Land-Use Price Wedges in a Spatial Economy: Externalities or Distortions?*

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Abstract

In Chinese cities, residential land is much more expensive than industrial land: after controlling for parcel characteristics and fine spatial-year fixed effects, the average residential premium is about 4.53, compared with 1.24 in the United States and 1.53 in Taiwan. This paper attempts to gauge whether the relatively high residential premiums are corrections of spatial externalities or distortions themselves. We build a quantitative spatial model with trade, migration, heterogeneous productivities and amenities, idiosyncratic location preferences, productivity spillovers, and land used for production and residential purposes. Theoretically, laissez-faire land allocation is optimal in an efficient benchmark without idiosyncratic preferences and productivity spillovers. Given these sources of inefficiency, optimal land-use policy generally deviates from laissez-faire, but our quantitative results indicate that the optimal residential premium is not far from 1 (laissez-faire), with an average of around 1.1 in the baseline model and between 1.04 and 1.25 across a wide range of migration and spillover elasticities. Moving from China's status quo to the optimal land-use allocation raises aggregate welfare by 4.75%, while moving to laissez-faire raises welfare by 4.71%. The observed residential premiums are therefore better interpreted as land-use distortions than as second-best corrections to spatial externalities.

Key words: land policy, land use distortions, residential premium, optimal land policy

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1 Introduction

Land is a fixed local factor, but its allocation is not a local issue only. When urban land is shifted from factories to housing, it changes firms' production costs, households' housing costs, goods prices, and migration incentives. These general-equilibrium effects are especially important in a spatial economy such as China, where local governments have substantial authority over urban land supply. In China, all urban land is state-owned, and local governments allocate leasehold rights across uses. This institutional arrangement gives local officials far more discretion over the residential-industrial composition of land supply than in most economies.

A central feature of China's urban land system is often described as "low-price industrialization and high-price urbanization." Local governments have incentives to supply ample industrial land to make it cheap to attract manufacturing activity and support local GDP growth, while restricting residential land supply in order to sustain high land-sale revenue. This phenomenon results from the combination of three features of the Chinese political economy. First, the local governments (especially the prefectural governments) controlled the supply of land and dictated its uses. Second, local governments were constrained in their tax revenues and prohibited from borrowing before local government financial vehicles were allowed. Third, the promotion of local leaders crucially depends on their jurisdictions' GDP growth (Li and Zhou, 2005).[1] This system of political economy results in a high relative price of residential land compared with industrial land. In our data, residential land in mainland China is about 4.53 times as expensive as industrial land after detailed controls, whereas comparable premiums are only 1.24 in the United States and 1.53 in Taiwan.

At first glance, such a wedge appears to be a distortion. In a free land market, the same parcel would earn the same return in residential and industrial use, so a persistent residential premium would indicate an inefficient restriction on residential land. Yet this conclusion is not automatic in an economy with spatial externalities. If workers have idiosyncratic location tastes, and if production exhibits local spillovers, then laissez-faire land allocation need not be optimal. A planner might want to use land-use policy to redirect population and production across space. The question, then, is quantitative: can the observed residential-industrial land price wedge in China be rationalized as an optimal response to spatial externalities, or is it mainly a policy-induced distortion?

This paper answers that question by computing optimal land-use allocations in a spatial

[1] For more details of the institutional background, see Hsu et al. (2016).

economy. The exercise differs from standard discussions of zoning. Zoning's main aims are to separate uses and manage local externalities within a city. The Chinese policy environment studied here is instead about the aggregate quantity of land assigned to residential versus industrial use across cities, under an institutional system in which local governments can control land supply and use. Our goal is to measure whether these land-use choices improve or reduce aggregate welfare, and by how much.

We start with the empirical object that motivates the analysis: the residential land premium. Using the universe of Chinese government land sales from 2007 to 2017, we annualize land prices to account for different leasehold lengths and estimate hedonic regressions that compare residential and industrial parcels within fine grid-year cells. The preferred nationwide estimate implies a residential premium of 4.53. We then construct comparable estimates for the United States and Taiwan. The cross-economy comparison shows that mainland China's residential premium is unusually large. Moreover, the city-level estimates of residential premiums reveal substantial variation.

Building on the quantitative spatial framework of Tombe and Zhu (2019), we develop a model with urban and rural regions, trade costs, migration costs, heterogeneous amenities and productivities, residential and production land, idiosyncratic location preferences, and productivity spillovers. The last two elements are canonical sources of inefficiency in competitive spatial economies: idiosyncratic location preferences create dispersion in the marginal utility of income across locations (Donald et al., 2025), while productivity spillovers generate agglomeration externalities. The allocation of land between residential and industrial uses is determined by local governments, but we do not model the political economy behind these choices; instead, we take the allocation as given when solving the decentralized equilibrium and vary it when studying laissez-faire and optimal land-use policies. A residential premium, defined as the ratio of residential to industrial land rent, summarizes the land-use allocation in each city. In a laissez-faire land market, the two land rents are equal, and the premium is one.

We clarify when land-use policy can and cannot improve welfare. In an efficient benchmark without these two canonical sources of inefficiency, laissez-faire land allocation is optimal. Once they are introduced, optimal residential premiums can differ from one. Idiosyncratic location preferences give the planner a redistributive motive similar to Mirrlees (1972) and Donald et al. (2025): the planner tends to push population toward lower-wage, higher-marginal-utility locations. Productivity spillovers generate the opposite force: the planner wants to move workers toward places where additional population raises productivity more. Trade is the key channel that gives land-use policy spatial bite. When trade in manufactured goods is shut down in the two-region environment, land-use policy no longer affects other regions through goods prices, and the laissez-faire allocation becomes optimal.

These theoretical mechanisms leave open the quantitative question. We calibrate the model to China in 2015, using data on land prices, population, migration shares, income, trade flows, transportation times, and land endowments. We solve for optimal land-use allocations for all 279 cities (urban regions). Because the unrestricted city-level optimization is high-dimensional, we allow city-specific premiums for large cities and impose a common premium for cities with fewer than 3 million people. The optimal residential premium ranges from 0.92 to 1.43 in the baseline, with an average of around 1.1. In contrast, the observed residential premiums (as those shown in Figure 2) range from 0.15 to 29, with an average of around 5.1. Thus, the dispersion in optimal premiums across cities is relatively small and the average optimal premium is much lower.

Moving from the status quo to the optimal land-use allocation raises aggregate welfare by 4.75%. Moving from the status quo to laissez-faire raises welfare by 4.71%. Thus, most of the welfare gain comes from undoing the observed pro-industrial land allocation; the additional gain from fine-tuning land use beyond laissez-faire is small. Over a wide grid of migration elasticities and productivity-spillover elasticities, the average optimal premium ranges only from 1.04 to 1.25, and the welfare gain from eliminating status-quo distortions ranges from 3.50% to 5.32%. These values are far below the average of observed premiums of 5.1. We therefore find no plausible combination of these externality parameters that can justify China's observed land-use allocations as an optimal second-best policy.

We also study the interaction between land-use distortions and migration frictions. Because high residential land prices make urban living more expensive, land-use distortions can act like an additional barrier to rural-urban migration. Correcting land-use distortions raises rural-urban and urban-urban migration, but the magnitude is modest relative to the effect of removing the rural-urban hukou divide. Eliminating the rural-urban divide raises welfare by 14.44%, while combining that reform with optimal land-use policy raises welfare by 19.75%. Land-use distortions, therefore, matter for migration, but they are a relatively indirect mobility friction.

This paper connects to several strands of literature. First, the paper contributes to quantitative spatial economics and the study of spatial policy. In particular, the model builds on the class of spatial equilibrium frameworks with trade and migration frictions developed in, among others, Redding (2016) and Tombe and Zhu (2019). Moreover, the establishment of the efficient benchmark model is motivated by Allen et al. (2016), even though their paper focuses on optimal city structure, whereas ours focuses on optimal land-use policies in a cross-region context. As we include rural regions and migration frictions, our work is also related to studies that quantify the effects of migration frictions, including Fan (2019), Ma and Tang (2020), Hsu and Ma (2021), and Ma and Tang (2024). Our contribution is to introduce government-stipulated urban land allocation as the central policy instrument and to evaluate its aggregate welfare consequences.

The paper also relates to research that clarifies the welfare properties of spatial equilibria and the role of spatial policy. A central lesson from this literature is that competitive spatial equilibria need not be efficient once local externalities (congestion or agglomeration), uninsured idiosyncratic location tastes, or redistributive concerns are present, and that the welfare effects of policy depend on both the planner's objective and the available instruments (Glaeser and Gottlieb, 2008; Fajgelbaum and Gaubert, 2020, 2025; Gaubert et al., 2025; Luo and Zou, 2026). In particular, Fajgelbaum and Gaubert (2020) show how optimal spatial policies trade off agglomeration forces, congestion, and redistribution across locations. As we also use a competitive spatial equilibrium, our contribution is to study a different but empirically important instrument: the allocation of land between residential and production uses. This allows us to ask whether large observed land-price wedges can be interpreted as the shadow prices implied by an optimal spatial allocation. In this sense, the paper brings the welfare logic of optimal spatial policy to the land market and uses it to derive an optimal benchmark against which to compare the magnitude and distribution of observed residential premiums in China.

This paper is also related to work on land markets and land-use distortions in China. Henderson et al. (2022) show that political incentives can distort urban land markets by leading local leaders to value measured GDP relative to residents' welfare. Their structural model studies these incentives jointly with capital-market distortions, infrastructure finance, and local budget constraints. Without modeling the political economy behind the observed wedges, we take residential premiums as given and ask whether their magnitude can be justified as optimal land-use policy. The closest paper is Lu et al. (2026), who study pro-manufacturing land policies in China in a quantitative spatial model that also builds on Tombe and Zhu (2019). They introduce monopolistic competition and input-output linkages in manufacturing and services, and model local governments' land-policy choices non-cooperatively under alternative objectives. Although their object is close to ours, our paper differs in three ways. First, by staying within the competitive spatial-equilibrium framework of Tombe and Zhu (2019), we are able to characterize the welfare properties of land-use policy in a multi-region setting, rather than only in a one-region theoretical benchmark. In particular, while Lu et al. (2026) find that sectoral linkages can rationalize some pro-manufacturing land policy, we show that optimal residential premiums can be either greater or smaller than one, depending on how productivity and amenity differences interact with idiosyncratic location preferences and productivity spillovers. Second, in our quantitative results, optimal residential premiums are close to one, making China's observed premiums difficult to rationalize as optimal land-use policy. Third, using prefecture-level trade-flow data allows us to conduct the quantitative analysis at the city rather than provincial level, which matters because the overall welfare gains from eliminating land-use distortions are larger in this more granular analysis.

The remainder of the paper is organized as follows. Section 2 documents residential land premiums in mainland China and compares them with estimates for the United States and Taiwan. Section 3 presents the quantitative spatial model. Section 4 characterizes the welfare properties of land-use allocations. Section 5 describes the calibration. Section 6 reports optimal land-use allocations and the welfare consequences of China's status-quo land-use allocation. Section 7 concludes.

2 Land Price Wedges between Residential and Industrial Uses

We first empirically examine the land price gaps between residential and industrial uses. We focus on analyzing such gaps in Chinese cities, but we will also conduct similar analysis for other economies as a comparison.

2.1 The Nation-wide Residential Premium in China

For a given parcel of land with two potential uses, residential or industrial, the no-arbitrage condition in a laissez-faire allocation implies that the prices of the two uses must be the same. However, land uses are seldom allocated in a laissez-faire fashion, and hence price premiums often exist. A parcel of land is said to exhibit a positive (negative) *residential premium* if the ratio of its residential price to its industrial price exceeds 1 (less than 1). Empirically, since we do not observe the land price of a parcel for its other use, we estimate such premiums (or the lack of) by hedonic regressions and control for land characteristics as much as possible. In particular, as locations are the most important determinant of land prices, we will adopt a granular approach in dealing with locations.

For Chinese cities, we will first estimate a nation-wide residential premium so that we can compare with other economies by similar regressions. We will estimate a prefecture-specific residential premium to examine the heterogeneity among Chinese cities. The data we use is from the universe of government land sales. The key institutional background here is that all urban land in China is state-owned, and the governments (at different levels) sell land usage rights, i.e., leaseholds, to private parties for certain durations. After 2004, all of the information about government land sales need to made public and posted online. We source the data of all land sales from 2007 to 2017 from the website of the Ministry of Natural Resources of China. The dataset contains detailed information such as land area, total payment, location, transaction year, land use, and the type of auctions.

We exclude all land transfers through non-market mechanisms; for examples, these could be transfers between different branches of the governments. Most of the land transfers for residential and industrial uses are through market mechanisms by three types of auctions: tendering (Zhaobiao), English auction (Paimai), and listing (Guapai, which is a two-stage auction). As we focus on urban land, we restrict the sample to transactions within the urban cores of prefectures, i.e., the collections of direct-control districts of a prefecture. According to Fujita et al. (2004), such collections of direct-control districts approximate the metropolitan areas in China. To sharpen our focus on residential or industrial land uses, other land use types are also dropped from the analysis. The resulting dataset comprises 336,606 land transactions from 2007 to 2017, of which approximately 43% are for residential purposes and 57% for industrial use.

The unit price of a parcel of land is obtained by dividing the purchase price by the land area of the parcel. As the tenure of leasehold differs across industrial and residential land, the prices need to be annualized to ensure comparability. Denoting the unit price of a parcel k by P_k, the corresponding annualized price p_k is calculated as:

$$p_k = P_k \cdot \frac{1 - \frac{1}{1+r}}{1 - \left(\frac{1}{1+r}\right)^T},$$

where r is the interest rate, set to 5%, and T denotes the leasehold duration — typically (but not always) 70 years for residential land and 50 years for industrial land.

With the annualized price for each transaction, the residential land premium relative to industrial use can be estimated using a hedonic regression framework. Following the monocentric city model, a commonly used control for location is the distance from a metropolitan area's city center. However, to have a more granular control of locations, we partition the entire territory of an urban region, i.e., the collection of direct-control districts of a prefecture, into uniform 1km × 1km grid cells based on geographic coordinates. The inclusion of grid-year fixed effects allows comparisons of residential and industrial parcels within the same local grid and year, thereby controlling for fine-scale differences across locations and time. We still control for distance from the city center, effectively capturing its effect within the same grid and year.

Specifically, we estimate the following specification:

$$\ln(p_{kft}) = \delta D_{kft} + \mathbf{X}_{kft} + \xi_{ft} + \epsilon_{kft}, \tag{1}$$

where p_{kft} denotes the annualized unit land price of land parcel k in grid cell f, and year t; D_{kft} is a dummy variable that equals 1 if the parcel sold is designated as residential use and 0 if it is industrial use; $\mathbf{X}_{kft}$ is a vector of observable land characteristics, including land area, distance to the city center,[2] auction types, the sources of land parcels[3] and land grade;[4] ξ_{ft} denotes grid-year-fixed effect, and ϵ_{kft} is the error term. Thus, $\exp(\hat{\delta})$ is the estimate for the hedonic residential premium within China. All regressions are weighted by land parcel area.

The results are presented in Table 1. In all five columns, the coefficient for the residential dummy is positive and statistically significant. Column 1 is a simple regression of the logarithm of annualized unit land price on the land use dummy only. Column 2 introduces prefecture and year fixed effects, which absorb substantially more variation ($R^2 = 0.72$), as expected. Column 3 further includes all the above-mentioned control variables $\mathbf{X}_{kft}$ (only the coefficient for the distance to the city center is shown), along with the fixed effects in Column 2. As expected, the distance to the city center is negative and statistically significant. Column 4 drops the prefecture fixed effects and adds grid fixed effects. Column 5 further replaces grid and year fixed effects with grid-year fixed effects. In both Columns

[2]The city centers are defined as the locations of the local government headquarters.

[3]There are two types of land sources in China's land market: newly assigned land and previously assigned land. Newly assigned land refers to parcels allocated for the first time, whereas previously assigned land refers to parcels that had been allocated in earlier periods but had not yet been sold.

[4]Land grades range from 0 to 18, which are obtained from a standard official procedure to help set the reservation prices for the land parcels. Even though this variable reflects reservation prices in some way, a simple regression shows that its explanatory power on the actual price is low ($R^2 = 0.05$). However, even when all of the regressors are included in our most preferred specification, including the grid-year fixed effects, this variable remains significant, suggesting that it may have captured certain relevant characteristics of the land parcels that are observable to the bureaucrats but not directly to us, even conditioned on all of the other controls. Thus, it is a useful control to be included.

Table 1: Nationwide Residential Premium in China

	(Log) Annualized Land Price				
	(1)	(2)	(3)	(4)	(5)
$D_{residential}$	1.328***	1.975***	1.721***	1.547***	1.512***
	(0.008)	(0.005)	(0.005)	(0.004)	(0.004)
Distance			−0.08***	−0.006	−0.006
			(0.001)	(0.005)	(0.07)
Other controls			✓	✓	✓
Prefecture fixed effects		✓	✓		
Year fixed effects		✓	✓	✓	
Grid fixed effects				✓	
Year-grid fixed effects					✓
Weights	✓	✓	✓	✓	✓
Obs	336,606	336,605	334,966	306,428	234,320
R^2	0.07	0.72	0.84	0.96	0.98

Notes: This table reports estimates of the nationwide residential land price premium in China. The dependent variable is the logarithm of annualized land price at the parcel level. $D_{\text{residential}}$ is an indicator equal to one for residential land parcels and zero otherwise. Distance measures capture proximity to city centers. All regressions are weighted by parcel area. The grid size is 1 km × 1 km. Standard errors are reported in parentheses. Statistical significance is denoted by $^{*}p < 0.10$, $^{**}p < 0.05$, and $^{***}p < 0.01$.

4 and 5, the R^2 are substantially higher than that in Column 3, and the coefficient for the distance from the city center becomes insignificant, indicating that the grid fixed effects explain considerably more variation in prices than the distance from the city center. Column 5 is our most preferred specification, and even under these stringent controls, the residential dummy remains highly significant. The estimated coefficient on the residential dummy implies that, on average, residential land was sold at a premium of $\exp(1.512) \approx 4.54$ times the price of industrial land over the 2007–2017 period.[5]

2.2 Residential Premiums in Different Economies

Next, we conduct a cross-economy comparison by applying the same regression design as in (1) (or Column 5 of Table 1) to the land price data of the US and Taiwan. As before, we keep only residential and industrial land uses and drop commercial and other types of uses, and 1 km × 1 km grid size is adopted for the baseline.

The US dataset includes approximately 5.7 million parcel-level government-assessed

[5] As a robustness check, Appendix Table 7 reports the results when the annualized price is calculated using a 3% interest rate instead of the 5% used in the baseline. Under this specification, the estimated residential land premium is $\exp(1.454) \approx 4.28$, indicating that the choice of interest rate in the annualization has only a marginal effect on the estimated residential premium.

Table 2: Residential Premium: Cross-Economy Comparison

	Mainland China	U.S.	Taiwan
$D_{residential}$	1.512***	0.212***	0.419***
	(0.004)	(0.004)	(0.007)
Controls	✓	✓	✓
Grid fixed effects		✓	
Grid-year fixed effects	✓		✓
Weights	✓	✓	✓
Obs.	234,320	5,696,576	109,474
R^2	0.98	0.70	0.86

Notes: The dependent variable is the logarithm of annualized land price at the parcel level. $D_{\text{residential}}$ is an indicator equal to one for residential land parcels and zero otherwise. All regressions are weighted by parcel area. The grid size is 1 km × 1 km. Standard errors are reported in parentheses. Statistical significance is denoted by $^{*}p < 0.10$, $^{**}p < 0.05$, and $^{***}p < 0.01$. Estimated residential premiums are $\exp(1.512) \approx 4.53$ for mainland China, $\exp(0.212) \approx 1.24$ for the United States, and $\exp(0.419) \approx 1.52$ for Taiwan.

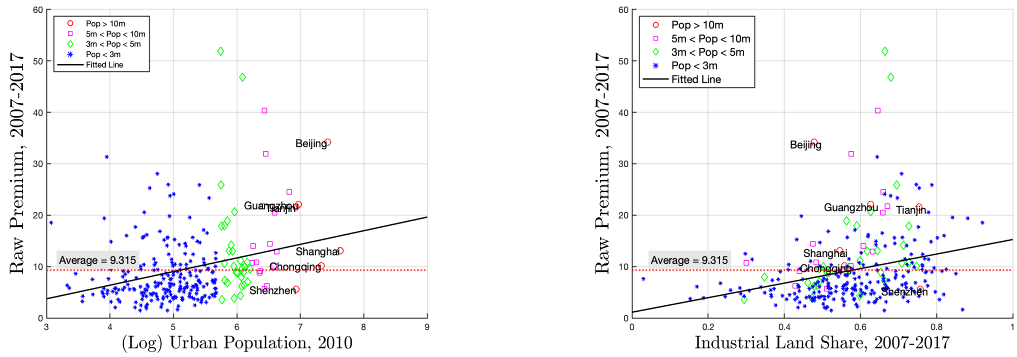
values from 2017 across five counties—Maricopa, Los Angeles, Miami-Dade, Dallas, and Harris—that account for the bulk of the following metropolitan areas: Phoenix, Los Angeles, Miami, Dallas, and Houston, respectively. Among the assessed land parcels, 1.9% are classified as industrial and 98.1% as residential. The control variables include distance to the city center, parcel area, and grid fixed effects. There are no year fixed effects because the U.S. data are cross-sectional.

The Taiwan dataset includes all land transactions from 2012 to 2018, covering both private and public transactions. In total, the dataset contains approximately 113,000 transactions, of which 8.52% are industrial, and 91.48% are residential. The control variables include distance to the city center, transacted land area, a dummy variable indicating whether the property has a management committee, a dummy variable indicating whether the "remark" variable is nonempty, and the number of parcels in the same transaction, as well as the grid-year fixed effects.[6]

[6] A management committee of a building is a self-governing organization that oversees and handles public matters for the building. Some building types are required to have such committees by law, but not all. However, because our data focuses on land-only transactions, only 0.85% of transactions involve a management committee. When a transaction's remark variable is nonempty, it typically indicates something noteworthy about the transaction; 37% of transactions include non-empty remarks. The content of the remarks can be quite diverse, and a common type of remark concerns related-party transfers. Land is partitioned into different parcel numbers in the Taiwanese land administration system, and a transaction could involve multiple "land parcels". The number of land parcels is a set of dummy variables indicating 1 parcel, 2 parcels, 3 parcels, and at least 4 parcels. Approximately 65% of transactions involve a single parcel, 18% involve two parcels, 7% involve three parcels, and the remaining 10% involve at least four parcels.

Figure 1: Raw Residential Premium (RRP) Statistics

Panel A: RRP and Urban Population | Panel B: RRP and Industrial Land Share



Notes: This figure plots the annualized raw residential premium (RRP) against urban population and industrial land share. The RRP slope with respect to log urban population is 2.64 with a standard error of 0.53, and the slope with respect to industrial land share is 14.14 with a standard error of 2.80.

As reported in Table 2, residential land is approximately $\exp(0.212) \approx 1.24$ times more expensive than industrial land in the United States. In Taiwan, the corresponding ratio is approximately $\exp(0.423) \approx 1.53$. Both of these numbers are way lower than the corresponding number for mainland China's: $\exp(1.512) \approx 4.53$. These comparative findings remain robust across alternative spatial resolutions, including a coarser grid size of 3km×3km, as summarized in Appendix Table 8.

2.3 Prefecture-Level Residential Premium within China

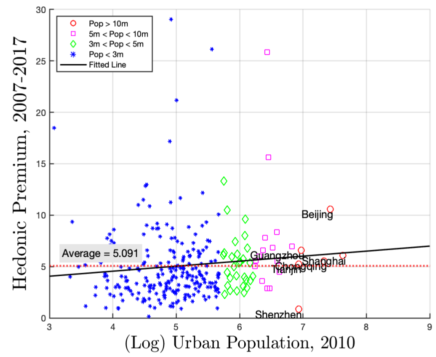
Next, we examine the heterogeneity of residential premiums across prefectures in China. We begin by analyzing the raw residential land premium, defined as the ratio of annualized residential to industrial land prices. For each prefecture, we calculate the land-area-weighted averages of annualized residential and industrial land prices across parcels, and then compute the prefectural raw residential premium (henceforth RRP) as the ratio of these two averages. Across cities, the (simple) mean premium is 9.31, with a standard deviation of 7.02, indicating substantial heterogeneity in the RRPs across prefectures. Panels A and B of Figure 1 plot the RRPs against the urban population in each prefecture and the share of industrial land (in terms of land area) among all land sales during 2007-2017. Prefectures with larger urban populations exhibit higher raw residential premiums, and those prefectures that saw a more aggressive industrial land sales (as measured by the industrial land share) also exhibit higher raw residential premiums.

To further account for heterogeneity in land attributes, we estimate a hedonic residen-

Figure 2: **Hedonic Residential Premium (HRP) Statistics**

Panel A: HRP and Poplution

Panel B: HRP and Industrial Land Share



Notes: This figure plots the hedonic residential premium (HRP) against urban population and industrial land share. In the hedonic specification, the slope with respect to log population is 0.48 (s.e. = 0.30), while the slope with respect to industrial land share is 6.13 (s.e. = 1.52).

tial land premium as a contrast to the annualized residential premium. Specifically, for each prefecture n, we estimate the following hedonic regression:

$$\ln p_{k(n)ft} = \delta_n D_{k(n)ft} + \mathbf{X}_{k(n)ft}\lambda_n + \delta_{ft} + \epsilon_{k(n)ft}, \tag{2}$$

where $p_{k(n)ft}$ is the annualized unit land price of transaction k in prefecture n, grid cell f, and year t; $D_{k(n)ft}$ is a dummy variable equal to 1 for residential land use and 0 for industrial use; $\mathbf{X}_{k(n)ft}$ is a vector of observable land characteristics, including distance to the city center, land area, auction types, land sources and land ranking. δ_{ft} denotes grid-year-fixed effect, which absorb all unobserved time-varying local factors at the 1km$\times$1km level; and $\epsilon_{k(n)ft}$ is an error term. The coefficient $\exp(\delta_n)$ thus measures the hedonic residential land premium relative to industrial parcels within prefecture n, conditional on observable parcel attributes and localized temporal variation.

The distribution of the hedonic residential premium across prefectures is shown in Figure 2. Relative to the unadjusted annualized residential premium depicted in Figure 1, the overall pattern remains consistent: cities with larger populations and higher cumulative shares of land allocated to industrial use tend to exhibit higher residential land premiums over the period 2007–2017. However, the hedonic-adjusted average premium is notably lower, at 5.09 with a standard deviation of 3.75. Overall, the comparison between the unadjusted (annualized) premium and the hedonic premium indicates that approximately (9.31-5.09)/9.31= 45.32% of the residential land price differential is attributable to observable attributes. The remaining 54.68% appears to reflect broader institutional or regulatory factors, highlighting the critical role of land use policies and government intervention in shaping urban land markets in China.

3 Quantitative Model

We develop a quantitative spatial model with multiple prefectures, each consisting of two regions: urban areas (cities) that produce non-agricultural goods, and rural areas that produce agricultural goods. Land in both regions can be used for production or residential purposes. Conditional on an exogenously given overall land endowment for each region, urban land allocations across uses are determined by governments.

As is standard in the quantitative spatial economics literature (Redding, 2016; Tombe and Zhu, 2019), our model incorporates heterogeneous productivities and amenities, idiosyncratic locational preferences, migration with frictions, and trade with frictions. Relative to Tombe and Zhu (2019), our key departure is that we study the effect of government-stipulated allocation between urban land uses, whereas land allocation in the urban region in their study is determined by the markets in a laissez-faire manner.

3.1 Basic Environment

The economy consists of N prefectures, each containing an urban region and a rural region, so that the total number of regions is $2N$. We denote the set of urban regions by $\mathscr{U}$ and the set of rural regions by $\mathscr{R}$. There are two production sectors: agriculture ($j = a$) and manufacturing ($j = m$). Agricultural production occurs exclusively in rural regions, while manufacturing is confined to urban regions (cities). In each region $n \in \mathscr{U} \cup \mathscr{R}$, the fixed land endowment T_n is allocated between production and residential uses: $T_n = T_n^y + T_n^h$, where T_n^y denotes land used for production and T_n^h land used for housing. Let L denote the total population in the economy. We denote $\bar{L}_n$ as the initial population distribution across regions, such that $L = \sum_{n\in\mathscr{U}\cup\mathscr{R}} \bar{L}_n$.

3.2 Preferences and Migration Decisions

Every individual ω draws a vector of idiosyncratic locational preferences $\{\iota_n(\omega)\}_{n=1}^{2N}$. For any individual ω living and working in n, her utility is derived from her locational preference toward n and her consumption consisting of amenity B_n, agricultural goods C_n^a, manufacturing goods C_n^m, and residential land t_n^h, in a multiplicative way.[7] The consumption utility takes the form

$$U_n = B_n \left(\frac{C_n^a}{\alpha \xi_a} \right)^{\alpha \xi_a} \left(\frac{C_n^m}{\alpha \xi_m} \right)^{\alpha \xi_m} \left(\frac{t_n^h}{1-\alpha} \right)^{1-\alpha}, \tag{3}$$

where $0 < \alpha, \xi_a, \xi_m < 1$, and $\xi_a + \xi_m = 1$.

The agricultural good is homogeneous and freely traded. Consumption of manufacturing goods is defined over a continuum of differentiated products aggregated via a CES function:

$$C_n^m = \left(\int_0^1 c_n^m(v)^{\frac{\sigma-1}{\sigma}} dv \right)^{\frac{\sigma}{\sigma-1}},$$

where σ denotes the elasticity of substitution across products. The corresponding price index of manufactured goods is

$$P_n^m \equiv \left(\int_0^1 p_n^m(v)^{1-\sigma} dv \right)^{\frac{1}{1-\sigma}},$$

where $p_n^m(v)$ is the price of product v. Let I_n denote individual income in region n. The indirect utility from consumption is then

$$V_n = \frac{B_n I_n}{(P_a)^{\alpha\xi_a} (P_n^m)^{\alpha\xi_m} (r_n^h)^{1-\alpha}}, \forall n \in \mathscr{R} \cup \mathscr{U}, \tag{4}$$

where r_n^h is the rental price of residential land and P_a the price of the agricultural good. We normalize agricultural goods as the numeraire, so $P_a = 1$.

Given the initial population distribution across regions, individuals decide whether to remain in their origin or to migrate, based on (i) the indirect utility from amenities and consumption, (ii) their idiosyncratic locational preferences, and (iii) region-pair-specific migration costs.[8] Formally, the utility of an individual ω originally from region i who chooses to relocate to region n is

$$\frac{\iota_n(\omega) V_n}{\tau_{ni}},$$

where $\tau_{ni} > 1$ denotes the migration friction from i to n. Each individual from origin region

[7] To isolate the role of residential land, we treat other housing components such as structures, decoration, and interior design as part of manufacturing goods consumption.

[8] Such costs exist even between the rural and urban regions within the same prefecture, since China's hukou system distinguishes between urban and rural hukou statuses.

i chooses the destination region n that offers the highest utility, i.e.,

$$n = \arg \max_{k \in \mathcal{U} \cup \mathcal{R}} \frac{\iota_k(\omega) V_k}{\tau_{ki}}.$$

Assume that the locational preferences are drawn *i.i.d.* from a Fréchet distribution: $F(\iota) = e^{-\iota^{-\kappa}}$, with the shape parameter $\kappa > 1$ governing the dispersion of these preferences.[9]

The discrete choice problem yields that the share of workers from region $i \in \mathcal{U} \cup \mathcal{R}$ who choose to move to region $n \in \mathcal{U} \cup \mathcal{R}$ is given by

$$m_{ni} = \Pr\left(\frac{\iota_n V_n}{\tau_{ni}} \geq \max_k \left\{\frac{\iota_k V_k}{\tau_{ki}}\right\}\right) = \frac{(V_n/\tau_{ni})^{\kappa}}{\sum_{k \in \mathcal{U} \cup \mathcal{R}} (V_k/\tau_{ki})^{\kappa}}. \tag{5}$$

The equilibrium population of region n is the sum of all migrants who choose n:

$$L_n = \sum_{i \in \mathcal{U} \cup \mathcal{R}} m_{ni} \bar{L}_i. \tag{6}$$

As in Tombe and Zhu (2019), the expected utility of workers originating from i after migration decisions is given by $V_i m_{ii}^{-\frac{1}{\kappa}} \equiv u_i$. Aggregate welfare is therefore the initial-population weighted average of these expected utilities across all regions:

$$W = \sum_{n \in \mathcal{U} \cup \mathcal{R}} \frac{\bar{L}_n}{L} W_n = \sum_{n \in \mathcal{U} \cup \mathcal{R}} \frac{\bar{L}_n}{L} \left(\sum_{k \in \mathcal{U} \cup \mathcal{R}} (V_k/\tau_{kn})^{\kappa}\right)^{\frac{1}{\kappa}}. \tag{7}$$

3.3 Production and Trade

Manufacturing Sector. The production of manufacturing goods in each urban region $i \in \mathcal{U}$ follows the framework of Eaton and Kortum (2002), with land included as a factor of production. For each product $\nu \in [0, 1]$, firms in each urban region i draw the productivity $z_i(\nu)$ from a Fréchet distribution with shape parameter $\theta > 1$ and scale parameter $A_i^m > 0$:

$$F_i(z) = e^{A_i^m z^{-\theta}},$$

[9] Note that even though we will introduce productivity spillovers, our utility specification in (3) does not incorporate amenity spillovers. This is because Allen and Arkolakis (2014) have shown the isomorphism between *i.i.d.* Fréchet locational preferences and isoelastic amenity spillovers.

where A_i^m is the city-specific productivity. We consider local spillovers through city size such that

$$A_i^m = \bar{A}_i^m L_i^{\gamma}, \ \forall i \in \mathcal{U} \tag{8}$$

where $\bar{A}_i^m$ is the exogenous component of productivity, and γ is the spillover parameter. The production function of a firm with productivity draw z in region i is

$$y_i^m = z \left(\frac{\ell_i}{\eta_m} \right)^{\eta_m} \left(\frac{t_i}{\beta_m} \right)^{\beta_m},$$

where ℓ_i and t_i are the labor and land inputs, and η_m and β_m are the labor and land shares, respectively. Assume constant returns to scale so that $\eta_m + \beta_m = 1$. For a firm with unit productivity ($z = 1$), the unit cost of production c_i^m is

$$c_i^m = w_i^{\eta_m} (r_i^y)^{\beta_m}, \tag{9}$$

where w_i is the local wage and r_i^y the rental price of industrial land.

For every product v and consumers in each region n, they purchase v from the cheapest source determined by $\min_i \{c_i^m d_{ni}/z_i(v)\}$, where $d_{ni} \geq 1$ represents the iceberg trade cost. As in Eaton and Kortum (2002), the price index for manufacturing goods in region $n \in \mathcal{U} \cup \mathcal{R}$ is:

$$P_n^m = \Gamma \left(\frac{\theta - (\sigma - 1)}{\theta} \right)^{\frac{1}{1-\sigma}} \left(\sum_{i \in \mathcal{U}} A_i^m (d_{ni} c_i^m)^{-\theta} \right)^{-\frac{1}{\theta}}, \tag{10}$$

where $\Gamma(\cdot)$ denotes the Gamma function. For any region n, the share of manufacturing goods purchased from city i is represented as:

$$\pi_{ni} = \frac{A_i^m (d_{ni} c_i^m)^{-\theta}}{\sum_{k \in \mathcal{U}} A_k^m (d_{nk} c_k^m)^{-\theta}}. \tag{11}$$

Agricultural Sector. In each rural region $n \in \mathcal{R}$, the production of a homogeneous agricultural good follows a Cobb-Douglas production technology:

$$y_n^a = A_n^a \left(\frac{\ell_n^a}{\eta_a} \right)^{\eta_a} \left(\frac{t_n^a}{\beta_a} \right)^{\beta_a},$$

where A_n^a denotes the region-specific agricultural productivity, and ℓ_n^a and t_n^a labor and land inputs, respectively. The parameters η_a and β_a correspond to the labor and land shares, with $\eta_a + \beta_a = 1$.

3.4 Equilibrium Conditions

Land Rent Rebate and Income. We assume that the total land rents collected from all regions are equally rebated to every individual in the economy. Namely,

$$I_n = w_n + \frac{\Pi}{L}, \tag{12}$$

where

$$\Pi \equiv \sum_{n \in \mathcal{R} \cup \mathcal{U}} \left(r_n^y T_n^y + r_n^h T_n^h \right).$$

Within each region, cost minimization and zero-profit conditions for firms imply a relationship between total rents paid for industrial land and total wages paid to manufacturing workers:

$$r_n^y T_n^y = w_n L_n \frac{\beta_j}{\eta_j} \quad \forall j = m, a \tag{13}$$

Utility maximization by workers yields the relationship between total residential land rents within a region and total labor income:

$$r_n^h T_n^h = (1 - \alpha) I_n L_n, \tag{14}$$

Market Clearing Conditions. We now formalize the market clearing conditions for goods, labor, and land. In the manufacturing sector, market clearing requires that the total revenue generated by manufacturing firms in region i, denoted by X_i^m, equals the total expenditure on these goods across all regions:

$$X_i^m = \alpha \xi_m \sum_{n \in \mathcal{R} \cup \mathcal{U}} \pi_{ni} I_n L_n \tag{15}$$

In each region, the land resource constraint holds:

$$T_n^y + T_n^h = T_n. \tag{16}$$

When T_n^y and T_n^h are exogenously given, say, by the governments, (16) holds as a feasibility constraint, and (13) and (14) are used to pin down the two land prices r_n^y and r_n^h. When land allocations are freely determined by the market, (16) is the land market clearing condition with the demand functions T_n^y and T_n^h given by (13) and (14) and the no-arbitrage condition:

$$r_n^y = r_n^h = r_n. \tag{17}$$

Since our main focus is on government-stipulated land allocation in cities, we adopt a simplified treatment for rural land allocation and assume it is determined freely by the market.

An exogenous land-use equilibrium is defined as follows.

Definition 1. ***Exogenous Land-use Equilibrium (denoted as $\mathscr{F}_g$)*** *Given government-stipulated allocations of urban land between residential and industrial uses, $\{T_n^h, T_n^y\}_{n\in\mathscr{U}}$, an exogenous land-use equilibrium is given by the tuples $\{V_n, m_{ni}, L_n, P_n^m, w_n, I_n\}_{n,i\in\mathscr{U}\cup\mathscr{R}}$, $\{c_n^m, r_n^h, r_n^y\}_{n\in\mathscr{U}}$, $\{r_n, T_n^h, T_n^y\}_{n\in\mathscr{R}}$, and $\{\pi_{ni}\}_{i\in\mathscr{U},n\in\mathscr{U}\cup\mathscr{R}}$ such that all conditions from (4) to (6) and from (8) to (16) hold, as well as (17) for the rural regions.*

Next, we define a laissez-faire equilibrium in which the market determines the land allocation in urban regions.

Definition 2. ***Laissez-faire Equilibrium (denoted as $\mathscr{F}_{lf}$)*** *A laissez-faire equilibrium is given by the tuples $\{V_n, m_{ni}, L_n, P_n^m, w_n, I_n\}_{n,i\in\mathscr{U}\cup\mathscr{R}}$, $\{c_n^m\}_{n\in\mathscr{U}}$, $\{r_n, T_n^h, T_n^y\}_{n\in\mathscr{U}\cup\mathscr{R}}$, and $\{\pi_{ni}\}_{i\in\mathscr{U},n\in\mathscr{U}\cup\mathscr{R}}$ such that all conditions from (4) to (6) and from (8) to (17) are satisfied.*

4 Welfare Properties

This section studies the welfare properties of land-use policy in the model. We first identify the canonical sources of inefficiency in the laissez-faire equilibrium and construct an efficient benchmark in which laissez-faire land allocation is optimal. We then use simple two-region simulations to illustrate how these inefficiencies shape optimal residential premiums, how spatial frictions determine the reach of land-use policy, and why the welfare gains from land-use policy can remain limited even when laissez-faire is not exactly efficient.

4.1 Sources of inefficiency in a laissez-faire equilibrium

To understand whether the government-stipulated land use allocation is good or bad, we first need to consider the laissez-faire equilibrium in which the markets determine the allocation. There are multiple sources of inefficiency in a laissez-faire equilibrium in the model we have developed, and hence, the government-stipulated land use allocation could potentially improve welfare. However, governments might also do too much or too little, thereby harming welfare and not necessarily better than the laissez-faire equilibrium.

The first source of inefficiency in a laissez-faire equilibrium is obviously the productivity spillovers as specified in (8). The second source of inefficiency is idiosyncratic locational preferences, as explained by Donald et al. (2025) and Mongey and Waugh (2024). The underlying reasons are two-fold. First, when people differ in their utility levels ex post (after the draws), the welfare criterion is necessarily utilitarian (an ex ante expectation). Under this welfare criterion and even without individual heterogeneity, Mirrlees (1972) shows that equilibrium is suboptimal because the marginal utility of consumption generally differs across locations, whereas only the average utility is required to be the same across locations in equilibrium. Donald et al. (2025) extend this result to a setup with individuals facing idiosyncratic tastes on locations. Second, the idiosyncratic locational preferences act as uninsured risks to individuals, and hence, the markets are incomplete, as highlighted by Mongey and Waugh (2024).[10]

4.1.1 An efficient benchmark model

To verify the above discussion on the sources of inefficiency in a laissez-faire equilibrium, we establish a benchmark model in which the two sources are eliminated, and we show that the laissez-faire allocation is indeed optimal. Productivity spillovers are first assumed away by setting $\gamma = 0$ in (8). On the preferences side, stripping off the idiosyncratic locational preferences is insufficient because Mirrlees (1972) has shown that there is room for welfare improvement from equilibrium in a model with homogeneous individuals and under the utilitarian welfare criterion. This, as mentioned, is due to the dispersion of marginal utility across locations in equilibrium. Fujita and Thisse (2002) show that such room is eliminated when the planner's objective is changed to maximizing the equilibrium utility of homogeneous individuals. Thus, we also adopt this criterion such that the planner maximizes V subject to

$$V_n = \frac{B_n I_n}{(P_a)^{\alpha\xi_a}(P_n^m)^{\alpha\xi_m}(r_n^h)^{1-\alpha}} = V, \quad \forall n \in \mathscr{R} \cup \mathscr{U}, \tag{18}$$

[10]If the locational preferences are distributed Fréchet (our setup), then having amenity spillovers in an isoelastic way (as is standard) is isomorphic in equilibrium to the model without them by relabeling parameters, as explained by Allen and Arkolakis (2014). Thus, we do not incorporate amenity spillovers in our model.

as well as other equilibrium conditions. Note that migration frictions are inconsistent with this setup with homogeneous individuals, and hence they are also assumed away.[11] Instead of using (6), the labor resources satisfy

$$\sum_{n \in \mathscr{U} \cup \mathscr{R}} L_n = L. \tag{19}$$

For this homogeneous-individual model, the two equilibrium definitions are as follows.

Definition 3. ***Exogenous Land-use Equilibrium (denoted as $\mathscr{F}_g^V$)*** *Given government-stipulated allocations of urban land between residential and industrial uses, $\{T_n^h, T_n^y\}_{n \in \mathscr{U}}$, an exogenous land-use equilibrium is given by the tuples $\{V_n, L_n, P_n^m, w_n, I_n\}_{n,i \in \mathscr{U} \cup \mathscr{R}}$, $\{c_n^m, r_n^h, r_n^y\}_{n \in \mathscr{U}}$, $\{r_n, T_n^h, T_n^y\}_{n \in \mathscr{R}}$, and $\{\pi_{ni}\}_{i \in \mathscr{U}, n \in \mathscr{U} \cup \mathscr{R}}$ such that all conditions (8)–(16) and (18)–(19) hold, as well as (17) for the rural regions.*

Definition 4. ***Laissez-faire Equilibrium (denoted as $\mathscr{F}_{lf}^V$)*** *A laissez-faire equilibrium is given by the tuples $\{V_n, L_n, P_n^m, w_n, I_n\}_{n,i \in \mathscr{U} \cup \mathscr{R}}$, $\{c_n^m\}_{n \in \mathscr{U}}$, $\{r_n, T_n^h, T_n^y\}_{n \in \mathscr{U} \cup \mathscr{R}}$, and $\{\pi_{ni}\}_{i \in \mathscr{U}, n \in \mathscr{U} \cup \mathscr{R}}$ such that all conditions (8)–(19) hold.*

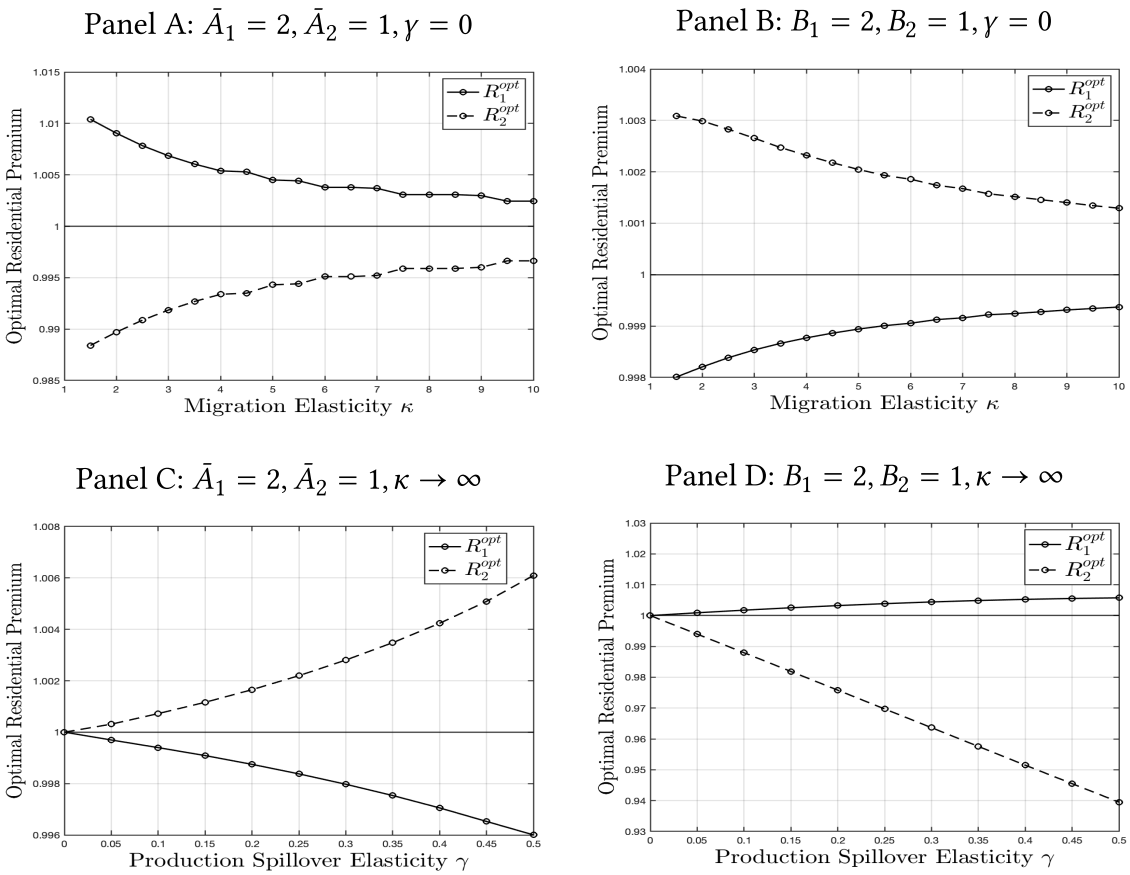
A social planner's problem is to choose the land use allocation $\{T_n^h, T_n^y\}_{n \in \mathscr{U}}$ to maximize V subject to all equilibrium conditions in Definition 3. We have the following proposition.

Proposition 1. *If $\gamma = 0$, then the laissez-faire equilibrium $\mathscr{F}_{lf}^V$ is optimal. In particular, for any feasible allocation $\mathscr{F}_g^V$ that deviates from the land-use allocation in $\mathscr{F}_{lf}^V$, aggregate welfare V is strictly lower than that attained under $\mathscr{F}_{lf}^V$.*

The detailed proof is provided in Appendix 1, and we provide a sketch here. We demonstrate that the laissez-faire equilibrium is optimal by showing that it decentralizes the solution of the social planner's problem that maximizes V. Specifically, we show that the first-order conditions of the planner's problem are the same as the equilibrium conditions in a laissez-faire equilibrium. The planner maximizes aggregate welfare V subject to resource constraints on labor, land, and goods. By mapping the Lagrange multipliers to equilibrium variables such as goods and factor prices, as well as land rent rebate, the planner's optimal choices exactly replicate the laissez-faire allocation. An exogenous land-use equilibrium is suboptimal as long as it deviates from the laissez-faire allocation.

[11] If the rebates of fixed-factor income (e.g., land rent) differ across locations, this also distorts people's incentives for location choices Fajgelbaum and Gaubert (2025). This issue does not exist in our model because we assume a universal land rent rebate (the same rebate for each individual).

Figure 3: Optimal Residential Premiums (Locational Fundamentals; Migration and Spillover Elasticities)



Notes: Unless otherwise indicated, parameter values are set to $\bar{A}_n = 1$, $B_n = 1$, $T_n = 1$, $\bar{L}_n = 1$, $d_{21} = d_{12} = 1$, $\tau_{21} = \tau_{12} = 1$, $\theta = 4$, $\alpha = 0.9$ and $\beta_m = 0.12$.

The intuition is as follows. In this homogeneous-individual model without productivity spillovers and with the welfare criterion (18), the two above-discussed sources of inefficiencies are eliminated. The remaining concern of potential sub-optimality of laissez-faire allocation is any spatial transfers across locations. The fact that the land-rent rebate is the same for all individuals eliminates this concern.

4.2 *Determinants of Optimal Residential Premiums*

4.2.1 *Locational Fundamentals*

Define the residential premium as $R_n = r_n^h / r_n^y$. Relative to the laissez-faire allocation, there exists a positive (negative) premium if $R_n > 1$ ($R_n < 1$). Let R_n^{opt} denote the optimal residential premium. Note that land use allocations (the fraction of land allocated for each use) are one-to-one with residential premiums, as the levels of land prices are determined by the amount of the land endowment T_n.

To explore how the optimal residential premiums are affected by locational fundamentals under isolated inefficiency mechanisms, we conduct simulations based on a simplified environment with only two urban regions (no rural regions and no agricultural goods).

In the first simulation, we use the full-fledged model, shut down production spillovers ($\gamma = 0$), and compute the optimal residential premiums for various values of the migration elasticity κ. In the second simulation, we use the homogeneous-individual model and compute the optimal residential premiums for various values of the production spillover elasticity γ. For simplicity, we assume zero trade and migration frictions here. We return to the role of these frictions in subsequent analyses.

In the first simulation, inefficiencies arise solely from idiosyncratic preference shocks. Panels A and B of Figure 3 illustrate how the optimal residential premiums respond to exogenous productivities and amenities, respectively, in this simulation.

Panel A shows that the planner should subsidize the industrial (residential) land in the more (less) productive region, relative to laissez-faire allocation. For the intuition, first note that region 1 has higher wages and attracts more workers in the laissez-faire equilibrium. This results in lower marginal utility of consumption in region 1 than region 2. As the price index of manufactured goods is the same between the two regions due to zero trade frictions, the social planner would like to tax (subsidize) the residential land in region 1 (region 2) to encourage less (more) residential consumption, to make the marginal utilities of consumption more even.

Panel B shows that the planner should subsidize the residential (industrial) land in the more (less) amenity-abundant region, relative to laissez-faire allocation. When the two regions have the same productivity but differ in amenity, the wages and hence income of the amenity-abundant region are lower, resulting in higher marginal utility of consumption there. By a similar logic, the planner would like to subsidize (tax) the residential land in the more (less) amenity-abundant region. In both panels, it is clear that the optimal residential premiums in both regions go toward 1 as κ increases. A larger κ means that individuals are more similar in terms of their idiosyncratic locational preferences, and $\kappa \to \infty$ is the special case where the distribution of the idiosyncratic becomes degenerate (regional utilities V_i become perfect substitutes; see (7)).

In the absence of idiosyncratic shocks and migration frictions, and when only production spillover effects are present, the existing literature—such as Glaeser and Gottlieb (2008) and Moretti (2014)—suggests that there is no scope for welfare-enhancing spatial policies when spillover elasticities are common across locations. Fajgelbaum and Gaubert (2020) show that this prevailing view relies on ruling out policies that redistribute income across space. Beyond spatial transfers that operate directly through income, optimal land-use allocations can also generate welfare gains relative to the laissez-faire equilibrium, as illustrated by the second simulation.

Panels C and D of Figure 3 plot the optimal residential premiums from the second simulation. Both panels imply that the planner should subsidize residential (industrial) land in higher-wage (lower-wage) locations. This pattern is the opposite of that observed in Panels A and B, reflecting a change in the underlying source of inefficiency.

In the absence of idiosyncratic preference shocks and migration frictions, marginal-utility dispersion no longer plays a role under the welfare criterion in (18). Instead, the planner reallocates workers toward higher-wage regions, which reflect higher labor productivity, in order to exploit production spillovers. Consistent with Proposition 1, as the production spillover elasticity γ approaches zero, the optimal residential premiums converge to one, implying that the laissez-faire allocation becomes efficient.

In summary, these simulations illustrate how the two sources of inefficiency affect optimal residential premiums in distinct ways, consistent with the analysis in Section 4.1. Moreover, they show that the direction of the optimal residential premium hinges on the interaction between the underlying inefficiency mechanism and cross-location differences in wages and incomes arising from asymmetries in locational fundamentals.

4.2.2 *Spatial Frictions*

To show how the spatial frictions affect the optimal land use allocations, we conduct simulations under a two-urban-region setup (assuming no rural regions) as in the pervious section. Under asymmetric productivities $[\bar{A}_1, \bar{A}_2] = [100, 1]$ and for different values of trade and migration costs, Table 3 shows that the optimal residential premium is not equal to 1 except in the case with infinite trade costs.[12] Note that with positive productivity spillovers ($\gamma = 0.1$), both sources of inefficiency mentioned above are present. In other words, if governments can allocate land to achieve the optimal residential premium, they eliminate the distortions present in the laissez-faire equilibrium.

[12]For the remaining parameter values, both amenities and total land endowments are the same across locations: $B_n = 1$, and $T_n = 1$. Trade and migration elasticities are set to be $\theta = 4$ and $\kappa = 1.5$. The goods consumption share is $\alpha = 0.9$, leaving 0.1 for residential land. In production, land accounts for a share of $\beta_m = 0.12$, with labor comprising the remaining 0.88.

Table 3: Optimal Residential Premium (Spatial Frictions)

	$\tau = 1$	$\tau = 5$	$\tau = \infty$
$d = 1$	$[1.049, 0.9136]$	$[1.0348, 0.9495]$	$[1.0130, 0.982]$
$d = 1.5$	$[1.0374, 0.9369]$	$[1.0181, 0.976]$	$[0.996, 1.004]$
$d = \infty$	$[1, 1]$	$[1, 1]$	$[1, 1]$

Notes: Each cell shows the optimal residential premiums $[R_1^{\text{opt}}, R_2^{\text{opt}}]$ under different values of migration frictions $\tau_{21} = \tau_{12} = \tau$ and trade frictions $d_{12} = d_{21} = d$. The other parameter values are $\gamma = 0.1$, $\bar{A}_n = [100, 1]$, $B_n = 1$, $T_n = 1$, $\bar{L}_n = 1$, $\theta = 4$, $\kappa = 1.5$, $\alpha = 0.9$, and $\beta_m = 0.12$.

The simulation result that the laissez-faire allocation is optimal when trade costs are infinite is general. In the following proposition, we show that this result holds true under a weak condition (for any number of regions).

Proposition 2. *Let* $\psi_n \equiv (T_n^h)^{1-\alpha}(T_n^y)^{\alpha\beta_m}$. *In the setting without the agricultural sector (hence no rural regions), the laissez-faire equilibrium is optimal when trade is not allowed and when* $\frac{\partial V_n}{\partial \psi_n} \neq 0$ *for all n.*

The proof is relegated to Appendix B.2, and we provide a sketch here. When trade in manufactured goods is prohibited, individual utility in each region reduces to

$$V_n \propto \psi_n L_n^{\rho}, \tag{20}$$

where $\psi_n = (T_n^h)^{1-\alpha}(T_n^y)^{\alpha\beta_m}$, and $\rho \equiv \alpha\left(\eta_m + \frac{\gamma}{\theta}\right) - 1$ incorporates productivity spillovers. Together with the migration share (5), this implies that both the equilibrium population distribution and aggregate welfare depend on region characteristics only through the Cobb-Douglas composites $\{\psi_n\}_n$. Since both T_n^h and T_n^y enter W only through ψ_n, optimality requires

$$\frac{\partial W}{\partial \psi_n}\frac{\partial \psi_n}{\partial T_n^h} = \frac{\partial W}{\partial \psi_n}\frac{\partial \psi_n}{\partial T_n^y}.$$

Thus, whenever $\frac{\partial W}{\partial \psi_n} \neq 0$, this reduces to $\frac{\partial \psi_n}{\partial T_n^h} = \frac{\partial \psi_n}{\partial T_n^y}$, which entails the welfare-maximizing land use ratio

$$\frac{T_n^h}{T_n^y} = \frac{1-\alpha}{\alpha\beta_m}, \tag{21}$$

which, in turn, is also the land use ratio under the laissez-faire allocation. The rest of the proof involves showing $\frac{\partial W}{\partial \psi_n} \neq 0$ is the same as $\frac{\partial V_n}{\partial \psi_n} \neq 0$. That $\frac{\partial V_n}{\partial \psi_n} \neq 0$ for all n is a fairly weak condition and is generically true. In words, it requires that no regional utility is insensitive

Table 4: Optimal Residential Premiums and the Associated Welfare Gains

	Case	$\bar{A}_n$	B_n	R_n	R_n^{opt}	$\widehat{W}$
1	Symmetric Regions & Laissez-faire	[1, 1]	[1, 1]	[1, 1]	[1, 1]	1
2	Large Gap in $\bar{A}_n$ & Laissez-faire	[100, 1]	[1, 1]	[1, 1]	[1.05, 0.91]	1.0001
3	Large Gap in $\bar{A}_n$ & Exogenous Land Use	[100, 1]	[1, 1]	[5, 5]	[1.05, 0.91]	1.0610
4	Small Gap in $\bar{A}_n$ & Exogenous Land Use	[2, 1]	[1, 1]	[5, 5]	[1.01, 0.99]	1.0617
5	Large Gap in B_n & Laissez-faire	[1, 1]	[100, 1]	[1, 1]	[0.99, 1.31]	1.00004
6	Large Gap in B_n & Exogenous Land Use	[1, 1]	[100, 1]	[5, 5]	[0.99, 1.31]	1.0616
7	Small Gap in B_n & Exogenous Land Use	[1, 1]	[2, 1]	[5, 5]	[0.98, 1.03]	1.0617

Notes: The other parameter values: $T_n = 1$, $\theta = 4$, $\kappa = 1.5$, $\alpha = 0.9$, $\beta_m = 0.12$, $\tau_{12} = \tau_{21} = 1$, $d_{12} = d_{21} = 1$, and $\gamma = 0.1$. The residential premium is defined as $R_n = r_n^h / r_n^y$; there exists a positive (negative) premium if $R_n > 1$ ($R_n < 1$). R_n^{opt} denotes the optimal premium. The welfare gains from implementing the optimal premium, i.e., the optimal land use allocation, are denoted as $\widehat{W}$.

to the region's land allocation.

Note that the optimal land use allocation given by (21) is, indeed, both the laissez-faire and optimal allocations in a single-region model. Thus, even though prohibitive trade costs do not render regions autarkic — labor remains mobile — the planner's problem is solved *as if* each region were autarkic. This result critically hinges on trade costs being prohibitive. *When trade costs are finite, the land use allocation in one region affects the price indices in the other regions, and hence it becomes a lever for the planner.* In that case, regional welfare can no longer be written in the simple form (20). Instead, it depends on the entire distribution of $\{\psi_n\}$, and thus the laissez-faire equilibrium generically fails to internalize these inter-regional externalities.

4.3 Welfare Gains from Implementing Optimal Residential Premiums

To gauge the effects of locational fundamentals and exogenous land-use allocation on the optimal residential premiums and the associated welfare gains, we simulate a two-urban region model with both sources of distortions present ($\kappa = 1.5$ and $\gamma = 0.1$) under various scenarios. The results are shown in Table 4, in which $\widehat{W}$ denotes the ratio of optimal welfare (the welfare under R_n^{opt}) to the original welfare (the welfare under R_n). We start with the simple case where regions are symmetric and land allocation is laissez-faire. The symmetry between locations nullifies the need for any correction despite the presence of the two sources of inefficiency. Thus, the laissez-faire allocation is optimal.

In the second and third cases, there is a large gap in productivity between the two regions, but the approaches to land allocation differ. Case 2 is under laissez-faire, while the land allocation in Case 3 is exogenously determined and favors industrial use, such that each region has a residential premium of 5 (recall that the average residential premium in China, after controlling for various covariates, is 4.53). The optimal residential premiums are the same between the two cases, but the welfare gains differ drastically. In Case 2, despite a large gap in productivity, the laissez-faire allocation is quite close to the optimal situation, as the welfare gains are just around 0.01%. In contrast, the welfare gains are much higher (6.1%), indicating a significant distortion. This comparison suggests that even though a planner could remedy the distortions that are present in a laissez-faire equilibrium, the welfare costs could be much larger than in the case without intervention if the planning allocation is off.

In Case 4, the gap in productivity is narrowed compared with Case 3, but the land use allocation are arranged such that the original residential premium remains the same as in Case 3. As the productivity differs less, the optimal residential premiums are closer to the laissez-faire level, indicating that the laissez-faire equilibrium causes smaller distortions compared with Case 2. However, the welfare gains from implementing the optimal residential premiums from the exogenous land use allocation remain at a similar magnitude to Case 3. Because the laissez-faire equilibrium is not far from optimal even when the productivity gap is large, it is even closer to optimal when the productivity gap becomes smaller. Thus, the effects from a sub-optimal exogenous land use allocation are at least as harmful as in Case 3. Cases 5, 6, and 7 parallel Cases 2, 3, and 4, except that they are concerned with amenity gaps instead of productivity gaps. The directions of the optimal residential premiums are the opposite of those in Cases 2, 3, and 4, but the takeaway messages are the same.

Why is the laissez-faire equilibrium so close to the optimal allocation in welfare terms? The fundamental reason is that differences in marginal utility across regions can only be partially reduced through land-use policies. The reasoning, in turn, is twofold. First, unlike labor, land is an immobile resource across locations; it is mobile only between the two uses within the same location. Second, because the two sources of externalities are exerted through labor, using land-use allocation to correct these externalities and move toward optimal labor allocation simultaneously creates a misalignment of private incentives for land uses, thus offsetting part of the gains.

5 Calibration

The model is calibrated to data from the Chinese economy in 2015. Several parameters are preset using values commonly adopted in the literature. Following Ahlfeldt et al. (2015) and Tan et al. (2020), we set the expenditure share on residential land to $1 - \alpha = 0.0975$.[13] For agricultural production, the land share is set to $\beta_a = 0.36$, following Adamopoulos et al. (2022). As in Allen and Arkolakis (2022), the productivity spillover parameter is set to $\gamma = 0.1$.[14]

Using China's 2015 input-output table, the share of agricultural goods in total consumption is approximately 11%. Since $\alpha\xi_a = 0.11$, $\xi_a = 0.12$ and $\xi_m = 0.88$. The land share in the manufacturing production is calibrated using the ratio of total annualized industrial land value to the sum of secondary GDP across cities.[15] We obtain $\beta_m = 0.12$.

To calibrate prefectural-level manufacturing productivities, we rely on the structural gravity equation implied by the model. Multiplying the total manufacturing expenditure in prefecture n, X_n^m, to both sides (11) and taking the logarithms, we obtain the following gravity equation (with an error term):

$$\ln X_{ni} = D_i^{\text{exp}} + D_n^{\text{imp}} - \theta \ln(d_{ni}) + \varepsilon_{ni}, \tag{22}$$

where X_{ni} is the trade flows from prefecture i to prefecture n, and D_i^{exp} and D_n^{imp} are exporter and importer fixed effects, respectively. We estimate this equation by the Poisson Pseudo-Maximum Likelihood (PPML; Santos Silva and Tenreyro 2006). We construct city-level bilateral trade costs d_{ni}, following the method of Ma and Tang (2024). Specifically, we use 2015 transportation time data for both rail and road to estimate trade costs.[16] Following Gao et al. (2020) and Luo (2020), the prefectural-level trade flows X_{ni} are constructed from

[13] Ahlfeldt et al. (2015) estimate the housing expenditure share at 0.25, while Tan et al. (2020) estimate the land share of housing value in China at 0.39. Multiplying these values gives $0.25 \times 0.39 \approx 0.0975$, which we take as the expenditure share of residential land $1 - \alpha$.

[14] There is a wide range of estimates of this elasticity parameter in the literature, depending on empirical contexts and models. Most of the estimates range in $[0.02, 0.2]$ (Combes and Gobillon, 2015; Fajgelbaum and Gaubert, 2020; Melo et al., 2009). We will conduct robustness checks for this parameter.

[15] For every city, the industrial land value is calculated as the product of the annualized industrial land price and total industrial land area, which is obtained from the China City Construction Yearbook. The city-level annualized industrial land price is the average annualized industrial price across land parcels, weighted by the area of each parcel.

[16] See their Transportation Networks of China Dataset at https://github.com/malin84/transportation_networks_of_china/.

China's value-added invoice data for 2018.[17]

The estimation entails $\theta = 7.34$. Note that the exporter fixed effects in (22) corresponds to $\ln\left(A_i^m \left(c_i^m\right)^{-\theta}\right)$ in the model. With the estimated exporter fixed effects, $\widetilde{D}_i^{\text{exp}}$, prefecture-level productivity in manufacturing can be recovered by

$$\widetilde{A}_i^m = e^{\widetilde{D}_i^{\text{exp}}} \left(\tilde{c}_i^m\right)^{\theta} = e^{\widetilde{D}_i^{\text{exp}}} \times \left[(\widetilde{w}_i)^{\eta_m}(\tilde{r}_i^y)^{\beta_m}\right]^{\theta}, \tag{23}$$

where $\widetilde{w}_i$ denotes inferred wages and $\tilde{r}_i^y$ are annualized industrial land prices. To infer wages, note that (12), (13), and (14) imply that

$$w_n = I_n - \frac{\Pi}{L}, \quad \forall n, \tag{24}$$

where

$$\frac{\Pi}{L} = (1-\alpha) \sum_{n \in \mathscr{R} \cup \mathscr{U}} \frac{I_n L_n}{L} + \frac{\beta_a}{\eta_a} \sum_{n \in \mathscr{R}} \frac{w_n L_n}{L} + \frac{\beta_m}{\eta_m} \sum_{n \in \mathscr{U}} \frac{w_n L_n}{L}.$$

Given data values of regional per capita income I_n and population shares L_n/L, (24) is a fixed-point mapping of $\{w_n\}_{n \in \mathscr{U} \cup \mathscr{R}}$. We combine population data from the 2010 Population Census and migration shares from the 2015 One-Percent Population Survey to compute the population in each region. Urban per capita income is calculated as the sum of secondary and tertiary GDP in each prefecture divided by its urban population, and rural per capita income is calculated as the primary GDP in each prefecture divided by its rural population. Using the fixed-point mapping in (24), we then infer the wages $\widetilde{w}_n$. With data values of $r_{i,\text{data}}^y$, inferred wages $\widetilde{w}_i$, and the estimated exporter fixed effects $\widetilde{D}_i^{\text{exp}}$ for each urban region, we use (23) to infer prefectural manufacturing productivities $\widetilde{A}_i^m$. Then, the exogenous components of these productivities are calibrated by

$$\bar{A}_i^m = \frac{\widetilde{A}_i^m}{L_i^{\gamma}}. \tag{25}$$

Finally, all of the productivity values $\bar{A}_i^m$ are normalized so that the value for Beijing is equal to one.

Multiplying the initial population size $\bar{L}_i$ to both sides of (5) and taking the logarithms,

[17] See Gao et al. (2020) for a detailed description that connects China's value-added invoice tax data to the regional IO table.

we obtain the following gravity equation (with an error term):

$$\ln L_{ni} = D_n^{\text{des}} + D_i^{\text{ori}} - \kappa \log(\tau_{ni}) + \varepsilon_{ni}, \tag{26}$$

where L_{ni} is the migration flows from region i to region n, D_n^{des} and D_n^{ori} are destination and origin fixed effects, respectively. Using travel time data, Ma and Tang (2024) estimate prefecture-to-prefecture migration frictions, but the rural-urban divide in the hukou system is not addressed. To account for the rural-urban divide, (26) is modified as follows. Denote $p(n)$ as the prefecture to which region n belongs, and let $k(n) = U, R$ indicate whether region n is urban or rural. Assume that

$$\tau_{ni} = \tau_{p(n)p(i)} \times D_{k(n)k(i)}.$$

Then, (26) is revised to

$$\ln(L_{ni}) = D_{p(n)}^{des} + D_{p(i)}^{ori} + \widetilde{D}_{UR} + \widetilde{D}_{RU} + \widetilde{D}_{RR} - \kappa \ln\left(\tau_{p(n)p(i)}\right) + \varepsilon_{ni}, \tag{27}$$

where $\widetilde{D}_{k(n)k(i)} = -\kappa \ln\left(D_{k(n)k(i)}\right)$, or equivalently, $D_{k(n)k(i)} = e^{-\frac{1}{\kappa}\widetilde{D}_{k(n)k(i)}}$. We set $\widetilde{D}_{UU} = 0$ as the base case of these new fixed effects. Using the migration flows data obtained from the 2015 One-Percent Population Survey for all region pairs and the prefectural bilateral frictions $\tau_{p(n)p(i)}$ from Ma and Tang (2024), (27) is estimated by PPML.

The κ estimate is 2.48, while $D_{UU} = 1$ (by construction), $D_{UR} = 1.43$, $D_{RU} = 2.01$, and $D_{RR} = 1.17$. Interestingly, the additional friction from rural-urban migration is higher than that from rural-rural migration but lower than from urban-rural migration.

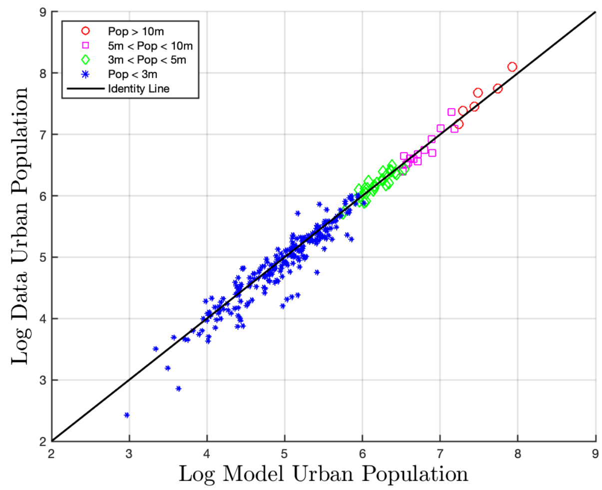
With the estimated κ and prefectural destination fixed effects $\widetilde{D}_{p(n)}^{\text{des}}$, the amenity of each urban region n is recovered by

$$B_n = \frac{\exp\left(\widetilde{D}_{p(n)}^{\text{des}}/\kappa\right)(P_n^m)^{\alpha\xi_m}(r_n^h)^{1-\alpha}}{I_n}, \qquad \forall n \in \mathcal{U}, \tag{28}$$

where r_n^h is proxied by the annualized residential land prices, and the manufacturing goods price index P_n^m is calculated by

$$\tilde{P}_n^m \propto \left(\sum_{i\in\mathcal{U}} \widetilde{A}_i^m (d_{ni}\tilde{c}_i^m)^{-\theta}\right)^{-\frac{1}{\theta}}.$$

Figure 4: Model Validation



Notes: This figure plots the model-implied equilibrium population in the urban regions against the data counterparts. The points are clustered around the 45-degree line with a correlation of 0.98.

This calibration is conducted for urban regions. Rural amenity values are approximated using their urban counterparts within the same prefecture. Finally, all amenity values are normalized so that Beijing's amenity value equals 1.

With $\{T_n\}$ and all other locational fundamentals, we calibrate the urban land use allocation $\{T_n^h, T_n^y\}_{n\in\mathcal{U}}$ so that the equilibrium $\{R_n\}_{n\in\mathcal{U}}$ matches the empirical counterparts, i.e., the estimated city-specific hedonic residential premiums from Section 2, denoted as $\{R_n^{\text{status quo}}\}_{n\in\mathcal{U}}$.[18] Such an equilibrium based on $\{R_n^{\text{status quo}}\}_{n\in\mathcal{U}}$ is called the status quo equilibrium.

Lastly, we validate the entire calibrated model by examining the fit in city size. In particular, Figure 4 plots the 2015 city sizes in the data against the model-generated counterparts.[19] The fit is reasonably good, with the points clustered around the 45-degree line and a correlation of 0.98.

[18]For the year 2015, the total urban land endowments T_n are obtained from the China City Construction Statistical Yearbook. For rural land endowment, we first use agricultural land data from the China Statistical Yearbook, which reports such land data at the provincial level. We then prorate each province's rural land endowments across its prefectures using prefectural-level primary-sector GDPs.

[19]To be consistent with the migration shares, we compute the data city size using (6) with the 2010 population distribution and the migration shares between 2010 and 2015.

6 Quantitative Analysis of Land Use Allocation

To evaluate the status quo land use allocation in urban China, this section conducts quantitative analyses using the calibrated model to compare the welfare under the status quo with that under two benchmarks: (1) optimal land use allocation and (2) laissez-faire allocation. We also investigate the properties of the optimal land use allocation, the consequences of land use distortions for individual cities, and the roles of migration barriers.

6.1 Land Use Distortions and Welfare Implications

For any exogenous urban land use allocation $\{T_n^h, T_n^y\}_{n\in\mathcal{U}}$, we can solve the exogenous land use equilibrium as defined in Definition 1 and obtain the resulting aggregate welfare W. As there is a one-to-one mapping between land use allocation and the residential premium $\{R_n\}_{n\in\mathcal{U}}$, the problem for optimal land use allocation can be formulated as follows.

$$\max_{\{R_n>0,\forall n\in\mathcal{U}\}} W = \max_{\{R_n>0,\forall n\in\mathcal{U}\}} \sum_{n\in\mathcal{U}\cup\mathcal{R}} \frac{\bar{L}_n}{L} \left(\sum_{k\in\mathcal{U}\cup\mathcal{R}} (V_k/\tau_{kn})^{\kappa} \right)^{\frac{1}{\kappa}}, \tag{29}$$

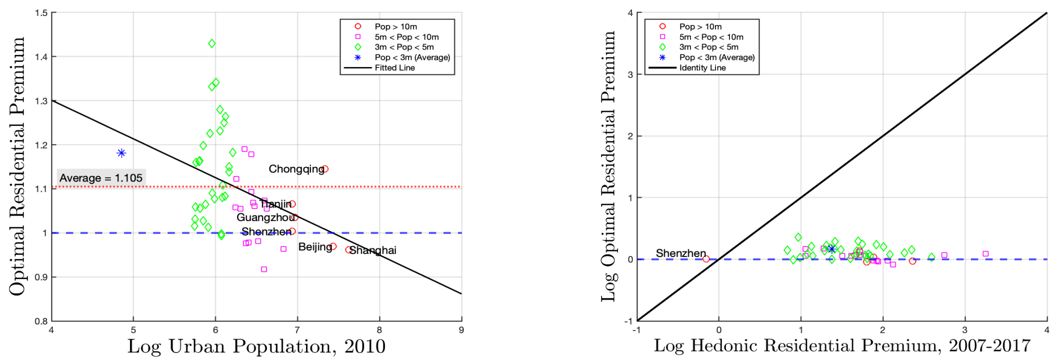
subject to the equilibrium conditions in Definition 1.

Solving for optimal land-use policies in 279 urban regions in the spatial equilibrium is a computationally daunting task. To address this challenge, we adopt a grouped optimization strategy. Specifically, we impose a uniform residential premium for all cities with populations below three million, while allowing for individual premiums for cities with populations above this threshold. This reduces the number of policies $\{R_n\}$ to solve to 51, striking a balance between computational feasibility and policy heterogeneity. The resulting global optimum proves stable and robust.

Figure 5 plots the optimal residential premiums for Chinese cities in the baseline model against population size (Panel A) and against estimated hedonic premiums from Section 2 (Panel B). Panel A shows that optimal residential premiums range from 0.92 to 1.43. Most cities have optimal residential premiums exceeding 1, and those with optimal residential premiums less than 1 are relatively large cities. On average, the average optimal premium is about 1.1. Generally, there is a negative correlation between city size and the optimal premium. In Panel B, we show the logarithms of the two premiums, along with a 45-degree line. The result indicates that the variation of the optimal residential premium is dwarfed by

Figure 5: Optimal Residential Premium in the Baseline Model

Panel A: Optimal Premium vs. Population　　　　Panel B: Optimal vs. Hedonic Premium



Notes: This figure plots the optimal residential premium against urban population and hedonic residential premium. The OLS regression slope in Panel A is -0.088 (s.e. =0.030).

that of the empirically estimated city-specific premium.[20] Moreover, the optimal premiums are all lower than their empirically estimated counterparts, except in one city (Shenzhen), and the gaps are large. These gaps indicate that the social planner would want to reallocate land from industrial to residential use, to a degree that is relatively close to laissez-faire.

Table 5 shows the results of regressing the optimal premiums on the four locational fundamentals (productivity, amenity, land endowment, and initial population) simultaneously. Consistent with our results based on two urban regions in Section 4.2, the optimal premiums increase with productivity and decrease with amenity. In words, the social planner tends to tax residential use in a more productive city but subsidize it in a more amenity-abundant city.

What are the welfare implications of these land use distortions? First, implementing optimal land-use policies raises aggregate welfare from the status quo equilibrium by 4.75%. Underlying this is the large variation in the regional welfare gains. For each city, we measure distortion as the distance between the status quo premium and the optimal premium, in logarithmic terms, i.e., $\log(R_n^{\text{status quo}}) - \log(R_n^{\text{opt}})$. Recall that regional welfare is defined as $W_n = \left(\sum_{k\in\mathcal{U}\cup\mathcal{R}} (V_k/\tau_{kn})^{\kappa}\right)^{\frac{1}{\kappa}}$ as given in (7),[21] Panel A of Figure 6 plots the gross welfare gains $\widehat{W}_n = W_n^{\text{opt}}/W_n^{\text{status quo}}$ for each city against the city's land use distortion. All cities experience welfare gains, with an average increase of 1.049. The greater a city's land-use distortion, the more it benefits from eliminating it (along with other cities' distortions), and the relationship is tight. Moreover, the regional welfare gains vary substantially, ranging

[20]For those cities with more than 3 million, we take a simple average of their premiums.
[21]This is the expected utility for anyone originated from region n.

Table 5: Optimal Premium and Fundamentals

Variable	Estimate	Standard Error
Productivity $\bar{A}_n^m$	0.005^{**}	0.001
Amenity B_n	-0.248^{***}	0.032
Land Endowment $\log(T_n)$	0.045^{**}	0.020
Initial Population $\log(\bar{L}_n)$	-0.063^{*}	0.032
Constant	1.389^{***}	0.129

Notes: This table shows how the optimal residential premium responds to city attributes. Dropping cities with populations below 3 million, the number of observations is 50. Statistical significance is denoted by $^{*}p < 0.10$, $^{**}p < 0.05$, and $^{***}p < 0.01$.

from nearly 0% to nearly 19%. Panel B plots each rural region's welfare change against the welfare changes of the urban region in the same prefecture. The figure shows a tight positive correlation between welfare gains in rural and urban regions within the same prefectures, with a slope less than 1. This reflects spatial spillovers of urban land-use policies on rural regions and highlights the role of spatial frictions in trade and migration. The average gain in rural regions is 2.3%, roughly half the gains in urban regions.

Next, we compare the status quo equilibrium with the laissez-faire equilibrium, in which $R_n = 1$ for all $n \in \mathcal{U}$. The aggregate welfare gain from moving the status quo to the laissez-faire equilibrium is 4.71%. Therefore, optimal land-use policies imply only a very slight additional gain $(4.75 - 4.71)/4.71 = 0.85\%$ compared with the laissez-faire equilibrium. The additional regional welfare gains from optimal land-use policies over the regional welfare gains in the laissez-faire equilibrium are also very slight.[22]

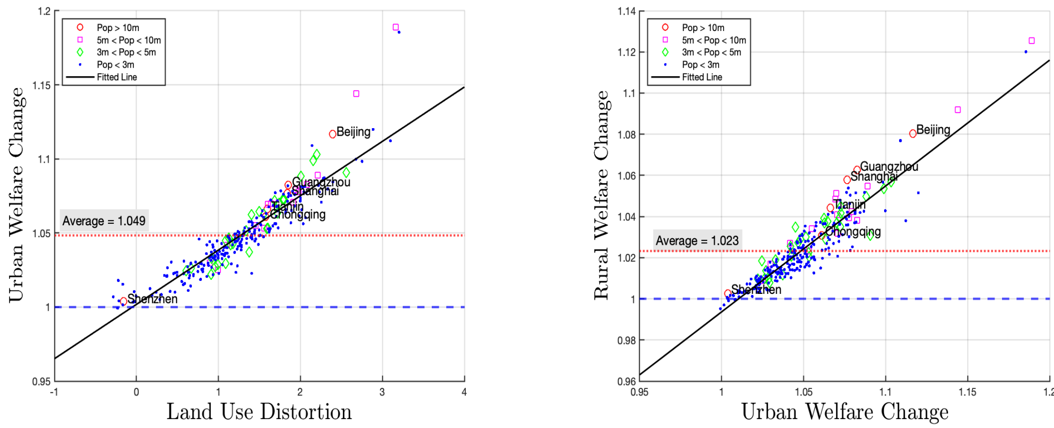
This finding echoes the results in Section 4.3. In the two-region simulations, the welfare gains from laissez-faire to optimal allocations are almost nil, with a maximum of just 0.01%. In the full-fledged model, a larger set of locations and greater heterogeneity in productivity and amenities across multiple regions lead to larger, yet still modest, welfare gains of about 0.85%. As mentioned in Section 4.3, the key intuition is that using land-use allocation to correct externalities exerted through labor simultaneously creates a misalignment of private incentives for land use, thereby offsetting part of the gains from correcting the externalities. In other words, when correcting the externalities using land-use policies to reduce the differences in marginal utilities across locations, they also create the differences in the marginal benefits of the two land uses, compared with the laissez-faire equilibrium.

[22] Appendix Figure 9 plots the regional welfare changes in both scenarios.

Figure 6: Welfare Implications of Eliminating Land Use Distortions

Panel A: Urban Welfare Change vs. Distortion

Panel B: Rural Welfare Change



Notes: This figure plots individual regions' welfare changes from eliminating land use distortions. Panel A shows the relationship between welfare changes of urban regions and land use distortions, while Panel B plots each rural region's welfare change against the welfare changes of the urban region in the same prefecture. A region's land use distortion is measured as the log difference between the status quo and the optimal residential premiums.

6.2 *Comparative Statics of Migration and Production Spillover Elasticities*

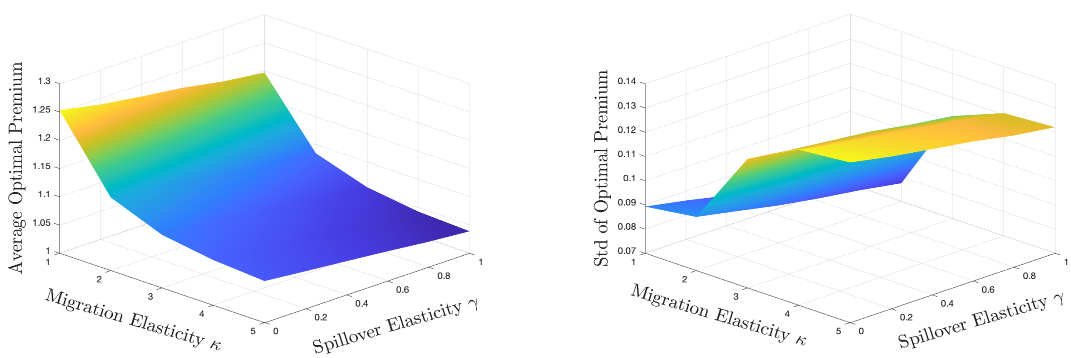
Next, we examine the comparative statics of the migration elasticity κ and the production Spillover elasticity γ on optimal residential premiums. We would like to know whether there exists a reasonable parameter range that could justify the estimated empirical premiums in China. For this purpose, we solve for the optimal land-use policies for each point in a dense grid where κ ranges from 1 to 5 and γ ranges from 0 to 1. This is already a much wider range than most estimates of migration elasticity and productivity spillovers. We then compute the optimal residential premium and the associated aggregate welfare gains relative to the status quo welfare, evaluated for each combination of κ and γ.

Figure 7 reports the mean and dispersion of optimal residential premiums across parameter configurations. Panel A shows that the average premium declines with both κ and γ. The average optimal premium ranges from 1.04 (at $\gamma = 1, \kappa = 5$) to 1.25 (at $\gamma = 0, \kappa = 1$). These values are substantially below the status quo average of approximately 4.53. Panel B reports the cross-city dispersion of optimal residential premiums. The standard deviation of optimal premiums increases with κ and decreases with γ. Overall, the standard deviation ranges from 0.082 to 0.136, whereas the status quo standard deviation is 3.95.[23] Taken

[23]To be comparable with the quantitative analysis, the number 3.95 is obtained after averaging across cities with populations below 3 million.

Figure 7: Comparative Statics of Migration and Production Spillover Elasticities

Panel A: Optimal Residential Premium | Panel B: STD of Optimal Premium



Notes: This figure plots the average optimal residential premium as migration and production spillover elasticities vary (Panel A), and the standard deviation (STD) of the optimal premium (Panel B). A uniform residential premium is imposed for all cities with populations below three million, while city-specific premiums are assigned to cities with populations above this threshold. In total, this yields 51 optimal residential premiums.

together, both the mean and standard deviation of the optimal premiums under this wide range are one order of magnitude smaller than the empirical counterparts. In other words, there is no combination of externality parameters that could justify the observed residential premiums, suggesting that status quo land-use allocations are indeed distortions rather than distortion corrections.

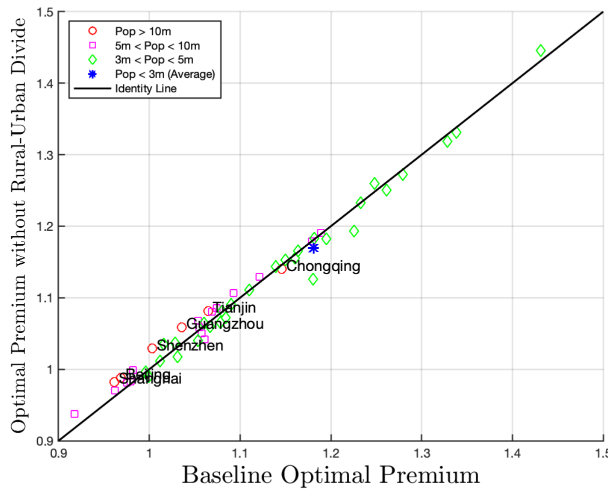
Since the above results show that the optimal premiums do not differ substantially from our baseline, welfare gains from moving from the status quo to optimal land-use allocations within this wide range of parameters should remain similar to our baseline result. Indeed, the welfare gains range from 3.50% (at $\gamma = 0, \kappa = 1$) to 5.32% (at $\gamma = 1, \kappa = 5$).

6.3 Land Use Distortions as Another Migration Friction?

In this subsection, we examine whether migration frictions and land-use distortions interact in shaping welfare outcomes. We also study how land-use distortions may affect migration. The rationale is that, since the status quo land-use policies make residential prices in Chinese cities suboptimally high, they discourage rural-urban migration. In other words, land-use distortions may act as another source of migration friction. We would like to examine the extent to which this is true.

Migration frictions in China are largely shaped by institutional constraints such as the hukou system. All hukou registrations carry an urban vs. rural label, and this label is a key factor because hukou restrictions are particularly stringent for rural-urban migration com-

Figure 8: Optimal Residential Premiums when Rural-Urban Divide is Eliminated



Notes: This figure compares the optimal residential premium when the rural-urban divide is eliminated with the baseline optimal premiums. The result shows most points cluster around the 45-degree line.

pared with other types of migration. Recall from (27) that our bilateral migration frictions consist of prefectural-level bilateral frictions and dummies that depend on the rural vs. urban status. In particular, relative to the urban–urban migration frictions, the rural–rural migration barrier is 1.17 times larger, the urban–rural barrier is 1.43 times larger, while the rural–urban barrier is 2.01 times larger.

We conduct a counterfactual analysis in which the urban and rural labels are wiped out, leaving only prefectural-level bilateral frictions. Keeping prefectural-level bilateral frictions is realistic, as they account for various migration barriers that naturally exist even without the hukou system. In terms of (27), we set $D_{RU} = D_{UR} = D_{RR} = D_{UU} = 1$. We then solve for the optimal land-use allocations under this setting.

As Figure 8 shows, the optimal residential premium when the rural-urban divide is wiped out remains similar to the case where the divide exists. This suggests that removing the rural-urban divide has only a negligible effect on optimal land-use allocations. Table 6 reports the aggregate migration shares for the 2×2 matrix between rural and urban labels for different scenarios. Rows denote origins and columns denote destinations. Specifically, the unconditional migration shares from region i to region n are $m_{ni} \times \frac{\bar{L}_i}{\bar{L}}$, where the conditional migration shares are given by (5). The entries in Table 6 are the sums of these unconditional migration shares within their respective categories. The column "staying put" reports the fraction of individuals who stay in their original region $n \in \mathscr{U} \cup \mathscr{R}$. We consider four scenarios. Panel A reports the aggregate migration shares in the status quo

Table 6: Migration Shares and Welfare Gains under Alternative Policies

	Rural Dest.	Urban Dest.	Staying Put	Welfare Gains
Panel A: Baseline Status Quo Equilibrium				
Rural Orig.	0.026	0.159	0.296	0
Urban Orig.	0.063	0.057	0.396	
Panel B: Optimal Land Use Policy				
Rural Orig.	0.025	0.172	0.284	4.75%
Urban Orig.	0.057	0.060	0.400	
Panel C: Without Rural-Urban Divide				
Rural Orig.	0.023	0.265	0.194	14.44%
Urban Orig.	0.192	0.038	0.287	
Panel D: Combined Policy				
Rural Orig.	0.021	0.276	0.184	19.75%
Urban Orig.	0.180	0.040	0.296	

Notes: Each panel reports the aggregate bilateral migration share between rural and urban regions. Rows denote origins and columns denote destinations. We also report, for each scenario, the welfare gains relative to the baseline.

equilibrium. Panel B isolates the effect of correcting land-use distortions while maintaining the rural-urban divide. Panel C instead removes the rural-urban divide while holding land-use allocations fixed as in the status quo. Panel D considers the joint removal of the rural-urban divide and land-use distortions. For each scenario, we also report the welfare gains relative to the baseline.

Removing the rural-urban divide (comparing Panel C with Panel A) yields substantial gains of 14.4%. The fraction of people who stay put is also substantially reduced by about 10 percentage points for both rural and urban origins. For rural origin, all additional migration comes from rural-urban migration, while rural-rural migration has slightly reduced. For urban origin, all additional migration comes from urban-rural migration, while urban-urban migration has also reduced. These suggest that the rural-urban divide is the major hurdle of labor mobility. Correcting land use distortions (comparing Panel B with Panel A) yields a modest welfare gain of 4.8%. This correction increases both rural-urban and urban-urban migration, with the increase slightly greater for rural-urban migration. But the overall changes of migration are dwarfed by the comparison between Panels A and C. This indicates that land-use distortions do act as another migration friction but are rather indirect. The comparison between Panels A and D indicates no evidence of strong complementarity or substitution between the two policy changes, as the numbers are close to the sum of their effects.

7 Conclusion

This paper studies whether China's large residential-industrial land price wedge can be justified as a second-best land-use policy. We document that, after controlling for parcel characteristics and fine spatial-year fixed effects, residential land in mainland China is about 4.53 times as expensive as industrial land, far above comparable estimates for the United States and Taiwan. We then build a quantitative spatial model in which land is used for both residential and production purposes, workers can migrate across locations, regions differ in their productivities and amenities, and spatial externalities arise from idiosyncratic location preferences and productivity spillovers.

The model shows that land-use policy can, in principle, improve on laissez-faire. In an efficient benchmark, the laissez-faire allocation is optimal; with idiosyncratic preferences and productivity spillovers, optimal residential premiums may deviate from one. The two forces push in opposite directions: redistributive motives associated with marginal-utility dispersion tend to move population toward lower-wage locations, while productivity spillovers favor productive agglomerations. Quantitatively, the two sources of spatial inefficiency combined do not imply that optimal premiums differ far from 1, making it difficult to rationalize China's observed premiums. In the baseline calibration, the optimal residential premium averages about 1.1 and ranges from 0.92 to 1.43. Moving from the status quo to the optimal allocation raises aggregate welfare by 4.75%, while moving to laissez-faire raises welfare by 4.71%.

These results speak to a broader question about second-best spatial policy. As emphasized by Fajgelbaum and Gaubert (2025), much of the optimal spatial policy literature characterizes first-best taxes and subsidies, while less is known about how far more restricted instruments, such as zoning or housing policies, can go toward correcting spatial inefficiencies. Our analysis evaluates land-use policy as one such restricted instrument. The two sources of inefficiency we study are canonical in competitive spatial economies: idiosyncratic location preferences create dispersion in the marginal utility of income across locations, while productivity spillovers create agglomeration externalities. These forces push optimal land-use wedges in different directions and partly offset each other. More fundamentally, land-use policy corrects spatial inefficiencies only indirectly: it changes labor allocation by changing relative land prices, but doing so also creates wedges in the marginal value of land across uses. These explain why optimal residential premiums remain close to laissez-faire, even though laissez-faire is not exactly efficient. If the goal is to correct these canonical spatial inefficiencies, more direct place-based instruments are likely to be more effective.

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A Data Sources and Summary Statistics

Table 7: Nationwide Average Residential Premium in China with an Interest Rate of 0.03

	(Log) Annualized Land Price				
	(1)	(2)	(3)	(4)	(5)
$D_{residential}$	1.267***	1.896***	1.766***	1.487***	1.454***
	(0.008)	(0.003)	(0.003)	(0.004)	(0.004)
dis_{city}			−0.077***	−0.008	−0.005
			(0.002)	(0.008)	(0.007)
Other controls			✓	✓	✓
Prefecture fixed effects		✓	✓		
Year fixed effects		✓	✓	✓	
Grid fixed effects				✓	
Year-grid fixed effects					✓
Weights ✓		✓	✓	✓	✓
Obs	336,606	336,605	334,966	306,428	234,320
R^2	0.06	0.71	0.84	0.96	0.98

Notes: Standard errors in parentheses. * Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level. The grid size is 1 km × 1 km. In the regression, land area is used as weights.

B Theory Appendix

In this section, we provide the proofs for the main propositions, as well as the algorithm for solving the system of hat algebra equations.

B.1 Proof of Proposition 1

In this proof, we do not impose the Fréchet assumption, as the social planner's problem applies to all distributions of productivity draws. Let L_{nv} and T_{nv}^{y} denote the total labor and land inputs used in producing product v in urban region n, respectively. Similarly, let L_{na} and T_{na}^{y} denote the total labor and land inputs used in producing agricultural goods in rural region n, respectively. In the following formulation of the social planner's problem, most variables are positive, and the first-order conditions hold in equality. However, because manufacturing production features differentiated products and comparative advantages, the social planner, as consumers in equilibrium, also faces a discrete choice problem: for any region n, which urban region i should it source from? For this discrete choice problem, we use the Kuhn-Tucker conditions, of which the Lagrange multipliers are $\epsilon_{ni,v}$. We define

Table 8: **Residential Premium Comparison with 3 km × 3 km Grid Size**

	Mainland China	US	Taiwan
$D_{residential}$	1.595***	0.515***	0.491***
	(0.004)	(0.003)	(0.005)
Controls	✓	✓	✓
Grid fixed effects		✓	
Grid-year fixed effects	✓		✓
Weights	✓	✓	✓
Obs.	285,700	5,698,616	112,291
R^2	0.97	0.68	0.77

Notes: Standard errors in parentheses. * Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level. The grid size is 3 km × 3 km. In the regression, land area is used as weights. Estimated residential premiums are exp(1.595) ≈ 4.92 for mainland China, exp(0.515) ≈ 1.67 for the United States, and exp(0.491) ≈ 1.64 for Taiwan.

an indicator function $\mathbb{I}\left(\epsilon_{ni,v} > 0, \exists n\right) = 1$ if there exists a region n such that n sources from i for product v, in which case $\epsilon_{ni,v} > 0$ so that the corresponding first-order condition holds in equality; otherwise, $\epsilon_{ni,v} = 0$ and $\mathbb{I}\left(\epsilon_{ni,v} > 0, \exists n\right) = 0$.

For expositional purposes, we define the consumption bundle

$$Q_n \equiv \left(\frac{C_n^a}{\alpha\xi_a}\right)^{\alpha\xi_a} \left(\frac{C_n^m}{\alpha\xi_m}\right)^{\alpha\xi_m} \left(\frac{t_n}{1-\alpha}\right)^{1-\alpha},$$

where the CES composite of the manufacturing good is given as

$$C_n^m = \int_v \sum_{i\in\mathcal{U}} c_{ni,v}\mathbb{I}(\epsilon_{ni,v} > 0)dv.$$

The social planner's problem is then formulated as follows:

$$\max_{\{V,L_n,L_{na},T^y_{na},t_n,T^h_n,T^y_n,C^a_n\}\in\mathbb{R}^{11N+1}_{++},\{L_{nv},T^y_{nv},c_{ni,v},\epsilon_{ni,v}\}\in\mathbb{R}^{2N+4N^2}_{+}\forall\, v} V$$

s.t.

$$V = B_n Q_n, \forall n \in \mathscr{U} \cup \mathscr{R}$$

$$\sum_{n\in\mathscr{R}\cup\mathscr{U}} L_n = L,$$

$$\epsilon_{ni,v}\left((\eta_m)^{\eta_m}(\beta_m)^{\beta_m}\sum_{n\in\mathscr{R}\cup\mathscr{U}} c_{ni,v}L_n\tau_{ni} - z_i(v)(L_{iv})^{\eta_m}(T^y_{iv})^{\beta_m}\right) = 0, i \in \mathscr{U},$$

$$(\eta_a)^{\eta_a}(\beta_a)^{\beta_a}\sum_{n\in\mathscr{R}\cup\mathscr{U}} C^a_n L_n = \sum_{i\in\mathscr{R}} A^a_i (L_{ia})^{\eta_a}(T^y_{ia})^{\beta_a},$$

$$\int_v \mathbb{I}\left(\epsilon_{ni,v} > 0, \exists n\right) L_{iv} dv = L_i, \forall i \in \mathscr{U}$$

$$\int_v \mathbb{I}\left(\epsilon_{ni,v} > 0, \exists n\right) T_{iv} dv = T^y_i, \forall i \in \mathscr{U}$$

$$L_{na} = L_n, \forall n \in \mathscr{R}$$

$$T_{na} = T^y_n, \forall n \in \mathscr{R}$$

$$L_n t_n = T^h_n, \forall n \in \mathscr{U} \cup \mathscr{R},$$

$$T^y_n + T^h_n = T_n, \forall n \in \mathscr{U} \cup \mathscr{R}.$$

The Lagrangian is written as

$$\begin{aligned}
\mathscr{L} = V &+ \sum_{n\in\mathscr{R}\cup\mathscr{U}} \kappa_n\left(B_n\left(\frac{C^a_n}{\alpha\xi_a}\right)^{\alpha\xi_a}\left(\frac{C^m_n}{\alpha\xi_m}\right)^{\alpha\xi_m}\left(\frac{t_n}{1-\alpha}\right)^{1-\alpha} - V\right) + \lambda\left(L - \sum_{n\in\mathscr{R}\cup\mathscr{U}} L_n\right) \\
&+ \sum_{i\in\mathscr{U}}\int_v \epsilon_{ni,v}\left(\eta_m^{\eta_m}(\beta_m)^{\beta_m}\sum_{n\in\mathscr{R}\cup\mathscr{U}} c_{ni,v}L_n\tau_{ni} - z_i(v)(L_{iv})^{\eta_m}(T^y_{iv})^{\beta_m}\right) dv \\
&+ \sum_{i\in\mathscr{R}} \epsilon_a\left((\eta_a)^{\eta_a}(\beta_a)^{\beta_a}\sum_{n\in\mathscr{R}\cup\mathscr{U}} C^a_n L_n - \sum_{i\in\mathscr{R}} A^a_i(L_{ia})^{\eta_a}(T^y_{ia})^{\beta_a}\right) \\
&+ \zeta_{L_{nv}}\left(\int_v \mathbb{I}\left(\epsilon_{ni,v} > 0, \exists n\right) L_{iv}dv - L_i\right) + \zeta_{T^y_{nv}}\left(\int_v \mathbb{I}\left(\epsilon_{ni,v} > 0, \exists n\right) T_{iv}dv - T^y_i\right) \\
&+ \zeta_{L_{na}}\left(L_{na} - L_n\right) + \zeta_{T_{na}}\left(T_{na} - T^y_n\right) + \zeta_{T_{nh}}\left(L_n t_n - T^h_n\right) + \zeta_{T_n}\left(T^y_n + T^h_n - T_n\right)
\end{aligned}$$

The first-order conditions are

$$\frac{\partial \mathscr{L}}{\partial V} = 1 - \sum_{n \in \mathscr{R} \cup \mathscr{U}} \kappa_n = 0, \tag{B1}$$

$$\frac{\partial \mathscr{L}}{\partial L_n} = -\lambda + (\eta_m)^{\eta_m}(\beta_m)^{\beta_m} \sum_{i \in \mathscr{U}} \int_v \epsilon_{ni,v} c_{ni,v} \tau_{ni} dv + \epsilon_a (\eta_a)^{\eta_a}(\beta_a)^{\beta_a} c_{na} - \zeta_{L_{nv}} + \zeta_{T_{nh}} t_n = 0, \forall n \in \mathscr{U}, \tag{B2}$$

$$\frac{\partial \mathscr{L}}{\partial L_n} = -\lambda + (\eta_m)^{\eta_m}(\beta_m)^{\beta_m} \sum_{i \in \mathscr{U}} \int_v \epsilon_{ni,v} c_{ni,v} \tau_{ni} dv + \epsilon_a (\eta_a)^{\eta_a}(\beta_a)^{\beta_a} c_{na} - \zeta_{L_{na}} + \zeta_{T_{nh}} t_n = 0, \forall n \in \mathscr{R}, \tag{B3}$$

$$\frac{\partial \mathscr{L}}{\partial t_n} = \kappa_n B_n \frac{\partial Q_n}{\partial t_n} - \zeta_{T_{nh}} L_n = 0, \tag{B4}$$

$$\frac{\partial \mathscr{L}}{\partial C_n^a} = \kappa_n B_n \frac{\partial Q_n}{\partial C_n^a} - \epsilon_a (\eta_a)^{\eta_a}(\beta_a)^{\beta_a} L_n = 0, \tag{B5}$$

$$\frac{\partial \mathscr{L}}{\partial c_{ni,v}} = \mathbb{I}(\epsilon_{ni,v} > 0, \exists n) \kappa_n B_n \frac{\partial Q_n}{\partial c_{ni,v}} - \epsilon_{ni,v} (\eta_m)^{\eta_m}(\beta_m)^{\beta_m} L_n \tau_{ni} = 0, \tag{B6}$$

$$\frac{\partial \mathscr{L}}{\partial L_{iv}} = (\eta_m)^{\eta_m}(\beta_m)^{\beta_m} \eta_m \epsilon_{ni,v} z_i(v) L_{iv}^{\eta_m - 1} (T_{iv}^y)^{\beta_m} - \zeta_{L_{iv}} \mathbb{I}(\epsilon_{ni,v} > 0, \exists n) = 0, \forall i \in \mathscr{U} \tag{B7}$$

$$\frac{\partial \mathscr{L}}{\partial T_{iv}^y} = (\eta_m)^{\eta_m}(\beta_m)^{\beta_m} \beta_m \epsilon_{ni,v} z_i(v) L_{iv}^{\eta_m} (T_{iv}^y)^{\beta_m - 1} - \zeta_{T_{iv}^y} \mathbb{I}(\epsilon_{ni,v} > 0, \exists n) = 0, \forall i \in \mathscr{U} \tag{B8}$$

$$\frac{\partial \mathscr{L}}{\partial L_{ia}} = (\eta_a)^{\eta_a}(\beta_a)^{\beta_a} \eta_a \epsilon_a A_i^a L_{ia}^{\eta_a - 1} (T_{ia}^y)^{\beta_a} - \zeta_{L_{ia}} = 0, \forall i \in \mathscr{R} \tag{B9}$$

$$\frac{\partial \mathscr{L}}{\partial T_{ia}^y} = (\eta_a)^{\eta_a}(\beta_a)^{\beta_a} \beta_a \epsilon_a A_i^a L_{ia}^{\eta_a} (T_{ia}^y)^{\beta_a - 1} - \zeta_{T_{ia}^y} = 0, \forall i \in \mathscr{R} \tag{B10}$$

$$\frac{\partial \mathscr{L}}{\partial T_n^y} = -\zeta_{T_{nv}^y} + \zeta_{T_n} = 0, n \in \mathscr{U}, \tag{B11}$$

$$\frac{\partial \mathscr{L}}{\partial T_n^a} = -\zeta_{T_{na}^y} + \zeta_{T_n} = 0, n \in \mathscr{R}, \tag{B12}$$

$$\frac{\partial \mathscr{L}}{\partial T_n^h} = -\zeta_{T_{nh}} + \zeta_{T_n} = 0, \forall n \in \mathscr{R} \cup \mathscr{U}. \tag{B13}$$

$$\frac{\partial \mathscr{L}}{\partial \epsilon_{ni,v}} = \mathbb{I}\left(\epsilon_{ni,v} > 0, \exists n\right) \left[(\eta_m)^{\eta_m}(\beta_m)^{\beta_m} \sum_{n \in \mathscr{R} \cup \mathscr{U}} c_{ni,v} L_n \tau_{ni} - z_i(v)(L_{iv})^{\eta_m} (T_{iv}^y)^{\beta_m} \right] = 0, \tag{B14}$$

Let $\zeta_{T_{iv}^y} \mathbb{I}(\epsilon_{ni,v} > 0, \exists n) = \zeta_{T_{ih}} = \zeta_{\bar{T}_i} = r_i, \forall i \in \mathscr{U}$ and $\zeta_{T_{na}^y} = \zeta_{T_{nh}} = \zeta_{T_n} = r_n, \forall n \in \mathscr{R}$, implying that land markets are perfectly competitive across all regions. Under these laissez-faire conditions, the first-order conditions given by equations (B11) to (B13) are satisfied.

To fulfill conditions from (B7) and (B10), we set $\zeta_{L_{ia}} = w_i, \forall i \in \mathscr{R}$, and $\zeta_{L_{iv}} \mathbb{I}(\epsilon_{ni,v} > 0, \exists n) =$

$w_i, \forall i \in \mathscr{U}$ and define

$$\tilde{\epsilon}_{ni,v} = \frac{1}{z_i(v)} \left(\frac{w_i}{\eta_m}\right)^{\eta_m} \left(\frac{r_i}{\beta_m}\right)^{\beta_m}, \forall i \in \mathscr{U},$$
$$\epsilon_a = \frac{1}{A_i^a} \left(\frac{w_i}{\eta_a}\right)^{\eta_a} \left(\frac{r_i}{\beta_a}\right)^{\beta_a} \equiv (\eta_a)^{-\eta_a}(\beta_a)^{-\beta_a} P_a, \forall i \in \mathscr{R}.$$

Let $\kappa_n = (P_a)^{\alpha\xi_a} P_n^{\alpha\xi_m} r_n^{1-\alpha} \frac{L_n}{B_n}, \forall n \in \mathscr{R} \cup \mathscr{U}$, and normalize the summation of κ_n to be 1 so that condition (B1) holds. For any given n and v and by (B6), the social planner sources from i if $i = \arg\min_k \{\tilde{\epsilon}_{nk,v}\tau_{nk}\}$, in which case $\epsilon_{ni,v} = \tilde{\epsilon}_{ni,v} > 0$. Furthermore, conditions (B4) and (B5) are satisfied. Letting $\lambda = \Pi$, condition (B2) and (B3) becomes:

$$\Pi - \sum_{i \in \mathscr{U}} \int_v \frac{1}{z_i(v)} (w_i)^{\eta_m} (r_i)^{\beta_m} c_{ni,z} \tau_{ni} \mathbb{I}(\epsilon_{ni,v} > 0) dv - P_a C_n^a + w_n - r_n t_n = 0, \forall n \in \mathscr{U} \cup \mathscr{R}.$$

which coincides with budget constraint:

$$r_n t_n + P_n^m C_n^m + P_a C_n^a = w_n + \Pi, \forall n \in \mathscr{U} \cup \mathscr{R}.$$

Finally, the goods market clearing condition $(\eta_m)^{\eta_m}(\beta_m)^{\beta_m} \sum_{n \in \mathscr{R} \cup \mathscr{U}} c_{ni,v} L_n \tau_{ni} - z_i(v)(L_{iv})^{\eta_m}(T_{iv}^y)^{\beta_m}$ holds when there exists at least one region n that purchase variety v from the urban region i. This condition coincides with (B14).

B.2 Proof of Proposition 2

In the economy without an agricultural sector and without trade in manufacturing, the goods market-clearing condition (15) implies

$$I_n = \frac{w_n}{\eta\alpha}. \tag{B15}$$

The price index becomes

$$P_n^m = \Gamma\left(\frac{\theta - (\sigma - 1)}{\theta}\right)^{\frac{1}{1-\sigma}} (A_n^m)^{-\frac{1}{\theta}} (r_n^y)^{\beta_m} (w_n)^{\eta_m}.$$

Combining (8), (13) and (14), with $\xi_a = 0$, individual utility in region n in (4) can be written as

$$V_n = \chi_n \, (T_n^h)^{1-\alpha} \, (T_n^y)^{\alpha\beta_m} \, L_n^\rho,$$

where $\chi_n \equiv \frac{B_n \eta_m^{\alpha\beta_m}}{(1-\alpha)^{1-\alpha} \, (\beta_m)^{\alpha\beta_m} \, (\eta_m \alpha)^\alpha \, \Gamma\left(\frac{\theta-(\sigma-1)}{\theta}\right)^{\frac{\alpha}{1-\sigma}} \, (\bar{A}_n^m)^{-\frac{\alpha}{\theta}}}$, and $\rho \equiv \alpha\left(1 - \beta_m + \frac{\gamma}{\theta}\right) - 1$. The social planner's problem is formulated as:

$$\max_{\{T_n^h, T_n^y\}} W = \max_{\{T_n^h, T_n^y\}} \sum_n \bar{L}_n \left(\sum_i \left(\frac{V_i}{\tau_{in}} \right)^\kappa \right)^{\frac{1}{\kappa}},$$

subject to

$$V_n = \chi_n (T_n^h)^{1-\alpha} (T_n^y)^{\beta_m \alpha} L_n^\rho, \tag{B16}$$

$$T_n^h + T_n^y = T_n, \tag{B17}$$

$$L_n = \sum_i \bar{L}_i \frac{(V_n/\tau_{ni})^\kappa}{\sum_k (V_k/\tau_{ki})^\kappa}. \tag{B18}$$

Define $\psi_n = (T_n^h)^{1-\alpha} (T_n^y)^{\beta_m \alpha}$. From the labor supply condition (B18) and the indirect utility expression (B16), we observe that L_n is an implicit function of the vector $\{\psi_n\}$. The relevant first-order condition for maximization under the land constraint (B17) requires equality of the marginal contributions of land uses:

$$\frac{\partial W}{\partial T_n^h} = \frac{\partial W}{\partial T_n^y}.$$

Since both T_n^h and T_n^y enter W only through ψ_n, the chain rule gives

$$\frac{\partial W}{\partial \psi_n} \frac{\partial \psi_n}{\partial T_n^h} = \frac{\partial W}{\partial \psi_n} \frac{\partial \psi_n}{\partial T_n^y},$$

so that whenever $\frac{\partial W}{\partial \psi_n} \neq 0$, the condition reduces to

$$\frac{\partial \psi_n}{\partial T_n^h} = \frac{\partial \psi_n}{\partial T_n^y},$$

which yields

$$\frac{T_n^h}{T_n^y} = \frac{1-\alpha}{\alpha\beta_m}. \tag{B19}$$

Combining (13), (14), and (B15), the laissez-faire equilibrium condition $r_n^h = r_n^y$ delivers precisely the same land use ratio (B19). Hence, the welfare-maximizing allocation of land between residential and industrial uses coincides with the laissez-faire allocation. Thus, as long as the population distribution is not excessively responsive to ψ_n, the laissez-faire equilibrium without trade is optimal.

Differentiating W with respect to ψ_n yields

$$\frac{\partial W}{\partial \psi_n} = \frac{\partial V_n}{\partial \psi_n} \times \sum_i \bar{L}_i \left(\sum_k \left(\frac{V_k}{\tau_{ik}} \right)^{\kappa} \right)^{\frac{1}{\kappa}-1} \left(\frac{V_n}{\tau_{in}} \right)^{\kappa-1} \frac{1}{\tau_{in}}.$$

Thus, $\frac{\partial W}{\partial \psi_n} \neq 0$ for all n if and only if $\frac{V_n}{\partial \psi_n} \neq 0$ for all n. Observe that

$$\frac{\partial V_n}{\partial \psi_n} = \frac{V_n}{\psi_n} \left(1 + \rho \frac{\partial \ln L_n}{\partial \ln \psi_n} \right) \equiv \frac{V_n}{\psi_n} \left(1 + \rho \epsilon_{L_n, \psi_n} \right),$$

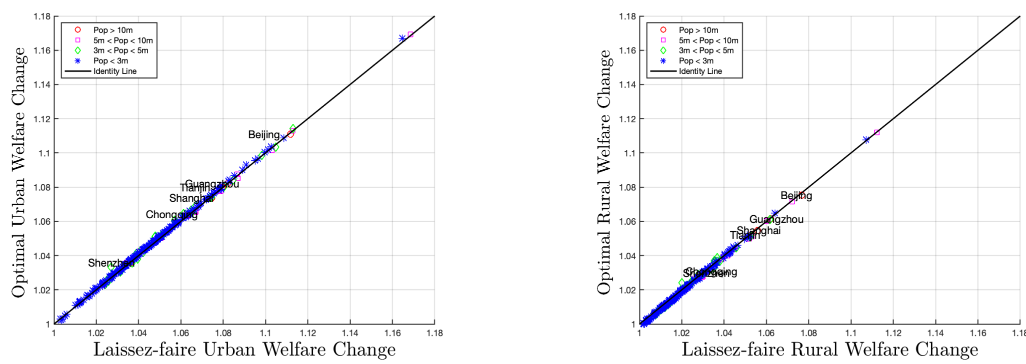
where $\epsilon_{L_n,\psi_n} \equiv \frac{\partial \ln L_n}{\partial \ln \psi_n}$ is the elasticity of population with respect to ψ_n. As $\{\bar{A}_n, B_n\} \gg 0$, corner land use allocations are excluded, and hence $\{\psi_n\} \gg 0$. With (B16) and (B18), this implies that $\{V_n, \psi_n\} \gg 0$. From the labor-supply condition (B18), L_n is strictly increasing in V_n (holding other regions fixed), and V_n is strictly increasing in ψ_n, so $\epsilon_{L_n,\psi_n} > 0$ is finite. Thus, to have $\frac{\partial W}{\partial \psi_n} = 0$ for some region n evaluated at the equilibrium, it requires the equilibrium elasticity ϵ_{L_n,ψ_n} happens to be $-1/\rho$, a unlikely knife-edge case.

C Figures

Figure 9: **Welfare Change: LF vs Optimium**

Panel A: Urban Welfare Change

Panel B: Rural Welfare Change



Notes: This figure plots the gross regional welfare gains from optimal land-use policies against those from laissez-faire equilibrium. Panel A is for urban regions, whereas Panel B is for rural regions. In both panels, the points cluster tightly around the 45-degree line, indicating that there are limited additional welfare gains from optimal policies over the laissez-faire equilibrium.