.39	2.41	4.14
Employee	Person	877383	192.37	293.80	12	97	1985
East	Dummy	877383	0.80	0.40	0	1	1
Panel B. Prefecture-level Variables							
Ln(tfp_op)	Prefecture TFP (OP)	1792	3.16	0.42	1.41	3.22	3.96
Ln(tfp_lp)	Prefecture TFP (LP)	1792	7.11	0.44	5.02	7.12	8.04
Ln(tfp_acf)	Prefecture TFP (ACF)	1792	4.70	0.65	2.39	4.74	6.15
East	Dummy	1792	0.32	0.47	0	0	1

Notes: This table summarizes the main data we use – the *National Industrial Enterprise Database (NIED)*, published by the National Bureau of Statistics. It covers all enterprises “above scale” (main business revenue greater than 5 million RMB) from 2001 to 2007. Variables in Panel A are calculated at the firm-level. Variables in Panel B are averaged at the prefecture-level, weighted by firm employment. East is a dummy variable set to 1 if the firm/prefecture is in the eastern area.

2.2.2 Data for the Quantitative Analysis

The main dataset we use in the quantitative analysis is the Chinese Population Census. It is the most comprehensive household survey in China. Every ten years, the National Bureau of Statistics thoroughly investigates all households in the country. All families must complete a short survey, which requires provision of basic demographic information such as name, education, and living address. 10% of all families must take a longer survey, including additional information such as job and place of birth. Between each decennial Census, there is a mini-Census. For each mini-Census, the statistics bureau randomly chooses 10% of the population to complete a survey similar to the long survey in the decennial Census. For simplicity, we call both the decennial and mini-census “Census data”. In this study, we use Census data from 2005 and 2010. This gives us prefecture-area-level migration flows and housing rents for individuals with different education levels. In total, we have 2,585,481 (4,803,589) individuals in 2005 (2010), which covers 0.2% (0.36%) of the population.

Besides the Census, we utilize the Urban Statistical Yearbook and each prefecture’s (manually collected) City Statistical Yearbook. The Urban Statistical Yearbook summarizes key characteristics of all Chinese prefectures. We derived prefecture-level GDP growth and built urban land area data from the Urban Statistical Yearbook. Since we do not directly observe land quotas at the prefecture-level, we use built urban land area as the land supply in the quantitative analysis and provide sensitivity checks using province-level land quota data. We discuss this issue

in more detail in Sections 6.1 and 8. Local branches of the statistics bureau annually compile the City Statistical Yearbooks. We use these books’ prefecture-industry-level wage information to impute prefecture-skill-level wages following an impute method in the literature.¹¹ We also conduct sensitivity checks using another imputation method from individual-level wage data in Census 2005. A complete list of prefectures with corresponding GDP, measured productivity, and land tightness is in Appendix B1.

3 Empirical Analysis

We first empirically analyze how the inland-favoring policy affected productivity across regions. We show causal evidence that this policy shrank the productivity gap between eastern and inland prefectures. This reduction can be primarily attributed to the decreased productivity of eastern prefectures. Furthermore, we investigate other outcome variables, including prefecture-level wages, land prices, housing prices, and migrants as supplementary evidence.

3.1 Empirical Specification

In the main empirical analysis, we run a simple prefecture-level DID regression to identify the effect of the inland-favoring land supply policy on productivity. We use the region definitions published by the National Bureau of Statistics of China.¹² For prefecture j in year t , we have the following regression:

$$\ln(Prod_{jt}) = \alpha + \delta_1 Post2003_t \times East_j + \phi_j + \gamma_t + \epsilon_{jt} \quad (1)$$

where $\ln(Prod_{jt})$ is prefecture average firm productivity. We first calculate firm-level productivity using our firm-level data and then take the average in different prefectures, weighted by firm employment. The coefficient δ_1 is the effect of the 2003 inland-favoring policy on relative prefecture average productivity in the eastern region. $Post2003$ indicates whether the time period is after 2003 (includes 2003). $East_j$ indicates whether the prefecture is in the eastern region. ϕ_j and γ_t are the sets of prefecture and year fixed effects. ϵ_{jt} is the error term. It is important to clarify that the inland-favoring land policy can potentially affect the productivity of both regions. Therefore, the regression coefficient should be interpreted as the policy’s effect on the regional gap (relative level) rather than on the absolute level of productivity for either region.

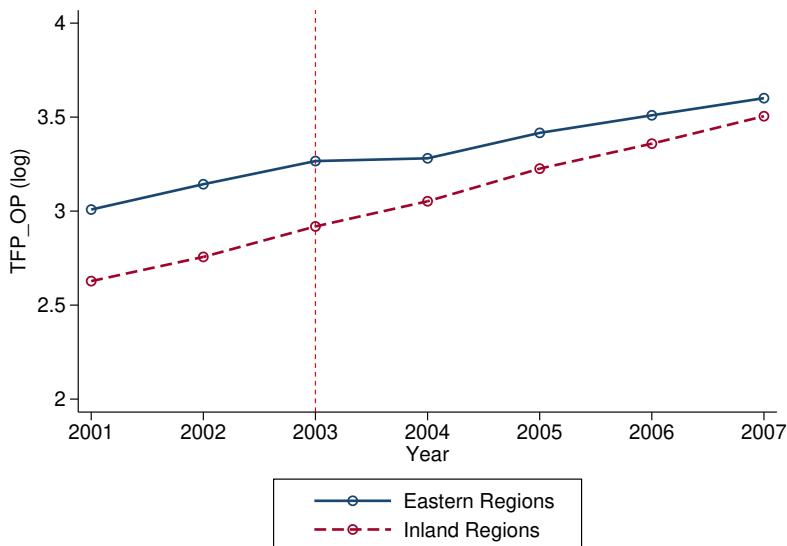
¹¹The basic idea is that we know each individual’s industry and skill from the Census data. We also have average wages for each industry from the City Statistical Yearbooks. We assign this average wage to each individual in the Census data based on their prefecture and industry information as imputed individual wages. We then calculate average wages in each prefecture for each skill using these imputed wages. The detailed imputation method is identical to the one used in Fang and Huang (2022).

¹²We consider northeastern provinces as inland.

3.2 Regression Assumptions Validation

We validate our regression method by checking the key DID assumptions. First, we investigate the time trend of firm productivity in the eastern and inland regions. Our regression specification assumes that productivity in eastern and inland prefectures should have a similar time trend. Figure 4 shows the time trends of firm productivity. The black line is average productivity in the developed eastern region, and the grey line is average productivity in the inland region. The dashed vertical line is located just after 2003 when the inland-favoring land policy was implemented. We find no evidence of divergent time trends in productivity before the policy. Despite the 2003 policy’s aim to boost inland development, we do not observe a corresponding increase in the growth rate of inland productivity. Instead, the policy seems to have stymied the growth of eastern productivity.

Figure 4: Time Trends of Firm Productivity

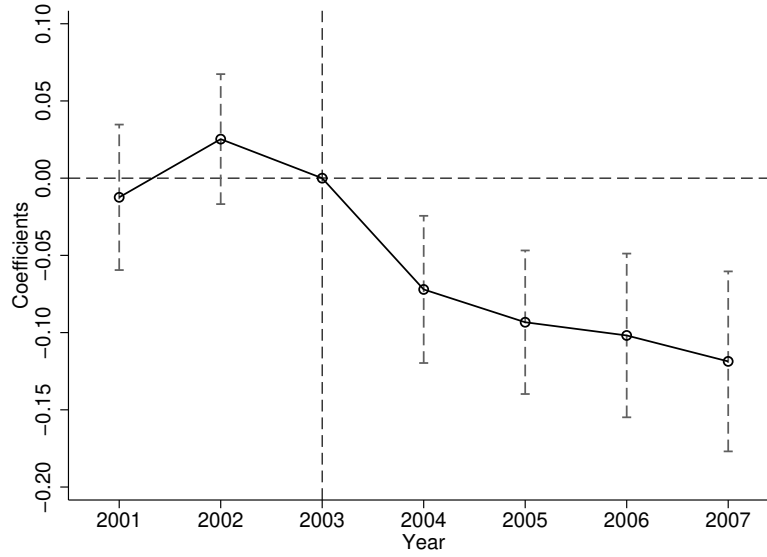


Notes: This figure shows the time trends of firm-level productivity calculated using the [Olley and Pakes \(1992\)](#) method. The blue solid line is average productivity in the developed eastern region, and the red dashed line is average inland productivity. The dashed vertical line indicates the implementation of the inland-favoring land policy.

Second, we implement a traditional event study regression to investigate the evolution of the eastern region effect across time. We take 2003 as the baseline year and then run the following regression for the event study:

$$\ln(Prod_{jt}) = \alpha + \sum_{s \neq 2003} \delta_{1s} \mathbf{1}(s = t) \times East_j + \phi_j + \gamma_t + \epsilon_{jt} \quad (2)$$

Figure 5: Event Study: Productivity



Notes: The dependent variable is average firm productivity in different prefectures calculated using the [Olley and Pakes \(1992\)](#) method. The corresponding confidence interval is 95%. We control for prefecture and year-fixed effects. We also control for linear time trends in different provinces and prefectures with different initial period (2001) characteristics, including GDP per capita and industry composition.

We plot the evolution of the coefficient δ_{1s} across time s in Figure 5, illustrating the changing of the eastern region effect across time, with 95% confidence intervals. We find that all coefficients are very close to zero before 2003. They become statistically and economically distinguishable from zero only after the policy implementation. The results from this event study confirm that there is no divergent pre-trend in our data. These figures also give us a preview of the main results. After the central government imposed the inland-favoring land policy in 2003, there was a decrease in the productivity gap between eastern and inland prefectures.

3.3 Empirical Results

Main Results on Productivity Table 2 shows the regression results for productivity. In the first column, we control for prefecture fixed effects, year fixed effects, and linear time trends in prefectures with different initial period (the year 2001) characteristics, including GDP per capita and industry composition. In the second column, we further control for linear time trends in different provinces. When including all control variables, we find that the reduction in land supply after 2003 reduced the measured productivity gap of eastern prefectures relative to inland prefectures by about 7.5%. The qualitative results are consistent across regression settings.

Other Variables and Potential Mechanism We further investigate the policy’s effect on additional outcome variables, including prefecture-level wages, land prices, housing prices, and migrants in Appendix A.7. This investigation aims to briefly discuss the policy’s mechanism while assembling empirical evidence to support our quantitative model. The results are summarized in Table 3.

Our findings reveal that the inland-favoring land policy directly led to relative increases in inland land and housing prices, and relative reductions in eastern wages and migration. The mechanism is as follows. On one hand, the surge in eastern land prices raised costs for firms, leading to a decrease in wages and a reduction in labor demand. On the other hand, the rise in housing prices drove up the cost of living, further diminishing labor supply. These channels combined to noticeably reduce worker migration from inland to eastern regions. Consequently, the 2003 land policy impacted productivity not merely by distorting the land market but also by distorting the decision-making processes of firms and workers in the labor market. We intend to explore this mechanism more comprehensively through a quantitative spatial model in the forthcoming sections.

Table 2: **DID Results on Productivity**

	(1)	(2)
Post2003×East	-0.0705*** (0.0267)	-0.0749*** (0.0266)
Province × Time Trend	N	Y
GDP Per Capita × Time Trend	Y	Y
Industry Share × Time Trend	Y	Y
Year FE	Y	Y
Prefecture FE	Y	Y
Observations	1,792	1,792
R-squared	0.7529	0.7537

Notes: The dependent variable is prefecture-level average firm productivity. We first measure firm productivity by the [Olley and Pakes \(1992\)](#) method, then take an average for each prefecture, weighted by firm employment. The standard errors are clustered at the prefecture-level. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Robustness Checks We further implement six groups of robustness analyses to address an extensive set of potential empirical concerns. The results are available in Appendix A. Our main results are robust across all checks. First, in Appendix A.1, we address concerns with the robustness of our productivity estimates. We verify robustness by repeating the empirical analysis using productivity calculated with the methods proposed by [Levinsohn and Petrin \(2003\)](#) and [Akerberg, Caves, and Frazer \(2015\)](#). Second, in Appendix A.2, we change the model specification using province-level quota changes as the treatment variable. Similar to the main results, we find that prefectures with larger quota reductions experienced larger productivity drops. We do

Table 3: **Summary of Policy Effects**

	Land Price	Housing Price	Average Wage	Migration Inflow
Post2003×East	↑	↑	↓	↓

Notes: This table summarizes the policy’s effect on additional outcome variables, including prefecture-level wages, land prices, housing prices, and migration. Detailed regression results are in Appendix A.7. We present the direction of changes in these variables to indicate the potential policy transmission mechanism.

not use this as the main specification since we only have province-level quota data. Third, the policy was enacted in 2003, and we categorize 2003 as part of the treatment group in the main context. In Appendix A.3, we change the definition and include 2003 in the control group.

We also address concerns about possible confounding policies around 2003. In Appendix A.4, we discuss the potential spatial effects of China joining the WTO in 2001. To address this issue, we run regressions keeping only firms with zero exports and regressions controlling for prefecture-level exports to eliminate any WTO effect. In Appendix A.5, we try to rule out the effects of other firm subsidy and tax policies implemented around 2003. In Appendix A.6, we investigate potential confounding effects from two rural reform policies.

3.4 Empirical Remarks

This empirical analysis shows that the inland-favoring land policy decreased the productivity gap between developed eastern regions and the underdeveloped inland regions. As depicted in Figure 4, this change is primarily driven by a slowdown in eastern productivity growth rather than an acceleration in inland productivity growth. Our supplementary findings regarding land prices, wages, housing prices, and migration patterns offer preliminary evidence supporting our proposed mechanism. These findings suggest that while the government’s policy succeeded in reducing eastern-inland gaps it may have created significant distortions in Chinese land and labor markets. This regional convergence is potentially achieved at the cost of spatial misallocation. To better understand the aggregate and spatial effects and the mechanism, we construct a spatial equilibrium model to conduct further quantitative analysis in the following sections.

4 The Model

The economy consists of discrete locations, precisely, **prefectures** (administrative cities in China), indexed by $i = 1, \dots, K$. Each prefecture j consists of two areas: urban u and rural r . The economy is populated by an exogenous measure of H workers, who are imperfectly mobile within

the economy and subject to migration costs. Each worker is either low-skill $s = l$ or high-skill $s = h$. They are endowed with a Hukou/hometown location which cannot be changed. Each location i has an inelastic supply of urban floor space S_i^u , produced by a fixed amount of urban land supply L_i^u . In urban areas, floor space can be used for production or residence. We denote the endogenous fractions of floor space allocated to production and residential use by θ_i and $(1 - \theta_i)$, respectively. Rural housing markets are simplified such that their rents are proportional to the average urban rent in the same prefecture.¹³

After observing idiosyncratic utility shocks between each possible pair of destinations and their original location, workers decide whether and where to move given their skills and Hukou locations. Firms produce a single final good, which is costlessly traded within the country and is chosen as the numeraire.¹⁴ Locations differ in terms of their final urban goods productivity (A_i^u), rural final goods productivity (A_i^r), and supply of urban floor space (S_i^u). Finally, agglomeration effects exist in urban production, where prefecture-level productivity in urban areas is positively related to the density of workers. We estimate the agglomeration parameters using our empirical findings above, joint with our structural model, with an indirect inference method.

4.1 Worker Preferences

The utility of worker o with skill s , originating from region i area n , migrating to region j area k , is a combination of final good consumption ($c_{in,jk}^o$), residential floor space consumption ($s_{in,jk}^o$), migration cost ($\tau_{in,jk}^s$), and an idiosyncratic shock ($z_{in,jk}^o$) in a Cobb-Douglas form:

$$U_{in,jk}^o = \frac{z_{in,jk}^o}{\tau_{in,jk}^s} \left(\frac{c_{in,jk}^o}{\beta} \right)^\beta \left(\frac{s_{in,jk}^o}{1 - \beta} \right)^{1-\beta} \quad (3)$$

We model the heterogeneity in the utility that workers derive from working in different parts of the economy following the migration literature (Tombe and Zhu, 2019; Fan, 2019). We also do not distinguish between urban and rural residence in the utility function but allow rural workers to construct their own residential floor space by paying construction costs. For each worker o originating from region i area n , migrating to region j area k , the idiosyncratic component of

¹³This model reflects rural China's unique land distribution system. All land in rural China is owned collectively by the village but not by individuals. There is no housing market in rural areas. The village council first distributes land to farmers (housing land, or in Chinese, *Zhaijidi*), and then farmers build their houses by themselves. Farmers effectively cannot sell or buy houses. Thus, their housing cost is the building cost.

¹⁴We do not specifically model prefecture-to-prefecture trade flows mainly due to data limitations. The most dis-aggregate intra-China trade flow data is the trade flows between Chinese provinces constructed from China's 2002 inter-regional input-output table, which is insufficient to support our analysis of prefecture-to-prefecture flows. Literature dealing with trade and migration (Tombe and Zhu, 2019; Fan, 2019; Zi, 2020) shows that reducing internal and external trade costs would accelerate labor reallocation towards more developed regions. In our model that does not include trade, such an effect would be mapped into urban final goods productivity.

utility ($z_{in,jk}^o$) is drawn from an independent Fréchet distribution:

$$F(z_{in,jk}^o) = e^{-z_{in,jk}^o{}^{-\epsilon}}, \quad \epsilon > 1$$

where the shape parameter $\epsilon > 1$ controls the dispersion of idiosyncratic utility. We assume that migration costs can be separated into two parts, $\tau_{in,jk}^s = \bar{\tau}_{in}^s d_{in,jk}$, where $d_{in,jk}$ captures the physical distance and institutional costs due to the Hukou system and other frictions in migrating from prefecture i area n to prefecture j area k , and $\bar{\tau}_{in}^s$ captures cost differences between individuals with different skills which may include skill-biased migration policies or differences in their preferences for specific amenities such as schools, entertainment, or transportation.¹⁵

After observing the realizations of idiosyncratic utility for each pair of origination and potential employment locations, workers choose their locations and areas of employment to maximize utility, taking as given residential housing prices, factor prices, and the decisions of other workers and firms. Residential housing prices serve as the first congestion effect in our model because when more and more people migrate to a city, the housing prices will be increased, resisting further migration (Allen and Arkolakis, 2014; Eckert and Peters, 2022).

Each worker is endowed with one unit of labor that is supplied inelastically with zero disutility. Taking the final good as numeraire and combining the worker's first-order conditions, we obtain the following demands for the final good and residential floor space for worker o with skill s from location i area n who migrates to location j area k :

$$c_{in,jk}^o = \beta v_{in,jk}^s, \quad s_{in,jk}^o = (1 - \beta) \frac{v_{in,jk}^s}{Q_{jk}}$$

where $v_{in,jk}^s$ is total income for a worker with skill s who stays in area k , and Q_{jk} is the rental cost of residential floor space in area k in prefecture j .

Floor space is not tradeable across political boundaries and is owned in common by Hukou-registered workers from prefecture i area n . This assumption is broadly consistent with the institutional features of China and implies that migrant workers have no claim to this fixed factor income. Therefore, the income $v_{in,jk}^s$ is a combination of wage income which depends on skill s in prefecture j area k and equally-divided residential floor space rental income among all Hukou registrants in prefecture i area n :

$$v_{in,jk}^s = w_{jk}^s + \frac{Q_{in} S_{in}^R}{H_{in}^R} \quad (4)$$

¹⁵The Hukou system is a household registration system in China that restricts worker mobility. A household's social welfare programs, including educational, medical, and other public services, are tied to their Hukou registration. Households who attempt to use such services in non-Hukou-registered prefectures pay a substantially higher cost in terms of both money and time. For more details, please refer to Song (2014).

where H_{in}^R denotes all Hukou registrants, including those who migrated to work elsewhere, and S_{in}^R denotes all the residential floor space owned by H_{in}^R Hukou registrants.¹⁶ Substituting equilibrium consumption of the final good and residential land use into utility, we obtain the following expression for the indirect utility function:

$$U_{in,jk}^o = \frac{z_{in,jk}^o v_{in,jk}^s Q_{jk}^{\beta-1}}{\tau_{in,jk}^s} \quad (5)$$

4.2 Distribution of Migration Flows

Using the monotonic relationship between utility and the idiosyncratic shock, the distribution of utility for a worker migrating from prefecture i area n and moving to the prefecture j area k is also Fréchet distributed:

$$G_{in,jk}^s(u) = Pr[U \leq u] = F\left(\frac{u \tau_{in,jk}^s Q_{jk}^{1-\beta}}{v_{in,jk}^s}\right)$$

$$G_{in,jk}^s(u) = e^{-\Phi_{in,jk}^s u^{-\epsilon}}, \quad \Phi_{in,jk}^s = (\tau_{in,jk}^s Q_{jk}^{1-\beta})^{-\epsilon} (v_{in,jk}^s)^\epsilon$$

Since the maximum of a sequence of Fréchet distributed random variables is itself Fréchet distributed, the distribution of utility across all possible destinations is

$$1 - G_{in}^s(u) = 1 - \prod_{jk=11}^{JK} e^{-\Phi_{in,jk}^s u^{-\epsilon}}$$

Therefore we have

$$G_{in}^s(u) = e^{-\Phi_{in}^s u^{-\epsilon}}, \quad \Phi_{in}^s = \sum_{jk=11}^{JK} \Phi_{in,jk}^s$$

We derive the gravity equation for migration flow in spatial equilibrium models as follows. Let $\pi_{in,jk}^s$ denote the share of workers with skill s registered in in who migrated to jk . The law of large numbers implies that the proportion of workers who migrate to area-region jk is

$$\pi_{in,jk}^s = \frac{(\tau_{in,jk}^s Q_{jk}^{1-\beta})^{-\epsilon} (v_{in,jk}^s)^\epsilon}{\sum_{j'k'=11}^{JK} ((\tau_{in,j'k'}^s Q_{j'k'}^{1-\beta})^{-\epsilon} (v_{in,j'k'}^s)^\epsilon)} = \frac{\Phi_{in,jk}^s}{\Phi_{in}^s} \quad (6)$$

¹⁶This assumption is different than Tombe and Zhu (2019), which assumes that migrant workers have no claim to any fixed factor income from the land of either their current working prefecture or their Hukou prefecture. In their model, whenever a worker migrates, she loses all fixed factor income from her previously owned local property in her Hukou prefecture. Our mechanism in this paper would be even stronger with their assumption.

4.3 Production

A single final good y is costlessly traded within the economy. In urban regions, it is produced with constant returns to scale following a Cobb-Douglas form, using some efficient combination of labor X_j and production floor space S_j^M :

$$Y_{ju} = (X_{ju})^\alpha (S_{ju}^M)^{1-\alpha}, \text{ where } X_{ju} = [(A_{ju}^h H_{ju}^h)^{\frac{\sigma-1}{\sigma}} + (A_{ju}^l H_{ju}^l)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \quad (7)$$

where X_{ju} is a CES combination of high skill labor H_{ju}^h and low skill labor H_{ju}^l multiplied by their corresponding prefecture-level efficiencies A_{ju}^h and A_{ju}^l . In rural regions, production is simply $Y_{jr} = A_{jr} H_{jr}$. Since we are not focusing on trade or substitution between agricultural goods and other goods, we assume that Y_r and Y_u are perfect substitutes. In equilibrium, A_{jr} equals the agricultural wage w_{jr} in prefecture j rural area r .¹⁷

Firm Optimization We assume that the goods market is perfectly competitive. Urban firms choose their inputs of workers and production floor space to maximize profits, taking as given final goods productivity ($\{A_{ju}^h, A_{ju}^l\}$), the distribution of idiosyncratic utility, factor prices, and decisions of other firms and workers. The production input factor prices serve as the second congestion effect in this model since when more and more people migrate to a city, production floor space prices will be increased and wages will be decreased, resisting further migration. From the first-order conditions, we obtain the following:

$$w_{ju}^l = \alpha X_{ju}^{\alpha-1} S_{ju}^{M1-\alpha} A_{ju}^l \frac{\sigma-1}{\sigma} X_{ju}^{\frac{1}{\sigma}} H_{ju}^l^{-\frac{1}{\sigma}} \quad (8)$$

$$w_{ju}^h = \alpha X_{ju}^{\alpha-1} S_{ju}^{M1-\alpha} A_{ju}^h \frac{\sigma-1}{\sigma} X_{ju}^{\frac{1}{\sigma}} H_{ju}^h^{-\frac{1}{\sigma}} \quad (9)$$

$$S_{ju}^M = \left(\frac{1-\alpha}{q_{ju}} \right)^{\frac{1}{\alpha}} X_{ju} \quad (10)$$

The zero profit property from the constant returns to scale production function determines the equilibrium production floor price q_{ju} by:

$$(X_{ju})^\alpha (S_{ju}^M)^{1-\alpha} - W_{ju} X_{ju} - q_{ju} S_{ju}^M = 0$$

where $W_{ju} X_{ju} = w_{ju}^l H_{ju}^l + w_{ju}^h H_{ju}^h$. This, together with profit maximization (10), yields the following expression for the equilibrium production floor price:

$$q_{ju} = (1-\alpha) \left(\frac{\alpha}{W_{ju}} \right)^{\frac{\alpha}{1-\alpha}} \quad (11)$$

¹⁷We make a simplification such that $w_{jr}^h = w_{jr}^l = w_{jr}$.

Agglomeration We now introduce endogenous agglomeration forces as in [Ahlfeldt et al. \(2015\)](#) with slight modifications at the prefecture-level. We allow urban labor productivity for both skills to depend on production fundamentals (a_{ju}^h and a_{ju}^l) and production externalities (D_{ju}). Production externalities impose structure on how the productivity of a given region is affected by the density of workers within the urban area of the prefecture,

$$A_{ju}^s = a_{ju}^s \times (D_{ju})^\gamma \quad (12)$$

where $D_{ju} = (H_{ju}^h + H_{ju}^l)/\bar{L}_{ju}$ is the urban density, in thousands of workers per square kilometer of administrative prefecture urban districts (urban core and its surroundings) as in [Chauvin et al. \(2017\)](#), and γ controls density's relative importance in determining overall productivity.¹⁸

4.4 Land Market Clearing

Urban Regulations Before moving to urban land market clearing, we highlight the regulation of the supply of urban floor space. For total supply, the central and local governments jointly determine a quota on how much floor space can be built each year in each prefecture. Such a quota is determined by the regulated density of development ϕ_j (the ratio of floor space to land) and the geographic construction land L_j . Therefore, we assume that floor space S_{ju} is supplied by a highly-regulated construction sector that uses construction land L_j and a regulated density of development ϕ_j to produce $S_{ju} = \phi_j L_j^u$.

Local governments then exogenously determine the usage allocation between production and residence by their preferences. Such preferences are heterogeneous across prefectures and depend on many characteristics. We treat this preference heterogeneity as creating a reduced form wedge between prices of production (q_{ju}) and residential (Q_{ju}) floor space $q_{ju} = \eta_j Q_{ju}$ where η_j captures the prefecture-specific land use regulations that restrict the price of production land relative to the price of residential land.

Urban Clearing Production land market clearing requires that the demand equals the supply of floor space allocated to production use in each location: $\theta_j S_{ju}$. Using the first-order conditions for profit maximization, this production land market clearing condition is:

$$S_{ju}^M = \left(\frac{(1 - \alpha)}{q_{ju}} \right)^{\frac{1}{\alpha}} X_{ju} = \theta_j S_{ju} \quad (13)$$

¹⁸We choose to use administrative prefecture urban districts rather than construction land area as our main measure of \bar{L}_{ju} for two main reasons: (1) most importantly, to be consistent with existing literature so our results are comparable, and (2) many loosely constructed amenities including some parks and all scenic tourism areas are not included in construction land areas. We use the other measure for sensitivity checks.

where $\theta_j \in (0, 1)$ is the measured proportion of floor space allocated to production use.¹⁹

Residential land market clearing implies that the demand for residential floor space equals the supply of floor space allocated to residential use in each location: $(1 - \theta_j)S_j$. Using utility maximization for each worker and taking expectations over the distribution for idiosyncratic utility, this residential land market clearing condition can be expressed as:

$$S_{ju}^R = E[s_{ju}]H_{ju} = (1 - \beta) \frac{E[v_{ju}]H_j}{Q_{ju}} = (1 - \theta_j)S_{ju} \quad (14)$$

Rural Clearing Rural housing markets are more straightforward as there is no production land. We assume that rural housing costs are a fixed fraction of the urban cost $Q_{jr} = \tau Q_{ju}$. Therefore, the price Q_{jr} is the cost of building a unit of floor space on rural land. Given the cost, rural residents choose the optimal floor space to build.

4.5 Definition of Spatial General Equilibrium

We now define and characterize the properties of a spatial general equilibrium given the model's fixed parameters $\{\beta, \epsilon, \alpha, \sigma, \mu, \gamma\}$.

Definition 1 A **Spatial General Equilibrium** for this economy is defined by a set of exogenous economic conditions $\{\tau_{in,jk}^s, a_j^s, \eta_j, \phi_j, L_j, H_{in}^s\}$, a list of endogenous prices $\{Q_{ju}, q_{ju}, w_{jk}^s\}$, quantities $\{v_{in,jk}^s, Y_{jk}, H_{jk}^s, S_{ju}\}$, and proportions $\{\pi_{in,jk}^s, \theta_j\}$ that solve the firms' problem, workers' problem, floor space producers' problem, and satisfy market clearing such that:

(i).[**Worker Optimization**] Taking the exogenous economic conditions $\{\tau_{in,jk}^s, A_{jk}^s\}$ and the aggregate prices $\{Q_{ju}, w_{jk}^s\}$ as given, workers' optimal migration choices pin down the equilibrium labor supply in each prefecture H_{jk}^s and the migration flow between each prefecture pair $\pi_{in,jk}^s$.

(ii).[**Firm Optimization**] Taking the exogenous economic conditions $\{A_{jk}^s\}$ and the aggregate prices $\{q_{ju}, w_{jk}^s\}$ as given, firms' optimal production choices pin down the equilibrium labor demand H_j^s and equilibrium production floor space demand $\theta_j S_{ju}$ in each prefecture.

(iii).[**Market Clearing**] For all prefectures, labor supply equals labor demand, floor space supply equals floor space demand, and final good supply equals final goods demand. This pins down the equilibrium aggregate prices $\{Q_{ju}, q_{ju}, w_{jk}^s\}$, equilibrium floor space S_{ju} , and equilibrium output Y_{ju} .

¹⁹Because production requires both production land and labor, and there is no commuting to work across prefectures, a prefecture cannot have 100% production or 100% residential land, $\theta_j \in (0, 1)$ always hold.

5 Equilibrium Analysis

In this section, we first solve the model for the unobserved fundamentals of the economy using the Census data in 2005 and 2010. We then estimate the agglomeration parameters using indirect inference (Gourieroux, Monfort, and Renault, 1993), which combines our prefecture-level regression from the empirical analysis and the solved unobserved fundamentals of the economy in 2005. Finally, we quantitatively analyze the spatial distributions of measured productivity and land tightness across regions with different levels of development. We conduct a thorough sensitivity check in Section 8 to ensure the robustness of our quantitative results.

5.1 Calibrating the Parameters

We fix a set of parameters to match data moments. Table 4 summarizes our calibrated parameters. Our calibration relies on various data sources and estimates from Fang and Huang (2022) for the migration elasticity (ϵ).

Table 4: Parameters

Parameter	Description	Value	Source
<i>From Our Microdata</i>			
β	share of consumption in utility	0.77	Urban Household Survey
α	share of labor in production	0.88	Enterprise Surveys
η_j	relative cost of production to residential land	prefecture-specific	China Land Market Website
ϵ	migration elasticity	1.9	Fang and Huang (2022)
τ	relative cost of rural housing	0.34	Population Census
γ	agglomeration elasticity	0.13	Indirect Inference
<i>From Literature</i>			
σ	elasticity of skill substitution	1.4	Katz and Murphy (1992)

Notes: This table summarizes all calibrated parameters. We first match $(1 - \beta)$ to the cost share of residential floor space in consumer expenditure from the Urban Household Survey of China, $(1 - \alpha)$ to the cost share of production floor space in firm costs from the Enterprise Surveys of Chinese manufacturing firms conducted by the World Bank in 2005, and $(\eta - 1)$ to the ratio of production land price to residential land price in each prefecture from land transaction data via the China Land Market Website (<http://www.landchina.com/>). We then calibrate the prefecture pair migration elasticity (ϵ) to be 1.9, which is estimated in Fang and Huang (2022) using the same Census data and the relative cost of rural housing (τ) to be 0.34 using the average rent paid by rural workers over the average rent paid by urban workers in the Population Census. Unfortunately, we failed to generate a robust estimate for σ using our microdata and various empirical methods. As a result, we rely on Katz and Murphy (1992) to choose the elasticity of substitution between high and low skill (σ) to be 1.4. We have conducted various sensitivity checks concerning all of our parameters and ensured the robustness of the model mechanisms.

We match $(1 - \beta)$ to the cost share of residential floor space in consumer expenditure, $(1 - \alpha)$ to the cost share of production floor space in firm costs, and $(\eta - 1)$ to the ratio of production land price to residential land price. To match $(1 - \beta)$, we use the average accommodation expenditure

share of total consumption from the Urban Household Survey of China (UHS). The National Bureau of Statistics of China conducts the survey and partially redesigned it in 2012. We believe the post-2012 measurement standard is more realistic, which gives us an average share of roughly 23% from 2013 to 2017.²⁰ Hence, we choose β to be 0.77. Second, to match $(1 - \alpha)$, we use average production floor space cost per output unit. Unfortunately, there is no direct measure of floor space costs available. We rely on the Enterprise Surveys of Chinese Manufacturing Firms conducted by the World Bank in 2005. Firms reported tax payments based on land usage, through which we can infer the costs of production land. The mean across all firms and prefectures is 12% of output. Therefore, we choose the labor share of production (α) to be 0.88. Finally, to match $(\eta - 1)$, we need to compare the prices of production and residential land. Prefecture governments may have different incentives to promote residential or production construction through tax or development motivations. Therefore, we use land price differences to match η_j for each prefecture j . The land price differences in each prefecture come from land transaction data via the China Land Market Website (<http://www.landchina.com/>). We define land used for both industrial and service firms as production land.

The elasticity of substitution between skills (σ) is calibrated to be 1.4 as in [Katz and Murphy \(1992\)](#), which has been widely used in previous literature.²¹ The prefecture pair migration elasticity (ϵ) is calibrated to be 1.9. [Tombe and Zhu \(2019\)](#) estimates this elasticity at the province-area pair level and finds a value of 1.5. [Fang and Huang \(2022\)](#) show that the migration elasticity is around 1.9.²² We choose the latter value since it is estimated in an almost identical model context to this study. Finally, the relative cost of rural housing (τ) is calculated using the average rent paid by rural area workers over the average rent paid by urban area workers in each prefecture in both Census 2005 and Census 2010. This gives us a value of 0.34.

5.2 Solving for Unobservables

Based on the data we have on the observed equilibrium allocations and prices $\{H_{jk}^s, \pi_{in,jk}^s, w_{jk}^s, Q_{jk}, q_{jk}\}$, we can calculate all unobserved variables except the agglomeration parameters: productivities $\{A_{jk}^l$ and $A_{jk}^h\}$; migration costs ($\tau_{in,jk}^s$), floor spaces $\{S_{ju}^M, S_{ju}^R, S_{jr}^R\}$, and construction density (ϕ_i) in both 2005 and 2010 as follows. We then estimate the agglomeration parameters.

Productivities First, from profit maximization and zero profits, we can infer productivity from

²⁰According to the old statistical standard, the average housing expenditure share ranged from 11.7% in 2012 to 14.3% in 2002, which is very low because imputed rent costs of self-owned houses and apartments were not included. They were added in 2013, resulting in a range from 22.7% in 2017 to 23.3% in 2013. The average expenditure share is stable across time within each of these measurement regimes.

²¹Unfortunately, we failed to generate a robust estimate for σ using our microdata and other individual-level datasets across various empirical methods, including several IVs and the 1999 college expansion quasi-natural experiment, among others. We test for the sensitivity of this parameter in the following section.

²²In a different but related setup, [Bryan and Morten \(2019\)](#) and [Fan \(2019\)](#) have a relatively higher elasticity.

the data on employment and wages. First, we solve for productivity A_j^h as a function of A_j^l using the first order conditions $A_{ju}^h = A_{ju}^l \left(\frac{H_{ju}^h}{H_{ju}^l} \right)^{\frac{1}{\sigma-1}} \left(\frac{w_{ju}^h}{w_{ju}^l} \right)^{\frac{\sigma}{\sigma-1}}$. Plugging A_{ju}^h into the definition of X_{ju} , we have:

$$X_{ju} = A_{ju}^l H_{ju}^l \left[\frac{w_{ju}^h H_{ju}^h + w_{ju}^l H_{ju}^l}{w_{ju}^l H_{ju}^l} \right]^{\frac{\sigma}{\sigma-1}} \equiv A_{ju}^l H_{ju}^l (\Xi_{ju}^l)^{-\frac{\sigma}{\sigma-1}}$$

where $\Xi_{ju}^l = \frac{w_{ju}^l H_{ju}^l}{w_{ju}^h H_{ju}^h + w_{ju}^l H_{ju}^l}$ is the share of labor income distributed to low skill workers. We also assume that agricultural productivity equals agricultural wages $A_{jr}^s = w_{jr}$, for both $s = \{h, l\}$. Combining the previous equation with the definition of W_{ju} , we have $W_{ju} = \frac{w_{ju}^h H_{ju}^h + w_{ju}^l H_{ju}^l}{X_{ju}} = \frac{w_{ju}^l}{A_{ju}^l} (\Xi_{ju}^l)^{\frac{1}{\sigma-1}}$. Plugging W_j into the price function of q_j , we can solve:

$$A_{ju}^l = \frac{q_{ju}^{\frac{1-\alpha}{\alpha}} w_{ju}^l (\Xi_{ju}^l)^{\frac{1}{\sigma-1}}}{\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}}, \quad A_{ju}^h = \frac{q_{ju}^{\frac{1-\alpha}{\alpha}} w_{ju}^h (\Xi_{ju}^h)^{\frac{1}{\sigma-1}}}{\alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}} \quad (15)$$

where $\Xi_{ju}^h = 1 - \Xi_{ju}^l$. Intuitively, higher production floor prices, wages, or skill shares s require higher skill s productivity at equilibrium.

Land Market Clearing Second, from workers' first-order conditions for residential floor space, the summation of all workers residing in each prefecture j (residential demand), and firms' first-order conditions for production floor space, we can calculate both urban and rural floor space:

$$S_{ju}^R = \frac{1-\beta}{\beta Q_{ju}} [w_{ju}^l H_{ju}^l + w_{ju}^h H_{ju}^h], \quad S_{ju}^M = \left(\frac{(1-\alpha)}{q_{ju}} \right)^{\frac{1}{\alpha}} X_{ju}, \quad S_{jr}^R = \frac{1-\beta}{\beta Q_{jr}} [w_{jr} H_{jr}]$$

We are then able to calculate the total amount of urban floor space $S_{ju} = S_{ju}^R + S_{ju}^M$ and finally back out the implied construction intensity $\phi_j = S_{ju}/L_j$.

Migration Costs To compute migration costs, we need first to compute the prefecture-level equally-divided rent income for residents $\frac{Q_i S_i^R}{H_i}$ from the residential floor space S_i^R calculated above, to which we can add observed wages to determine incomes of workers of skill s moving from in to jk : $v_{in,jk}^s = w_{jk}^s + \frac{Q_{in} S_{in}^R}{H_{in}^R}$. Then, we can calculate all migration costs between all prefecture pairs from the gravity equations. We assume the iceberg migration cost for staying in one's original prefecture is $\tau_{in,in}^s = 1$. With Q_{in} , $v_{in,jk}^s$ and $\pi_{in,jk}^s$ in hand, along with the gravity equation, we have:

$$\Phi_{in}^s = \sum_{jk=11}^{JK} (\tau_{in,jk}^s Q_{jk}^{1-\beta})^{-\epsilon} (v_{in,jk}^s)^{\epsilon} = \frac{(Q_{jk}^{1-\beta})^{-\epsilon} (v_{in,in}^s)^{\epsilon}}{\pi_{in,in}^s}$$

by inserting Φ_{in}^s into the original gravity equation, we have:

$$\tau_{in,jk}^s = \frac{v_{in,jk}^s}{Q_{jk}^{1-\beta} (\pi_{in,jk}^s \Phi_{in}^s)^{1/\epsilon}}, \quad \text{for } i \neq j \quad (16)$$

and for prefecture-area pairs with zero migration flow we assign a migration probability $\pi_{in,jk}^s \sim 0$, resulting in a prohibitive migration cost approaching infinity.

5.3 Estimating the Agglomeration Parameters

Finally, we employ a novel method similar to [Ahlfeldt et al. \(2015\)](#) to identify the agglomeration effect by exploiting the inland-favoring land supply policy natural experiment in an indirect inference regression.²³ We lay out the basic ideas below and the details of the estimation process are presented in [Appendix B.3](#).

Method The estimation is in three steps. The first step is our prior regression (1), which gives us an estimate of the coefficient $\hat{\delta}_1$. The second step is to simulate productivity in different prefectures using our model. We simulate productivity in two cases. The first case is the original equilibrium in 2005 after the inland-favoring policy, as in the real world. The second case is a counterfactual equilibrium in 2005 assuming no inland-favoring land supply policy. Given different guessed agglomeration parameters γ , we calculate different simulated productivities in each scenario. The third step is to run regressions same to (1) using the simulated data from both the original and the counterfactual equilibria. We repeat this progress until the model-simulated regression coefficient $\hat{\delta}_1^*$ converges to our empirical estimation $\hat{\delta}_1$ in regression (1).

Results From step one, we find the 2003 inland-favoring policy led to a 5-7.5% (with different productivity measures) decrease in eastern prefecture average productivity relative to inland (1). From step three, we find a monotonic negative relationship: the stronger agglomeration effects are, the larger the loss generated by the inland-favoring land policy in the model. Matching the model-simulated coefficient $\hat{\delta}_1^* \in [-0.075, -0.05]$ gives us a range of estimates for $\gamma \in [0.13, 0.21]$.

This estimated range is larger than the common point estimate of 0.07 in developed countries [Combes and Gobillon \(2015\)](#). As documented in the literature, the estimates in developing countries tend to be larger than in developed countries.²⁴ [Chauvin et al. \(2017\)](#) estimated a density elasticity for wages as high as 0.19 for China, while [Combes, Démurger, and Li \(2013\)](#) estimates between 0.10 to 0.12. Since the agglomeration parameter plays an essential role in the magni-

²³Previous studies have used various strategies to tackle this issue, such as instrumenting current variables with lagged historical variables ([Ciccone and Hall, 1996](#); [Combes, Duranton, and Gobillon, 2008](#)) or geological variables ([Rosenthal and Strange, 2008](#); [Combes et al., 2010](#)). However, data restrictions make it hard to identify the causal agglomeration effect in China. Previous studies in China have typically calibrated agglomeration parameters using values estimated from developed countries.

²⁴There are two explanations. First, China has much higher regional trade and migration costs than developed countries ([Fan, 2019](#); [Tombe and Zhu, 2019](#)), making supply chain integration much more profitable. Second, it is very hard for inland regions to benefit from technological progress in developed areas when China is still relatively underdeveloped. Thus, knowledge spillover effects are strong within Chinese prefectures or regions relative to across regions. Our result also aligns with other studies of China ([Glaeser and Lu, 2018](#); [Khanna et al., 2021](#)). Although these studies consider a different kind of externality, namely human capital externalities, they also find that the effect of prefecture-level average education on wages is much larger in China than in developed countries ([Moretti, 2004](#)).

tude of misallocation, we conservatively choose the parameter as our estimated lower bound of $\gamma = 0.13$, which is within the range in the literature. We check the sensitivity of our results across a wide range of values for γ , and our results hold qualitatively.

5.4 Equilibrium Productivity and Land Tightness

Our model quantifies the spatial distribution of productivity and land tightness. The complete list of prefectures by measured productivity and land tightness is provided in Appendix B1; here, we show only the crucial moments. We first show how productivity differs across regions with different levels of development and which component of productivity contributes most to these differences. We then show similar patterns for land tightness. Finally, we examine the model-implied spatial correlation of productivity and land tightness in the equilibrium.

Spatial Distribution of Productivity To start, we define and decompose the measured productivity in our model. We define measured productivity by dividing local output by the local labor force, mirroring the productivity calculated in the empirical analysis. Importantly, both these productivity measures incorporate land input as a component. The decomposition of measured productivity in the model is executed as follows:

$$\begin{aligned}
\ln(\widetilde{Prod}_{ju}) &= \ln\left(\frac{Y_{ju}}{(H_{ju}^h + H_{ju}^l)^\alpha}\right) \\
&= (1 - \alpha)\ln(S_{ju}^M) + \alpha\ln\left(\frac{[(A_{ju}^h H_{ju}^h)^{\frac{\sigma-1}{\sigma}} + (A_{ju}^l H_{ju}^l)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}}{H_{ju}^h + H_{ju}^l}\right) \\
&= \underbrace{(1 - \alpha)\ln(S_{ju}^M)}_{\text{land scale premium}} + \frac{\alpha\sigma}{\sigma - 1} \left[\underbrace{\ln\left(\frac{(A_{ju}^h)^{\frac{h}{\sigma}} \Gamma_{ju}^h}{(A_{ju}^l)^{\frac{l}{\sigma}} \Gamma_{ju}^l}\right)}_{\text{skill premium}} + \underbrace{\ln(a_{ju}^l)}_{\text{fundamental}} + \underbrace{\gamma\ln(D_{ju})}_{\text{agglomeration}} \right] \tag{17}
\end{aligned}$$

where $\Gamma_{ju}^h = \frac{H_{ju}^h}{H_{ju}^h + H_{ju}^l}$ and $\Gamma_{ju}^l = 1 - \Gamma_{ju}^h = \frac{H_{ju}^l}{H_{ju}^h + H_{ju}^l}$ are the corresponding high-skill and low-skill labor shares. The decomposition shows that measured productivity in prefecture j can be decomposed into four components: a land scale premium (LSP) from more construction land, a skill premium (SP) from a higher share of high-skill workers, fundamental low-skill productivity (Fund), and agglomeration (Agg) from a higher population density. The place-based land policy's effect is transmitted through these four components to measured productivity.

Using this decomposition, we calculate each component of the measured productivity for each prefecture. To better illustrate the spatial patterns, we display the results by summarizing six regions classified by location (eastern or inland) and level of development in 2005. For level of development, we divide all prefectures into three categories {high, mid, and low} to capture

{10%, 45%, 45%} of the distribution of GDP per capita.²⁵ Each region has the same prefectures in 2005 and 2010 for consistent comparisons. We first highlight that the magnitude of differences between the components are not the focus since these depend on the unit of measure. The essential differences are the gaps across regions.

Table 5: Spatial Distribution of Measured Productivity and Land Tightness

Regions (loc., dev.)	No. of prefectures	Measured Productivity										Land Tightness	
		2005					2010					2005	2010
		Total	LSP	SP	Fund	Agg	Total	LSP	SP	Fund	Agg	Land/Worker	Land/Worker
National	225	33.84	2.19	0.59	31.06	-0.01	35.86	2.22	0.62	32.92	0.11	0.093	0.083
(east, high)	21	35.21	2.24	0.67	32.07	0.22	36.81	2.29	0.67	33.51	0.33	0.077	0.068
(east, mid)	51	33.84	2.25	0.49	31.06	0.04	35.75	2.24	0.57	32.76	0.17	0.084	0.082
(east, low)	25	32.61	2.13	0.50	30.00	-0.02	34.84	2.06	0.50	32.57	-0.30	0.080	0.108
(inland, high)	2	33.69	2.06	0.59	31.44	-0.40	35.24	2.13	0.77	32.65	-0.33	0.127	0.130
(inland, mid)	50	32.97	2.11	0.69	30.34	-0.17	35.35	2.17	0.69	32.40	0.09	0.140	0.101
(inland, low)	76	32.50	2.09	0.56	30.21	-0.37	35.10	2.14	0.52	32.74	-0.30	0.104	0.086

Notes: This table displays a summary of measured productivity $\ln(\widetilde{Prod}_{ju})$ and land tightness in the model by group (weighted by population) in 2005 and 2010, as well as the decomposition of measured productivity. *LSP* stands for land scale premium, *SP* stands for skill premium, *Fund* stands for fundamental, and *Agg* stands for agglomeration. Land tightness is measured by km^2 /thousand workers. Regions are classified by the location of the prefecture (east or inland) and the level of development (GDP per capita) in 2005, as in the data. For the level of development, we divide all prefectures into three categories {high, mid, and low} to capture {10%, 45%, 45%} of the distribution of GDP per capita. Each region has the same prefectures in 2005 and 2010 for consistent comparisons.

Table 5 shows a summary of measured productivity and its decomposition following equation (17) across regions. There are two main observations. First, the significant differences in measured productivity across regions are from the fundamentals and agglomeration effects. The more developed eastern prefectures have much higher fundamental productivity and agglomeration effects than inland or less developed prefectures. Regional variations in the land scale premium and the skill premium are smaller. Second, measured productivity changes are also mainly attributed to growth in fundamental productivity and agglomeration effects rather than the land scale or skill premium.

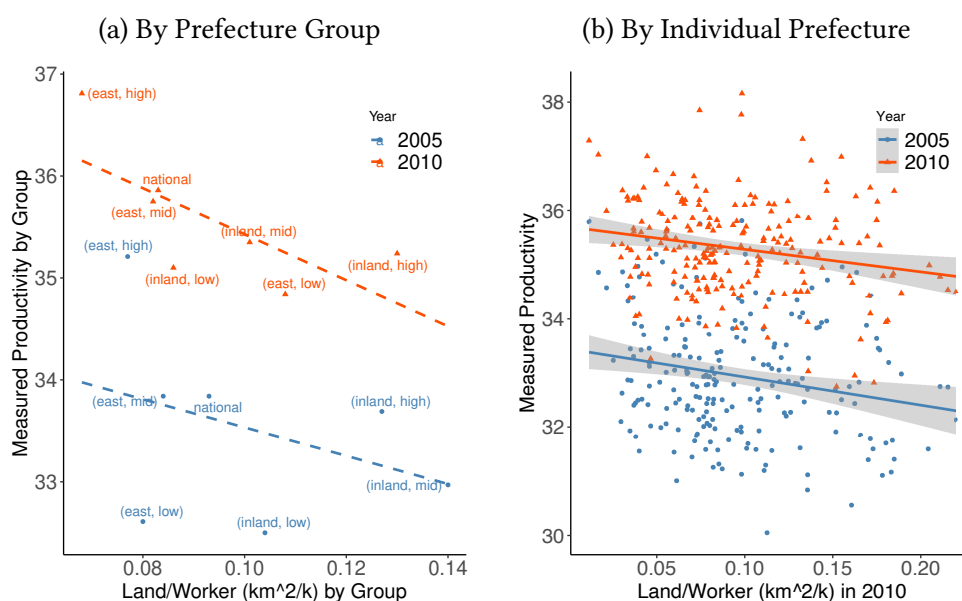
Since national productivity is the average of prefecture-level productivity weighted by the number of workers, we can investigate the changes in national productivity from place-based land policy in later sections using our decomposition. National productivity directly affects the land scale premium (LSP) across regions and indirectly affects labor demand and supply, and consequently the skill premium (SP) and fundamental low-skill productivity (Fund) across regions. Finally, it modifies regional agglomeration (Agg) effects.

Spatial Distribution of Land Tightness As discussed in the empirical section, the inland-

²⁵We also examined several alternate summary presentations, but the results are consistently robust.

favoring land allocation policy likely constrains land supply in eastern and more developed prefectures. Now, we examine the spatial distribution of land tightness. We measure cross-prefecture differences in land tightness using land per thousand workers. The last two columns of Table 5 summarize land tightness across regions. The cross-prefecture differences in land tightness show that eastern and more developed prefectures have much lower and decreasing land tightness, which matches the trend in Figure 1. Compared to inland and less developed prefectures, eastern and more developed prefectures have, on average, 30% to 50% less land per worker. Though the total construction land supply is growing, much land quota is distributed to prefectures with many people migrating out. Hence, the population-weighted national average land tightness is worsening even though the total land supply is increasing faster than the Chinese population.

Figure 6: Correlation between Productivity and Land Tightness



Notes: This figure plots the correlation between productivity and land tightness in the model. Plot (a) shows the correlation by prefecture group as in the tables above. Plot (b) shows the correlation between individual prefectures. Plot (b) excludes six extreme values for visual clarity; for the plot with the whole sample, please refer to Figure B2 in Appendix B.4. The correlation is stronger when we include the extreme values.

Correlation Between Productivity and Land Tightness We further show the correlation between productivity and land tightness in Figure 6. Plot (a) shows the correlation by prefecture group as in the tables above. Plot (b) shows the correlation by individual prefectures, from which the prefecture group plot is created. We have two observations. First, there is a strong negative correlation between productivity and land tightness. More developed eastern prefectures are much more productive but much more land-constrained. Second, the negative relation is increasingly severe across time, even though productivity is generally improving. Both patterns show the existence of substantial spatial misallocation of land and labor in the presence of the place-based land policy.

Additional Results We provide additional results that examine the spatial distribution of economic development and income in depth, containing three key observations consistent with our findings in Appendix B.5. First, more developed eastern prefectures have much higher output, especially urban output. Second, these prefectures are much more densely populated with higher floor space prices. Third, workers in these prefectures earn higher incomes (higher wages for all workers and higher non-wage incomes for Hukou workers). These findings supplement our results above on the spatial misallocation created by the place-based land policy.

5.5 Equilibrium Remarks

The patterns in measured productivity and the spatial distribution of land tightness indicate potential losses in productivity and equality due to the place-based land policy that reallocates construction land supply from eastern and more developed prefectures to inland and less developed prefectures. Since eastern and more developed prefectures have much higher fundamental productivity but tighter land constraints, this land reallocation mitigates migration to these developed prefectures and generates much lower national average productivity. The losses grow when agglomeration effects are taken into consideration.

6 Counterfactual Analysis

This section simulates counterfactual land allocation policies to alleviate land supply distortions. In the counterfactual world, we assume that the inland-favoring land supply policy was not implemented, and the pre-2003 land allocation rule was maintained. Then, we investigate the effects in two scenarios. First, we remove the policy without any other changes. Second, we remove the policy and replace it with regional transfers.²⁶

6.1 Constructing the Counterfactual Land Policy

Removing the Inland-favoring Policy We investigate what would have happened if the 2003 inland-favoring land supply policy was not implemented. To do so, we preserve the total new land supply increments from 2003 to 2005 and 2010 but redistribute the total new land supply based on the land supply growth rate from 2000 to 2003. We choose the 2000-2003 growth rate because pre-1999 land supply data at the prefecture-level is unavailable. The following equation

²⁶Since the model features non-linear interactions between skills and contains multiple floor space markets, classical hat algebra is not feasible. Therefore, we develop a multi-layer global solution iteration algorithm to compute the counterfactuals. The algorithm clears all markets, including labor, production floor space, and residential floor space markets across prefectures and areas. The details are described in Appendix B.2.

shows the details of the new supply rule:

$$\widehat{L}_j(t) = L_j(2003) + \underbrace{\sum_j [L_j(t) - L_j(2003)]}_{\text{actual total increment of land}} \times \underbrace{\frac{L_j(2003)(1 + g_{L_j})^{t-2003}}{\sum_j L_j(2003)(1 + g_{L_j})^{t-2003}}}_{\text{prefecture } j\text{'s share if no inland-favoring}} \quad (18)$$

where the first component $L_j(2003)$ is prefecture j 's urban land stock in 2003, just before the structural change happened. The second component multiplies the actual national total increment of land $\sum_j [L_j(t) - L_j(2003)]$ and prefecture j 's share of land supply if total land supply followed the pre-2003 growth rate. We consider this constrained counterfactual policy since it still fulfills the central government's strict goal of controlling the national total urban land usage.

A key question is whether developed regions have enough land to fulfill these allocations. We contend that this issue is not a concern. First, according to satellite data, in 2005, only 23% of land in tier-1 prefectures (the most developed) was developed, and a mere 9.3% of land in tier-2 prefectures was developed (Wu and You, 2023). Second, a significant portion of land in developed regions remains farmland due to the farmland redline policy (Yu, 2019).

Another important question is the difference between actual land usage and the land quota, as we explained in Section 2. *In this quantitative model, land supply refers to actual land usage in the data.* Given the absence of detailed land quota data at the prefecture level, we cannot rely on an analysis of land quota. Consequently, we abstract from the reality that some local governments may reserve land for future sales, assuming that the land market clears in each period. One potential concern is whether sufficient market demand exists to ensure land utilization upon reallocating supply to a new location when we implement our counterfactual. We claim that this will not change our counterfactual analysis. As illustrated in Figure 3, the constraint imposed by land quotas is quite stringent in eastern regions, where, in certain years, land usage even slightly exceeds the quota. Conversely, inland regions have not fully utilized their quotas since the inland-favoring land policy was enacted in 2003. Therefore, by reallocating land supply (usage) from inland to eastern regions within our model, we anticipate an actual increase in land utilization in eastern areas alongside a corresponding decrease in inland regions. We implement a sensitivity check in Section 8 by using imputed (from province-level quotas) prefecture-level land quotas as land supply, and it shows no qualitative changes.

Policy Summary The counterfactual land allocation policy is summarized in Table 6. Columns 3-4 present actual land supply under the policy, while Columns 5-6 display the counterfactual land supply based on the allocation rule in equation (18). Without the inland-favoring policy in 2003, more developed prefectures would have received more land. For example, the land quota for highly developed eastern prefectures would have been $10,958 \text{ km}^2$ in 2010 without the inland-favoring policy instead of the observed $7,272 \text{ km}^2$. Conversely, the land quota for low-development inland prefectures would have been $4,244 \text{ km}^2$ 2010 without the policy, compared

Table 6: Counterfactual Total Land Supply (km^2)

Regions (loc., dev.)	No. of prefectures	Reality		Counterfactual	
		2005	2010	$\widehat{2005}$	$\widehat{2010}$
National	225	22268	28336	22268	28336
(east, high)	21	5838	7272	6597	10958
(east, mid)	51	5875	7832	5734	6551
(east, low)	25	1418	1681	1472	1596
(inland, high)	2	169	206	169	169
(inland, mid)	50	5131	6578	4537	4819
(inland, low)	76	3837	4767	3760	4244

Notes: This table displays a summary of total urban land supply data by prefecture group (summations within the group) in 2005 and 2010, as well as the counterfactual land supply in 2010 (unit: km^2). Regions are classified by prefecture location (east or inland) and the level of development (GDP per capita) in 2005, as in Table 5.

to the observed 4,767 km^2 . Further details of the changes are in Appendix C.1.

6.2 Constructing the Regional Transfer Policy

Regional Transfer Policy We want to demonstrate that a direct monetary regional transfer produces less spatial misallocation and genuinely assists people from poor regions. Rather than implementing the place-based land policy, we consider that the central government opts to redistribute the additional land income generated by the counterfactual land allocations from developed to underdeveloped prefectures. The sole difference between *Removing the Inland-favoring Policy With Regional Transfers* and *Removing the Inland-favoring Policy Without Transfer* counterfactuals is that the former incorporates a feasible direct regional transfer on top of the latter.

Policy Summary We choose a specific but sophisticated transfer rule since we only aim to demonstrate that such a regional transfer can reduce regional income gaps and spatial misallocation. The detailed construction of the policy is in Appendix C.2. We only provide the key idea here. The essence of the transfer is: (1) preserve urban land income by transferring funds from land-gaining prefectures to land-losing prefectures, (2) adjust for housing prices by transferring from price-decreasing prefectures to price-increasing prefectures, and (3) transfer additional production land income from urban to rural regions. We also provide a simpler transfer rule in Appendix C.3 that also works. Notice that the sophisticated transfer rule redistributes additional production land income to rural workers as aggregate income would be much higher.

6.3 Calculating Welfare Changes

We can calculate the ex-ante expected utility of workers based on the properties of the Fréchet distribution. The cumulative distribution function of the utility of workers originating from region i area n with skill s is $G_{in}^s(u) = e^{-\Phi_{in}^s u^{-\epsilon}}$ where $\Phi_{in}^s = \sum_{j'k'=11}^{JK} (\tau_{in,j'k'}^s Q_{j'k'}^{1-\beta})^{-\epsilon} (v_{in,j'k'}^s)^\epsilon$. Therefore, their expected utility is $E_{in}^s[u] = \Gamma\left(1 - \frac{1}{\epsilon}\right) \times (\Phi_{in}^s)^{\frac{1}{\epsilon}}$ where the Gamma function $\Gamma\left(1 - \frac{1}{\epsilon}\right)$ is a constant and Φ_{in}^s reflects the expected utility from access to all alternative regions and areas. Φ_{in}^s is positively correlated with potential income $v_{in,j'k'}^s$ and is negatively correlated with migration and housing costs. We can then calculate the changes in ex-ante welfare as follows:

$$\Delta E_{in}^s[u] = \frac{\widehat{E_{in}^s[u]}}{E_{in}^s[u]} - 1$$

When calculating aggregate or regional welfare, we assign equal weights to each worker and sum across all individuals nationally or within each region.

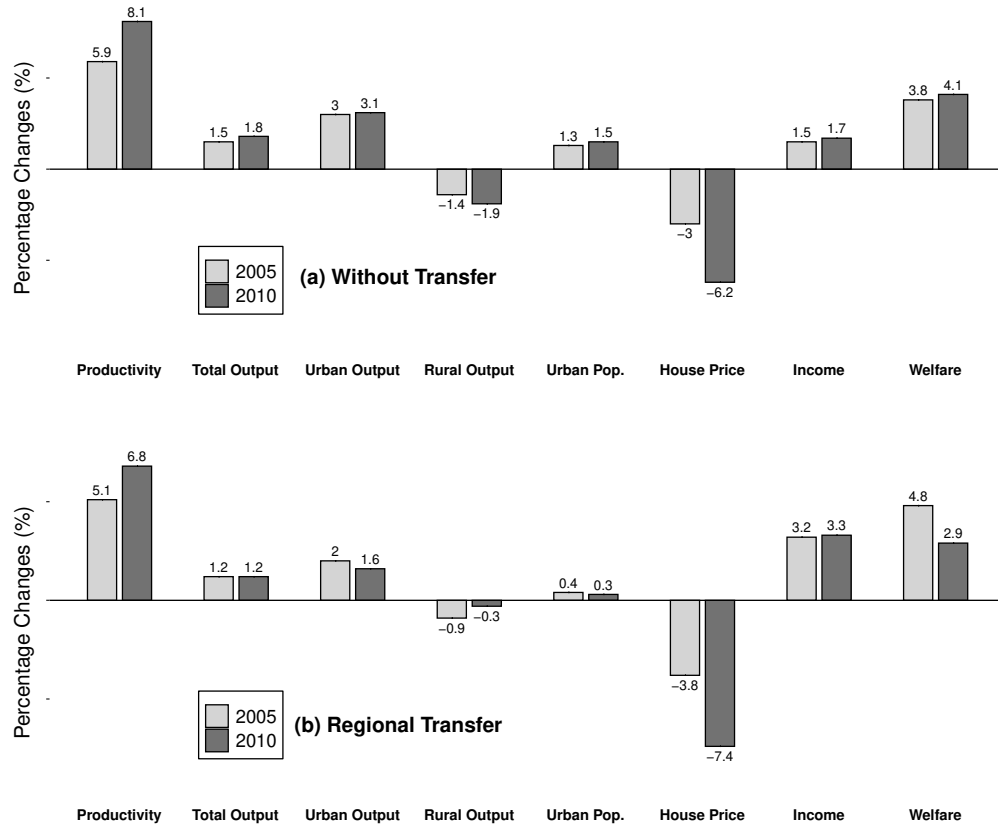
6.4 Aggregate Effects

We first present the aggregate effects of removing the inland-favoring land policy with and without regional transfers on measured national productivity, urban output, rural output, urban population, house prices, national average income, and welfare.

The results are illustrated in Figure 7. Eliminating the place-based land policy significantly increased productivity, urban output, average income, and welfare in 2005 and 2010, with or without the regional transfer. First, aggregate economic development is significantly boosted by removing the inland-favoring land policy. Without the regional transfer, the national gain in productivity is 5.9% in 2005 and 8.1% in 2010, while total output rises by 1.5% and 1.8%, respectively. With the regional transfer, the national gain in productivity is 5.1% in 2005 and 6.8% in 2010, while total output rises by 1.2% in both years. Removal of the policy also boosts the urban population by lowering the price of residential floor space in developed prefectures' urban areas. In contrast, rural output declines due to worker emigration. With the regional transfer, the economic development gains are weaker but qualitatively in the same direction. The results for the simple regional transfer are in Appendix C.4.

Second, income and welfare increase, but magnitudes vary significantly depending on the regional transfer. Incomes with the regional transfer are significantly higher than without because the additional return to more production land in more productive prefectures is redistributed to rural workers. Aggregate welfare is also sensitive to whether or not the regional transfer is applied as welfare is more affected by rich urban workers because they have much larger initial welfare level and sensitive to the housing prices. For instance, the 4.1% welfare gain in 2010 with-

Figure 7: Aggregate Effects of Removing the Inland-favoring Policy



Notes: This figure shows the aggregate effects of removing the inland-favoring policy on the Chinese economy in 2005 and 2010. Grey columns represent changes in 2005. Black columns represent changes in 2010. In both years, we find substantial national changes in productivity, total output, urban output, urban population, house prices, income, and welfare. Plot (a) shows the results without the regional transfer, and plot (b) shows the results with the regional transfer.

out the transfer is mainly driven by large gains in more developed regions. We explain further in Section 6.7 below.

6.5 Aggregate Effects Decomposition

We now show the decomposition of the aggregate effects into three channels: (1) the direct effect from production floor space changes, (2) the indirect effect from induced labor demand and supply changes, and (3) the agglomeration effect from induced population density changes. All three channels of the inland-favoring land policy lead to spatial misallocation of production and labor towards less productive regions and reduce national productivity. Please refer to Appendix C.5 for details of constructing the decomposition.

Table 7: Aggregate Effects Decomposition

Decomp.	$\Delta \widehat{\text{Productivity}}$		$\Delta \widehat{\text{Urban Output}}$		$\Delta \widehat{\text{Rural Output}}$		$\Delta \widehat{\text{Urban Pop.}}$	
	2005	2010	2005	2010	2005	2010	2005	2010
	(a) Without Transfer							
Total	5.9%	8.1%	3.0%	3.1%	-1.4%	-1.9%	1.3%	1.5%
Direct	0.3%	-0.8%	0.3%	-0.8%	0.0%	0.0%	0.0%	0.0%
Indirect	3.2%	5.8%	1.6%	3.2%	-1.4%	-1.7%	1.3%	1.2%
Agglomeration	2.4%	3.1%	1.0%	0.8%	0.0%	-0.3%	0.0%	0.3%
	(b) Regional Transfer							
Total	5.1%	6.8%	2.0%	1.6%	-0.9%	-0.3%	0.4%	0.3%
Direct	0.3%	-0.8%	0.3%	-0.8%	0.0%	0.0%	0.0%	0.0%
Indirect	2.9%	5.3%	1.1%	2.4%	-0.9%	-0.6%	0.4%	0.3%
Agglomeration	1.9%	2.3%	0.6%	0.0%	0.0%	0.3%	0.0%	0.0%

Notes: This table summarizes the decomposition of the aggregate effects into three components in 2005 and 2010 for the production and allocation variables. Other variables are shown in Table C3. All numbers are relative changes from the observed data to the counterfactual results without the inland-favoring policy. The three channels are (1) the direct effect from production floor space changes, (2) the indirect effect from induced labor demand and supply changes, and (3) the agglomeration effect from induced population density changes. All three channels of the inland-favoring land policy lead to spatial misallocation of production and labor towards less productive regions and cause national productivity to stay relatively low. Please refer to Appendix C.5 for details of constructing the decomposition and additional results (Table C3).

Table 7 shows the decomposition of the production and allocation variables. Our main focus is on changes in measured productivity and total output. We have three observations in general. First, the direct effect is the least important in magnitude and may work in the opposite direction. This is because the national land input is unchanged. Second, the indirect effect of worker reallocation plays a central role. It contributes the most to the gains in measured productivity and urban output. Finally, agglomeration is also important. Agglomeration is about half to two-thirds of the indirect effect on measured productivity and total output. Other variables, including house prices, income, and welfare, follow similar patterns and are displayed in Table C3 in Appendix C.5. These decomposition results highlight that migration and agglomeration are the essential considerations for place-based policies (Morten, 2019; Duranton and Puga, 2023).

6.6 Spatial Effects on Economic Development

We further show the spatial effects of removing the inland-favoring policy on economic development. Table 8 shows the changes in productivity, urban output, rural output, urban population, and housing prices across different regions without transfers. For results with the regional transfer, see Appendix C.7. Three main conclusions can be drawn. First, after eliminating the

inland-favoring land policy, housing prices decreased significantly in developed eastern prefectures but increased in other prefectures. Second, more workers migrated to developed eastern prefectures, resulting in a 13.9% rise in the urban population in 2010. Third, productivity and output increased in developed eastern prefectures and decreased in other prefectures. Specifically, measured productivity rose by 14.9% and urban output grew by 17.8% in these prefectures in 2010 under our counterfactual. The declines in productivity and output in other prefectures are smaller in magnitude. We provide additional results in Appendix C.6, C.7, and C.8, including a productivity decomposition and changes in the urban population by skill type. We discover that most of the increases in national productivity result from improvements in fundamental productivity and agglomeration.

Table 8: Spatial Effects on Economic Development

Regions (loc., dev.)	No. of prefectures	Δ Productivity		Δ Urban Output		Δ Rural Output		Δ Urban Pop.		Δ House Price	
		$\widehat{2005}$	$\widehat{2010}$	$\widehat{2005}$	$\widehat{2010}$	$\widehat{2005}$	$\widehat{2010}$	$\widehat{2005}$	$\widehat{2010}$	$\widehat{2005}$	$\widehat{2010}$
National	225	5.9%	8.1%	3.0%	3.1%	-1.4%	-1.9%	1.3%	1.5%	-3.0%	-6.2%
(east, high)	21	7.4%	14.9%	8.1%	17.8%	0.0%	3.3%	6.9%	13.9%	-17.4%	-32.4%
(east, mid)	51	-0.3%	-2.3%	-0.7%	-4.4%	-0.4%	0.0%	-0.7%	-3.0%	1.4%	11.9%
(east, low)	25	-0.6%	-2.7%	-0.8%	-4.6%	-1.4%	-3.5%	-0.6%	-3.2%	-3.3%	2.8%
(inland, high)	2	-0.1%	-2.6%	0.0%	-3.2%	0.0%	1.7%	0.1%	-1.0%	1.6%	18.5%
(inland, mid)	50	-0.7%	-7.8%	-2.6%	-11.8%	-1.5%	-2.9%	-1.9%	-7.5%	1.6%	9.6%
(inland, low)	76	-0.4%	-4.9%	-1.7%	-6.7%	-1.9%	-3.2%	-1.6%	-5.1%	-3.8%	-1.7%

Notes: This table displays a summary of changes in core economic development variables by prefecture group (weighted by population) in 2005 and 2010 without transfer. All numbers are relative changes from the observed data to the counterfactual results without the inland-favoring policy. For each variable, we show the changes in 2005 and 2010. Regions are classified by prefecture location (east or inland) and the level of development (GDP per capita) in 2005, as in Table 5.

In general, our findings indicate that removing the inland-favoring policy can increase national productivity and output. However, it exacerbates the regional development gap and attracts more migrants to developed areas. Consequently, the inland-favoring land policy seems to have achieved its original objective of balancing development between eastern and inland regions. However, does this mean workers from underdeveloped regions benefited from this policy? Not necessarily.

6.7 Spatial Effects on Income and Welfare

The first four columns in Table 9 display income and welfare changes for workers from different regions when we remove the inland-favoring policy. Additional results are provided in Appendix C.9. Incomes of workers from all regions increased in 2005. Incomes of workers from inland (eastern) prefectures with low development levels rose by 2.24% (1.10%) in 2005 and by 1.92%

(1.92%) in 2010. This highlights a paradox: the inland-favoring land policy narrows the regional output gap but reduces the incomes of workers from impoverished regions because the policy diminishes land supply in developed areas, leading to higher housing costs and reduced labor demand. Consequently, many workers from underdeveloped regions who would have migrated remain in their hometowns with lower wages.

Table 9: Spatial Effects on Income and Welfare

Regions (loc., dev.)	No. of prefectures	Without Transfer				Regional Transfer			
		Δ Income		Δ Welfare		Δ Income		Δ Welfare	
		$\widehat{2005}$	$\widehat{2010}$	$\widehat{2005}$	$\widehat{2010}$	$\widehat{2005}$	$\widehat{2010}$	$\widehat{2005}$	$\widehat{2010}$
National	225	1.46%	1.74%	3.8%	4.1%	3.18%	3.26%	4.8%	2.9%
(east, high)	21	2.69%	7.43%	10.8%	14.5%	-10.3%	-10.9%	7.7%	2.5%
(east, mid)	51	0.28%	-0.08%	-0.2%	-4.0%	0.49%	5.03%	1.2%	2.1%
(east, low)	25	1.10%	1.92%	-1.5%	1.2%	0.72%	6.49%	1.9%	6.3%
(inland, high)	2	0.01%	-1.61%	-0.6%	-5.3%	2.30%	5.63%	2.0%	3.1%
(inland, mid)	50	0.95%	-0.91%	-0.1%	-5.1%	20.0%	6.94%	5.8%	4.2%
(inland, low)	76	2.24%	1.92%	2.7%	-3.5%	6.49%	7.05%	5.0%	4.0%

Notes: This table summarizes income and welfare changes in our main counterfactuals in 2005 and 2010. Regions are classified by prefecture location (east or inland) and the level of development (GDP per capita) in 2005, as in Table 5. Each row represents all workers whose hometowns are in the relevant prefectures. Columns 1-4 show the changes when we remove the inland-favoring land policy. Columns 5-8 show the changes when we replace the inland-favoring land policy with a direct regional transfer.

What about welfare? Are workers from poorer regions better off because they can find jobs in their hometowns thanks to the inland-favoring policy? The answer is not necessarily. We observe that the changes in utility for workers from underdeveloped prefectures are *mixed*. When eliminating the inland-favoring policy, the average utility of workers from eastern low-development prefectures decreases by 1.5% in 2005. In contrast, the average utility of workers from inland low-development prefectures increases by 2.7%. However, the situation reversed in 2010. Overall, we find mixed evidence of whether the inland-favoring land supply policy enhanced the welfare of workers from poorer regions. This policy significantly reduces national welfare without clearly assisting workers from impoverished regions.

Columns 5-8 in Table 9 display the income and welfare changes experienced by workers from different regions when we replace the inland-favoring land policy with a regional transfer. There are two main findings. First, the regional transfer effectively reduces the income disparities between workers from developed and underdeveloped regions. Incomes of workers from inland prefectures with low (middle) development levels increased by 6.49% (20.0%) in 2005 and 7.05% (6.94%) in 2010. The incomes of workers from eastern and developed regions decrease. Second, national welfare still rises following the regional transfer. Workers from nearly all regions benefit from replacing the inland-favoring land policy with the regional transfer. Specifically, welfare increases by 2.5% for those from eastern high-development prefectures and by 4.0% for those from

inland low-development prefectures in 2010. Workers from underdeveloped regions benefit from better opportunities to migrate to developed regions with higher wages, while workers from developed regions benefit from significantly lower housing costs. Generally, compared with the inland-favoring land policy, a regional transfer policy can unambiguously promote the welfare and incomes of workers from poor regions without creating large aggregate efficiency losses.

6.8 Counterfactual Remarks

We show that the inland-favoring land supply policy resulted in a severe misallocation of both production and labor. It increased the price of residential and production floor space and discouraged workers in underdeveloped prefectures from migrating to developed prefectures. This resulted in lower national output and productivity. The observed regional convergence is geographical. The government achieved its goal of reducing regional output and productivity gaps; however, workers from developed and underdeveloped regions did not necessarily benefit from this. The income gap narrowed not because incomes of people from impoverished areas increased but because everyone's income decreased, and those from affluent areas were impacted more severely.

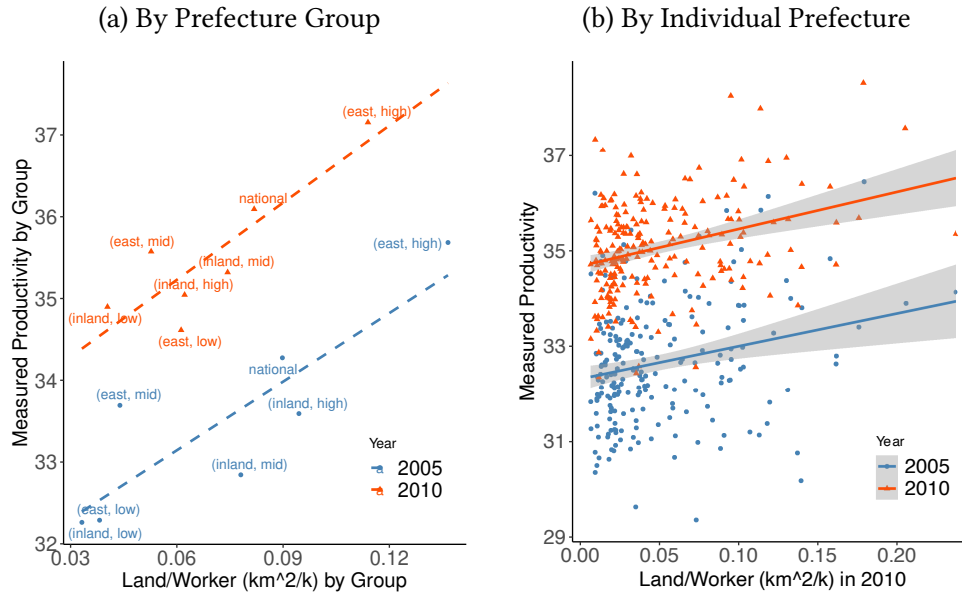
Furthermore, this policy reduced national welfare but did not necessarily improve worker welfare in underdeveloped regions. In essence, this place-based land policy aided underdeveloped regions but potentially failed to help the people from those regions. Finally, we demonstrate that a direct regional monetary transfer policy could reduce regional inequality without intensifying spatial misallocation. It effectively reduces inequality by directly assisting workers from poorer regions rather than causing a substantial spatial misallocation of production and labor.

7 Eliminating All Land Frictions

This section simulates a counterfactual land allocation policy to eliminate all land supply distortions. In this counterfactual world, we make three assumptions. First, the central government distributes construction land supply to equalize the marginal product of land across all regions. Second, the distortion between residential and production floor space prices is eliminated. Third, the allocation policy never hits the natural limits of each region. These conditions are unattainable in practical terms. However, this counterfactual scenario is constructed to serve as a benchmark for efficient land allocation. By comparing actual outcomes to this idealized baseline, we can quantify the overall magnitude of spatial misallocation within China's economy and how much the inland-favoring land policy contributed to it.

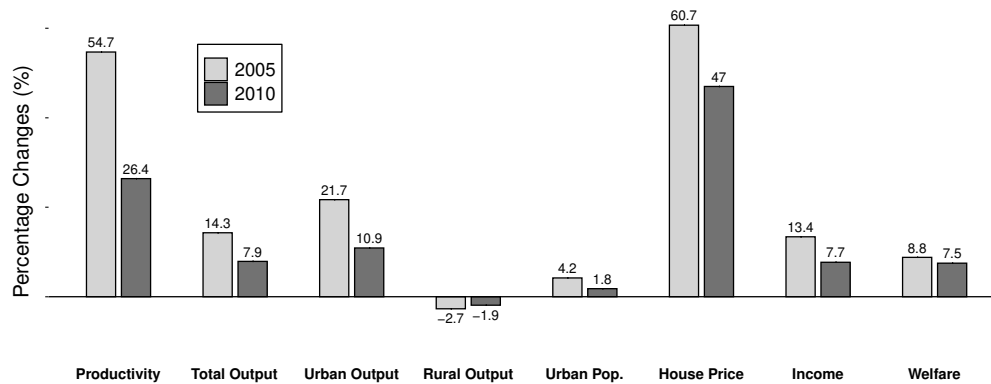
Land Frictions There are three layers of land frictions in the current equilibrium: national,

Figure 8: Correlation between Productivity and Land Tightness with Optimal Policy



Notes: This figure plots the correlation between productivity and land tightness in the model with optimal policy. Plot (a) shows the correlation by prefecture group as in the tables above. Plot (b) shows the correlation by individual prefecture. Plot (b) excludes six extreme values for visual clarity; please refer to Appendix D for the plot with the whole sample. The correlation is stronger when the extreme values are included. The optimal policy reverses the negative correlations between productivity and land per thousand workers in Table 6 and distributes more land to more productive prefectures.

Figure 9: Aggregate Effects of Eliminating All Land Frictions



Notes: This figure shows the aggregate effects of removing the inland-favoring policy on the Chinese economy in 2005 and 2010. Grey columns represent changes in 2005. Black columns represent changes in 2010. In both years, we find substantial changes in national productivity, total output, urban output, urban population, house prices, incomes, and welfare. Plot (a) shows the results without the regional transfer, and plot (b) shows the results with the regional transfer.

cross-prefecture, and within-prefecture. Natural limits and national food security concerns constrain national construction land supply, which is not our focus.²⁷ We focus on the cross-prefecture and within-prefecture distortions. Given all other frictions are fixed, cross-prefecture distortions exist as long as $S_{ju} \neq S_{ju}^{opt}$ for any prefecture ju , where S_{ju}^{opt} denotes the optimal allocation and $\sum S_{ju} = \sum S_{ju}^{opt}$. Meanwhile, within-prefecture distortions exist as long as $\eta_j \neq 1$, indicating that the marginal returns to residential and production floor space are unequal.

Optimal Policy Given these definitions of land frictions, we derive an optimal national productivity policy taking the national total construction land supply as given. Optimality requires no cross-prefecture distortions in production demand and no within-prefecture distortions between production and residential demands, that is (1) $\partial Y_{ju} / \partial S_{ju}^M = \partial Y_{iu} / \partial S_{iu}^M$, ($q_{ju} = q_{iu}$), for any i, j , and (2) $\eta_j = 1$, ($q_{ju} = Q_{ju}$), for any j . Certainly, these optimal conditions are rarely met in reality. However, it is still useful to serve as an efficient allocation baseline compared to the current equilibrium.

Main Results We show how far the current equilibrium allocation is from the hypothetical optimal allocation. We focus on two results: (1) the relationship between land tightness and productivity and (2) the aggregate effects. Additional results are in Appendix D.

We first show the correlation between productivity and land tightness in Figure 8. This optimal policy scenario yields two notable observations. First, a pronounced positive correlation emerges between productivity and land tightness, starkly contrasting with the strong negative relationship observed under the current equilibrium. This indicates that more developed eastern prefectures exhibit higher productivity with looser land constraints. Second, as productivity generally improves over time, land tightness is slightly alleviated.

We delve into the aggregate outcomes in Figure 9. Eliminating all land frictions results in substantial productivity, urban output, income, and welfare gains. Productivity in 2005 and 2010 increases by 55% and 26%, respectively, while total output rises by 14.3% and 7.9%. The smaller improvement in 2010 suggests a reduction in frictions over time, likely attributable to economic reforms (Tombe and Zhu, 2019). The welfare effects are not that large since the policy does not target national welfare maximization but production maximization.

Finally, we quantify how much the inland-favoring land policy contributed to aggregate spatial misallocation. First, we have the changes of outcomes when moving from real world equilibrium to the optimal no-friction equilibrium in this section. We then compare this change with the changes stemming from the removal of the inland-favoring policy in Section 6.1. We conclude that the contribution is significantly sizable. More specifically, 11% in 2005 and 31% in 2010 of the productivity misallocation, and 10% in 2005 and 23% in 2010 of the total output misallocation

²⁷The natural limits are beyond our discussion. National security needs are mainly food security, also known as the "Farmland Red Line," which is well-studied in Yu (2019). The central government of China is very restrictive on total construction land supply.

can be ascribed to the inland-favoring land policy.

8 Sensitivity Checks

To address concerns regarding model robustness, we perform several sensitivity checks for our quantitative model, focusing on critical parameter values, model data inputs, and counterfactual policy specifications. The key sensitivity results are in Appendix E. Many others are largely redundant and very close to what is presented in the paper, and are omitted for brevity.

Parameter Values We tested our results using numerous alternative specifications for parameter values. Our alternative specifications include variations in agglomeration strength ($\gamma \in [0.0, 0.21]$), migration elasticity ($\epsilon \in [1.0, 2.0]$), elasticity of substitution between H/L-skills ($\sigma \in [1.0, 4.0]$)²⁸, share of consumption in utility ($\beta \in [0.60, 0.90]$), share of labor in production ($\alpha \in [0.75, 0.95]$), and relative cost of rural housing ($\tau \in [0.20, 0.40]$). None of these overturn our results concerning either (1) the correlation between productivity and land tightness and (2) the gains in removing the inland-favoring policy.

Model Data Inputs We have also tested two alternative model data inputs. The first is to purge our observed wage measures using the method of Fajgelbaum and Gaubert (2020). The second is to use prefecture-level land quotas (imputed from the actual province-level land quotas) as the construction land supply in the model. Again our results are qualitatively unaffected.

Counterfactual Policies We use 2000-2003 prefecture-level land supply growth rates for the counterfactual post-2003 land allocation policy across prefectures, which follows the trend in Figure 1. We also test two alternative counterfactual allocations. The first is to use pre-2003 prefecture-level GDP growth rates, and the second uses pre-2003 prefecture-level migration inflow growth rates. Since these alternative trends are highly correlated with the pre-2003 prefecture-level land supply growth rates, our results are effectively unchanged.

Elastic Floor Space Supply We choose a fixed construction intensity in the model due to strong government regulations. We also model that construction intensity is a positive function of urban density (Ahlfeldt et al., 2015). The gains from removing the inland-favoring policy increase with elastic floor space supply.

Additional Congestion Effects We include additional congestion effects besides floor space constraints in workers' migration costs as an increasing function of urban density Allen and Arkolakis (2014); Allen and Donaldson (2020); Eckert and Peters (2022). Adding an upper bound to such congestion effects weakens the effect of removing the inland-favoring policy, but the gains are still substantial.

²⁸In a recent paper, Bils, Kaymak, and Wu (2022) argue this elasticity should be as large as 4. Our results hold qualitatively and are robust even under this upper bound in the literature.

9 Conclusion

This paper studies how place-based land allocation policy creates spatial misallocation of production and labor. We focus on a significant land policy in China that favors less-developed inland regions, intending to balance regional growth and reduce spatial inequality. Causal evidence demonstrates that this policy lowered productivity in developed eastern regions relative to underdeveloped inland regions. A spatial equilibrium model shows that this policy directly distorted the land market and indirectly distorted the labor market, causing spatial misallocation. A simulated counterfactual removing this inland-favoring policy suggests that resolving this spatial misallocation would increase national productivity and output.

Despite sacrificing national productivity and output, the inland-favoring policy did not necessarily benefit workers from underdeveloped regions. Eliminating this policy would increase incomes of workers from underdeveloped regions through increased migration to developed areas. Although the inland-favoring policy reduced regional output gaps, it adversely affected workers from underdeveloped regions by restricting their migration opportunities to higher-wage developed regions. The welfare effect on workers from underdeveloped regions is mixed and undetermined. Instead of the inland-favoring land supply policy, we propose a direct regional transfer that promotes regional convergence by enhancing income and welfare for workers from underdeveloped regions with fewer efficiency losses due to spatial misallocation.

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