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The Costs of Political Manipulation of Factor Markets in China

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Abstract

Despite China's economic achievements, factor market reforms have been slow. We analyze local political manipulation of land markets, along with capital market favoritism of certain cities, using a structural general equilibrium model. We estimate city-by-city local leaders' preferences over GDP enhancement versus residents' welfare. Equalizing capital prices across cities would increase worker welfare and returns to capital by 2.6% and 11%, respectively. Further, forcing local leader to focus just on enhancing welfare of residents would increase welfare by another 5.3%. Reforms would significantly reduce the population of favored cities like Tianjin and Beijing, while raising that of cities like Shenzhen.

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1. Introduction

China over the last four decades has undergone massive reform in output markets and experienced an average PPP income growth rate of 10-11% a year (WDI, 2017). While growth has been extraordinary, factor markets reforms for capital, labor and land markets have been much slower. At the local level, factor market distortions have deep roots in the administrative and political structure of the urban hierarchy. In land markets, more ambitious local political leaders have promotion incentives to manipulate local land markets to finance infrastructure investments and subsidize industrial land usage with the intention of promoting industrial growth, potentially at the expense of higher residential housing prices and lower local consumer welfare. Capital markets tend to favor certain cities with lower prices of capital, particularly big political players in the administrative hierarchy, as well as some smaller, heavy industry cities which have a history of strong state ownership of enterprises. Cities which are favored in capital markets tend to experience excessive in-migration and to be oversized. These two sets of distortions offer efficiency losses, with lowered returns overall to capital owners, misallocated land, and lower welfare of workers. There are also institutional frictions in labor markets inhibiting movement of workers from low productivity to higher productivity locations, resulting in welfare losses compared to a world with reduced institutional frictions.

While the general equilibrium and/or local impacts of capital market distortions and frictions in labor markets in China have been studied in the literature (Hsieh & Klenow, 2007; Brandt, Tombe, & Zhu, 2013; Chen, Henderson, & Cai, 2017; Tombe & Zhu, 2019) and we study them also, we view them through a somewhat different lens. What is entirely novel is our focus on the political economy of operation of land markets. We highlight the fiscal and political incentives faced by local political leaders when they make land allocation decisions. One key aspect concerns the fiscal reforms of the 1990's which left local governments with a much smaller share of national revenue sources (Lin & Yi, 2011). Facing fiscal hardship, local governments worked to secure extra-budgetary revenues, principally land sales revenue (He, Zhou, & Huang, 2016). In China, urban land is owned by the state and cities have great discretion regarding urban land use allocation (e.g. industrial vs. residential land development).[2] Urban land is sold by cities as leasehold and revenues go to the city treasury. According to Chen & Kung (2016), the importance of land revenues in the local fiscal budget grew phenomenally over time since 1998. The average share of land revenues in a city's extra-budgetary revenues and total fiscal revenues reached 79% and 38% respectively by 2008. More particularly, revenues from land leasehold sales funded over 50% physical infrastructure investments (such as highways and industrial parks) in the 1990's

[2]This is subject to quota constrains on rural-to-urban land conversion set by the upper level governments since 1998 (Wang, Zhang & Zhou, 2019).

and 2000's, with the remainder financed by loans using land as collateral (Peterson & Park, 2006; Ding, 2003).

Although China's economy has been largely decentralized and liberalized, China has remained politically centralized. Thus, another key aspects is that personnel control is still highly centralized in the hands of the upper-level officials and that the key elements in the evaluation and promotion criteria for local politician leaders are economic performance (GDP) and related competence indicators (Li & Zhou, 2005; Chen, Li, & Zhou, 2005; Xu, 2011). This economic performance-based evaluation system provides strong incentives for local leaders such party secretaries and mayors to enhance GDP and engage in yardstick competition (Qian & Xu, 1993), in attracting industrial and commercial firms. They have two main levers: first, provision of infrastructure relevant to firms financed mostly from high priced land sales for residential use and, second, cheap land offered to firms. Infrastructure investment can further enhance firms' productivity and thus GDP growth (Wang, Zhang and Zhou, 2019; Wu, Deng, Huang, Randall, & Bernald, 2014); and, for the financing, about three quarters of land sale revenues come from residential sales. (Wang et al., 2019). As the sole supplier of land, local governments use their "monopoly" on land allocation as a key instrument in competition for industry (Tao, Su, Liu, & Cao, 2010), through low pricing of land for industrial use (Tao et al. 2010 and Cao, Feng, & Tao 2008).

While city leaders in China tend to manipulate land allocations so as to improve their promotion chances, they may also care about city residents' welfare. We know that in some cities there is more of a focus on resident welfare where the scorecard for leaders may also involve environmental and social considerations and tamping down escalating residential housing prices (Zheng, Kahn, Sun, & Luo, 2014; Su, Tao, Xi, & Li, 2012). There are large variations in the relative weights of these objectives, enhancement of GDP versus residents' welfare (Wang et al., 2019).

Accordingly, in the structural model in this paper, we assume land revenues provide the funding for infrastructure investment, that investment is intended to improve productivity of firms, and local leaders maximize an objective function that has weights for GDP and for the welfare of the representative local resident. The main goal of calibration, apart from inferring the usual benchmark consumer and producer exogenous amenities is to infer the relative weights for each city on enhancement of GDP versus resident welfare. One set of counterfactuals will then ask what would change if city leaders opted to just maximize resident welfare.

A feature of this paper is that we tackle capital misallocation due topolitical favoritism of certain cities, land misallocation and distorted incentives of local leaders, all under migration and trade frictions. We study their welfare implications in a comprehensive fashion using a structural general equilibrium model of China based on prefecture level data. There are many spatial general equilibrium models of the within country distribution of resources (for example Allen & Arkolakis 2014, Donaldson & Hornbeck 2016, Alder 2019, Redding 2016, and Bryan & Morten 2019). The closest paper to ours is Tombe & Zhu (2019). They find that reducing trade and migration frictions in China has important welfare implications. Our elements of studying both misallocations of land and capital are novel.

We first draw out features of the current (2010) equilibrium. Then we calibrate the key parameters of the model using data from the three factor markets. Specifically, for China as we discuss later, banks are state owned and the state controls and manipulates the capital market favoring certain types of enterprises, cities and regions. We use the estimated cost of capital city-by-city based on firm level information from China's industrial survey data and ask what would happen if favored (and all cities) faced a level playing field and one national market equilibrium price of capital. For land markets we estimate hedonic land prices by city in industrial and commercial versus residential use. For the labor market, the 2010 and 2000 population censuses are used to estimate the migration cost from city to city. After developing and calibrating the model, we analyze counterfactuals to assess the impact of capital and land market reforms on where people reside, returns to capital, overall welfare of workers, and inequality given heterogeneous labor across space.

While our focus is on China, some of the issues are well known and apply to many countries. Political favoritism of certain regions or cities is a focus of the literatures on urban bias (Lipton, 1977) and big city bias (Renaud, 1981; Ades & Glaeser, 1995; Moomaw & Shatter, 1996; Henderson & Kuncoro, 1996; Davis & Henderson, 2003; Duranton & Storper, 2008). Papers show empirically that favored cities, with national capitals being a prime example, tend to be larger than other cities ceteris paribus, especially in non-democratic countries. For national capitals that can lead to excessive urban primacy in a country and result in reduced economic growth (Henderson, 2003; Castells-Quintana, 2017). Chen et al. (2017) present evidence for China that cities which enjoyed lower prices of capital in the late 1990's and early 2000's grew faster than other cities from 2000-2010.

The local political side and manipulation of local land markets is more China specific but contains elements that may seem familiar: for the USA, historical over-zoning of land for industrial use in certain cities and mayors facing a perceived trade-off in introducing specific policies which may promote local industrial growth, at the expense of allocating resources to improve the quality of life of residents. Business developers may have also played a salient role in influencing local land development policies (Molotch, 1976; Logan & Motloch, 2007; Solé & Viladecans-Marsal, 2012).[3]

Major findings from the counterfactual analysis are as follows. First, we equalize the capital price across cities while keeping the total national capital supply unchanged; that increases consumer welfare and returns to capital by 2.6 and 11.0% respectively, compared to the current state. Second, we further correct for the distortion of local leaders' preference towards GDP, so that the objective of each local leader switches to just maximizing the welfare of city residents. Then the local leader will cease to oversupply industrial land relative to residential land. As a result, consumer welfare rises by another 5.3%. In addition, with both reforms, there is a gain of 3.8% in the total factor productivity compared to the benchmark. Cities such as Tianjin and Beijing have significant losses in population as they are no longer favored. We do note that while the reforms generally raise welfare, there are losers, especially people living in older more remote industrial cities working in heavily subsidized firms, who now face higher prices of capital in the face of high migration costs. The losses to these places mean inequality rises with reforms.

The rest of the paper is organized as follows: we briefly describe the institutional background in Section 2. Section 3 presents the model. In Section 4, empirical work and calibration results are discussed. We first show how to estimate migration costs, hedonic land prices and the capital costs by city. Then we discuss the calibration results of the model, check the plausibility of the results and provide some supporting evidence. In Section 5, we conduct counterfactual analysis based on the calibrated parameters from Section 4. Welfare implications of several reforms are discussed. Section 6 concludes.

2. Institutional Background

For the institutional context, we examine China's urban political hierarchy and governance of cities, land markets and local governments' land-finance policies, capital markets, and labor markets. We start with the urban hierarchy since we will always account for this in displaying results. In China, there is an urban administrative hierarchy which has three distinct levels:

[3] There are some studies that argue for the importance of local governments and business developers in urban development. Molotch (1976) proposes the idea of a "growth engine" and highlights how the close connections between local government officials and local business leaders help to create land policies that favor of local economic growth. Logan & Motloch (1987) argue that "urban growth machines", which combine real estate, banking, and commercial interests to support the expansion of cities, are a typical feature of many U.S. cities. However, these arguments do not provide a formal theory or empirical analysis of the role of developers in the formation of land development policies. Solé & Viladecans-Marsal (2012) find some indirect empirical evidence pointing to the influence of developers on local land development regulations in Spain. A recent paper on China by Deng, Tang, & Wang (2020) looks at distortions across cities in how residential land is treated, whereas we are focused on more first order distortions in the politically driven allocation of land between industrial and residential uses within cities.

provincial level cities of which there are 4 (Beijing, Shanghai, Tianjin and Chongqing), provincial capitals of which we will have 25, and ordinary prefectures. In addition, there are 5 sub-provincial level prefectures (Qingdao, Dalian, Xiamen, Ningbo, Shenzhen)[4] which enjoy similar political power as provincial capitals in the hierarchy; we will lump those together with provincial capitals. In the paper we work with the 266 prefectures in Han China which covers about 90% of China's population, avoiding minority areas due to differential governance and lack of data.

In China, many governmental functions, such as making economic development plans, providing public services, and land allocation, are decentralized to first the provinces and then to prefectures. Fiscal decentralization has also been a fundamental aspect of China's transition to a market economy, with a tax sharing system introduced in 1994 (Shen, Jin, & Zou, 2012). Since this 1994 fiscal reform, budgetary revenue has been shared between the local governments and their upper-level governments with 75 percent of the value-added tax, the largest source of tax revenue, going to the central government. Corporate income tax, originally designated as a local tax in 1994, was reclassified as a shared tax between the central and local governments after 2000. The fiscal landscape produced by these tax sharing arrangements is one where subnational governments account for over 70% of total public expenditure while collecting less than 50% of total government revenue (Wong & Bhattasali, 2003). This has left local governments under great fiscal pressure. Understanding this pressure, the central government allows local governments to collect and control land sale revenues as a major source of extra-budget revenue (Lin, 2007), with no sharing with the central government.[5] As noted above, land sale revenues are used primarily to finance infrastructure such as highways. This forms a positive feedback cycle, wherein such infrastructure investment boosts city's GDP, real estate prices and land sales revenue in the next round, which then finance further transportation infrastructure investment, and so on (Wu et al., 2014).

Although the fiscal system and the economic development functions are quite decentralized, the political system is still rather centralized. Local leaders are evaluated and appointed by provincial leaders who in turn are appointed by national leaders, with strong systems of patronage within different factions of the party. Economic performance (GDP and related indicators) dominates the evaluation and promotion criteria of local leaders. For the urban administrative hierarchy, provincial level cities have the same powers as provinces, enjoying greater revenue sources and fiscal freedoms. Then come provincial capitals which can favor themselves relative to other prefectures and which make many decisions about other prefectures within a province can do and

[4] The sub-provincial level prefectures here refer to the deputy-province-level cities or separate-planning cities.

[5] Before 2011, China had no property tax system. Since 2011, just two cities (Shanghai and Chengdu) have begun to levy property taxes on second houses and luxury villas. Property taxes are still in the experimental stage in China.

what monies they receive, including for example major bank lending decisions.

Next let us turn to factor markets specifically. Here we outline the basics with more details in Section 4. As noted above land sale revenues are the main source of funds for infrastructure investment. In the highly centralized political system, to enhance their likelihood to be promoted, local officials compete for investments from other regions and encourage local business development in their jurisdictions. Manufacturers who compete on the global market are footloose and are sensitive to production costs. In response to this mobility, to attract industry and enhance GDP, local officials have to offer attractive packages in which cheap industrial land is an effective instrument (Tao et al., 2010). The complement to supplying cheap industrial land is that it tightens residential land supply and thus raises residential land prices (as well as housing prices), reducing at the margin consumer welfare. This results in radically different baseline hedonic prices for comparable properties in industrial versus residential use. Later in the section on empirics we discuss the issue of arriving at comparable properties and how we derive our estimates, but here we show the estimated ratio of residential to industrial land prices, for comparable land sold at auction in Figure 1.

In Figure 1, the ratio of residential to industrial land prices is generally well over 1, although close to 1 in a number of smaller, ordinary prefecture cities in grey dots where leaders may be less likely to be on the fast track for promotion and thus GDP growth may not be so important an objective. For bigger political cities, with ambitious leaders, such as provincial level cities, the ratio for Shanghai is 4 and in Beijing it is almost 10. For provincial capitals, the vast majority of ratios are over 2 and a number well over 4. In general, the ratio rises with the size and importance of the city. These are extraordinary wedges between prices in a market; and, below, they will reveal the weight leaders place on GDP enhancement versus resident welfare in different cities.

For capital markets, the slow reform in capital markets has been written about widely (Hsieh & Klenow, 2007; Gao, 2013; Chen et al., 2017; Brandt et al., 2013; Jefferson & Singhe, 1999). The key issue is that banks are state-owned and loans are often made on political grounds. Banks favor state owned firms nationally as is well known (Dollar & Wei, 2007), but also certain cities (Chen et al., 2017) based in part on place in the urban administrative hierarchy (Liu, 2007). In Figure 2, we show the estimated, normalized capital prices faced by firms in each city, based on work reported in the section of empirics. We note that many provincial level cities and provincial capitals face distinctly lower capital market prices, while other cities face heavy discrimination. Also, some small cities which have a tradition of a high state-owned enterprise presence face low prices. Again, these are major national distortions with considerable welfare implications.

For labor, migration restrictions are a subject of much analysis (Chan, 2010; Au & Henderson, 2006a; Au & Henderson, 2006b; Cai, 2006; Tombe & Zhu, 2019). While most formal restrictions under the hukou registration system were lifted by the early 2000's, informal restrictions keep the cost of moving extremely high, especially across provinces in rural to urban moves (Tombe & Zhu, 2019). Informal restrictions on immigrants are sometimes described as raising the doorsill especially in the biggest cities (Cai, 2006) and include poor access to public services such as schooling and to public utilities (e.g., indoor running water) in areas into which migrants are funneled (Zheng & Kahn, 2008). Different regions have different policies towards migrant workers and the history of migration paths are different across provinces. In this paper, we consider heterogeneous migration frictions in the model and estimate migration costs which limit the impact of reforms. We do look at one counterfactual based on a central government intention to divert migrants away from the largest cities by lowering the cost of migrating to less accessible hinterland locations.

3. Model

In this section, we develop a spatial general equilibrium model incorporating three factor markets. We consider a system of N cities with a fixed national population where workers can move across cities at differential migration costs. Non-traded intermediate goods are produced using capital, labor and land and are the only input into traded final goods production. Workers consume houses and a composite of tradable goods. Inter-city trade is costly. Capital is allocated to cities at different prices set by the central government. Public goods which improve production efficiency are set by city leaders and financed from land revenues, where the objective of the city government is to maximize the weighted average of the local workers' welfare per capita and the city's GDP. We now describe the model in detail.

3.1 Preferences

Consider a worker who lives in city i and provides one unit of effective labor. His base utility (with other non-market elements of realized utility defined later under the migration cost section) is $U_i = {h_i}^{\beta} {E_i}^{1-\beta}$ where h is house and $E_i = \left[\int_0^1 e_i(v)^{\frac{\sigma-1}{\sigma}} dv\right]^{\frac{\sigma}{\sigma-1}}$ is a CES composite good made up of a continuum of tradable goods. In this standard problem we have a base indirect utility function and price index of the composite good

$$V_i = \frac{w_i}{Q_i^{1-\beta} P_{hi}^{\beta}} \ ; \ Q_i = \left[\int_0^1 q_i(v)^{1-\sigma} dv\right]^{\frac{1}{1-\sigma}} ; \quad \sigma > 1 \ . \qquad (1)$$

The only worker income source is the wage, w_i . P_{hi} is the price of housing and the shares of wage spent on housing and the composite good are β and $(1-\beta)$.

3.2 Production and the factor demand

The city produces housing from land and capital. It produces an intermediate good with inputs of land, labor and capital, the value of which we call the GDP of the city, Y_i . The intermediate good is the only input into the production of public goods and tradable goods. We look at these sectors in turn.

3.2.1 Housing

Houses are produced by real estate firms according to $H_i = X_{\mathrm{Ri}}^{1-\rho} K_{Ri}^{\rho}$ where X_R is residential land and K_R is capital used in housing production. Given the price for residential land $P_{X_R i}$, and the capital price r_i which is specific to city *i*, the dual for technology from cost minimization is

$$P_{hi} = (1-\rho)^{\rho-1}\rho^{-\rho}{P_{X_R i}}^{1-\rho}{r_i}^{\rho}. \qquad (2)$$

Combining factor shares, $P_{X_R i}X_{Ri} = (1-\rho)P_{hi}H_i$ and $r_i K_{Ri} = \rho P_{hi} H_i$, with the demand for housing, we know for later reference that

$$P_{X_R i}X_{Ri} = (1-\rho)\beta w_i L_i \text{ and } r_i K_{Ri} = \rho\beta w_i L_i, \quad (3)$$

where L_i is total units of effective labor in the city paid at rate w_i.

3. 2.2 Production of the intermediate good

Traded goods production and public goods are made just from non-traded intermediate inputs, a competitive sector where the representative firm in city *i*, has technology $y_i = A_i {L_i}^{\epsilon} X_{Ii}^{\alpha_X} {L_i}^{\alpha_L} K_{Ii}^{\alpha_K}$, where $\alpha_{\mathrm{X}} + \alpha_{\mathrm{L}} + \alpha_K = 1$; *A* is the city's (endogenous) TFP; *L* is the city's effective labor used only in intermediate goods production; X_I and K_I are industrial land and capital; and there is an agglomeration economy which is captured by L^{ε}, $\varepsilon > 0$. Intermediate goods are sold at price c_i in city *i*. For later use, we define city GDP, Y_i , as

$$Y_i = c_i y_i \, . \qquad (4)$$

Where $P_{X_I i}$ is the price of industrial land in city *i,* which will differ from the residential price, from the firm's profit maximization problem we have $w_i = \frac{\alpha_L c_i y_i}{L_i}$, $\mathrm{r}_i = \frac{\alpha_K c_i y_i}{K_{Ii}}$, $P_{X_I i} = \frac{\alpha_X c_i y_i}{X_{Ii}}$. From these, we get the unit cost and rearrangement of that into a wage equation, as well as the derived demands for capital and land in intermediate goods production.[6]

$$c_i = \varphi(A_i L_i^{\epsilon})^{-1} P_{X_I i}{}^{\alpha_X} r_i^{\alpha_K} w_i^{\alpha_L}. \quad (5a)$$

$$w_i = [\varphi^{-1} c_i A_i L_i{}^{\varepsilon} P_{X_I i}{}^{-\alpha_X} r_i{}^{-\alpha_K}\ ]^{1/\alpha_L}. \quad (5b)$$

$$K_{Ii} = \varphi_1 [c_i A_i L_i{}^{\varepsilon+\alpha_L} P_{X_I i}{}^{-\alpha_X} r_i{}^{-(\alpha_L+\alpha_K)}]^{1/\alpha_L} \quad (6)$$

$$X_{Ii} = \varphi_2\ [c_i A_i L_i{}^{\varepsilon+\alpha_L} P_{X_I i}{}^{-(\alpha_X+\alpha_L)} r_i{}^{-\alpha_K)}]^{1/\alpha_L} \quad (7)$$

Also using the wage expression in (5b), we can derive the demands for land and capital by the city's housing sector which are

$$X_{\mathrm{Ri}} = (1-\rho)\beta[\ \varphi^{-1} c_i A_i L_i{}^{\varepsilon+\alpha_L} P_{X_I i}{}^{-\alpha_X} r_i{}^{-\alpha_K}\ \ P_{X_R i}{}^{-\alpha_L}]^{1/\alpha_L}. \quad (8)$$

$$K_{\mathrm{Ri}} = \rho\beta[\ \varphi^{-1} c_i A_i L_i{}^{\varepsilon+\alpha_L} P_{X_I i}{}^{-\alpha_X} r_i{}^{-(\alpha_L+\alpha_K)}]^{1/\alpha_L}\ . \quad (9)$$

3.2.3 Pubic goods

There is a public sector in each city supplying public infrastructure, G_i, such as transportation and communications, improving the efficiency of intermediate good producers operating in the city by helping firms interact and even reducing commuting times so workers are more efficient. For simplicity this is modelled as improving firm TFP of the city such that

$$A_i = A_i{}' G_i{}^{\gamma}, \quad (10)$$

where $A_i{}'$is a measure of the city's base production amenities assumed to be exogenous, and $\gamma > 0$ captures how effective the government's investment in public goods is in enhancing TFP. The government decision as to the level of public investment is modeled later. Here implications of the government budget constraint are discussed.

In the Chinese context, the city government collects fiscal revenues from selling industrial land and residential land and uses that money to finance these infrastructure investments. G is produced one-for-one out of intermediate goods. We do not cover local consumer public goods like schools, many of which are provided at the district or even neighborhood level. One could think of these as being Tiebout (1956) public goods where sorting across neighborhoods leaves

[6] $\varphi \equiv \alpha_L^{-\alpha_L} \alpha_K^{-\alpha_K} \alpha_X^{-\alpha_X}$; $\varphi_1 \equiv \alpha_K^{\frac{\alpha_K+\alpha_L}{\alpha_L}} \alpha_X^{\frac{\alpha_X}{\alpha_L}}$; $\varphi_2 = \alpha_X^{\frac{\alpha_L+\alpha_X}{\alpha_L}} \alpha_K^{\frac{\alpha_K}{\alpha_L}}$

then akin to private consumer goods. For infrastructure investments, *G*, the public budget constraint is

$$G_i = \left(P_{X_I i} X_{Ii} + P_{X_R i} X_{Ri}\right) c_i{}^{-1} \qquad (11)$$

Using the factor demand relationships and the demand for housing, the RHS of (11) can be written as $(\alpha_X c_i y_i + (1-\rho)\beta\alpha_L c_i y_i)c_i^{-1} = (\alpha_X \alpha_L{}^{-1} w_i L_i + (1-\rho)\beta w_i L_i)c_i^{-1}$. Substituting $A_i = A_i{}' G_i{}^{\gamma}$ into the wage equation (5b) and then the wage equation into the budget, with rearrangement we have:[7]

$$G_i = \varphi_3 \left[\, c_i^{1-\alpha_L} A_i' L_i{}^{\varepsilon+\alpha_L} P_{X_I i}{}^{-\alpha_X} r_i{}^{-\alpha_K}\right]^{1/(\alpha_L-\gamma)}. \qquad (11a)$$

3.3 Trade and consumer market access

We adopt a conventional trade framework based on Eaton & Kortum (2002) as applied, for example, in Donaldson & Hornbeck (2016) or Alder (2019). Each city produces a continuum of tradable goods of mass one. For variety *v* in city *i,* the production technology is $t_i(v) = B(v)y_i(v)$, where $t_i(v)$ is the city's output of variety *v*, $y_i(v)$ is the amount of intermediate goods used in the production of *v*, and $B(v)$ is a productivity shock to variety *v* in city i . The shock follows a Frechet distribution with cdf $F(B(v)) = exp\left(-B(v)^{-\theta_t}\right)$ and is i.i.d. across cities and varieties. The unit cost of variety *v* is thus $c_i/B(v)$, noting that we already have a production amenity that is city specific A'_i. The trade cost between city *i* and *n* is defined in iceberg fashion: if one unit of good is to arrive at city *n*, then $d_{in} \geq 1$ units of good need to be shipped from city *i*. We assume symmetric pairwise trade cost so $d_{in} = d_{ni}$. Given the trade cost, the actual price that city *n* pays for one unit of variety *v* from city i is $p_{in}(v) = d_{in}c_i/B(v)$. Notice the tradable goods producers are competitive, so they earn zero profits. The workers in city *n* choose different varieties of tradable goods from all cities.

In this framework, the probability that city *n* demands varieties from city *i* by offering the lowest price to city *n* is simply $\pi_{\text{in}} = \frac{\left(c_i d_{in}\right)^{-\theta_t}}{\sum_{i=1}^{N}\left(c_i d_{in}\right)^{-\theta_t}}$. With the continuum of goods, this probability just equals the fraction of city *n*'s total expenditure on city *i*'s good. The value of total demand for city *i*'s tradable goods is based on the share of labor incomes spent on tradable goods, the share of labor in output and these π_{in} fractions. The value of total demand is

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[7] $\varphi_3 \equiv \{[\alpha_X + (1-\rho)\beta\alpha_L](\alpha_X)^{\frac{\alpha_X}{\alpha_L}}(\alpha_K)^{\frac{\alpha_K}{\alpha_L}}\}^{\frac{\alpha_L}{\alpha_L-\gamma}}$

$\sum_{n=1}^{N} \pi_{in}(1-\beta) w_n L_n = \sum_{n=1}^{N} \frac{\left(c_i d_{in}\right)^{-\theta_t}}{\sum_{i=1}^{N}\left(c_i d_{in}\right)^{-\theta_t}} (1-\beta)\alpha_{\mathrm{L}} c_{\mathrm{n}} y_n$. On the supply side, the value of production is the value of inputs going into traded good production in city i. Those inputs are total intermediate good production less inputs into G and payments to capital owners, or $c_i y_i - c_i G_i - r_i(K_{Ii} + K_{Ri})$. Substituting for G from (11) in terms of rents $\left(P_{X_I i} X_{Ii} + P_{X_R i} X_{Ri}\right)$ and then for factor shares in y production (e.g., $P_{X_I i} X_{Ii} = \alpha_X c_i y_i$) and labor shares in that production (e.g., $r_i K_{Ri} = \rho\beta\alpha_L c_i y_i$)), the value of inputs going into production of tradeables in city i is $(1-\beta)\alpha_L c_i y_i$. Equating this to the value of demand, we get $(1-\beta)\alpha_L c_i y_i = \sum_{n=1}^{N} \frac{\left(c_i d_{in}\right)^{-\theta_t}}{\sum_{i=1}^{N}\left(c_i d_{in}\right)^{-\theta_t}} \left(1-\beta\right) \alpha_{\mathrm{L}} c_{\mathrm{n}} y_n$. Then using (4) this becomes

$$Y_i = \sum_{n=1}^{N} \frac{\left(c_i d_{in}\right)^{-\theta_t}}{\sum_{i=1}^{N}\left(c_i d_{in}\right)^{-\theta_t}} Y_n . \qquad (12a)$$

Finally, we note the following conventional relations based on the distribution of minimum prices faced by consumers in city i for the realized price index in (1) and for city's i's consumer market access [CMA] (Donaldson and Hornbeck, 2016):

$$Q_i = \left[\Gamma\left(\frac{\theta_t+1-\sigma}{\theta_t}\right)\right]^{\frac{1}{1-\sigma}} \cdot \left[\sum_{j=1}^{N}\left(c_j d_{ji}\right)^{-\theta_t}\right]^{-\frac{1}{\theta_t}} = CMA_i^{-1/\theta_t}. \qquad (13)$$

If we define $\kappa \equiv \left[\Gamma\left(\frac{\theta_t+1-\sigma}{\theta_t}\right)\right]^{\frac{-\theta_t}{1-\sigma}}$ using (13), then (12a) can be written as

$$Y_i = \kappa c_i^{-\theta_t} \sum_{n=1}^{N} \frac{d_{in}^{-\theta_t}}{\kappa \cdot \sum_{i}^{N}\left(c_i d_{in}\right)^{-\theta_t}} Y_n = \kappa c_i^{-\theta_t} \sum_{n=1}^{N} \frac{d_{in}^{-\theta_t}}{CMA_n} Y_n , \qquad (12b)$$

where in (12b) on the RHS, the term under summation is proportional to firm market access [FMA], defined in the literature (e.g., Donaldson & Hornbeck 2016).

3.4 Migration and the spatial allocation of population and effective labor

In this subsection, we describe migration flow, derive the amount of effective labor for each city, and national effective labor supply. A worker who moves from city n to city i has the following realized utility

$$U_{ni} = Z_i a_i V_i g_{ni}$$

where Z_i denotes the amenity of living in city i and V_i is the base utility of city i defined in eqn. (1). This worker gets a random productivity draw a_i in city i from a Frechet distribution with cdf $\Psi\ (a_i) = e^{-a_i{}^{-\theta}}$, where θ is the dispersion parameter. We assume the draw is independent across cities and workers. The worker's effective labor supply is a_i and she earns $a_i w_i$ if she moves from city n to city i . $g_{ni} \leq 1$ is the fraction of utility left-over net of migration costs, where we assume $g_{ii} = 1$ so that the stayers suffer no migration cost.

Workers from city n choose to move to cities that can bring the highest net utility to them. As is standard, the proportion of people moving from n to i is

$$M_{\text{ni}} = Prob(U_{ni} > \max\{U_{ns}, s \neq i\}) = \frac{(Z_i V_i g_{ni})^\theta}{\sum_s (Z_s V_s g_{ns})^\theta} \qquad (14)$$

For N cities in the economy, the migration flow matrix determined by equation (14) implies a relationship between initial and final population that

$$\tilde{L}'_i = \sum_{\text{n}\in\text{N}} \frac{(Z_i V_i g_{ni})^\theta}{\sum_{k\in N}((Z_k V_k g_{nk})^\theta)} \cdot \tilde{L}_n. \qquad (15)$$

$\tilde{L}_i$ is the population of city i in an initial year (which will be 2000), while $\tilde{L}'_i$ is the population of city i in the current equilibrium (which will be 2010). We normalize the 2000 population to be the same as the 2010 given national population growth is not a focus. Thus, the labor supply constraint is

$$\sum_{n\in N} \tilde{L}_n = \sum_{n\in N} \tilde{L}'_n = \tilde{\tilde{L}}. \qquad (16)$$

Apart from bodies, there is the allocation of effective labor. The total effective labor at city i is given by $\text{L}_\text{i} = \sum_n E(a_i | moving\ from\ n\ to\ i) * \tilde{L}_n * M_{ni}$. Thus total effective labor of city i is provided by workers from various origins multiplied by their corresponding average productivity conditional on moving to city i. The average productivity conditional on moving from city n to city i is given by $\text{E}(a_i | moving\ from\ n\ to\ i) = \left(\frac{1}{M_{ni}}\right)^{\frac{1}{\theta}} \cdot \Gamma(1 - \frac{1}{\theta})$. Here the average labor productivity conditional on moving from city n to city i is inversely related to the migration share. Intuitively, more people moving to the same city means that the productivity draws reach deeper into the distribution. Combining the above two conditions yields

$$L_i = \sum_n \tilde{L}_n \, M_{ni}^{1-\frac{1}{\theta}} \Gamma(1 - \tfrac{1}{\theta}). \qquad (17)$$

A greater inflow of migrants to city i will increase total effective labor, but average labor productivity will be lower.

3.5 City government's decision on land supply

As discussed in the introduction, each local government maximizes an objective function, given certain weights to the welfare of a representative worker, $(1-f)$, versus to total output value, f.[8] Informed by the institutional background, we assume the local government chooses the allocation of industrial land versus residential land, given the fixed total land supply to maximize the objective function. Thus, for any city i, the local government's objective function is

$$\max_{s_i} V_i^{1-f_i} Y_i^{f_i} \qquad s.t. \, s_i \bar{X}_i = X_{Ri}, \; (1-s_i)\bar{X}_i = X_{Ii} \qquad (18)$$

where $\bar{X}$ is the total amount of available land in city i and s_i the share going to residential use. $Y_i = c_i \, y_i$, the measure of local GDP. Before solving this problem, we need to express the two equilibrium outcomes Y and V as functions of X_I, X_R and the effective labor L.

For Y_i, applying the public good eq.(11a) and $P_{X_I} X_I = \alpha_X Y$ and $wL = \alpha_L Y$ from the factor share equations to the unit cost eqn. (5), we can express the unit cost c as a function of industrial land X_I, Y and effective labor L. Then substituting the result into (12b) for Y, and using the definition of s_i, we get Y as a function of the share of residential vs. industrial land, total available land and effective labor[9]

$$Y_i = F_i \left[A_i' \varphi_4 \, r_i^{-\alpha_K} \bar{X}_i^{\alpha_X} (1-s_i)^{\alpha_X} L_i^{\epsilon+\alpha_L} \right]^{\frac{\theta_t}{(1-\gamma)+\theta_t(\alpha_X+\alpha_L-\gamma)}},$$

$$F_i = \left(\kappa \sum_{n=1}^{N} \frac{d_{in}^{-\theta_t}}{CMA_n} Y_n \right)^{\frac{1-\gamma}{(1-\gamma)+\theta_t(\alpha_X+\alpha_L-\gamma)}} \qquad (12c)$$

The term inside the parentheses of F_i is proportional to what is termed firm market access [FMA]

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[8] This weight may reflect the local leader's preference. Because the central government evaluates the local leader largely based on the local economic performance; i.e. total output, higher GDP will help the local leader's political career. If the local leader cares more about her own political career, she may place more weight (higher f) on output (Wang, Zhang and Zhou, 2019).

[9] $\varphi_4 \equiv [(1-\rho)\beta\alpha_L + \alpha_X]^{\gamma} \alpha_K^{\alpha_K}$

in the literature, as noted above.

Next, for the base utility per unit effective labor, V_i, we apply $P_{X_R}X_R = (1-\rho)\beta\alpha_L Y$ to the housing price eq. (2) to housing price P_h in terms of residential land and output. We use w $= \alpha_L Y/L$ and then substitute for P_h, w , and for Q from (13) into the base utility eqn. (1), to obtain $V_i = \vartheta \frac{Y_i^{1-\beta(1-\rho)} \cdot CMA_i^{\frac{1-\beta}{\theta_t}} \cdot s_i^{\beta(1-\rho)} \bar{X}_i^{\beta(1-\rho)}}{L_i \cdot r_i^{\rho\beta}}$, where ϑ is a constant. Substituting eq. (12b) into (16), we obtain V as a function of the share of residential vs. industrial land, total available land and effective labor

$$V_i = \Omega_i B_i \left\{ \left[(1-s_i)^{\alpha_X} L_i^{\epsilon+\alpha_L}\right]^{\frac{\theta_t(1-\beta(1-\rho))}{(1-\gamma)+\theta_t(\alpha_X+\alpha_L-\gamma)}} s_i^{\beta(1-\rho)} \bar{X}_i^{\beta(1-\rho)} / L_i \right\}$$

$$B_i = \left[r_i^{-\beta\rho - \frac{\alpha_K \theta_t(1-\beta(1-\rho))}{(1-\gamma)+\theta_t(\alpha_X+\alpha_L-\gamma)}} F_i^{(1-\beta(1-\rho))} CMA_i^{\frac{1-\beta}{\theta_t}} \right] . \qquad (1a)$$

Ω_i is a city constant., including exogenously given city amenities and total land.

In eqn. (18) after incorporating the constraint defining s_i, the first order condition of the city government's optimization problem is

$$(1-f_i) \cdot \left(\frac{\partial \ln V_i}{\partial s_i} + \frac{\partial \ln V_i}{\partial lnL_i} \cdot \frac{\partial lnL_i}{\partial s_i} \right) + f_i \cdot \left(\frac{\partial \ln Y_i}{\partial s_i} + \frac{\partial \ln Y_i}{\partial lnL_i} \cdot \frac{\partial lnL_i}{\partial s_i} \right) = 0. \quad (19)$$

The idea is that the observed choice in calibration of s_i in this FOC will reveal the city weights f_i . The key problem in solving (19) is that in principle the choice of s_i has general equilibrium effects throughout the economy affecting all CMA and all Y in the calculation of trade flows. Second, we must for now take r_i as a policy given; later in counterfactuals it would also be subject to general equilibrium effects. To deal with this as fully rational, the local government would need to resolve the whole economy equilibrium response to its choice of s_i . We assume the city government takes as fixed *r, F* (which is proportional to FMA), and CMA, as it is just one of 266 cities. Next in (19), to calculate $\frac{\partial lnL_i}{\partial s_i}$ would also require the local government to solve a general equilibrium problem. It is plausible that the city leader could recognize some direct impact of s_i in making the city more or less attractive to live in, although given our later high migration costs and those in Tombe & Zhu (2019) for China it is also plausible that the leader assumes $\frac{\partial lnL_i}{\partial s_i} = 0$. Under bounded rationality in Appendix A4 we consider what the leader might reasonably perceive as a non-zero $\frac{\partial lnL_i}{\partial s_i}$ and redo the optimization problem. Below, we note the impact of that on our ultimate goal, to solve for f_i's. Here we do the simpler case $\frac{\partial lnL_i}{\partial s_i} = 0$.

With these assumptions from (1a) and (12c) just above, we can obtain $\frac{\partial \ln V_i}{\partial s_i} = \beta(1-\rho)\frac{1}{s_i} - \frac{\alpha_X(1-\beta(1-\rho))}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)} \cdot \frac{1}{1-s_i}$, $\frac{\partial \ln V_i}{\partial \ln L_i} = \frac{(\epsilon+\alpha_L)(1-\beta(1-\rho))}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)} - 1$, and $\frac{\partial \ln Y_i}{\partial s_i} = \frac{\alpha_X}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)} \cdot \frac{-1}{1-s_i}$.

Substituting these into the leader's first order condition (19), and after factoring out and re-arranging items, we can solve for the optimal ratio of residential land to industrial land as

$$\frac{1-s_i}{s_i} = \frac{\theta_t\alpha_X(1-(1-f_i)\beta(1-\rho))}{(1-f_i)\beta(1-\rho)(1-\gamma+\theta_t(\alpha_X+\alpha_L-\gamma))} \quad (20a)$$

Correspondingly, the price ratio of residential land to industrial land given factor demand equations is

$$\frac{P_{X_R i}}{P_{X_I i}} = \frac{\theta_t\alpha_L(1-(1-f_i)\beta(1-\rho))}{(1-f_i)(1-\gamma+\theta_t(\alpha_X+\alpha_L-\gamma))} \quad (20b)$$

From (20a) and (20b), the higher the weight, *f*, that a city government places on GDP, the higher is the share of industrial land in the city's total land supply, and the higher the resulting residential relative to industrial land price.[10]

Note because of the specific way of financing public goods, our model setup is not a first best problem. Hence even if the political weight on output f is 0 -- i.e., no distortion from trying to maximize GDP-- we still won't have the land price ratio given by (20b) equal to 1, which would be a feature of the first best. A first best in counterfactuals would, amongst other things, not have a public budget constraint where all and only land rents are used to finance public goods. While the latter would hold in a Henry George world with an endogenous number of optimal city sizes (Flatters, Henderson and Mieszkowski , 1974), here the number of cities/prefectures is fixed and the constraint bites. Here, if, for example, $f = 0$ and $\gamma \to 0$ and $\theta_t \to \infty$, then $P_{X_R} < P_{X_I}$ (noting then that the numerator [denominator] in (20b) will be less [greater] than α_L). For the

[10] Note if $f = 1$, there will be a corner solution where the government would like to lower land for housing towards 0 and raise housing price towards infinity.

parameters we use below, the price ratio is 0.64, if $f = 0$.

3.6 Closing the model

Other elements include the following. Summing within city for land gives us each city's land supply ($\bar{X}_i$) and summing within and across cities gives the national supply of capital ($\bar{K}_{agg}$).

$$X_{Ri} + X_{Ii} = \bar{X}_i \qquad (21a)$$

$$\sum_{\mathrm{i}} K_{I,i} + \sum_i K_{R,i} = \bar{K}_{agg} \qquad (21b)$$

To assess counterfactuals, we need a welfare measure for workers, where capital income is a separate welfare item applying to "capital owners". Total national consumer welfare, as is conventional, is expressed as[11]

$$\mathrm{W} = \sum_{\mathrm{i}=1}^{\mathrm{N}} \frac{\tilde{L}_i}{\sum_{j=1}^{N} \tilde{L}_j} \cdot \beth\left[\sum_{k \in N} (Z_k V_k d_{ik})^{\theta}\right]^{\frac{1}{\theta}}, \qquad (22)$$

where $\beth = \Gamma(\frac{\theta - 1}{\theta})$, from the gamma function (Tombe & Zhu, 2018). Note that the expected utility of all people originating from city i is

$$\mathrm{E}[\mathrm{U_i}] = \beth\left[\sum_{k \in N} (Z_k V_k d_{ik})^{\theta}\right]^{\frac{1}{\theta}}. \qquad (23)$$

Relative inequality (weighted by the initial population) is thus measured by

$$\mathrm{Inequality_o} = \sum_{\mathrm{i}}^{\mathrm{N}} \frac{\tilde{L}_i}{\sum_{j=1}^{N} \tilde{L}_j} \cdot (\mathrm{E}[\mathrm{U_k}]/\mathrm{W} - 1)^2 \qquad (24).$$

3.7 Calibrating the model: The process

To calibrate the model, we need data for each city on the price of capital, the prices of residential

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[11] It is also possible to derive expressions to calculate average welfare and inequality based on where people end up. With the Frechet distribution, $\mathrm{E}[\mathrm{U_i}] = \mathrm{E}[\mathrm{U_i} | \mathit{moving\ to\ city\ k}]$, for any destination city k. Therefore, the average welfare of people currently living in city k (after migration) is given by$\mathrm{E}[\tilde{U}_\mathrm{k}] = \sum_{\mathrm{i \in N}} \frac{\tilde{L}'_{ik}}{\tilde{L}'_k} \mathrm{E}[\mathrm{U_i} | \mathit{moving\ to\ city\ k}] = \sum_{\mathrm{i \in N}} \frac{\tilde{L}'_{ik}}{\tilde{L}'_k} \cdot \beth\left[\sum_{s \in N} (Z_s V_s d_{is})^{\theta}\right]^{\frac{1}{\theta}} \cdot$ Thereby we can also define another measure of inequality using $\mathrm{E}[\tilde{U}_\mathrm{k}]$,$\mathrm{Inequality_d} = \sum_{\mathrm{k}}^{\mathrm{N}} \frac{\tilde{L}'_k}{\sum_{j=1}^{N} \tilde{L}'_j} \cdot \left(\mathrm{E}[\tilde{U}_\mathrm{k}]/\mathrm{W} - 1\right)^2$

and industrial land, GDP (Y), initial and final populations, and migration and transport costs to all other cities. We have data on GDP and populations form Yearbooks and the Census. Transport cost data are taken from Baum-Snow, Henderson, Turner, Zhang, & Brandt (2020) as explained in Appendix A.2. In the next section we show how we derive hedonic residential and industrial land prices, capital prices, and migration costs for every city. Given these data we can calibrate the model and solve for the f's. What are the steps?

Given (14) and (15) we can pin down migration flows, M_{ni} , $Z_i V_i$, and effective labor, L_i , for each city. From the FOC's for land use in housing and intermediate good production, given land prices, we solve for s_i for each city from $\frac{P_X^I}{\mathrm{P_X^R}} = \frac{\alpha_X}{(1-\rho)\beta\alpha_L} \cdot \frac{s_i}{1-s_i}$. Given the s_i's, from (20a), we get the f_i 's. We solve for the c_i's from eqn. (12a). We substitute for w from (5b) and then for G from (11a) into $Y = \frac{wL}{\alpha_L}$ to solve the A'_i , A_i, and G_i for each city. We use eqns. (6) – (9) to solve for each city's use of land and capital in residential and industrial use. Summing within city for land gives us each city's land supply ($\bar{X}_i$) and summing within and across cities gives the national supply of capital ($\sum_{\mathrm{i}} K_{I,i} + \sum_i K_{R,i} = \overline{K}_{agg}$). Eqns (2), (13) and (1) give us $P_{hi}, CMA_i\ Q_i,$ and V_i . Having already solved for $Z_i V_i$, we then know consumer amenities Z_i. Later we can use this information to calculate worker welfare. More details are in Appendix A1.

4. Empirical work

We now turn to the empirical work where we estimate the hedonic land prices by use type in each city and migration costs for China and the prices of capital by city. Then we turn to migration costs.

4.1 Hedonic land prices

We estimate land prices in every city in the residential versus industrial sector for the same quality piece of land. We have a large micro-level dataset that covers all the land transactions in Chinese cities for 15 years. The data set includes all land parcels that are sold through public auction of land in China (most common for residential land transactions since August 2004 and for industrial land since July 2007), but also those through negotiated sales (most common for industrial land transactions before July 2007). It contains residential, commercial and industrial land transactions. The sole allowed land use of a parcel is specified prior to auction, based on the overall supply decisions of the city. It is by far the most comprehensive land transaction data of urban China. This dataset is obtained from the website http:// landchina.mlr.gov.cn where China's Ministry of Natural Resources posts timely land transaction information to the public.

To have sufficient sample by use in each city, we use the data for the years 2008-2015, after the auction reforms. We run hedonic regressions while controlling for year fixed effects, in order to compare prices for equal quality land in different cities in different uses. To fit our model, we combine industrial land transactions with pure commercial land transactions (a small portion of total transactions) to form the (general) industrial land transactions. We exclude all transactions via negotiated sales because, since July 2007, the central government of China has enforced public auction for industrial land. Since then the majority of industrial land deals have been through auction (see Tan, Wang, & Zhang 2020), and those that are not we suspect are one-off either very corrupt or unusual transactions (de facto transfer of ownership among state owned enterprises at symbolic prices). We also drop outlier transactions with either zero price or price per square meter greater than 100k RMB.

There are 120,019 industrial (and commercial) land transactions, and 60,753 residential land transactions with no missing information, covering 266 cities nationwide. With eight years pooled, all cities have more than 40 land transactions and a majority of them have more than 100 transactions, for industrial land and residential land together. We run regressions for each city j. The regression specification is as follows

$$log\left(P^j_{X,it}\right) = b^j_0 + \beta^j R_i + I^j_t + D^j_i + \epsilon^j_{it} \,. \qquad (25)$$

In (25), $P^j_{X,it}$ is the unit (sq. mt.) sale price of the land parcel i, R_i is a vector of parcel characteristics including land area, maximum FAR, land quality tier, auction format, and distance to city center and its interaction with land area,[12] which coefficient vary by city, I^j_t is the city transaction year fixed effect. Finally, D^j_i is a land use type dummy with "1" for "residential" and "zero" for "industrial" in city *j*. Thus $exp(\,D^j_i)$ is the hedonic price ratio of residential land to industrial land in city *j*.

For each city we save the estimated coefficient vector denoted as π^j. We then predict the hedonic land price for city j and *each land use type* using π^j and the same set of characteristics of a national proto land parcel, according to the above hedonic regression equation. The characteristics of the proto land parcel are chosen as the national means of the above noted land

[12] These include total area of the land parcel, the regulatory maximum floor-area-ratio of the land to be developed, dummy variables for the quality tier of the parcel (in China, the city government categorizes the urban land into different tiers based on the amenity quality of land), the land parcel's distance to city center, the distance to the urban district center, and dummy variables for the auction format, which includes English auction, two-stage auction, and sealed-bid auction. Cai, Henderson, & Zhang (2013) show transaction format may significantly impact the land sale price.

characteristics of the combined residential land and industrial land sample. This then gives us our data for a nationally representative piece of land city by city by type.

In Figure 1, we plotted the relative price of residential to industrial land. The ratios range between 0.70 and 9.6 for the same quality land, with a median of 2.2 across all cities.[13] As noted above, cities like Tianjin, Nanchang or Shenzhen which are testing grounds for future national leaders who will be tasked with growing the economy have very high ratios. This also will reflect the extraordinarily high house prices in such cities displayed later, which are driven by land supply restrictions favoring industrial use.

4.2 Capital costs

Banks in China today remain de facto state owned. There have been extensive reforms over the last 20 years designed to put banks more on a market basis and to try to reduce the extent of non-performing loans. However, the Committee of the Chinese Communist Party retains the power to appoint the boards of directors and senior management of banks and offer directives. The state's interest is beyond the efficient allocation of capital and includes vague criteria such as “stability”, “lawfulness”, and national “macroeconomic measures”. Individuals appointed to bank senior management posts are personnel with high-level standing in the Communist Party hierarchy (Howson, 2009) and move between government and state bank corporate functions. As such, it is difficult for state owned banks to operate independently while facing pressure from different levels of government. Well known is the favoritism displayed toward state owned firms with evidence in Jefferson & Singhe (1999), Au & Henderson (2006a), Dollar & Wei (2007), and Chen et al. (2017).

Less well known and of focus here is spatial bias. Liu (2007) notes that while bank lending is concentrated on China's state-owned enterprises [SOE], it is also concentrated on major cities, which supposedly lead national economic growth. Commercial banks in China have cautiously retrenched credit-extending authority from their local branches (Liu, 2007), so that below the provincial level, they have limited autonomy to extend credit to new clients and investment projects. Branches in cities are allocated funds for loans with stated priorities, and such allocations may reflect the political influence and connections of local leaders to provincial and national leaders, as they attempt to garner credit for enterprises in their cities. Chen et al. (2017) argue that there is a lot of variation in local practices both in interest rate manipulation and

[13] One city with a ratio of 0.49, Deyang in Sichuan, was winsorized at the next lowest ratio in the data of 0.7019. This avoids having any $f<0$.

charges and in default provisions.[14]

Using the Annual Survey of Medium and Large Industrial firms for 1998-2007 accounting for 95% of industrial sales in China, Chen et al. (2017) estimate a traditional average revenue product [ARP] equation to quantify specific differentials in the price of capital faced by firms under different circumstances, just as in Song & Wu (2013) and Dollar & Wei (2007). Like Dollar & Wei (2007), Chen et al. (2017) find that SOE's have deep discounts on the price of capital. However, they also find that some provincial level and coastal cities have strong discounts of up to 30% or more for private firms, with strong year-by-year persistence in the price of capital for cities.

Using the data from the Annual Survey of Medium and Large Industrial Enterprises for 2006-2007, we simplify and estimate a single price of capital facing each city. We use a very simple form to the ARP equation based on the model, but considering industrial composition. For firm s in industry j in location i, from profit maximization

$$\ln\left(\frac{p_{ji}^{*}y_s}{k_s}\right) = \ln(r_i) - \ln\alpha_{Kj} + \epsilon_{ijs}\ . \qquad (26)$$

p_{ji}^{*} is the output price to the firm net of VA taxes. y_s and k_s are output and input of capital. r_i is the price of capital specific to city i , identified by city fixed effects. The α_{Kj} are industry fixed effects, capturing differences in capital intensity. The city capital price term reflects the *combined* influences of cities having greater shares of more favored SOE's and having more favored allocations for private firms. The city-specific prices of capital are from firm level data pooled for 2006 and 2007 (accounting for time fixed effects).

The resulting prices of capital normalized to Guangzhou at 1 were shown above in Figure 2. Three things are of note. First the price of capital rises with city size, which captures in part the fact that smaller and typically more remote cities such as in the north still have a high representation of SOE's with their low prices. Second, as noted earlier, certain political cities face very low prices. Finally, there is the wide dispersion in prices, a key issue in the original Hsieh and Klenow (2007) paper.

4.3 Estimation of migration costs

[14] Corruption in the disbursement of loans is analyzed in Nan & Meng (2009).

There is a large literature on migration restrictions in China; and we note papers by Chan (2010), Au & Henderson (2006a, 2006b), Cai (2006), and Tombe & Zhu (2019). Early papers focused on formal migration restrictions. Post 2000, there are no longer formal migration restrictions in China. Instead the policy is to 'raise the doorsill' and make life unpleasant for migrants in cities (Cai, 2006; Lim, Spence, Proter, & Romer, 2011). But other factors such as the development of migration networks may be important. To see this we quantify migration costs with our own data. Despite some differences in approach and data results are similar to Tombe & Zhu (2019). We do not dwell on this aspect of factor markets for two reasons. First our model is static, whereas migration involves forward looking dynamic behavior (Kennan & Walker, 2013; Balboni, 2019). We simply want a way to incorporate migration restrictions to explain equilibrium utility differences across cities. Second it is not clear how to formulate a counterfactual other than to pick an ad hoc arbitrary reduction in migration costs.

In quantification, we do not assume symmetry in migration costs (Bryan & Morten, 2019), because in China provincial barriers to in-migration and the history of migration paths may differ across provinces, so that the cost of moving from Beijing to Sichuan may differ than that for moving from Sichuan to Beijing (Tombe & Zhu, 2019). We focus on a formulation where there are asymmetric fixed costs of entering a province, but variable symmetric travel time costs. Tombe & Zhu find huge migration costs for China, based on low interprovincial flows, given barriers for rural migrants moving across provincial boundaries to take urban jobs. The implication is that people may be stuck in low productivity or undesirable places, which is a key efficiency and welfare issue.

Given the migration formulation in (14), migration costs (fraction of utlity lost at the destination when migtrating) are denoted as g_{ni}, which we decompose into $= t_{ni} * \tilde{t}_i$, where t_{ni} is variable, time- distance-based part of migration costs, and $\tilde{t}_i$ is a destination sunk cost. To get these costs, we use a formulation of province to province migation costs, based on the 2010 census. These give fixed and variable costs of inter-provincial migration. The formulation is standard, where, as in equation (14), migration costs can be inferred from flows. Then based on 2000 census information, we adjust these data to further infer within province fixed costs of movement. We then apply these results to specifying city-to-city fixed and variable migration costs (versus the province to province ones that we estimate). Appendix A3 gives more details and the assumptions under which the method of using province to province costs to infer city-to-city costs is valid. The costs we obtain are displayed in Figures 3 and 4.

Figure 3 plots the relative fixed costs of entering a province, with the 3 regions marked by color. Note a higher value means lower costs, or more real income survives $\tilde{t}_i$. The places with the lowest entry costs are Guangdong and Zhejiang provinces, but Beijing and Shanghai have also relatively low entry costs. Note these are east coast provinces. The most difficult places to enter are Shanxi, Ningxia, and Henan. Beijing and Shanghai resist immigration by offering migrants poor living conditions with poor housing facilities in migrant areas and poor access to state schools.[15] Yet they have relatively low fixed costs of entry as shown here based on huge inflows; the growth rate of migrants from outside the province in these cities in the 2000-2010 time period was 11-12% a year. The reality is that these cities have developed large long term migration networks, with, for example, many neighborhoods named after the origin of migrants there. These networks help migrants find housing, jobs and information on how to navigate the city and its regulations and restrictions. It is clear that typical doorsill policies are not enough to offset the years of development of the networks and their benefits. While intending not to be, Beijing, in net, given its history of migration, is a relatively welcoming place overall.

Figure 4 plots the total moving costs of all city pairs, g_{ni} where, again, a higher number is a lower cost, with more utility left over. While there are within provinces moves where migration costs are low, for the vast majority it costs more than half of a person's real income to move. Moreover, given the high costs of inter-province migration relative to within province moves, the vast majority of city pairs involving interprovincial moves (albeit relatively few moves) leave only 5-40% of real income. These numbers on what real income is left after migration are actually higher than in Tombe & Zhu (2019). While one can quiblle over absolute magnitudes, for later counterfactuals they will give *relative* gains from changing migration regimes, as well as impacts on city populations.

5. Calibration results

From Section 3.7, we can calibrate given the data we have assembled. We do need to specify parameters we don't estimate. We assume some parameter values from the literature as listed in Table 1. Given those parameters and the value added in production (or Y) for each the city which is recorded as city "GDP" for 2010, the estimated prices for capital, residential land and industrial

[15] There is a 2011 survey conducted by China's National Health and Family Planning Commission which covers 106,000 migrant families nationally, although these may be longer term migrants. We examined the data, which after controlling for household characteristics, suggests that in cities like Beijing, Shangahi and Tianjin households are significantly less likely to have indoor toilets and showers relative to east coast ordinary prefecture level cities. Such cities tend to offer migrants poorer access to social security and health care (Cai, 2006), but schooling is a big issue. In the biggest cities, migrant children may be denied entry to local state schools. Parents can send children to local 'private' schools which have quasi-legal status, are subject to shut-down, and have unqualified teachers (Kwong 2004) or can 'leave children behind' in home villages where they are cared for by grandparents and others. Based on the 2011 survey noted above, we find the stated cities tend to have significant fractions of children in private school and left behind, even though the survey may tend to capture longer term migrants.

land in each city, migration costs, and beginning (2000) and final population (2010) for each city, we can recover the other city-specific parameters as well as the equilibrium quantities of endogenous variables of the model. These are $A', G, c, f, X_{Ii,} X_{Ri,} K_{Ii,} K_{Ri}$, and Z. From the X's we know total land supply for each city and total capital stock of the nation, both in fictious units. The numeraire is the price of capital in Guangzhou, so all initial capital rents are divided by the price in Guangzhou.

The focus in this subsection is on evaluating our estimates of A', G, c, f, and Z. In Table 2, we provide a simple table of regressions of these magnitudes on a set of covariates. City productivity in col. (1) rises with education, which makes sense because labor is not in education units. Productivity rises with population and better political status of the city, perhaps reflecting Chinese policy on how resources affecting innovation were handled historically. Related, as we can see that cities that received initial high levels of FDI right after China opened to less regulated FDI have higher A'. Distance to the coast is not significant given we have incorporated trade costs, even though there could still be a flow of information and innovation with interior cities historically viewed as receiving trickle-down from the coast. For unit cost, *c,* covariate effects mirror with opposite sign to those for A', as expected, although here the distance to the coast effect is significant.

For consumer amenities, *Z*, which in some sense is a residual after everything else is solved for are interesting. Amenities for "ordinary" consumers increase with population. They also decline with share educated and political status, which may seem odd. However, for a key item such as weather, high winter temperatures are good. Correspondingly, direct pollution (PM2) and commuting times have negative effects, albeit at lower levels of significance, perhaps because of attenuation bias from measurement error.

Infrastructure levels measured by *G,* as expected, rise with population, political status, manufacturing share and education. We also have the city-level data on: (1) average annual local spending on infrastructure over 2008-2011[16] and (2) average annual city government's land sale revenue over the same period. Between our measure of *G* and data on infrastructure investments and land revenues, in the left panel of Table 3, the pairwise raw correlation coefficients arrange from 0.77 to 0.83. Even after factoring out the controls in Table 2 (to remove common influences), in the right panel, these pairwise coefficients range from 0.36 to 0.50. We interpret these strong

[16] We obtain this variable from Chinese city statistic yearbooks. City government spending on infrastructure is the sum of the funds from the city government's local fiscal expending on infrastructure investment, loans and securities (principle only) the city government borrows to finance infrastructure investment, and the city government's self-raised fund (through local bonds, etc.) for infrastructure investment. This variable does not include funds from upper-level governments (such as provincial and central governments) used for infrastructure investment.

results as affirming our characterization of the public good sector.

Finally, there is the political weight on GDP enhancement, f. These are graphed against city population in Figure 5. These f's average 0.67 with a median of 0.70. Many are over 0.8 and they are especially high for some political cities like Beijing and Tianjin, presumably assigned to ambitious political leaders. They are inferred from the residential to land price data and parameters. We note in Section 3 in deriving these results, we assumed $\frac{\partial lnL_i}{\partial s_i} = 0$ in eqn. (19). In Appendix A4, we make a different assumption and show that the resulting f's are almost perfectly correlated with the ones here. In Figure 5, there are more "enlightened" places with low f's which appear to value the welfare of residents, such as Shenzhen (the 2nd lowest dark blue dot). In the regressions in Table 2 col. (5), f rises with population and manufacturing share, where we might expect leaders in bigger and manufacturing cities to be focused on enhancing GDP; and f declines as we move to interior and far west cities, which have over the decades experienced not just trickle down but de facto neglect. We think the more ambitious leaders who seek promotion are more likely to be assigned to big, political and coastal cities.

In col. (6) in Table 2, we experiment with a key 'political' variable, the age of the local leader, the Party Secretary (averaged over 2000-2010). In Wang et al. (2019), local leaders are on a path to promotion, where promotion depends heavily on economic achievement measured by local GDP. Maximizing GDP involves effort to manipulate constraints imposed by the center and placate local citizens. Older leaders have a glass ceiling based on mandatory retirement ages and promotion is unlikely, so they exert less effort. Very young leaders are not at a critical stage yet, or may be more reform minded in 2010, having the welfare of local residents more in mind. Wang et al. (2019) find that effort to be promoted is maximized about age 50. In Table 2, remarkably, that is also the inflection point for average age of leaders in terms of a maximal f.

There are other equilibrium outcomes which can be backed out of the model, such as housing prices and built area of the city. In the Appendix A5, graphs show that actual housing prices from China's Regional Statistic Yearbooks correlate well with model ones, as do land areas.

6. Counterfactuals

For counterfactuals we are primarily interested in three experiments. What happens if we remove capital market favoritism, so the endogenous price of capital is equalized across cities? Then with our framework we can ask a neat hypothetical. Starting from free capital markets, we ask what is the impact of setting f's to 0, so leaders seek to maximize the welfare of residents in allocating land, which will alter the allocation of land within each city more towards residential use. [Note we cannot run the counterfactuals on *f* alone, since it would have capital markets impacts and we do not know how the politically driven prices of capital would then adjust.] Finally, we look closely at the joint impacts of simultaneously freeing capital markets and correcting bias in land allocation; and present a summary of the welfare implications of the joint reforms against the benchmark equilibrium. The detailed counterfactual solutions and method are explained in Appendix A1.

6.1 Effects of a free capital market

Here we re-solve the model, taking *f*'s as given but requiring that capital markets clear such that (21b) is satisfied with every city facing a capital price of 1, the numeraire and baseline price in Guangzhou. That raises the price of capital in some cities and lowers it in others. In cities with lowered [raised] capital prices, total capital usage rises [falls]. In cities with increased capital usage, unit costs of production fall with cheaper capital and scale economies from expansion in production as these cities become more competitive and draw in migrants. In these cities, this goes with a rise in wages from having more capital to work with and enhanced scale effects. All these are intuitive. Perhaps less intuitive is that, while generally housing prices fall with cheaper capital, residential land prices rise from the increased demand for land to complement capital in housing. Also industrial land prices rise with increased output in gaining cities. In these cities, the government revenues from land sales increase consequently, which can finance more investment in public infrastructure. TFP rises due to improved infrastructure and scale economies. These are show in figures in Appendix A6.1.

Given all background we show two outcomes graphically: the effects on population and the expected utility of people originating in each city as graphed against their *initial* prices of capital. Figure 6 shows the population effects. The x-axis has the benchmark price of capital relative to Guangzhou (=1 or log at 0). The y-axis on changes in population is centered around no change, with losing cities below the 0-line and gaining cities above. In general, cities with initial higher prices of capital experience population increases, but of course there are general equilibrium effects. In fact, Guangzhou's population increases slightly even though its price is unchanged. Cities like Beijing and Tianjin which are heavily favored in capital markets, in the counterfactual experience large population loses of 11.7 and 15.5% respectively. This suggests part of the very high population growth of these cities has been driven by capital market favoritism. On the contrary, cities that currently face discrimination gain. Shenzhen, as a typical example, experience a population gain of 30.8%.

Corresponding to population losses in some favored cities are welfare losses for people originating in favored cities. Part of these losses are offset by improved efficiency in capital markets. So while Chongqing loses population, its expected utility increases modestly by 2.5%; and, for price neutral Guangzhou, the expected utility of its original inhabitants rises by over 4% in Figure 7. But we can see that for big population losers like Beijing and Tianjin, with reduced capital and wages there, a portion of original residents emigrate with welfare losses and others have wage reductions, so that overall expected utility falls by almost 5.4% and 11.3% respectively. By contrast, Shenzhen has welfare gains over 4%.

6.2 Effects of leaders maximizing the welfare of residents (f=0), *conditional* on free capital markets

To gather intuition, we now do the effects of the counterfactual of setting f=0, from the world we just examined where capital prices are already equalized, using that counterfactual as, in essence, an inferred, new benchmark. Moving to f=0 is similar to freeing up land markets, so that the prices of industrial and residential land are closer together. However, as noted in the modeling section, we are in a *n*th-best world where there are constraints on both how land rents are spent and as well as on the total amount of government expenditures. That is, there is no tax or subsidy to raise more money to spend on G, nor can land rents be rebated to residents if less G is desired. Thus, rather than being at 1, the final ratio of residential to industrial land prices comes from the model where above, with $f = 0$, the model gives a ratio of 0.64 in equation (20b).

Freeing up land markets by policy makers who no longer over-allocate land to industrial use, has intuitive effects. Residential land prices decline, and industrial use prices rise in all cities. Cities increase the allocation of land to residential use monotonically in line with higher f's, correspondingly reducing industrial land usage. This lowers housing prices everywhere, which is the main channel leading to utility gains and population inflows. In very high-f cities like Beijing, population increases relative to the capital market counterfactual, and total capital usage increases with both the increased demand for housing in residential use and substitution of capital for more expensive industrial land in intermediate goods production. While G generally declines with the loss of focus on enhancing GDP, in a few of the various highest f cities like Beijing, G also increases as population increases. Although TFP tends to decline as G decreases, this might be mitigated or reversed by scale effects due to increased population in high-f cities. In general, the costs of production of intermediate goods rise, although less in high-f cities which gain population and enjoy increased scale effects. Figures showing these results are in Appendix A6.2.

As above, in the text we show graphs for population and welfare changes. Figure 8 shows that, given equalized returns to capital, setting f to 0 helps high-f cities and raises their population.

For example, Figure 8 shows that Beijing, Tianjin, and Shanghai all have pretty high biased leaders' objective towards GDP, as do Shenzhen and Guangzhou (with *f* values above top 10 percentile of our sample cities). When this bias is corrected, all of them gain population relative to the capital market counterfactual, although relative to the original benchmark Beijing and Tianjin still lose population. Figure 9 shows how initial residents' expected utility residents changes. Given the switch to maximizing resident welfare, expected utility rises everywhere relative to the capital market counterfactual. In general, the higher *f* is (with Beijing at the extreme), the greater the increase in expected utility, mirroring the population changes.

6.3. The joint effects of freeing capital markets and changing leader's behavior

6.3.1 Aggregate effects

We now turn to the aggregate impact of the joint reforms. Relative to the benchmark, social welfare of residents in China rises in total by 7.9% in response to the joint change in policy, as shown in Table 4, col. 1, rows 1 and 3. This effect is driven more by the impact of reducing housing prices from setting $f=0$ than freeing of capital markets, if we compare numbers in rows 1-3 in col. 1. On the other hand, in col. 2, an equalized price of capital removes the capital market bias towards certain political and other cities. Doing so brings broad efficiency gains relative to the benchmark (the current 2010 equilibrium), raising capital income by 11%. Note given capital is the numeraire, all the additional gains come from just freeing capital markets. Total production in col. 5 rises from the joint reform relative to the benchmark by 4.1%, although the partial impact of setting $f=0$ is negative.

Another noticeable aggregate impact is on TFP. Table 4 shows that overall TFP increases by 3.8% relative to the benchmark in col. 3, mostly due to the capital market reform. Considering that the overall TFP growth during 2010 - 2017 in China and U.S. is about 5% and 3% respectively (according to Penn World Data), our study suggests considerable potential TFP gains at 3.8% from improved factor market efficiency. Total effective labor rises overall with better allocation, but the aggregate effects are very small at 0.29%.

The final issue concerns inequality in the last column of Table 4. There joint reform contributes to a huge increase in national labor inequality, across our heterogeneous labor. Why? Some cities with older heavy industries (SOE's) and low capital returns are in low welfare and high migration cost places to begin with. When we raise the price of capital they lose and are trapped in even lower wage and still high migration cost places, so inequality rises nationally. Put another way, current capital subsidies in some cities forestall the wage and employment losses which would result if these heavy industry cities had to compete on a level playing field.

6.3.2 Winners and losers

These aggregate effects mask a set of winning and losing cities and degrees of changes. We examine this in two ways. First, we divide the set of cities into 4 groups: cities which start as high *f*- high *r* (75 cities), high *f* - low *r* (76 cities), low *f* - high *r* (46 cities) and low *f* - low *r* (69 cities). These are based on cities falling above or below the initial mean *r*'s and *f*'s nationally. In Table 5, initially *all* high-*r* cities gain population. However, they gain more, if they also start off as high-*f* cities and thus enjoy highly reduced housing prices when *f* falls so far to 0, compared to low-*f* cities. *All* low *r*-cities lose population with increased prices of capital, but the losses are less for initially high-*f* cities.

While in general, as we have seen, many outcomes are dominated by the capital market reform that is not the case for consumer welfare as driven by housing price changes. Although all *f*'s fall to zero, housing prices do not fall everywhere. In Figure 10, we show the 3-D surface for changes in housing prices against initial *r* and *f*. Starting on the west side of the graph, places with low initial *f*'s have noticeable housing price increases, if they start with low r's, so that capital prices rise. With low *f*'s and high initial *r*'s housing costs, the fall in *r* is enough to give housing price reductions (although parts of the surface are sparsely populated). Cities that start with high *f*'s generally all experience housing price declines although these are considerably magnified for cities that also start with high *r*'s. Finally, we note that this surface is not smooth; there are considerable general equilibrium effects where the impact of changing *r* and *f* differ by city location (and hence starting welfare of residents and trade and migration costs).

Figures 11a and 11b show that population and welfare changes generally mirror each other. We note that the *f* and *r* axes are switched compared to Figure 10, to improve visualization. Welfare and population rise in high *r*-cities and a careful look suggests that is generally accentuated modestly as *f* rises. For initial residents, some of whom move at high cost, those in cities losing population tend to incur welfare losses. Note, there are distinct non-monotone patterns with peaks and valleys. An important take-away is that holding either *f* or *r* fixed and changing the other does not give monotone increases or decreases in population or welfare over the surfaces.

6.4 An extension of counterfactuals: Lowering the fixed cost of high cost destinations to that of Jiangsu province

Part of our results are driven by the fact that in losing cities, it is costly in many places for residents to move out. That also drives a rise in inequality. Relaxing migration barriers would help the residents trapped in poor locations to move out. For this final counterfactual, in addition to the changes in the joint counterfactual above, in Figure 12 we raise the fixed-cost, ease of access across provinces to 0.34, the same as that of Jiangsu. The idea is to follow the intended national government policy of diverting migration away from attractive coastal provinces, towards hinterland ones. As a counterfactual this is strained, in the sense the government can ease hukou based restrictions for migrants to these less favored places, in terms of access to housing, education, and social services. However, it cannot install strong migration networks in these locations, although it could facilitate job and house search. Nevertheless, in comparison to the joint counterfactual above, we show the impact on populations of lowering migrations costs in Figure 12.

Figure 12 shows changes in population relative to the joint counterfactual against the change in migration costs. On the far left are cities where there is change to migration costs. These cities all lose population, relative to those who have reductions in costs. Then as the extent of migration cost declines rise, cities start to gain population. Clearly this would be a successful policy to divert migration away from Beijing, Shanghai and other favored cities. Relative to the joint counterfactual, Beijing and Shanghai would lose population by 13.8 and 9.9%, with final populations of 16.3mn and 21.9mn; these are also lower compared to the baseline of 19.6 and 23mn respectively. Finally, national inequality relative to the joint counterfactual falls from 0.0177 to 0.0161, given the lowered cost of migration and ability to move to better jobs. Note we do not compare welfare since it rises due to the mechanical effect of lowered utility loss from lowering migration barriers and costs.

7. Conclusions

China has experienced enormous economic growth over the last four decades, driven by reforms in output markets. However, reforms in factor markets have lagged. The ability of China to sustain growth in the future may depend crucially on factor markets reforms. This problem was clearly acknowledged in a policy directive recently issued by China's Central Government and Central Committee of the Communist Party, which called for new reforms to improve "factor market allocation mechanisms" in capital, labor and land markets[17]. While the current literature has studied factor misallocations in China from various perspectives (Hsieh and Klenow, 2009; Tombe and Zhu, 2019), a comprehensive framework is needed that incorporates all of the three key markets of capital, labor and land. This paper fills this gap by constructing a spatial general equilibrium model with all three factor markets and trying to get a handle on the net gains to be made by key reforms.

Key to understanding the issues is China's characteristic political centralization and fiscal

[17] See the policy directive here: http://www.gov.cn/zhengce/2020-04/09/content_5500622.htm

decentralization system. The model structure conforms to China's institutional background and our empirical work utilizes large up-to-date datasets on all three factor markets covering 266 prefectures in China. We do calibration and counterfactual analyses. One counterfactual reforms capital markets, so that all cities compete on a level playing field, eliminating favoritism of certain types of cities and firms. A second counterfactual reforms local land markets so industrial land allocations are not favored over residential ones. Such favoritism arises from local leaders giving a weight to GDP enhancement and competing for footloose firms with cheap industrial land with other regions, as opposed to focusing just on maximizing welfare of residents. Leveling the playing field in capital markets and reallocating land towards residential use would increase aggregate welfare by 7.9%, a large amount. It would lower the population of the biggest cities like Beijing and Tianjin while other cities like Shenzhen would gain population. And it would lower housing prices everywhere, in a context where rising housing prices in China are a critical political and social issue.

Labor market reforms which would lower migration barriers are trickier, because we think a key part of migration costs are destination based migrant networks which arise from sustained migration. Still, policies raising or lowering 'doorsills', or eroding or improving migrant quality of life matter. Lowering doorsills generally would help people leave low productivity places to go to higher productivity ones. Lack of such reforms enhances inequality. Focusing just on trying to make entry to provinces easier for high cost (low history of migration) places encourages people to move to these lower welfare places

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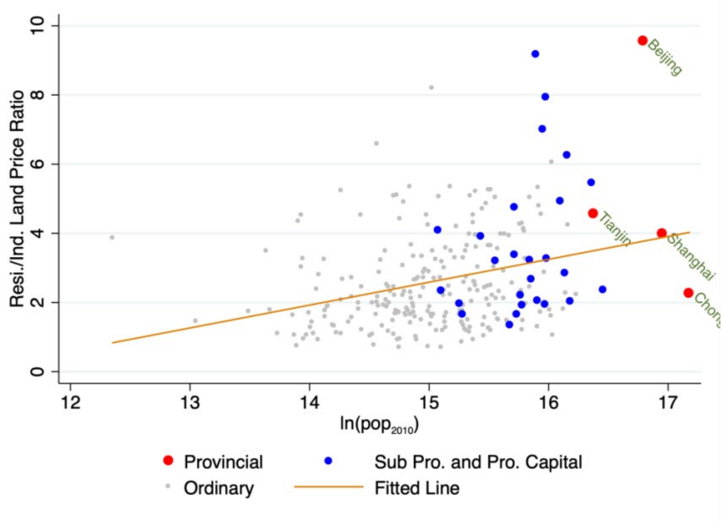


Figure 1. Residential versus industrial land prices

The graph shows the ratio of hedonic residential land prices to those for industrial land, The x-axis is the log of prefecture population in 2010.

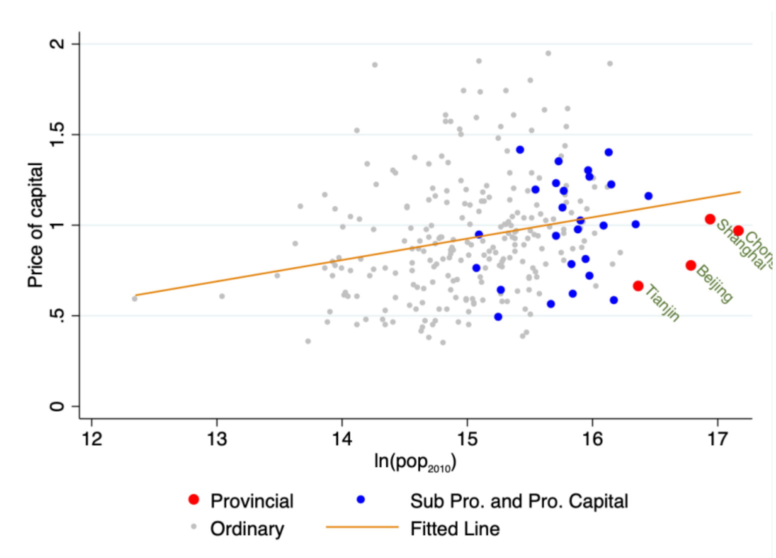


Figure 2. Capital market prices

Notes: The graph shows the estimated price of capital normalized to 1 for Guangzhou against the log of population in 2010.

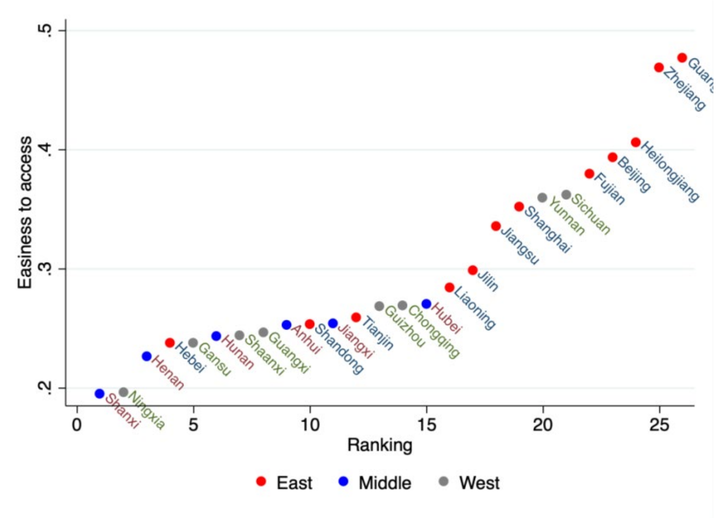


Figure 3. Fixed costs of migration
Notes: The figure shows the fixed cost of migration as the reverse: ease of migration (income left over after migration), against provinces ranked by ease of migration

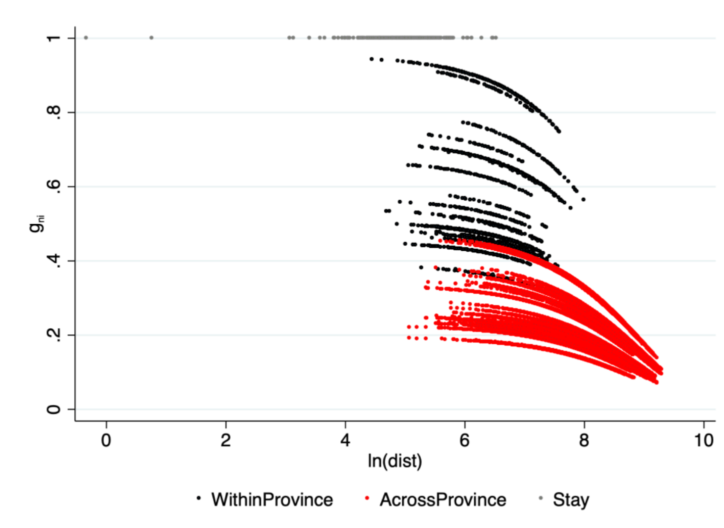


Figure 4. City pairwise moving costs: fraction of utility left after moving
Notes: The figure shows the total cost of city-to-city migration as the reverse: ease of migration (income left over after migration), with obervations ordered by the (log of) the pair-wise distances.

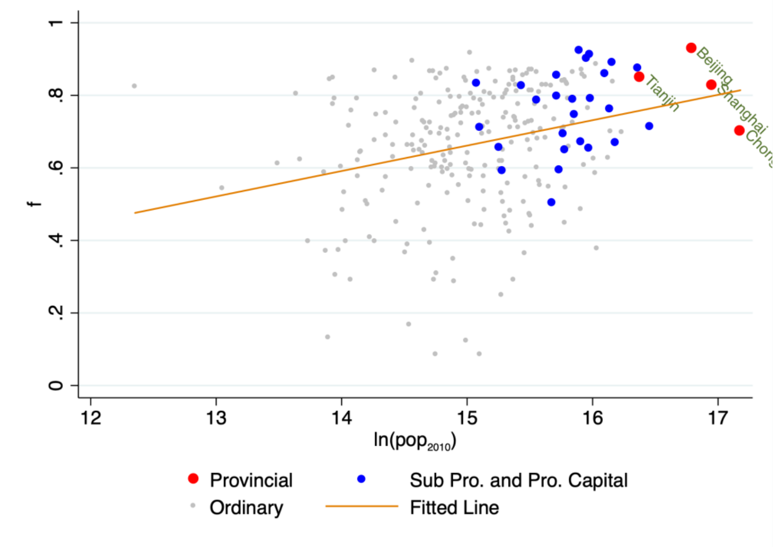


Figure 5. The calibrated values of the leaders' weight on GDP, *f*

Notes: The figure plots the inferred vales of *f*, the weight on GDP in city-leader preferences, against log population in 2010.

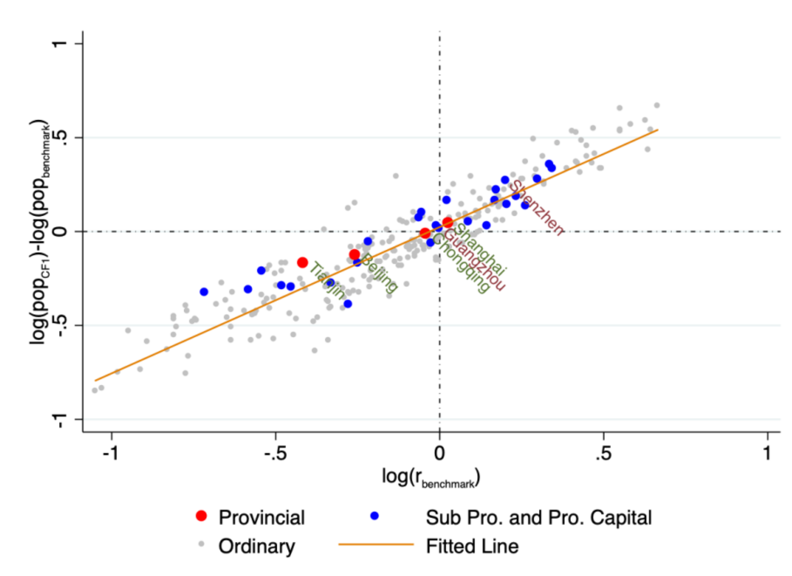


Figure 6. Capital market counterfactual: Percent change in ln population relative to the benchmark

Notes: On the y-axis is the percent changes in population of moving from the benchmark to freeing capital markets (only), plotted against the initial capital prices in the data

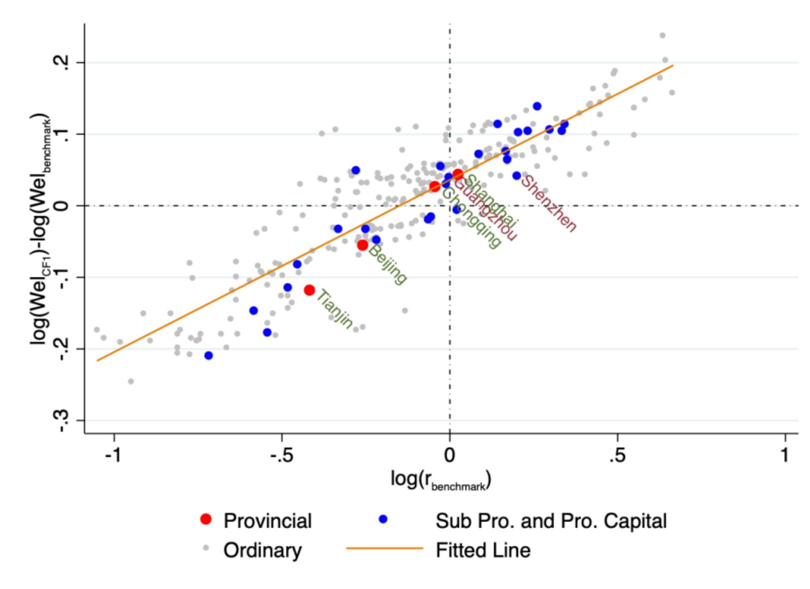


Figure 7. Capital market counterfactual: Percent change in expected utility of initial residents

Notes: The y-axis graphs the percent change in welfare of people initially in the city in moving to free capital markets from the benchmark. The a-axis are the initial prices of capital in the data.

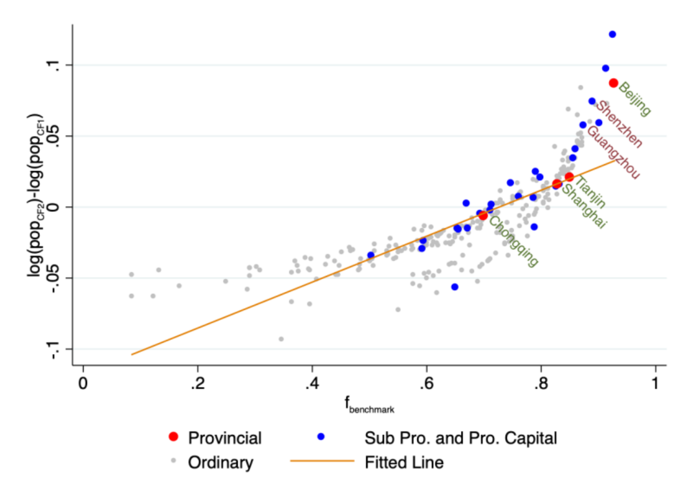


Figure 8. Effects of *f*=0 and capital market counterfactual relative to capital market counterfactual alone: population

Notes: The y-axis shows the increase in population from setting *f*=0, relative to the counterfactual equilibrium where there are free capital markets. The x-axis gives the baseline *f*'s.

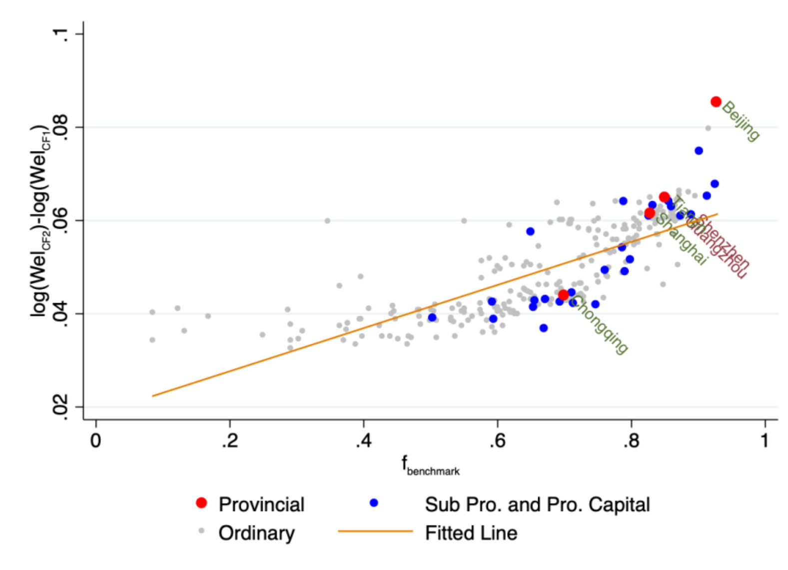


Figure 9. Effects of *f*=0 and capital market counterfactual relative to capital market counterfactual alone: consumer welfare

Notes: The y-axis shows the increase in consumer welfare of initial residents of a city from setting *f*=0, relative to the counterfactual equilibrium where there are free capital markets. The x-axis gives the baseline *f*'s.

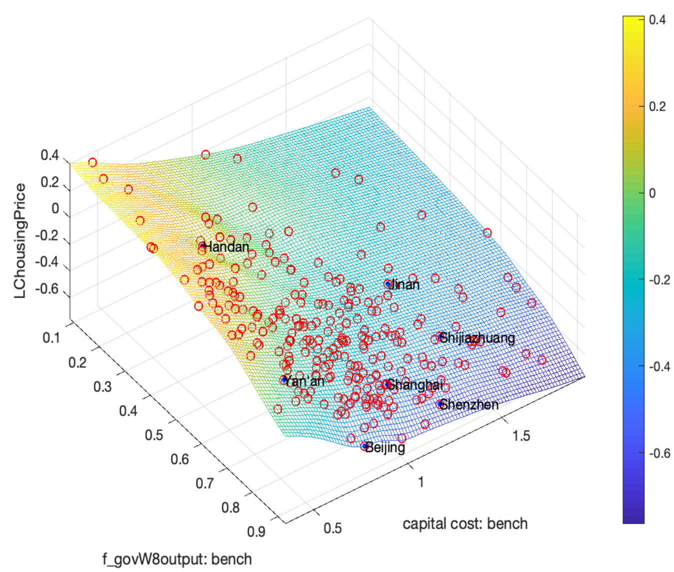
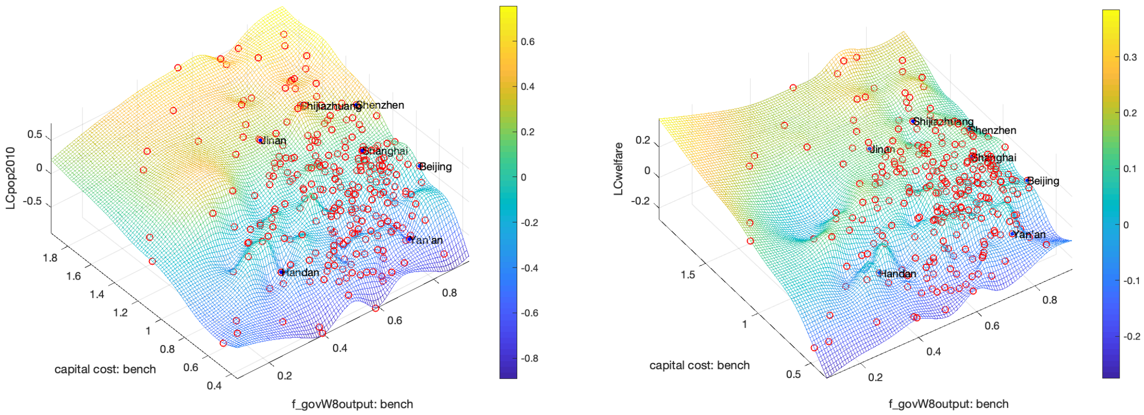


Figure 10. A 3-D representation of housing price changes

Notes: The two "x"-axes are for the benchmark price of capital and *f*. The vertical axis is the change in housing prices relative to the benchmark



a. Population changes **b. Changes in welfare of initial residents**

Figure 11. The 3-D representation of population and consumer welfare changes

Notes: The two "x"-axes are for the benchmark price of capital and *f*. The vertical axis is the percent change in in the relevant outcome, relative to the benchmark.

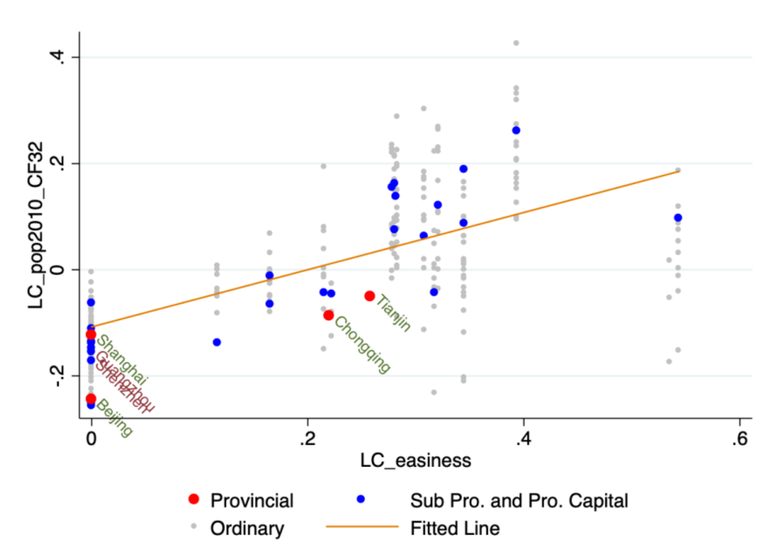


Figure 12. Population changes with lowered migration costs relative to the joint counterfactual

Notes: The y-axis shows the change in population from lowering migration costs in high migration provinces, relative to the joint benchmark, as graphed against the average ease[18] of access for each city.

[18] The x-axis represents the percentage change in ease-of-access g_{ni} of each city as a potential migration destination. More specifically, we recall that the ease-of-access is defined as $g_{ni} = \tilde{t}_i \cdot t_{ni}$, where $\tilde{t}_i$ denotes the destination "sunk cost" (the remaining portion after incurring the cost) and t_{ni} the symmetric distance effect. In the labor market counterfactual, we raise the $\tilde{t}_i$ to 0.34 (Jiangsu) if its original value is lower than 0.34. Since all cities in a specific province have the same entry cost $\tilde{t}_i$, the counterfactual can be interpreted as a provincial level reform where all cities simultaneously lower their migration doorsills to each other and to people from other provinces. Therefore, if the destination city is in the province with low sunk cost (i.e. high $\tilde{t}_i$), the percentage

Table 1: Parameters

Name	Value	Notes	Source
β	0.26	Housing spending share	Cao, Chen and Zhang (2018)
ρ	0.7	Capital share, housing	Tan et al. (2020)
α_L	0.55	Labor share, Y	Bai & Qian (2010)
α_X	0.07	Land share, Y	Valentinyi & Herrendorf (2008). We increases their share for the USA of 0.05 of land in capital income to reflect China's greater capital plus land share in production.
α_K	0.38	Capital share, Y	Back out from $\alpha_L + \alpha_K + \alpha_X = 1$
γ	0.06	Government investment productivity	Melo et al (2013 RSUE)'s meta study. 0.06 is the mean over all studies and countries. Non-US countries and long run studies tend to average modestly higher γ's. On the other hand, Wu, Feng, & Wang (2019) estimate 0.031 and 0.046 for China for transport and utilities infrastructure respectively.
ϵ	0.04	Agglomeration economies	Typical estimate cited in Rosenthal & Strange (2004) and consistent with recent work by de la Roca & Puga (2017)
θ	4.0	Dispersion parameter, Frechet	The number is based on Bryan & Morten (2018), although higher than their 3.2.
θ_t	4.0	Dispersion parameter, Trade Frechet	Tombe & Zhu (2019)

change is given by $\log(g_{ni}^{CF}) - \log(g_{ni}^{bench}) = \log(\tilde{t}_i^{CF} \cdot t_{ni}) - \log(\tilde{t}_i^{bench} \cdot t_{ni}) = 0$ since $\tilde{t}_i^{CF} = \tilde{t}_i$. This means that these cities will be centering at the lower-left corner in the figure, e.g. all the cities in Guangdong, Zhejiang, Jiangsu. For cities located in the province with high entry cost, e.g. Shanxi, Ningxia, Henan, they have the positive increases in the easiness-to-access, with the magnitude given by $\tilde{t}_i^{CF} - \tilde{t}_i^{bench} = 0.34 - \tilde{t}_i^{bench} > 0$. Since Shanxi and Ningxia originally have the lowest $\tilde{t}_i$, (destination) cities in these two provinces now enjoy the largest increases in ease-of-access. Note the counterfactual is capturing the labor market reform at province level, and each vertical bar in the figure represents a particular province.

Table 2, Regressions for calibrated parameters

VARIABLES	(1) Ln A'.	(2) Ln c	(3) Ln Z	(4) Ln G	(5) f	(6) f
Share of adults (age 19-55) with high school education 2000	4.919*** (0.909)	-1.599*** (0.243)	-5.257*** (1.111)	9.995*** (1.155)	0.150 (0.395)	0.247 (0.411)
Avg.winter temperature, (2014) (www.meteomanz.com)	0.00201 (0.00261)		0.00706** (0.00321)			
Ln distance to nearest of the 9 major seaports	-0.0218 (0.0177)	0.0120** (0.00525)	0.0338 (0.0211)	-0.0964*** (0.0261)	-0.0255*** (0.00891)	-0.0271*** (0.00923)
Share employment in manufacturing, 2000	0.885*** (0.204)	-0.337*** (0.0588)	-1.666*** (0.242)	2.281*** (0.270)	0.184** (0.0922)	0.165* (0.0950)
Provincial or sub-prov capital	0.206*** (0.0774)	-0.0820*** (0.0227)	-0.203** (0.101)	0.419*** (0.114)	0.0263 (0.0389)	0.0375 (0.0394)
Ln population 2000 Census	0.227*** (0.0411)	-0.196*** (0.0122)	0.121** (0.0468)	1.081*** (0.0527)	0.0370** (0.0180)	0.0406** (0.0185)
Ln avg daily PM2 (2014) Monitoring Center: Ministry of Environmental Protection			-0.0716 (0.0496)			
Ln commuting time (excludes walking). NBSC survey 2010			-0.277 (0.175)			
Ln Total FDI, 1996	0.0336** (0.0154)	-0.0160*** (0.00454)				
Avg Age of party secretary [PS] (2000-2010)						0.139* (0.0805)
Ave Age of PS Squared						-0.00138* (0.000807)
Constant	-9.592*** (0.636)	3.555*** (0.188)	9.570*** (0.875)	-12.64*** (0.869)	0.212 (0.297)	-3.325 (2.063)
Observations	213	213	222	265	265	265
R-squared	0.640	0.844	0.572	0.845	0.164	0.173

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 Correlations with producer public goods

	(1) No controls		(2) Controlling for $\ln(pop_{2010})$	
	Ln Ave. Inv	Ln cG	Ln Ave. Inv	Ln cG
Ln cG	0.766	1	0.362	1
Ln land revenue	0.769	0.83	0.463	0.502

Table 4. Aggregate outcomes: Counterfactuals versus benchmark

	Social welfare Eqn. (22) (1)	Total capital income (1000's) (2)	TFP* (3)	Total Effective Labor Eqn. (17) (4)	National sum of *y* (actual production) (5)	Inequality Eqn. (24) (6)
Benchmark, equilibrium	1.623	199	0.0260	3.460e+09	391421	0.00684
Counterfactual 1: Equalize *r*	1.666	220	0.0269	3.470e+09	418847	0.0175
Counterfactual 2: Equal *r* & *f*=0.	1.752	220	0.0270	3.470e+09	407625	0.0177

* $TFP_{agg} = \sum_i \frac{y_i}{\sum_{j \in N} y_j} A_i' G_i^{\gamma} L_i^{\epsilon}$, where y_i is the total amount of the intermediate goods produced in city i. Note

Table 5: Average population changes by groups

Group	Average r	Average f	Ave. pop change from freeing capital market	Ave. pop change: joint reform
High r, high f	1.22	0.79	18.3%	19.7%
High r, low f	1.21	0.52	14.1%	10.5%
Low r, high f	0.75	0.78	-24.7%	-23.9%
Low r, low f	0.65	0.51	-30.5%	-34.1%

On-Line Appendices

Appendix A1. Closing the model and calibration outline.

Calibration outline:

Given the data on $\{\tilde{L}, \tilde{L}', Y, r, P_X^I, P_X^R\}$, the trade cost $\{d_{ni}\}$, the migration cost $\{g_{ni}\}$, and the parameters $\{\beta, \rho, \alpha_L, \alpha_X, \alpha_K, \gamma, \epsilon, \theta, \theta_t\}$ in Table 1, we can solve the model to back out other model parameters from the equilibrium. The city-specific parameters include A', f, Z and the city land stock $\overline{X}$, while the economy-wide parameter is the aggregate capital stock $\overline{K}_{agg}$. We can also recover the equilibrium quantities of endogenous variables in model units: $G_i, X_{Ii,} X_{Ri,} K_{Ii,} K_{Ri}$. More specifically, the calibration procedure can be summarized as follows:

Step 1: Solve for $\{Z_i V_i\}_{i\in N}$ from (15); use (14) to pin down the corresponding migration share M_{ni}; use (17) to pin down the allocation of the effective labor L_i.

Step 2: Solve for the favoritism parameter f from (20b), and solve for s_i from (20a)

Step 3: Solve for $\{c_i\}$ from (12a).

Step 4: Solve for $\{A_i'\}$, $\{A_i\}$ and $\{G_i\}$ from the following three conditions,

$$Y = \frac{wL}{\alpha_L} = \alpha_L^{\frac{1}{\alpha_L}-1} c_i^{\frac{1}{\alpha_L}} A^{\frac{1}{\alpha_L}} L^{\frac{\epsilon+\alpha_L}{\alpha_L}} \left(\frac{1}{P_X^I}\frac{\alpha_X}{\alpha_L}\right)^{\frac{\alpha_X}{\alpha_L}} \left(\frac{1}{r}\frac{\alpha_K}{\alpha_L}\right)^{\frac{\alpha_K}{\alpha_L}},$$

$$Y = [\alpha_X + (1-\rho)\beta\alpha_L]^{\frac{\gamma}{\alpha_L-\gamma}} \left[\left(\frac{\alpha_X}{P_X^I}\right)^{\frac{\alpha_X}{\alpha_L}} \left(\frac{\alpha_K}{r}\right)^{\frac{\alpha_K}{\alpha_L}} \left(c_i^{\frac{1}{\alpha_L}} A'^{\frac{1}{\alpha_L}} L^{\frac{\epsilon+\alpha_L}{\alpha_L}}\right)\right]^{\frac{\alpha_L}{\alpha_L-\gamma}} \cdot c_i^{-\frac{\gamma}{\alpha_L-\gamma}},$$

$$A = A'G^{\gamma}.$$

These three conditions can be derived from combining (5b), (11a) and $Y = \frac{wL}{\alpha_L}$.

Step 5: Solve for $\{X_{Ii,} X_{Ri,} K_{Ii,} K_{Ri}\}$ from (6), (7), (8) and (9). This also gives $\{\overline{X}_i\}$ and $\overline{K}_{agg}$ by recalling their definitions.

Step 6: Use Eqns (2), (13), (5b) and (1) to derive $P_{hi}, CMA_i\ \ Q_i,$ and V_i.

Step 7: Derive the amenity Z_i from $Z_i = Z_i V_i / V_i$.

Step 8: Calculate the welfare and inequality index defined in (22) and (24).

Counterfactual outlines:

To be as general as possible, we will consider alternative values/rules of the model parameters {f}, {r}, $\{g_{ni}\}$ altogether in the following such that all markets clear (including the aggregate capital market).

Notice that we can directly derive the land allocation share s_i from (20a) with the new {f}. Then the land allocation $\{X_I, X_R\}$ for each city is pinned down according to $X_I = (1 - s_i)\bar{X}_i$ and $X_R = s_i\bar{X}_i$. To solve for other endogenous variables, we use the following iterative algorithm:

Step 1: Find a set of $\{Y_i, L_i, r_i\}$ such that (12a) and (17) are satisfied, and r_i's are equalized across cities. Note that in step 1, we do not require the aggregate capital market to clear. The algorithm is similar to the homotopy method.

> More specifically, suppose we have an initial guess of $\{Y_i(0), L_i(0), r_i(0)\}$, which can be the ones derived from the calibration. Let $\overline{r_i(0)}$ be the mean of $\{r_i(0)\}$, and let $r_i(n) = \frac{n}{N} \cdot \overline{r_i(0)} + \frac{N-n}{N} \cdot r_i(0)$ for a large fixed N.[19] Suppose for the (n-1)-th iteration, we already find a set of $\{Y_i(n-1), L_i(n-1), r_i(n-1)\}$ such that (12a) and (17) are satisfied. Now we consider the n-th iteration. With $r_i = r_i(n) = \frac{n}{N} \cdot \overline{r_i(0)} + \frac{N-n}{N} \cdot r_i(0)$, we plug $\{Y_i(n-1), L_i(n-1)\}$ into the right-hand sides of (12a) and (17).[20] The implied $\{Y_i, L_i\}$ can be plugged into the right-hand side of (12a) and (17) again. We can repeat this process until $\{Y_i, L_i\}$ converge. This gives a set of $\{Y_i(n), L_i(n), r_i(n)\}$ satisfying (12a) and (17). Then we can move on to the (n+1)-th iteration. When it comes to N-th iteration, we can automatically have a set of $\{Y_i, L_i, r_i\}$ satisfying (12) and (17). And it is worth noting that $r_i(N) = \overline{r_i(0)}$ by construction.

Step 2: Find a set of $\{Y_i, L_i, r_i\}$ such that (12a) and (17) are satisfied, r_i's are equalized across cities, and the aggregate capital market clears.

> Start with the results of $\{Y_i, L_i, r_i\}$ derived in step 1. The capital costs $\{r_i\}$ are equalized across cities, but the implied aggregate capital demand $\sum_i K_{I,i} + \sum_i K_{R,i}$ may not be equal to the $\bar{K}_{agg}$.[21] However, if there is excess demand, we can uniformly raise $\{r_i\}$ a bit; if there is excess supply, we can uniformly reduce $\{r_i\}$ a bit. With the small adjustment in $\{r_i\}$, we can find a new set of

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[19] An appropriate choice of N can help to raise the speed of convergence without reducing the probability of convergence.

[20] The terms of $\{V_i, c_i\}$ on the right-hand sides of (12a) and (17) can be written as functions of $\{Y_i, L_i, r_i\}$. To see this, recall that in the calibration stage we show $\{V_i, c_i\}$ are functions of factor prices and L_i. Given we already pin down $\{X_I, X_R, L\}$ in the counterfactuals, we can use Y_i and the expressions for the factor income shares to eliminate the corresponding factor prices.

[21] Noticing the Cobb-Douglas structures of the economy, one can write K_I and K_R as functions of $\{Y_i, L_i, r_i\}$ only.

$\{Y_i, L_i\}$ satisfying (12a) and (17) by following the similar iteration procedure detailed in step 1. With appropriate adjustments in $\{r_i\}$, we can eventually find the right level of $\{r_i\}$ such that the aggregate capital market also clears. To normalize the capital costs such that $r_i = 1$ for Guangzhou, we can rescale $\{Y_i, r_i\}$ by the same constant. Since money is neutral in the economy, the rescaled $\{Y_i, L_i, r_i\}$ still satisfy all the requirements in step 2.

Step 3: Back out all the other endogenous variables. Since we already know $\{Y_i, L_i, r_i, X_{R,i}, X_{I,i}\}$, we can derive the factor prices $\{w_i, P_{R,i}, P_{I,i}\}$ by using the factor income share expressions. Following similar procedures in the calibration outlines, the other endogenous variables can be easily pinned down using these factor prices.

Appendix A2. Trade costs

We take trade costs from Baum-Snow et al. (2020) and we note some details here. They digitize a large-scale national paper map for 2010 and calculate travel times between each pair of prefecture cities over the highway network. The 2010 map describes limited access highways and two classes of smaller roads, on which we assume travel speeds of 90 kph and 25 kph respectively. This allows them to calculate pairwise travel times between any pair of prefecture cities and between each prefecture city. For any good arriving in city i from city j we must ship d_{ij} units of that variety. To calculate d_{ij}, they assume $d_{ij} = 1 + 0.004\vartheta(\text{hours of travel from i to j})^{0.8}$. This expression captures both the pecuniary and time (opportunity) cost of shipping. Hummels & Schaur (2013) estimate that each day in transit is equivalent to an ad-valorem tariff of 0.6-2.1%. Limao & Venables (2001) and that the cost of shipping one ton of freight overland for 1000 miles is about 2% of value, or about 1% per day. This expression generates the resulting target with a loss of 1.6-3.1% in value per day, while also incorporating some concavity. Because the transformation from travel time to iceberg cost is necessarily speculative, they checked the robustness of their relevant results to alternative calculations of d_{ij} based on values of ϑ between 0.5 and 2, finding similar results.

Appendix A3. Estimating migration costs

We have 2010 census data on province-to-province moves of people in the last 5 years; for the 10 year period flows we simply double this number. Tombe & Zhu (2019) use 2005 inter-census data which have sampling issues and we wanted more recent data anyway. Based on the model below, we have 24*25 province origin destination pairs to estimate the fixed and variable costs of inter=provincial moves; then we will show how we add in the prefecture to prefecture part. We show first how we use this province to province information to calculate city-city migration costs. Then we detail the set of assumptions under which our calculations are valid.

A3.1 Using province to province costs

Under some suitable conditions as dsicussed in Section A3.2, the province n to province i migration share is given by $M_{ni} = \frac{\tilde{V}_i g_{ni}^{\theta}}{\sum_s \tilde{V}_s g_{ns}^{\theta}}$, where $\widetilde{\mathrm{V}}_{\mathrm{i}}$ represents destination province's attractivenss and g_{ni} is the province-to-province migration cost. Note that this expression is very similar to the city-level migration share in (14).[22] The migration share is aggregated from the city-level migration flow, with further details to be discussed later. For now, we take this as given.

Taking logs for M_{ni} and M_{ii} and subtracting gives $ln\left(\frac{M_{ni}}{M_{ii}}\right) = \theta\, ln(\mathrm{g}_{ni}) - ln\left(\sum_s \tilde{V}_s g_{ns}^{\theta}\right) + ln\left(\sum_s \tilde{V}_s g_{is}^{\theta}\right)$,where, as conventional, we assume that $\mathrm{g}_{ii} = 1$. Migration cost g_{ni} is given by $\mathrm{g}_{ni} = t_{ni} * \tilde{t}_i$, where t_{ni} is variable, time- distance-based part of migration costs where $t_{ni} = t_{in}$, and $\tilde{\mathrm{t}}_{\mathrm{i}}$ is a destination sunk cost, based on provincial barriers to entry. Substituting g_{ni} leads to an econometric formulation as follows,

$$ln\left(\frac{M_{ni}}{M_{ii}}\right) = \theta\, ln(t_{ni}) + \theta\, ln(\tilde{t}_i) - ln\left(\sum_s \tilde{V}_s g_{ns}^{\theta}\right) + ln\left(\sum_s \tilde{V}_s g_{is}^{\theta}\right)$$

$$= \delta \cdot \mathrm{dist_{ni}} + I_n + J_i. \tag{A3.1}$$

$I_n = -\,ln\left(\sum_s \tilde{V}_s g_{ns}^{\theta}\right)$ and $J_i = \theta\, ln(\tilde{t}_i) + ln\left(\sum_s \tilde{V}_s g_{is}^{\theta}\right)$ capture origin and destination fixed effects.[23]

With the estimated coefficients, by recalling $\mathrm{g}_{ni} = t_{ni} * \tilde{t}_i$, we have

$$\mathrm{g}_{ni} = \exp\left(\frac{\delta}{\theta} \cdot dist_{ni}\right) \cdot \exp\left(\frac{I_i + J_i}{\theta}\right)$$

$$= \exp\left(\frac{\delta}{\theta} \cdot dist_{ni} + \frac{I_i + J_i}{\theta}\right). \tag{A3.2}$$

By using data, we can estimate δ, I_i and J_i. Therefore, with assumed θ, we are able to derive the easiness-to-access g_{ni} for each migration pair (province-to-province). The distance measure is from Baum-Snow et al. (2020), based on inferred driving times between locations over the 2010 road network, where speeds on major highways are set at 90kms/hr and on other roads at 25kms/hr. For the province to province times we average all the city pair distances between the two provinces.

To derive city-level migration costs, we assume it has the same structure (variable time-distance-based cost + fixed destination sunk cost) as at the province level. For variable costs, we use the distance parameter from inter-provincial moves and the relevant distances. For fixed costs, for inter-provincial

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22 The share is 2*immigrants from *n* to *i* in last 5 years/2005 population. The stayer share is 1 -sum of all outflows from *i* / 2005 population.

23 The regression includes a constant term, where Guangdong as our base group for the dummies. This implies that the constant term is capturing the $\tilde{t}_i$ of Guangdong.

moves we continue to use the associated destination province fixed costs. For the fixed cost for intra-provincial moves, Tombe & Zhu (2019) argue that in general the costs of moving the same distance across provinces is twice within province moves. For the asymmeric case here, accordingly we simple double the $\tilde{t}_i$, correspondingly lowering intra-province migration costs. This assumes that the asymmetric cost pattern for within province moves mirrors the inter-provincial cost pattern across the heterogeneous provinces. Is this warranted? To investigate with available data, we know the extent of total within province moves in the years from 1995 to 2000. Low fractions of moves would suggest high barriers to internal movement. In Figure A3.1, we plot the fraction of within province moves against our estimated $\tilde{t}_i$, indicating the ease of entering a province. There is a strong positive, agruably proportional relationship, which motivates our choice.

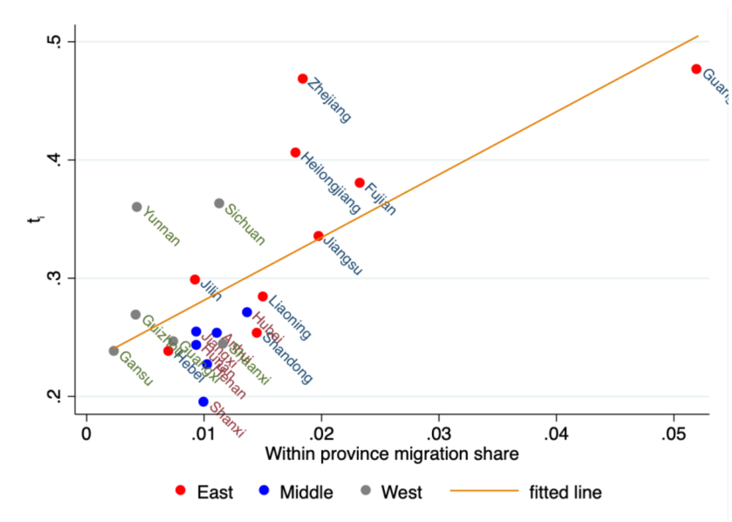


Figure A3.1. Within province flows and ease of entry

A3.2 Inferring city-to-city migration costs from province-to-province data

To see more clearly the aggregation issues in applying between province estimates to the estimation of city-to-city migration costs, we assume worker's productivity draws follow a more general form of Frechet distribution and make key assumptions. In the following, we will first show how to derive the province-to-province migration share in section (A3.1) and then we will also show that the results hold under our text assumptions.

Worker's utility is still given by $U_{ni} = Z_i a_i V_i g_{ni}$, where Z_i denotes the amenity of living in city i; V_i is the base utility of city i that depends on the effective wage rate and housing price of the city. Each worker born in city n gets a random vector of labor productivity draw $(a_1, a_2, \dots, a_N)$ from a nested Frechet distribution with cdf

$$\Psi(\mathrm{a};\mathrm{n}) = \exp\left\{-\sum_{\mathrm{P}}\left(\sum_{\mathrm{i}\in\mathrm{P}}\left[(\mathrm{a_i})^{-\frac{\theta}{1-\rho}}\right]^{\frac{1-\rho}{1-\sigma}}\right)^{1-\sigma}\right\},$$

where θ is the parameter that determines how dispersed the distribution is, while ρ and σ are productivity correlation parameters. More specifically, ρ governs productivity correlation within the same province, while σ governs productivity correlation across province. If $\rho = \sigma = 0$, the nested Frechet distribution is reduced to the i.i.d. Frechet distribution in the text.

According to Chen Liu (2019), the migration share from city n to city i is given by

$$\mathrm{M_{n,i}} = \mathrm{M}_{i|P} \cdot \mathrm{M}_{P|n}$$

$$= \frac{(\mathrm{Z_i V_i g_{ni}})^{\frac{\theta}{1-\rho}}}{\sum_{\mathrm{i}\in\Omega_\mathrm{P}}(\mathrm{Z_i V_i g_{ni}})^{\frac{\theta}{1-\rho}}} \times \frac{\left[\sum_{\mathrm{i}\in\Omega_\mathrm{P}}(\mathrm{Z_i V_i g_{ni}})^{\frac{\theta}{1-\rho}}\right]^{\frac{1-\rho}{1-\sigma}}}{\sum_{P\in\mathrm{N}}\left[\sum_{\mathrm{i}\in\Omega_\mathrm{P}}(\mathrm{Z_i V_i g_{ni}})^{\frac{\theta}{1-\rho}}\right]^{\frac{1-\rho}{1-\sigma}}},$$

where $\mathrm{M}_{P|n}$ and $\mathrm{M}_{i|P}$ are, respectively, the probability of workers born in city n and migrating to province P, and the probability of moving to city i conditional on moving to province P. We also use Ω_P to denote the set of cities in province P.

Since we only have migration flow data at the provincial level, we can derive the migration share at the provincial level as follows

$$\mathrm{M}_{P'|P} = \sum_{n\in\mathrm{P}} \omega_\mathrm{n} \mathrm{M}_{P'|n}$$

$$= \sum_{n\in\mathrm{P}} \omega_n \frac{\left[\sum_{\mathrm{i}\in\Omega_{\mathrm{P}'}}(\mathrm{Z_i V_i g_{ni}})^{\frac{\theta}{1-\rho}}\right]^{\frac{1-\rho}{1-\sigma}}}{\sum_{\tilde{P}'\in\mathrm{N}}\left[\sum_{\mathrm{i}\in\Omega_{\tilde{\mathrm{P}}'}}(\mathrm{Z_i V_i g_{ni}})^{\frac{\theta}{1-\rho}}\right]^{\frac{1-\rho}{1-\sigma}}},$$

where ω_n is the population weight of city n in the origin province P.

To use provincial migration flow data to estimate city-by-city migration cost, we have to make a few assumptions.

Assumption 1: *Suppose that the easiness-to-access between city* n *and city* i *is given by*

$$g_{ni} = g_{nP} \times g_{PP'} \times g_{p'i},$$

where g_{nP} *is the easiness-to-access within province* p*,* $g_{PP'}$ *is the easiness-to-access between province P and province* P'*,* $g_{P'i}$ *is the easiness-to-access across cities within province* P'*.*

Therefore, substituting $\mathrm{g_{ni}}$ into $\mathrm{M}_{P'|P}$ shows that it can be rewritten as

$$\mathrm{M}_{P'|P}$$

$$= \sum_{n\in \mathrm{P}} \omega_n \frac{\left[\sum_{\mathrm{i}\in\Omega_{\mathrm{P}'}} \left(\mathrm{Z_i V_i} g_{p'i}\right)^{\frac{\theta}{1-\rho}}\right]^{\frac{1-\rho}{1-\sigma}} \times \left(g_{nP} g_{PP'}\right)^{\frac{\theta}{1-\sigma}}}{\sum_{\tilde{P}'\in \mathrm{N}} \left[\sum_{\mathrm{i}\in\Omega_{\tilde{\mathrm{P}}'}} \left(\mathrm{Z_i V_i} g_{\tilde{p}'i}\right)^{\frac{\theta}{1-\rho}}\right]^{\frac{1-\rho}{1-\sigma}} \times \left(g_{nP} g_{P\tilde{P}'}\right)^{\frac{\theta}{1-\sigma}}}$$

$$= \sum_{n\in \mathrm{P}} \omega_n \frac{\tilde{V}_{P'} \times \left(g_{PP'}\right)^{\frac{\theta}{1-\sigma}}}{\sum_{\tilde{P}'\in \mathrm{N}} \tilde{V}_{\tilde{P}'} \times \left(g_{P\tilde{P}'}\right)^{\frac{\theta}{1-\sigma}}}$$

$$= \frac{\tilde{V}_{P'} \times \left(g_{PP'}\right)^{\frac{\theta}{1-\sigma}}}{\sum_{\tilde{P}'\in N} \tilde{V}_{\tilde{P}'} \times \left(g_{P\tilde{P}'}\right)^{\frac{\theta}{1-\sigma}}},$$

where $\tilde{V}_{P'} = \left[\sum_{\mathrm{i}\in\Omega_{\mathrm{P}'}} \left(\mathrm{Z_i V_i} g_{p'i}\right)^{\frac{\theta}{1-\rho}}\right]^{\frac{1-\rho}{1-\sigma}}$ is a term that only depends on destination province P'. Therefore, with $\sigma = \rho = 0$, we have shown that the province-to-province migration share is given by the one in section (A3.1) as long as Assumption 1 is satisfied.

As shown in section (A3.1), to derive the province-level migration cost estimation equation (A3.1) and (A3.2), we only need to assume the following assumption:

Assumption 2: *Suppose that the provincial level migration cost is given by*

$$g_{p^o p^d} = \tilde{t}_{p^d} \times t_{p^o p^d},$$

where $\tilde{t}_{p^d}$ *is meant to capture the destination province entry cost, while* $t_{p^o p^d}$ *is meant to capture the symmetric distance effect.*

The estimation procedure in section (A3.1) suggests that

$$t_{p^o p^d} = \exp\left[\frac{\delta}{\theta/(1-\sigma)} \cdot dist_{p^o p^d}\right],$$

$$\tilde{t}_{p^d} = \exp\left[\frac{(J_{p^d} + I_{p^d})}{\theta/(1-\sigma)}\right],$$

where I and J are the origin and destination fixed effects in the estimation, respectively.

To derive city level migration cost, we make the following assumption:

Assumption 3: *The city-to-city migration cost has the same structure as the province-to-province migration cost, with* $g_{ni} = \tilde{t}_{ni} \cdot t_i$*. For the variable costs* $\tilde{t}_{ni}$*, the distance parameter is the same as on the province level. For fixed costs* t_i*, for inter-provincial moves we continue to use the associated destination province fixed costs, but for intra-provincial moves we assume that the destination sunk cost is lower.*

Hence, with the estimates of δ, J_{p^d}, and I_{p^d} from the provincial regression, the easiness-to-access from city n to city i is then given by

$$\mathrm{g}_{\mathrm{ni}} = t_{ni} \times \tilde{t}_i$$

$$\mathrm{g}_{ni} = \exp\left[\frac{\delta}{\theta/(1-\sigma)} \cdot dist_{ni}\right] \times \left[Adj^{\mathrm{I}_{within}} \cdot \exp\left[\frac{(J_{p^d} + I_{p^d})}{\theta/(1-\sigma)}\right]\right],$$

where $dist_{ni}$ is the city-to-city distance, $Adj^{\mathrm{I}_{within}}$ is an adjustment term depending on whether the moves are within-province or across province.[24] As noted above, based on Tombe & Zhu (2019) and Figure A3.1, we assume that the within province entry cost is lower by taking $Adj^{\mathrm{I}_{within}} = 2$. For inter-provincial moves, we assume the sunk cost is the same as characterized by the provincial level regression so that $Adj^{\mathrm{I}_{within}} = 1$.

A4. Leaders recognize land allocation affects populations

If leaders were to account for the impacts of s on L, to derive dL/ds in (19), they would use equation (15) defining their based on $\mathrm{M_{ni}} = \frac{(\mathrm{Z_i V_i d_{ni}})^{\theta \mathrm{m}}}{\sum_{\mathrm{s}}(\mathrm{Z_s V_s d_{ns}})^{\theta \mathrm{m}}}$. Under bounded rationality we conceive that (1) they see the impact of influencing L on V in the numerator; and (2) they do not try to calculate out changes in the denominator that incorporate national full employment constraints, but rather they adjust their calculation

[24] Here Adj denotes the size of adjustment, while I_{within} is an indicator function with $\mathrm{I}_{within} = 1$ if the move is intra-provincial.

as explained below. We start by assuming that before adjustment they see $dM_{ni} = \theta_m M_{ni} dlnV_i$. To see the impacts on the effective labor, totally differentiating (15), we get $dL_i = \Gamma\left(1 - \frac{1}{\theta_m}\right)\sum_n \tilde{L}_n \left(1 - \frac{1}{\theta_m}\right) M_{ni}^{-\frac{1}{\theta_m}} \cdot dM_{ni} = (\theta_m - 1)\Gamma\left(1 - \frac{1}{\theta_m}\right)\sum_n \tilde{L}_n M_{ni}^{1-\frac{1}{\theta_m}} \cdot dlnV_i$. It follows that

$$\frac{dL_i}{ds_i} = (\theta_m - 1)\Gamma\left(1 - \frac{1}{\theta_m}\right)\sum_n \tilde{L}_n M_{ni}^{1-\frac{1}{\theta_m}} \cdot \frac{dlnV_i}{ds_i}. \text{(A5.1)}$$

To pin down $\frac{dlnV_i}{ds_i}$, recall from (1a) that we have $V_i \propto (1 - s_i)^{\frac{\alpha_X(1-\beta(1-\rho))}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)}} L_i^{\frac{(\epsilon+\alpha_L)(1-\beta(1-\rho))}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)}-1} s_i^{\beta(1-\rho)}$,

where we have ignored some multiplicative terms perceived as constants by the local leaders.

This implies that $\frac{dlnV_i}{ds_i} = \beta(1-\rho) \cdot \frac{1}{s_i} + \frac{\alpha_X(1-\beta(1-\rho))}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)} \cdot \frac{-1}{1-s_i} + \left(\frac{(\epsilon+\alpha_L)(1-\beta(1-\rho))}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)} - 1\right) \cdot \frac{dlnL_i}{ds_i}$.

Combining with condition (A5.1), we then have $\frac{dL_i}{ds_i} = (\theta_m - 1)\Gamma\left(1 - \frac{1}{\theta_m}\right)\left(\sum_n \tilde{L}_n M_{ni}^{1-\frac{1}{\theta_m}}\right) \cdot \frac{dlnV_i}{ds_i}$ or $\frac{dlnL_i}{ds_i} = \frac{\Theta_m}{L_i} \cdot \frac{dlnV_i}{ds_i}$. Thus

$$\frac{dlnL_i}{ds_i} = \frac{\Theta_m}{L_i} \cdot \frac{\beta(1-\rho)\cdot\frac{1}{s_i} + \frac{\alpha_X(1-\beta(1-\rho))}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)}\cdot\frac{-1}{1-s_i}}{1 - \frac{\Theta_m}{L_i}\cdot\left(\frac{(\epsilon+\alpha_L)(1-\beta(1-\rho))}{\frac{1-\gamma}{\theta_t}+(\alpha_X+\alpha_L-\gamma)} - 1\right)} \qquad \text{(A5.2)}$$

where the constant Θ_m is defined as $\Theta_m = (\theta_m - 1)\Gamma\left(1 - \frac{1}{\theta_m}\right)\left(\sum_n \tilde{L}_n M_{ni}^{1-\frac{1}{\theta_m}}\right)$.

We then adjust this as leaders do know that the reality is a fraction of this term in A5.2, from uncalculated changes in the denominator of M_{ni}, which would account for the fact as their city gains population, the response is limited because population losses in other cities raise base utility there making those cities more attractive.

We then resolve the model. For the response limited to 20 % of eqn. (A5.2), Figure A5.1 shows our text *f*'s versus these new *f*'s. They are almost perfectly correlated and would be under a suitable transformation. However, the problem is that now we get *f*'s in excess of 1, which violates the model. The higher we set the fraction, the greater the proportion of *f*'s that exceed 1. But given the close correlation we chose in the text to go with the assumption that dL/ds=0.

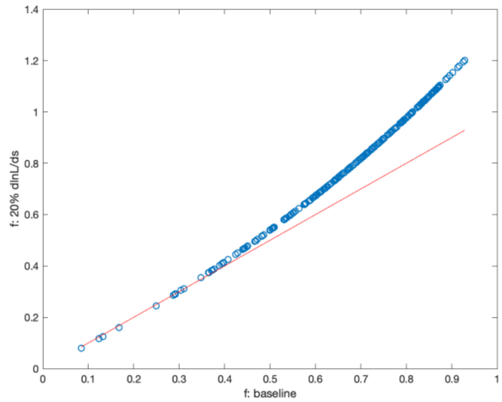


Figure A4.1 *f*'s under an alternative assumption versus the text

Appendix A5: Additional calibration checks

This section shows additional model inferred outcomes versus actual data. We start with land area. Figure A5.1 shows the correlation between model inferred total land ($\bar{X}_i$) and total built upon area of the prefecture for 2010. Figure A5.2 shows the correlation between model housing prices and data on housing prices.

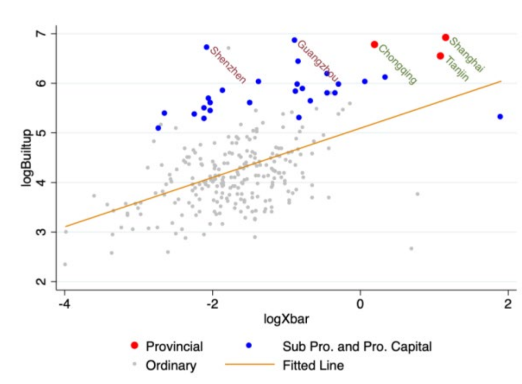


Figure A5.1 Built areas

Notes: On the x-axis is the model inferred values of total land, $\bar{X}_i$. On the y-axis is total built area of the prefecture in 2010 from the China Urban Construction Statistical Yearbook 2010**.**

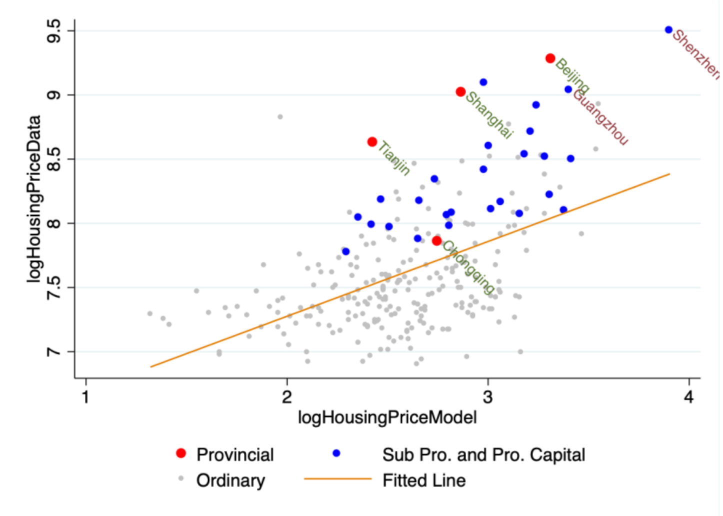
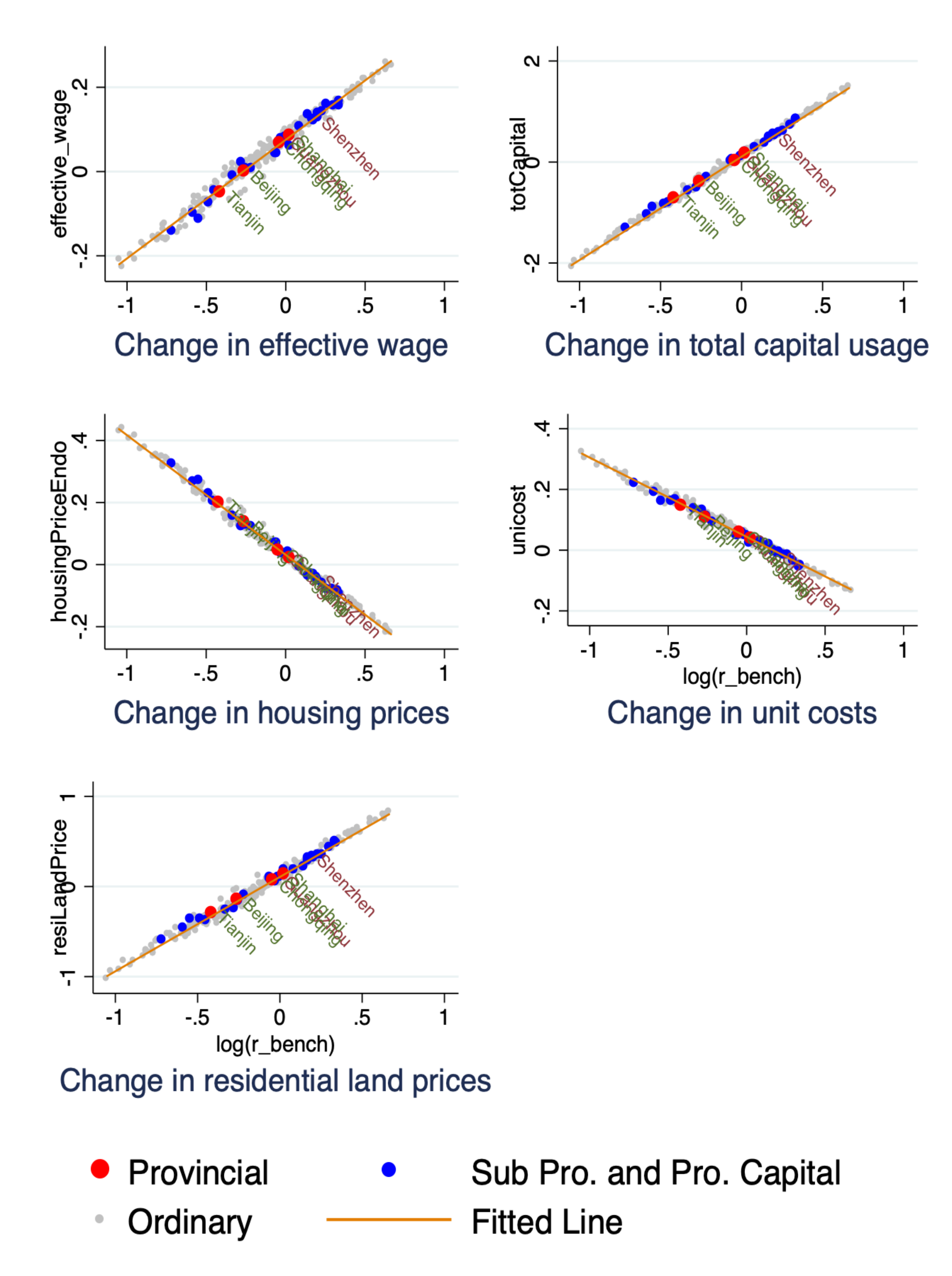


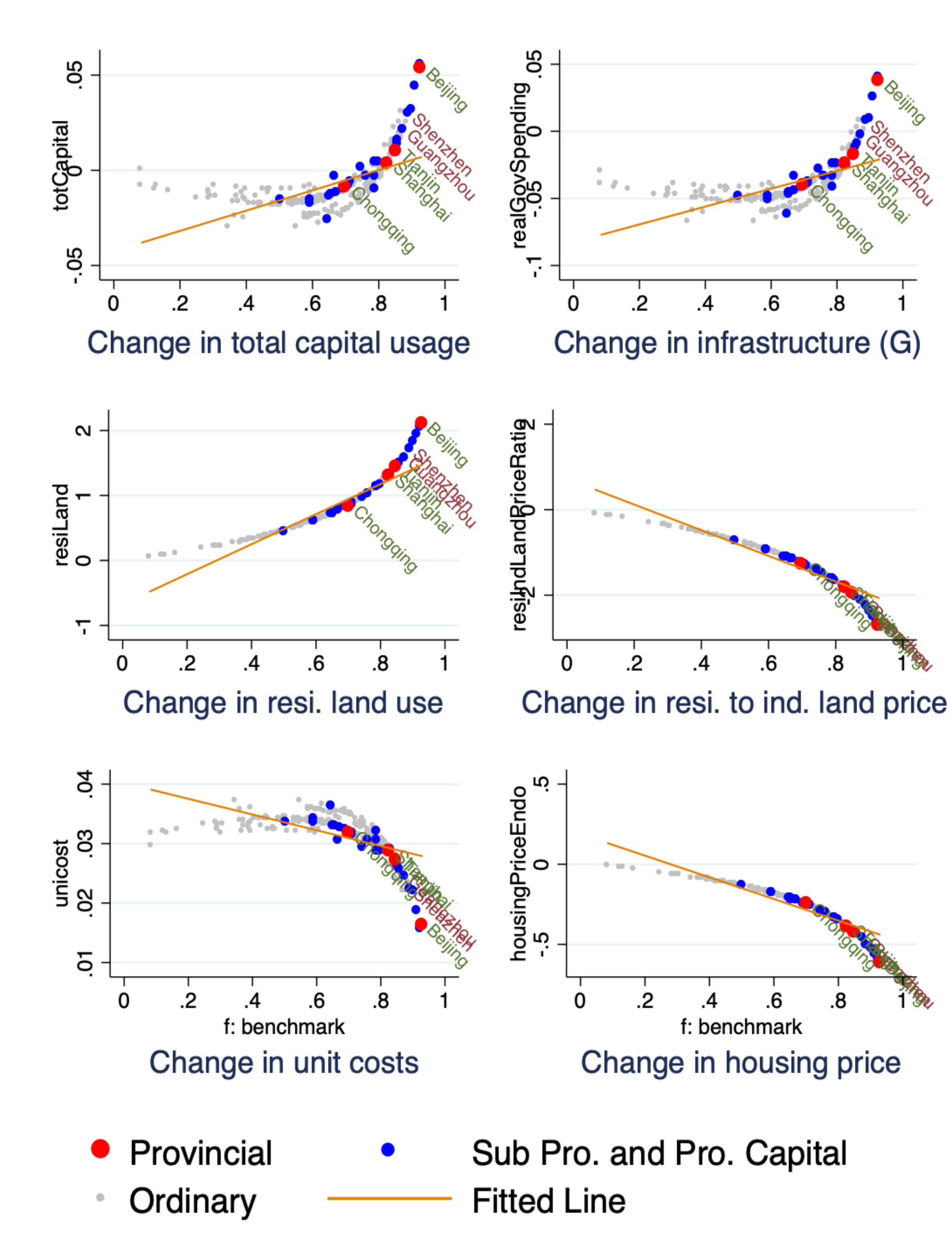
Figure A5.2 Housing prices

Notes: On the x-axis is the inferred housing price from the model. On the y-axis are housing prices for year 2010 from China Regional Statistics Yearbook.

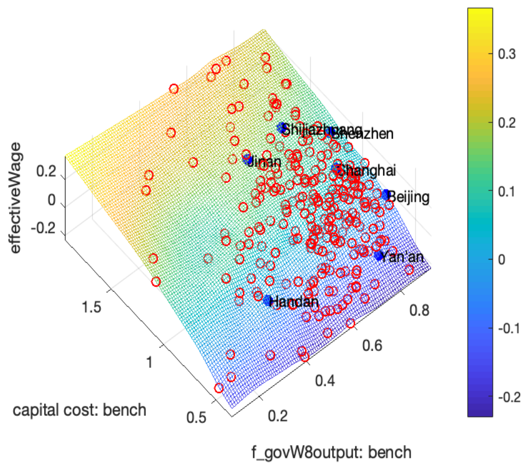
Appendix A6. Other figures



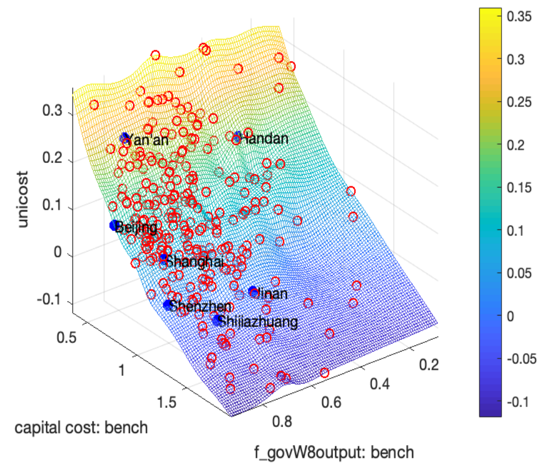
A6.1 Freeing capital markets only



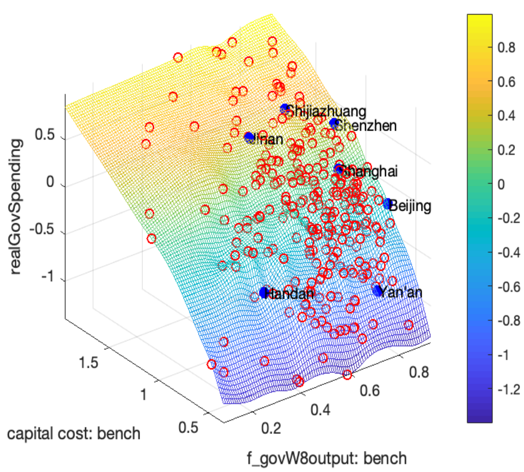
A6.2 Counterfactual, setting *f*=0, starting with free capital markets



Change in effective wage



Change in unit cost



Change in infrastructure (G)

A6.3 Joint counterfactual, relative to the benchmark

Additional References

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