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Political manipulation of urban land markets: Evidence from China

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ABSTRACT

Over the last forty years, China has experienced extraordinary growth under output market reforms, but the growth rates are now tapering off. Reforms in factor markets and city governance have been much slower and are viewed as having the potential to yield considerable efficiency gains. In this paper, we explore this possibility, tackling the key issues of local political manipulation of land markets and objectives of local leaders, constraints on the local budgetary process to finance infrastructure and capital market favoritism of certain cities. We use a structural general equilibrium model with trade and migration frictions, based on prefecture level data. We model the political process of land misallocation within cities which drives up housing prices and estimate city-by-city local leaders' preferences over economic performance versus residents' welfare. Counterfactual analysis shows that equalizing capital prices across cities, changing the political scorecard for city leaders to reward just maximization of local consumer welfare, and relaxing local budget constraints together increase welfare of consumers and returns to capital by 13.7% and 2.25% respectively. Housing prices would decline in almost all cities; and the reforms would reduce the current excessive, often showcase investment in local public infrastructure by 49% nationally. These reforms would significantly reduce the population of favored cities with low capital costs like Tianjin and Beijing and raise the population of cities with high costs of capital and low local-leader weights on consumer welfare like Shenzhen and Dongguan.

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1. Introduction

Over the last four decades, China has undergone major reforms in output markets and experienced extraordinary GDP growth, but at a rate that has been tapering off. Factor market reforms have been slow, but they are heralded as the way to sustain higher growth rates (World Bank & DRC, 2019). Capital market misallocations (Hsieh & Klenow, 2007; Brandt, Tombe, & Zhu, 2013) and labor market frictions (Tombe & Zhu, 2019) in China have been studied in a general equilibrium context. However, land market reforms have not been integrated into such models. They turn out to be of first order importance and thus the focus of this paper. Reforms deal with two issues. First is misallocation of land between residential and industrial use by political leaders. Second is the role of land in financing local public expenditures, in particular local infrastructure investments.

In studying local governance, the starting point involves the incentives of local leaders. Key elements in the evaluation and pro-

motion criteria for local political leaders in China are economic performance and related competence indicators (Li & Zhou, 2005; Chen, Li, & Zhou, 2005; Xu, 2011; Qian & Xu, 1993). This economic performance-based evaluation system provides strong incentives for local leaders to enhance local industry output and hence local GDP as currently measured in China, at the expense of maximizing the welfare of local residents.

Local leaders have two main levers to increase industry output: first is cheap land offered to firms. In China, urban land is owned by the state and sold as leaseholds with revenues going to the city treasury. As the sole supplier of land, local governments use their monopoly power to compete for footloose firms (Tao, Su, Liu, & Cao, 2010)¹, through higher allocations and thus lower pricing of land leaseholds for industrial usage (Tao, Su, Liu, & Cao, 2010; Cao, Feng, & Tao, 2008). The second lever is provision of public infrastructure relevant to production. Infrastructure investment can further enhance firms' productivity and thus measured GDP growth (Wang, Zhang, & Zhou, 2020; Wu, Deng, Huang, Morck, & Yeung, 2014). Showcase infrastructure investments may also raise a leader

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E-mail addresses: J.V.Henderson@lse.ac.uk (J.V. Henderson), sudongling@sufe.edu.cn (D. Su), zhangq@gsm.pku.edu.cn (Q. Zhang).¹ This is subject to quota constraints on rural-to-urban land conversion set by the upper-level governments since 1998 (Wang, Zhang, & Zhou, 2020).

and city's profile. However, allocating more land to industrial usage and devoting public revenues to overinvest in infrastructure will lead to higher residential housing prices and lower local consumer welfare.

While city leaders in China traditionally focus on enhancing industry output to cultivate promotion, they appear also to care in differing degrees about city residents' welfare. The scorecards for leaders now can involve items such as environmental and social considerations and tamping down escalating residential housing prices which have triggered social protests (Zheng, Kahn, Sun, & Luo, 2014; Su, Tao, Xi, & Li, 2012). The priorities of individual cities and their leaders as to how much to focus on industry output enhancement versus enhancement of local consumer welfare differ enormously across space and one novel aspect of this paper is to recover the relative weights for different cities on these objectives, enhancement of measured GDP (which does not reflect market based imputed rents) versus residents' welfare (Wang, Zhang & Zhou, 2020).

On the land market lever, there is a large literature on the regulation of local land markets to achieve various objectives such as enhancing economic or industrial development, exploiting monopoly power, or regulating who enters communities (Fischel, 1999; McDonald & McMillen, 2011; Lin, 2018; Shertzer, Twinam, & Walsh, 2018). Glaeser, Gyourko, & Saks (2005) model a land market regulator who is lobbied by residents and by developers to limit versus expand residential development, a precursor to this paper in modeling competing objectives. Papers analyze how commercial developers may have played a salient role in influencing local land development policies (Molotch, 1976; Logan & Motloch, 2007; Solé & Viladecans-Marsal, 2012).² Granting firms preferred access to land is considered one important place-based policy (Rauch, 1993). Lin (2018) models the environmental and spatial consequences in the USA of tilting zoning towards industrial land development as an historical practice. For China, Adamopoulos, Brandt, Leight, & Restuccia (2017) look at agricultural land misallocation, while Deng, Tang, Wang & Wu (2020) examine how residential housing allocations differ across the urban hierarchy. Here we focus on residential versus industrial land allocation in prefectures, where the Chinese data and context allow us to model and explicitly quantify the trade-offs of local leaders and the welfare losses in land market regulation.

For the infrastructure lever, as in other urban contexts, constraints on local revenue raising and the financing of local infrastructure are critical as reviewed in Bahl (2003) and Glaeser (2013). Again, China has the data and a neat context to study key issues. As a background, in China, local fiscal resources are dominated by national tax sharing arrangements (Shen, Jin, & Zou, 2012), where subnational governments account for over 70% of total public expenditure, while having, with transfers and collections, less than 50% of total budgetary revenues (Wong &

² 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 local economic growth. Logan & Motloch (2007) 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.

³ Note that 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. Other local taxes such as resource and environmental taxes, real estate transaction taxes, and urban construction fees are limited in terms of both legal ways of implementation and the actual amount collected.

Bhattachali, 2003; Zhang, 2006). This has left local governments under great fiscal pressure. Understanding this, 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.³ However, the use of these revenues is regulated.

Since 2008, the national government *requires* that land sales revenues be used for infrastructure construction *only* (after paying demolish fees, urban utilities, and compensation fees to farmers or original residents on the land).⁴ This regulation enshrines what was already in place. Land sales revenues directly funded over 50% of infrastructure investments such as highways and industrial parks in the 1990's and 2000's, with the remainder financed by loans using land as collateral (Peterson & Park, 2006; Ding, 2003). Cities use local government financing vehicles (LGFVs) to borrow from banks and issue bonds to finance infrastructure investments which have uncertain financial returns (Tsui, 2011), committing future land sales revenues to pay off these debts (Bai, Hsieh, & Song, 2016).

Local infrastructure investments are viewed as excessive in China.⁵ Presumed excess is the foundation of papers like that by Li & Zhou's (2005), which models the tournament competition to rise in the ranks by political leaders, by growing GDP through excessive investment in their locality. Ansar, Flyvbjerg, Budzier, & Lunn (2016) document the low returns to a large sample of local road and some rail infrastructure projects in China. Wang, Zhang, & Zhou (2020) find suggestive evidence that two thirds of Chinese cities experienced excessive spatial expansion. The literature also suggests a potential oversupply of industrial parks ("special economic zones") and their associated infrastructure. Thousands of such parks have been built to compete for FDI and stimulate local growth by local leaders who want to improve local economic performance and raise their cities' profiles (Zhang, 2011; Bai, Hsieh, & Song, 2016). Many such parks perform poorly and some have become "ghost towns" (Zheng, Sun, Wu, & Kahn, 2017; Kahn, Sun, Wu, & Zheng, 2021).⁶ Our structural model will suggest that, under current budget arrangements where all land revenues go to pay for infrastructure projects, local governments strongly overspend on infrastructure.

There is a final aspect to our analysis which involves capital markets. As detailed later, the state-owned banking sector favors certain cities with lower prices of capital, particularly big political players in the administrative hierarchy, as well as some smaller, historically industrial cities. Building on Chen, Henderson, & Cai (2017), we estimate the cost of capital in the private sector city-by-city using China's industrial survey data for 2006 and 2007.

We develop a spatial general equilibrium model to study issues of local governance, land market allocations, and financing of infrastructure investments, in a context with trade and migration frictions and capital market misallocations. In our benchmark case, we assume local leaders maximize an objective function that has weights for measured GDP and for the welfare of the representative local resident. We impose that leaders are constrained to use only and all land sales revenues to finance public infrastructure. In this benchmark, leaders optimize their objective function with

⁴ In 2008, China's Ministry of Land Resources, Treasury, and People's Bank of China jointly issued *Regulations on the Use and Management of Land Sales Revenues*, to ensure appropriate use of revenues.

⁵ A less mentioned aspect that holds universally across countries is that local infrastructure investments are ripe for corruption in both the contracting and construction phases.

⁶ Projects have high cost-overruns and usually much lower than projected usage, which contributes to China's high local debt ratio. At the provincial level, the average debt to GDP ratio is between 30 and 40% in 2019. For Qinghai and Guizhou provinces, the debt-to-GDP ratios are 71% and 58% respectively, while Guangdong's ratio is 10% (Fang, Li and Nie, 2020). Bai, Hsieh, & Song (2016) argue that a lot of debt borrowed by LGFVs is not officially classified as local government debt. Their estimates suggest that the outstanding debt of LGFVs is twice as much as the official size of local government debt and about two-thirds of GDP in 2015.

respect to the amount of local land designated for industrial use versus residential use. They face the following trade-off: on the one hand, more supply of low-price industrial land will attract firms and boost GDP; on the other hand, the resulting lower residential land supply will lead to higher housing prices and hurt consumers' welfare.⁷

We draw out features of the 2010 equilibrium that incorporates three factor markets: capital, land and labor. For land markets we estimate hedonic land prices by city in industrial and commercial versus residential use based on land transaction data between 2008 and 2015, from which we calibrate the relative weights (priorities) in each city's objective function. 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 study the welfare implications of reforms. We analyze counterfactuals to assess the impacts of capital market, land market, political and budgetary reforms on where people reside, returns to capital, overall welfare of workers, and inequality, given heterogeneous and mobile labor.

We note a few key findings here. Counterfactual analysis shows that equalizing capital prices across cities, changing the political scorecard for city leaders to reward just maximization of local consumer welfare, and relaxing local budget constraints together increase welfare of consumers and returns to capital by 13.7% and 2.25% respectively. Housing prices would fall in almost all cities; and the reforms would reduce the current excessive, often showcase investment in local public infrastructure by 48.7% nationally. These reforms would significantly reduce the population of favored cities with low capital costs like Tianjin and Beijing and raise the population of cities with high costs of capital and low local-leader weights on consumer welfare like Shenzhen and Dongguan.

While reforms generally raise welfare, there are losers, especially people living in more historically industrial cities working in heavily subsidized firms, who would then face higher prices of capital in the face of high migration costs. The losses to these places mean inequality between them and other places will rise with reforms.

As a final note, apart from the literatures on land market regulations and local public finance, we connect with two other literatures. Political favoritism of certain regions or cities is a focus of the literature 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, and that can affect national growth rates (Henderson, 2003; Castells-Quintana, 2017). Our paper demonstrates the welfare gains of removing capital market favoritism through counterfactual analysis. Second, we connect to the literature on structural models of the within country spatial distribution of resources, for example Allen & Arkolakis (2014), Donaldson & Hornbeck (2016), Alder (2019), Redding (2016), Bryan & Morten (2019), and Balboni (2019). In a precursor paper to ours, Tombe & Zhu (2019) find that reducing trade and migration frictions in China has important spatial allocation and welfare implications.

⁷ In principle, the allocation of land between the two different uses may also influence the total land sale revenues used to finance infrastructure. Granting more land for industrial use squeezes residential supply and raises residential land and housing prices. Depending on the price elasticities of housing and industrial demand for land, sales revenues may rise or fall, in a context where, according to Wang, Zhang, & Zhou (2020), about three quarters of total land sale revenues came from residential land sales.

The rest of the paper is organized as follows. Section 2 adds a few institutional details. Section 3 presents the model. In Section 4, empirical work and calibration results are discussed. We estimate migration costs, hedonic land prices and capital costs by city and infer trade costs. Then we discuss the calibration results of the model, check the plausibility of the results, and provide other supporting evidence for the model. 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 details and some related patterns in the data

China's political system is centralized with strong top-down mandates. On the personnel side, local leaders are appointed by provincial leaders who in turn are appointed by national leaders, with strong systems of patronage within different factions of the Chinese Communist Party. As noted, the economic performance-based evaluation system provides strong incentives for local leaders such as party secretaries and mayors to enhance measured GDP, by attracting industrial and commercial firms.

On the institutional side, China operates under an administrative urban hierarchy which we account for in displaying results. There are three levels: 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 deputy-province-level cities or separate-planning cities (Qingdao, Dalian, Xiamen, Ningbo, Shenzhen), which enjoy similar political power as provincial capitals in the hierarchy. We lump those together with provincial capitals. 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 for other prefectures within a province concerning, for example, major bank lending decisions. In the paper we work with the 266 prefectures in Han China which cover about 90% of China's population, avoiding minority areas due to differential governance and lack of accurate data.

As noted above, widespread underpricing and overallocation of land to industry as a lever to attract firms (Tao, Su, Liu, & Cao, 2010) results in reduced residential land supply and high residential land and housing prices, affecting consumer welfare. How big an issue is this? With details on the empirics in Section 4, we show the estimated ratio of residential to industrial land prices, for comparable land sold at auction in Fig. 1. In Fig. 1, the ratio of residential to industrial land prices is generally well over 1 with a median of 2.2. In some smaller, ordinary prefecture cities in grey dots the ratio can be close to 1, where those leaders are 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 ratios are high: 3.8 for Shanghai and 7.9 for Beijing. For provincial capitals, a number are well over 4 with Nanjing at 8.7. 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 measured GDP versus resident welfare enhancement in different cities.

For capital markets, the slow reform in capital markets is a subject of many papers (Hsieh & Klenow, 2007; Gao, 2013; Chen, Henderson, & Cai, 2017; Brandt, Tombe, & Zhu, 2013; Jefferson & Singhe, 1999). Banks in China remain *de facto* state owned. There have been reforms to try to put banks on more of a market basis and reduce the extent of non-performing loans. However, these banks cannot operate freely. The Committee of the Chinese Communist Party retains the power to appoint the boards of directors

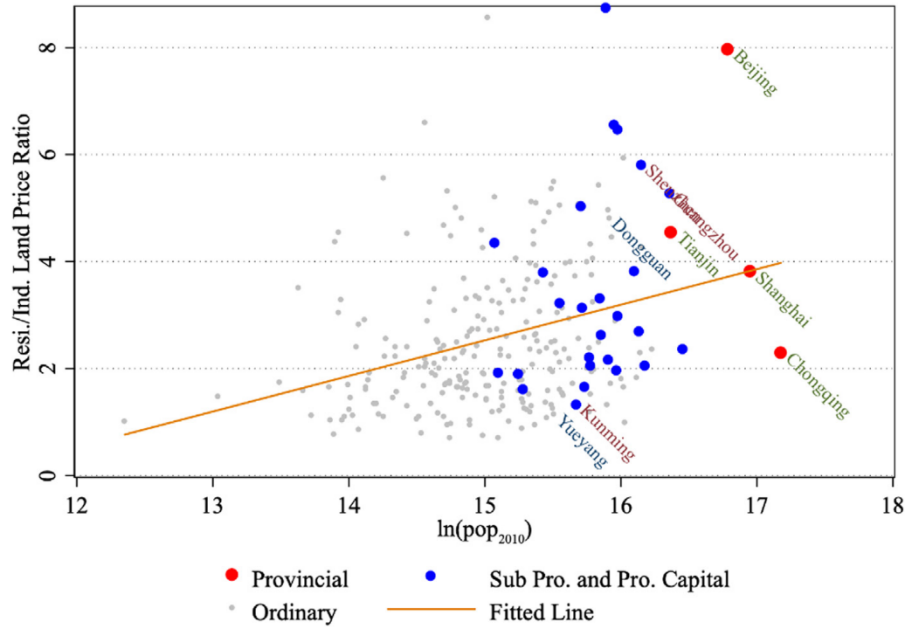


Fig. 1. Residential versus industrial land prices. The graph shows the ratio of hedonic residential land prices to those for industrial land, The x-axis is the log of prefecture population in 2010.

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”, “fairness”, and “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, Henderson, & Cai (2017).

Less well known and of focus here is spatial bias. Commercial banks in China have retrenched credit-extending authority from their local branches (Liu, 2007), so that below the provincial level, branches have limited autonomy to extend credit to new clients and investment projects. They are allocated funds for loans with stated priorities, with allocations influenced by the connections of local leaders to provincial and national leaders. Chen, Henderson, & Cai (2017) argues that there is a lot of variation locally in interest rates, charges and default provisions.⁸

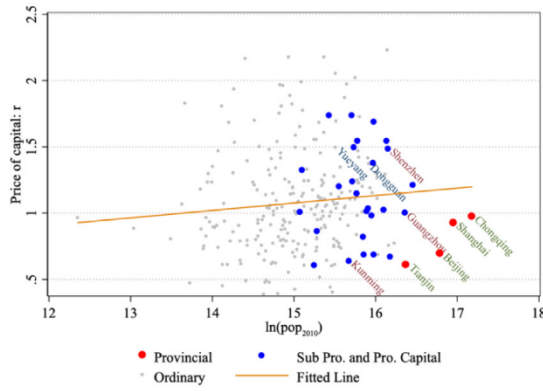
In Fig. 2a, we show the estimated, normalized capital prices faced by firms in each city, based on work reported in Section 4.2. The numbers are the prices of capital faced by private firms (only), which we think is the relevant margin for market expansion. We started by using a combined average of prices facing private and SOE firms, but decided that, by 2010, private firms were the relevant margin. Fortunately, the prices facing private firms and SOE’s are correlated as Fig. 2b shows (with a simple correlation coefficient of 0.47). In Fig. 2a, 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 strong industrial presence face low prices. These distortions have 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 moving costs high, especially for moves across provinces (Tombe & Zhu, 2019). Informal restrictions on immigrants are sometimes described as raising the door-sill 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, Long, Fan, & Gu, 2009). Different regions have different policies towards migrant workers; and the histories of migration paths differ across provinces. Some regions have long-developed migration networks. These networks help new migrants find housing, jobs and information on how to navigate the city and its regulations. In this paper, we estimate how migration frictions vary across cities. At the end, we briefly describe 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.

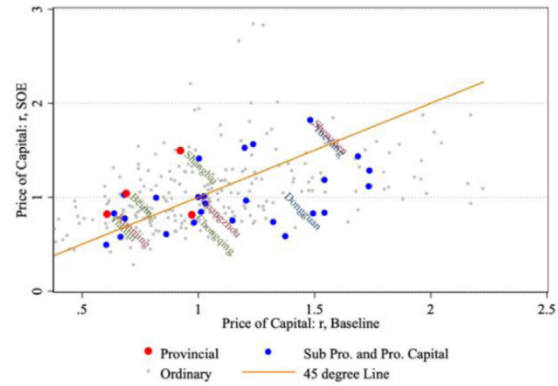
3. Model

We develop a spatial, general equilibrium model incorporating the 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. In the benchmark equilibrium, capital is allocated to cities at different prices set by the central government. Public infrastructure and land allocations are set by city leaders, who use all land revenues and, in counterfactuals, also wage taxes at either a positive or negative rate to finance infrastructure. The objective of the city government is to maximize the weighted average of the

⁸ Corruption in the disbursement of loans is analyzed in Nan & Meng (2009).



a. Initial price of capital (private firms)



b. Price of capital: SOE's vs private firms

Fig. 2. Capital market prices. Part a shows the price of capital normalized to 1 for Guangzhou against the log of population in 2010. Part b shows the strong correlation between prices of capital facing private firms (x-axis) vs SOE's (y-axis).

representative local worker's welfare and the city's measured 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 upon which market good allocations are made is $U_i = h_i^\beta E_i^{1-\beta}$ where h_i is housing and $E_i = [\int_0^1 e_i(v)^{\frac{\sigma-1}{\sigma}} dv]^{\frac{\sigma}{\sigma-1}}$ is a CES composite good made up of a continuum of tradable goods. His realized utility is $Z_i V_i$, where Z_i is the amenity level offered in city i , which will include a "congestion" cost that is a function of city population. In this standard problem we have a base indirect utility function, V_i , corresponding to U_i and a price index of the composite good, Q_i , where

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

The only worker income source are wages at rate w_i , which, in a counterfactual will be taxed by the city at a rate τ_i . P_{hi} is the price of housing, and the shares of worker income 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, given how "GDP" is calculated at the city level in China (see Section 3.7), 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 $H_i = X_{Ri}^\alpha K_{Ri}^{1-\alpha}$ where X_{Ri} is residential land and K_{Ri} is capital used in housing production. Given the price for residential land $P_{X_{Ri}}$, and the capital price r_i which is specific to city i , the dual for technology from cost minimization is

$$P_{hi} = (1 - \rho)^{\rho-1} \rho^{-\rho} P_{X_{Ri}}^{1-\rho} r_i^\rho. \quad (2)$$

We also know that factor demand equations given the demand for housing take the form, for example, for residential land of $P_{X_{Ri}} X_{Ri} = (1 - \rho)\beta w_i(1 - \tau_i)L_i$, 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 all firms have the same CRS production function, so total output is $y_i = A_i L_i^\varepsilon X_i^{\alpha_X} L_i^{\alpha_L} K_i^{\alpha_K}$, where $\alpha_X + \alpha_L + \alpha_K = 1$; 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 , $\varepsilon > 0$. Where P_{X_i} is the price of industrial land in city i , from the firm's profit maximization problem, we can derive factor share equations and solve for the unit cost function

$$c_i = \varphi (A_i L_i^\varepsilon)^{-1} P_{X_i}^{\alpha_X} r_i^{\alpha_K} w_i^{\alpha_L}. \quad (3a)$$

Intermediate goods are sold at price c_i in city i . For later use, we define city GDP, Y_i , as

$$Y_i = c_i y_i. \quad (4)$$

As detailed later, measurement of local GDP in China ignores market rents and imputed rents on housing and almost exclusively reflects value added in industry.

Relevant footnoted expressions give φ , a wage equation, the derived demands for capital and land in intermediate goods production and then the demands for land and capital by the city's housing sector, with more details in Henderson, Su, Zhang, & Zheng (2020).⁹

3.2.3. Public infrastructure

The public sector in each city supplies 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 G_i is modeled as improving firm TFP of the city such that

$$A_i = A_i' G_i^\gamma, \quad (5)$$

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.

⁹ $\varphi \equiv \alpha_L^{\alpha_L} \alpha_K^{\alpha_K} \alpha_X^{\alpha_X}$; $\varphi_1 \equiv \alpha_K^{\alpha_L + \alpha_X} \alpha_X^{\alpha_L}$; and $\varphi_2 \equiv \alpha_X^{\alpha_L} \alpha_K^{\alpha_L}$. $w_i = [\varphi^{-1} c_i A_i L_i^\varepsilon P_{X_{Ri}}^{-\alpha_X} r_i^{-\alpha_K}]^{1/\alpha_L}$; $K_{Ri} = \varphi_1 [c_i A_i L_i^{\varepsilon + \alpha_X} P_{X_{Ri}}^{-\alpha_X} r_i^{-(\alpha_L + \alpha_X)}]^{1/\alpha_L}$; $X_{Ri} = \varphi_2 [c_i A_i L_i^{\varepsilon + \alpha_X} P_{X_{Ri}}^{-(\alpha_L + \alpha_X)}]^{1/\alpha_L}$; $X_{Ri} = (1 - \rho) \beta (1 - \tau_i) [\varphi^{-1} c_i A_i L_i^{\varepsilon + \alpha_X} P_{X_{Ri}}^{-\alpha_X} r_i^{-\alpha_K} P_{X_{Ri}}^{-\alpha_L}]^{1/\alpha_L}$; and $K_{Ri} = \rho \beta (1 - \tau_i) [\varphi^{-1} c_i A_i L_i^{\varepsilon + \alpha_X} P_{X_{Ri}}^{-\alpha_X} r_i^{-(\alpha_L + \alpha_X)}]^{1/\alpha_L}$.

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 just that money to finance these infrastructure investments. In the key counterfactual, we will also allow the city to tax wages at an endogenous rate τ , either positive or negative. A tax rate of zero corresponds to our current baseline situation. Local taxation of worker income (tax rate greater than 0) may not be an institutional option at the moment. However, since in counterfactuals the optimal tax rate will turn out to be negative, it is more plausible that cities could rebate some portion of land revenue sales directly or indirectly to residents (through other public good provision), although in current practice they do not and, as explained above, in principle they cannot. Related, we do not cover local consumer public goods like schools and green parks, many of which are provided at the district or even neighborhood level. One could think of these being Tiebout (1956) public goods where sorting across neighborhoods leaves them akin to private consumer goods. For infrastructure investments, G , the public budget constraint is

$$G_i = (P_{X_i} X_{iI} + P_{X_{Ri}} X_{Ri} + W_i \tau_i L_i) c_i^{-1}, \tag{6a}$$

where G is produced one-for-one out of intermediate goods. Using the factor demand relationships and the demand for housing, (6a) can be written as

$$G_i = [\alpha_X + (1 - \rho)\beta(1 - \tau_i)\alpha_L + \tau_i\alpha_L] y_i. \tag{6b}$$

We can also rewrite the unit cost function as

$$c_i^{1-\gamma} = (\alpha_X + (1 - \rho)\beta(1 - \tau_i)\alpha_L + \tau_i\alpha_L)^{-\gamma} \cdot (A' L_i^e)^{-1} X_{iI}^{-\alpha_X} L_i^{-\alpha_L} \left(\frac{r_i}{\alpha_K}\right)^{\alpha_K} Y_i^{\alpha_X + \alpha_L - \gamma}. \tag{3b}$$

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 $F(B(v)) = \exp(-B(v)^{-\theta_t})$ 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 $p_{in}(v) = d_{in} c_i / B(v)$. Traded 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 with standard derivations in Appendix A2, one has the probability that a city buys a variety from any other city and the total demand for any city's tradable goods is based on the share of labor incomes spent on goods in all cities and their likelihoods of buying this city's varieties. 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

$c_i y_i - c_i G_i - r_i(K_{iI} + K_{Ri})$. Equating demand and supply for a city and incorporating Eq. (6b) will yield

$$(1 - \tau_i) Y_i = \sum_n \frac{(c_i d_{in})^{-\theta_t}}{\sum_{i=n}^N (c_i d_{in})^{-\theta_t}} (1 - \tau_n) Y_n, \tag{7a}$$

with detailed derivation in Henderson, Su, Zhang, & Zheng (2020).

Next let us introduce some key expressions which we shall use later in our model derivations. These are Donaldson & Hornbeck's (2016) terms for consumer market access to products through trade, CMA_i , and firm market access to selling opportunities through trade, FMA_i . Specifically, the definitions of CMA_i and FMA_i are given by

$$CMA_i \equiv Q_i^{-\theta_t} = \left[\Gamma\left(\frac{\theta_t + 1 - \sigma}{\theta_t}\right) \right]^{\frac{\theta_t}{1-\sigma}} \cdot \left[\sum_{j=1}^N (c_j d_{ji})^{-\theta_t} \right], \tag{8a}$$

$$FMA_i \equiv \sum_n \frac{(d_{in})^{-\theta_t}}{CMA_n} (1 - \tau_n) Y_n, \tag{8b}$$

where Q_i is the realized price index in Eq. (1) and $\Gamma(\cdot)$ refers to the usual gamma function. Intuitively, the higher the production costs in the surrounding cities of city i (discounted by respective distance to city i), the higher the price index faced by consumers in city i and hence the lower the consumer market access of city i . Also, the higher the total income in the surrounding cities of city i (discounted by respective distance to city i), the higher the demand faced by firms in city i and hence the higher the firm market access of city i . Using the above expressions and Eq. (3b), we can then rewrite Eq. (7a) and get an expression for city output which is a function of variables we optimize over (e.g., s_i , the land share going to residential use) or we treat as given to the city (e.g., r_i and \bar{X}_i):

$$Y_i = F_i [A'_i \varphi_4 r_i^{-\alpha_K} X_i^{-\alpha_X} (1 - s_i)^{\alpha_X} L_i^{\alpha_X + \alpha_L}]^{\frac{\theta_t}{(1-\gamma) + \theta_t(\alpha_X + \alpha_L - \gamma)}}, \tag{7b}$$

where $F_i \equiv \left(\left[\Gamma\left(\frac{\theta_t + 1 - \sigma}{\theta_t}\right) \right]^{\frac{\theta_t}{1-\sigma}} \cdot FMA_i \right)^{\frac{1-\gamma}{(1-\gamma) + \theta_t(\alpha_X + \alpha_L - \gamma)}}$ and $\varphi_4 \equiv \alpha_K^{\alpha_K} [(1 - \rho)\beta(1 - \tau_i)\alpha_L + \tau_i\alpha_L + \alpha_X]^\gamma (1 - \tau_i)^{\frac{\gamma-1}{\theta_t}}$.

3.4. Realized utility, migration and the spatial allocation of population and effective labor

In this subsection, we derive the amount of effective labor for each city, and national effective labor supply. Our framework involves heterogeneous labor, and we spell out some of the needed details. 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 Eq. (1). There are three key components to this. First, a worker gets a random productivity draw a_i in city i from a Frechet distribution with cdf $\Psi(a_i) = e^{-a_i^\theta}$, for θ the dispersion parameter. 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 . Second, $g_{ni} \leq 1$ is the fraction of utility left-over net of migration costs. We assume $g_{ii} = 1$ so that the stayers suffer no migration cost. In this formulation, we have simplified the Chinese context by not distinguishing people within a city by local "citizenship" (*hukou*) status, where in-migrants typically may take some years to obtain local *hukou*. Ours is a long run equilibrium model not a dynamic one, and part of migration costs is the cost of eventually obtaining local *hukou*.

Third, Z_i consists of two components, \bar{Z}_i , the base (exogenous) amenity level for any city i , and an endogenous component dependent on city labor force, so that

$$Z_i = \bar{Z}_i \exp(-\omega L_i). \tag{9}$$

The motivation for adding this term is the local residents' concern with over-population of especially bigger cities due to "congestion" costs. Introducing this term has modest effects on our calculations of welfare costs but does affect the allocation of population in counterfactuals. Cities like Beijing which are "over-populated" in the baseline will lose less population in counterfactuals than without this term, because even small reductions in population improve outcomes just due to less congestion, making Beijing increasingly attractive as its population falls. While in (9) congestion appears as having a direct effect on consumer welfare, in the local leader's optimization problem below, this congestion factor could also represent the leader's preferences about city over-population, a political issue in China.

How do we relate city populations to migration flows? Workers move to the city offering them the highest utility and as is standard, the proportion of people moving from n to i is $m_{ni} = \text{Prob}(U_{ni} > \max\{U_{ns}, s \neq i\}) = \frac{(Z_i V_i g_{ni})^\theta}{\sum_s (Z_s V_s g_{ns})^\theta}$. For N cities in the economy, the migration flow matrix determined by this equation implies a relationship between initial and final population that

$$\tilde{L}'_i = \sum_{n \in N} \frac{(Z_i V_i g_{ni})^\theta}{\sum_{k \in N} (Z_k V_k g_{nk})^\theta} \cdot \tilde{L}_n. \tag{10}$$

\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 population constraint is

$$\sum_{n \in N} \tilde{L}_n = \sum_{n \in N} \tilde{L}'_n = \tilde{L}. \tag{11}$$

Eq. (11) gives a count of bodies. But we also need to know the allocation of effective labor. The total effective labor at city i is given by $L_i = \sum_n E(a_i | \text{moving from } n \text{ to } i) * \tilde{L}_n * M_{ni}$. 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 $E(a_i | \text{moving from } n \text{ to } i) = \left(\frac{1}{M_{ni}}\right)^{\frac{1}{\theta}} \cdot \Gamma(1 - \frac{1}{\theta})$. 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 further down into the distribution. Combining the above two conditions yields

$$L_i = \sum_n \tilde{L}_n M_{ni}^{1-\frac{1}{\theta}} \Gamma\left(1 - \frac{1}{\theta}\right). \tag{12}$$

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 and infrastructure provision

As discussed in the introduction, each local government maximizes an objective function, given city specific weights to the welfare of a representative worker, $(1 - f_i)$, versus to total output value, f_i . The local government chooses the allocation of industrial

land versus residential land from the city supply of land and, in one counterfactual, the rate of worker income taxation, τ_i , to maximize the objective function. Thus, for any city i , the local government's objective is.

$$\max_{s_i, \tau_i} (Z_i V_i)^{1-f_i} Y_i^{f_i}$$

$$\text{s.t. } s_i \bar{X}_i = X_{Ri}, (1 - s_i) \bar{X}_i = X_{Ii}, \text{ and } G_i = (P_{X_i} X_{Ii} + P_{X_{Ri}} X_{Ri} + w_i \tau_i L_i) c_i^{-1},$$

where \bar{X} is the total amount of available land in city i and s_i is the share going to residential use. In solving the problem, we need to express the two equilibrium outcomes Y and V as functions of X_I , X_R (or s) and τ_i . We already have Y from Eq. (7b). For V , with substitutions, we get

$$V_i = \Omega_i B_i \left\{ [(1 - s_i)^{\alpha_X} L_i^{\epsilon + \alpha_L}]^{\frac{\theta_t(1-\beta(1-\rho))}{(1-\gamma) + \theta_t(\alpha_X + \alpha_L - \gamma)}} s_i^{\beta(1-\rho)} / L_i \right\}, \tag{14}$$

$$B_i \equiv \left[r_i^{-\beta \rho - \frac{\alpha_X \theta_t(1-\beta(1-\rho))}{(1-\gamma) + \theta_t(\alpha_X + \alpha_L - \gamma)}} F_i^{(1-\beta(1-\rho))} CMA_i^{\frac{1-\beta}{\theta_t}} \right],$$

where Ω_i is a city constant given by

$$\Omega_i = (1 - \tau_i)^{1-\beta(1-\rho)} \alpha_L \left((1 - \rho)^{\rho-1} \rho^{-\rho} ((1 - \rho)\beta \alpha_L)^{1-\rho} \right)^{-\beta} \cdot \left[A_i' \varphi_4 \bar{X}_i^{\alpha_X} \right]^{\frac{\theta_t(1-\beta(1-\rho))}{(1-\gamma) + \theta_t(\alpha_X + \alpha_L - \gamma)}} \cdot X_i^{-\beta(1-\rho)}.$$

We notice that the city constant contains information about the tax rate τ_i and φ_4 , where the latter also depends on τ_i . Note in the calibration exercise right below, τ_i is set to 0.

In solving (13) we assume the local leader takes CMA_i , FMA_i , L_i and r_i as given, since her city is one of many. In Appendix A4, we discuss experiments trying to assess the impact of these assumptions by fully or partially relaxing $dnL_i/ds_i = 0$ and we show this will not affect the results of our key counterfactuals with $f = 0$.¹⁰ Using $s_i \bar{X}_i = X_{Ri}$, $(1 - s_i) \bar{X}_i = X_{Ii}$, and optimizing with respect to s in (13), we get

$$\frac{1 - s_i}{s_i} = \frac{\theta_t \alpha_X (1 - (1 - f_i) \beta (1 - \rho))}{(1 - f_i) \beta (1 - \rho) (1 - \gamma + \theta_t (\alpha_X + \alpha_L - \gamma))}. \tag{15}$$

If, as in calibration, $\tau_i = 0$ and total cG equals total land rents, we solve out land prices (given consumer and firm FOC's related to X_{Ri} and X_{Ii}) as

$$\frac{P_{X_{Ri}}}{P_{X_{Ii}}} = \frac{\theta_t \alpha_L (1 - (1 - f_i) \beta (1 - \rho))}{(1 - f_i) (1 - \gamma + \theta_t (\alpha_X + \alpha_L - \gamma))}. \tag{16a}$$

In (16a), in the calibrated equilibrium, 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.¹¹ We will use (16a) and the data on city land prices to solve for each city's f . We note that, if $f = 0$, under the parameter values we use in the paper, this ratio is 0.64 so the industrial price exceeds the residential, while in Fig. 1 residential prices in the benchmark equilibrium generally strongly exceed industrial ones.

In our key counterfactual we relax the local government budget constraint with $\tau_i \neq 0$ and set $f = 0$, so governments act just to max-

¹⁰ We can relax the assumption that $dL/ds = 0$ in solving the benchmark calibration to some degree and recalculate f 's. Appendix A4.1 shows these f 's are very highly correlated with the ones we solve under the assumption $dL/ds = 0$. In counterfactuals where the leader just maximizes welfare (i.e., $f = 0$) we do not have to assume that the leader sees $dL/ds = 0$. In fact, when s is optimized with $f = 0$, its marginal impact on local welfare is zero, which in turn means there is no incentive to migrate any more, thus $dL/ds = 0$.

¹¹ Note if $f = 1$, there will be a corner solution where the government would like to lower land for residential use to zero. And this pushes housing production towards 0 and raises housing price towards infinity.

imize the welfare of the representative agent in the city, V_i . Then optimizing gives

$$\tau = \frac{-\beta(1-\rho)\alpha_L - \alpha_X + \gamma}{\alpha_L(1-\beta(1-\rho))} \tag{17}$$

Under reasonable parametric values, τ will be negative. This implies that forcing the city to spend all rents on G leads to over-provision of G in the benchmark case. For this case where $f = 0$ and $\tau_i \neq 0$, the price ratio is given by

$$P_{X_R}/P_{X_i} = \frac{\theta_t(\alpha_X + \alpha_L - \gamma)}{\theta_t(\alpha_X + \alpha_L - \gamma) + 1 - \gamma}, \tag{16b}$$

which is 0.70 under the parameter values we use, or residential land is underpriced. Why are prices not equalized, even though the public budget constraint is relaxed, and leaders act to maximize just the welfare of residents?

The reason is that cities have monopoly power in trade, facing downward sloping demand curves for their varieties. In the case of (16b), with $f = 0$ and a relaxed budget constraint, higher-priced industrial land raises output prices. To illustrate this point, we consider two hypothetical cases. If there is no trade but still capital in the model, in this case, $P_{X_R}/P_{X_i} = 1$, so there is no land market distortion. Second, if there is no capital in the model when $f = 0$, but there is trade, under a relaxed budget constraint, P_{X_R}/P_{X_i} is less than one as in (16b) at $\theta_t/(1 + \theta_t)$.

3.6. Closing the model

To close the model, we sum within city so demand for land equals the city's land supply (\bar{X}_i) and we sum within and across cities so capital demand equals the national supply of capital (\bar{K}_{agg}):

$$X_{Ri} + X_{ii} = \bar{X}_i, \tag{18a}$$

$$\sum_i K_{L,i} + \sum_i K_{R,i} = \bar{K}_{agg}. \tag{18b}$$

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 as¹²

$$W = \sum_{i=1}^N \frac{\tilde{L}_i}{\sum_{j=1}^N \tilde{L}_j} \cdot \lrcorner \left[\sum_{k \in N} (Z_k V_k g_{ik})^{\theta} \right]^{\frac{1}{\theta}}, \tag{19}$$

where $\lrcorner = \Gamma(\frac{\theta-1}{\theta})$, from the gamma function (Tombe & Zhu, 2019). Note that the expected utility of all people originating from city i is

$$E[U_i] = \lrcorner \left[\sum_{k \in N} (Z_k V_k g_{ik})^{\theta} \right]^{\frac{1}{\theta}}. \tag{20}$$

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

$$Inequality_o = \sum_i \frac{\tilde{L}_i}{\sum_{j=1}^N \tilde{L}_j} \cdot (E[U_k]/W - 1)^2. \tag{21}$$

¹² It is also possible to derive expressions to calculate average welfare and inequality based on where people end up. With the Frechet distribution, $E[U_i] = E[U_i | moving to city k]$, for any destination city k . Therefore, the average welfare of people currently living in city k (after migration) is given by $E[\tilde{U}_k] = \sum_{i \in N} \frac{\tilde{L}_i}{\tilde{L}_k} E[U_i | moving to city k] = \sum_{i \in N} \frac{\tilde{L}_i}{\tilde{L}_k} \cdot \lrcorner \left[\sum_{s \in N} (Z_s V_s g_{is})^{\theta} \right]^{\frac{1}{\theta}}$. Thereby we can also define another measure of inequality using $E[\tilde{U}_k]$, $Inequality_d = \sum_k \frac{\tilde{L}_k}{\sum_{j=1}^N \tilde{L}_j} \cdot (E[\tilde{U}_k]/W - 1)^2$.

3.7. Calibrating the model

To calibrate the model, we need data for each city on the price of capital, the prices of residential and industrial land, GDP (Y), initial and final populations, and migration and transport costs to all other cities. Transport cost data are taken from Baum-Snow, Henderson, Turner, Zhang, & Brandt (2020) as explained in Appendix A2. We have data on GDP and populations from Yearbooks and the Census. Note, most crucially in Chinese cities, GDP statistics only include a very low symbolic housing component, unrelated to local housing prices¹³. The Chinese method differs from the North American and European methods which use rents for rental units and imputed rents (based on a market comparison approach) for owner-occupied units to calculate the value-added for housing service. China's GDP estimation method uses a national constant construction cost per square meter multiplied by the total floor area to get the total book value for the housing stock, and then takes a fixed depreciation rate of this total housing stock cost as the value-added of housing service from owner-occupied housing units (which are well over 80% of units in China). Thus, this component has nothing to do with the land values and housing prices in each city; it is just mechanically proportional to the total housing floor area of the city. This estimation method greatly under-estimates the housing component and makes it negligible in GDP (Liu, Zheng & Xu 2003). Thus, we treat GDP as equivalent to Y in our model. 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 migration costs and population in Eqs. (10)–(12) we can pin down migration flows, M_{ni} , $Z_i V_i$, and effective labor, L_i , for each city. Given land prices, Eq. (16a) gives f_i 's and then Eq. (15) gives inferred s_i 's. Using Eq. (3a) and wage equations, with manipulation and substitutions, we can solve for A_i given GDP and then pin down A_i and G_i in Eq. (5). We use equations in footnote 10 to solve for each city's use of land and capital in residential and industrial use, given land prices. Summing within the city for land gives us each city's land supply (X_i) and summing within and across cities gives the national supply of capital ($\sum_i K_{L,i} + \sum_i K_{R,i} = \bar{K}_{agg}$). Eqs. (2), (8a), (3a) and (1) give P_{hi} , CMA_i , Q_i , and V_i . Having already solved for $Z_i V_i$, we then know consumer amenities Z_i which can be decomposed in Eq. (9) into \bar{Z}_i and congestion costs, $\exp(-\omega L_i)$. Later we can use this information to calculate worker welfare. More details are in Appendix A1.

4. Deriving benchmark prices and costs

We now turn to estimation of hedonic land prices by use type in each city, migration costs, and the prices of capital by city.

4.1. Hedonic land prices

We estimate land prices in every city in the residential versus industrial sector. We have a large micro-level dataset that covers all the land transactions in Chinese cities for 15 years. This includes all land parcels that are sold through public auction of land in China (prevalent for residential land transactions since August 2004 and for industrial land since July 2007). We also have some negotiated sales transactions, common for industrial land transactions before July 2007. The data contain residential, commercial, and industrial land transactions. The sole allowed land use of a parcel is specified prior to auction, based on the overall supply deci-

¹³ See https://www.stats.gov.cn/tjzs/cjwjtjd/201308/t20130829_74319.html from the National Statistical Bureau.

sions of the city. This is the most comprehensive land transaction data of urban China, obtained from <http://landchina.mlr.gov.cn>.

To have sufficient sample by use in each city, we use the data for the years 2008–2015, after the auction reforms in 2007. We exclude the small number of negotiated sales transactions during this period, mostly for industrial land transactions, as outliers.¹⁴ We run hedonic regressions 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 what we label as industrial land transactions. We also drop outlier transactions with either zero price or price per square meter greater than 100 k 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 have more than 100. We run regressions for each city i :

$$\log(P_{xjt}^i) = b_0^i + \beta^i R_j^i + \Gamma_t^i + D^i \text{Type}_j^i + m_{jd}^i + \epsilon_{jt}^i. \quad (22)$$

In (22), P_{xjt}^i is the unit (sq. mt.) sale price of the land parcel j , R_j^i is a vector of parcel characteristics including land area, maximum floor-to-area ratio [FAR], land quality tier, auction format, and distance to city center and its interaction with land area.¹⁵ Coefficients vary by city. Γ_t^i is a year fixed effect. Type_j^i is a land use type dummy with “1” for “residential” and “zero” for “industrial” for parcel j . Thus $\exp(D^i)$ is the hedonic price ratio of residential land to industrial land in city i for otherwise identical plots. A concern is that parts of a city may be exclusively industrial or residential. To enhance identification, we add a district (d) fixed effect, m_{jd}^i , so as to compare parts of the city where these two uses are competing.

To solve out A' and land stocks in calibration, we also need absolute land prices. For each city we save the estimated coefficient vector denoted as π^j . We predict the hedonic land price for city j by land use type using π^j and the same set of characteristics of a national prototype land parcel. The characteristics of the prototype land parcel are chosen as the national means of the above noted land characteristics of the combined residential land and industrial land sample.¹⁶ This then gives us, for a nationally representative piece of land, price by city by type of use.

In Fig. 1 above, we plotted the relative price of residential to industrial land. The ratios range between 0.68 and 8.7 for the same quality land, with a median of 2.2 across all cities.¹⁷ As noted above, cities like Beijing and Shenzhen which are testing grounds for future national leaders who are tasked with growing the local economy have very high ratios and consequently also very high housing prices.

4.2. Capital costs

From the Annual Survey of Medium and Large Industrial firms for 1998–2007 accounting for 95% of industrial sales in China,

¹⁴ 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 Tian, Wang, & Zhang 2022), 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).

¹⁵ The tier quality of the parcel is given by indicator variables, where the city government categorizes tiers based on the amenity quality of land, and the land parcel's distance to city center. For auction formats, there are English auction, two-stage auction, and sealed-bid auction. Cai, Henderson, & Zhang (2013) show transaction format may significantly impact the land sale price.

¹⁶ For the district fixed effects, we do a weighted (by transactions) average for each city.

¹⁷ One city with the lowest ratio 0.49, Deyang in Sichuan, was winsorized at the next lowest ratio in the data of 0.68.

Chen, Henderson & Cai (2017) estimate an 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, Henderson & Cai (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 for private firms which persist from year to year.

Using the data from the Annual Survey of Medium and Large Industrial Enterprises for 2006–2007, we estimate the price of capital faced by private firms in each city. We use an ARP equation based on the model, but allow differences in capital intensity by industry, j , and city differences in items, J_{ji} , which influence firms elasticities of demand and hence revenue products. For firm s in industry j in location i , from profit maximization,

$$\ln\left(\frac{p_{sj}^* y_s}{k_s}\right) = \ln(r_i) - \ln\alpha_{kj} + J_{ji} + \epsilon_{ijs}. \quad (23)$$

p_{sj}^* 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. For the J_{ji} 's, we control items affecting price, such as the (log) number of firms in the prefecture in the industry of the firm from the 1995 Industrial Census (supply), distance to the coast, and (log) GDP in 1990 within 150 km of the prefecture city center (demand factors). While these measures are not explicitly derived from the model, they are reduced form historical controls, which mitigate current endogeneity issues. Estimation of (23) uses firm level data pooled for 2006 and 2007 (with a time fixed effect).

The resulting prices of capital normalized to Guangzhou at 1 were shown above in Fig. 2. Three things are of note. First, the price of capital rises modestly with city size, where smaller and typically more remote cities such as in the north may be favored historically. Second, as noted earlier, certain political cities face very low prices. Finally, there is the wide dispersion in prices, a key issue in the Hsieh & Klenow (2007) paper.

4.3. Estimation of migration costs

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). 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). In the Chinese context, we assume there are asymmetric fixed costs of entering a province, but variable symmetric travel time costs. From Eq. (10), migration costs (fraction of utility lost at the destination when migrating) are denoted as g_{ni} , which we decompose into $g_{ni} = t_{ni} * \tilde{t}_i$, 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 first use a formulation of province-to-province migration costs and run a gravity model regression, based on the 2010 census data. These give fixed and variable costs of inter-provincial migration. The formulation is standard, where in Eq. (10) migration costs

are 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.

Fig. 3 plots the relative fixed costs of entering a province, with the 3 regions of China marked by color. Note a higher value of \tilde{t}_i means lower costs, or more real income survives. 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 comparatively strongly resist immigration by offering migrants poor living conditions with poor housing facilities in migrant areas and poor access to state schools.¹⁸ Yet they have relatively low fixed costs of entry inferred from larger inflows. The reality is that these cities have developed extensive long term migration networks, with, for example, many neighborhoods named after the origin of migrants there. These networks help migrants find housing and jobs and provide information on how to navigate the city and its regulations and restrictions. It is clear that typical policies to make life miserable for migrants 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.

In Figure A3.2, we plot total pairwise migration costs. While many within province moving costs are *relatively* low, for the vast majority, it still costs more than half of a person's real income to move. Second, the vast majority of city pairs involving interprovincial moves leave much smaller fractions of real income. These numbers on what real income is left after migration are actually higher than in Tombe & Zhu (2019). While one can quibble over absolute magnitudes, for our last counterfactual, they will give *relative* gains from changing migration regimes, as well as impacts on city populations.

5. Calibration results

To calibrate, we need to specify parameters we do not estimate. These are in Table 1, with sources noted. Most are close to standard international numbers, with some deviation based on estimates for China. For agglomeration economies, given estimates tend to vary substantially by individual paper given the details of estimation, we use a "commonly accepted" number 0.04 from Rosenthal & Strange (2004) and also from de la Roca & Puga (2017). Counterfactual results are robust to raising or lowering the estimate by 0.02.¹⁹ For capital intensity we adjust the commonly accepted number of 0.25 upward, given the literature on China which shows high capital intensity (e.g., Jefferson & Singh (1999) and Bai & Qian (2010)). A dif-

¹⁸ 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, Shanghai 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.

¹⁹ We did some sensitivity checks for ε equal to 0.02 and 0.06. The counterfactual results change only modestly, and can be provided upon request.

ficult one is land's share in production, where we know of no modern econometric study using Chinese data. Given China's high historical industrial land intensity²⁰, we adjust the USA estimate of 0.05 upward to 0.07. We note our counterfactual results are robust to lowering the share to 0.05 or raising it to 0.08.²¹ For the measure of infrastructure productivity in production, γ , we use Melo, Graham, & Brage-Ardao (2013)'s meta study number of 0.06. While some developing countries reported in Melo, Graham, & Brage-Ardao (2013) have higher numbers, we balance that against Wang, Wu, & Feng's (2019)'s estimates of 0.031 and 0.046 for China for transport and utilities infrastructure respectively. Finally, there is the congestion cost parameter. We set $\omega = 4 \times 10^{-8}$. At a population of 4 million, this gives a population elasticity of -16% , for Z . This is higher than Combes, Duranton & Gobillon's (2019) estimates for "agglomeration" costs in French cities which range to 8% for larger cities. However, French cities are typically much smaller; and the agglomeration cost is just about housing prices in a monocentric model with commuting and no congestion. For China, Wang & Zhang (2022) for the same commuting distances estimate a density, or congestion elasticity of about 16% to 20%.

Given those parameters, the data, and the process described in Section 3.7 and in Appendix A1, we can solve for city-specific parameters as well as the equilibrium quantities of endogenous variables of the model. These are A'_i , G_i , c_i , f_i , X_{Hi} , X_{Ri} , K_{Hi} , K_{Ri} and \bar{Z}_i . From the X 's and K 's we know total land supply for each city and total capital stock of the nation, both in fictitious units. The numeraire is the price of capital in Guangzhou, so initial capital rents are divided by the price in Guangzhou.

The focus in this subsection is on evaluating the validity of our baseline model by seeing if our benchmark estimates of A'_i , G_i , c_i and f_i , vary across cities as expected, and by checking the model's ability to predict relative trade flows, land supplies by city, and house prices. In Table 2, we provide a simple table of regressions of A' , G , c and f on a set of covariates. City productivity, A' , in col. (1) rises with education as expected because labor is not in education units. Productivity rises with scale, or population, and better political status of the city, the latter 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 have higher A' . Distance to the coast has the "right" sign but is not significant, given we have accounted for trade costs, albeit not flows of information from coastal cities about technical innovations. For unit cost, c , covariate effects mirror those for A' with opposite sign as expected, although here the distance to the coast effect is significant.

Calibrated infrastructure levels, G , as expected, rise with population, political status, manufacturing share and education. While the model does not breakout manufacturing versus other sectors, manufactured goods are the main export goods from the city requiring infrastructure. These G levels are accumulations of flow investments. We have the city-level data on: (1) average annual

²⁰ Industrial land use has dominated other land uses in urban China: over 50% of newly developed urban land is for industrial use based on data from the 2004–2012 editions of the *Yearbooks of Land and Resources* and the official website of China's Ministry of National Land and Resources (<https://www.landchina.com>). In terms of stock, on average 20% of cities' urban built-up land area is for industrial use based on data from the *Yearbooks of Urban Construction*, which is much higher than USA.

²¹ In doing this we adjust capital's share up or down so factor shares still sum to 1. For the welfare results in Table 4 below, in the CF-2 comparison with the baseline, the percent changes vary by less than 7% of the reported values. In going from CF-2 to CF-3, for a share of 0.05 the incremental percent gain is reduced by 41%; while, for a share of 0.08, the incremental percent gain is increased by 20%. The counterfactual results can be provided upon request.

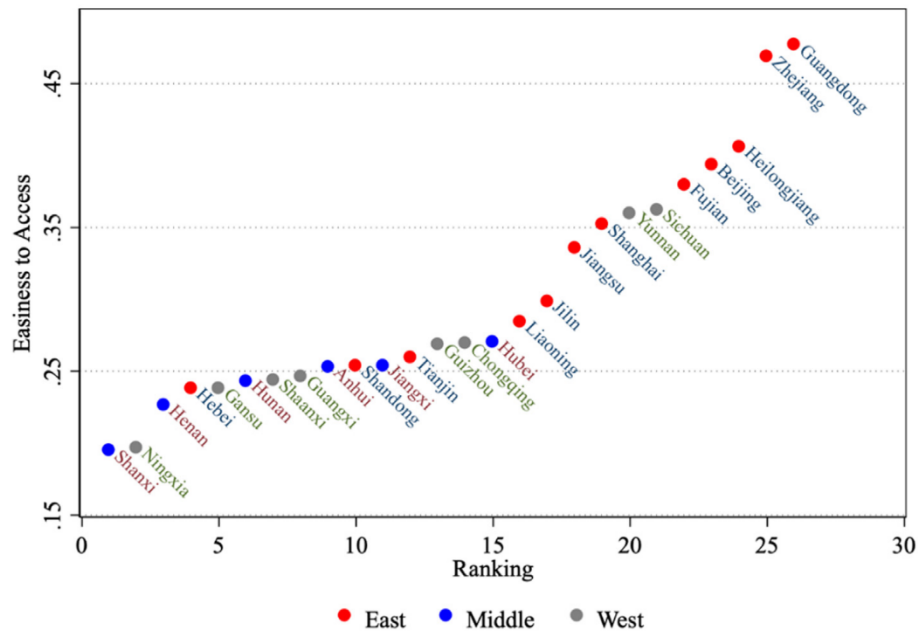


Fig. 3. Fixed costs of migration. Notes: The figure shows the fixed cost of migration as the reverse: ease of migration (income left over after migration), against provinces ranked by ease of migration.

Table 1
Parameters.

Name	Value	Notes	Source
β	0.26	Housing spending share	Cao, Chen, & Zhang (2018)
ρ	0.7	Capital share, housing	Tan, Wang, & Zhang (2020)
α_L	0.55	Labor share, Y	Bai & Qian (2010)
α_X	0.07	Land share, Y	Valentinyi & Herrendorf (2008). We increase their USA share of 0.05 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, Graham, & Brage-Ardao (2013) meta study. 0.06 is the mean over all studies and countries. Non-US countries and long run studies tend to average slightly higher γ 's. On the other hand, Wang, Wu, & Feng (2019) estimate 0.031 and 0.046 for China for transport and utilities infrastructure respectively.
ε	0.04	Agglomeration economies	Rosenthal & Strange (2004); also de la Roca & Puga (2017).
θ, θ_t	4.0	Dispersion parameters, Fréchet	θ is based on Bryan & Morten (2018), although higher than their 3.2. θ_t is from Tombe and Zhu (2019)
ω	4×10^{-8}	Congestion cost parameter	Combes, Duranton & Gobillon (2019) and Wang & Zhang (2022)

local spending on infrastructure over 2008–2011²² and (2) average annual city government's land sale revenue over the same period. In the left panel of Table 3, the pairwise raw correlation coefficients between our calibrated G , infrastructure investments and land revenues range from 0.77 to 0.83. Even after factoring out a control for population, or scale, in the right panel of Table 3, these pairwise

²² 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 spending on infrastructure investment, loans and securities which (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.

coefficients range from 0.65 to 0.68. We interpret these results as affirming our characterization of the public good sector.

Finally, in Table 2 there is the political weight on GDP enhancement f . These f 's are graphed against city population in Fig. 4. These f 's average 0.66 with a median of 0.69. 25% of the f 's are over 0.8 and they are especially high for some political cities like Beijing (0.91) and Tianjin (0.85), presumably assigned to ambitious political leaders. In Fig. 4, there are more "enlightened" places with low f 's which appear to value the welfare of residents, such as Yueyang or provincial capitals like Kunming and Jinan (0.59).

There is a conceptual issue. The f 's reflect leader preferences. We think there is persistence over time in f 's because more ambitious leaders who seek promotion (by growing GDP) are more likely to be assigned to big, political, and coastal cities. In the regression in Table 2 col. (4), f rises with population and also with manufacturing share, where such cities may face pressure to lead the country's GDP growth. f declines with distance to major sea-ports perhaps because those interior and far west cities have experienced de facto neglect in assignment of leaders. There is also a link from f 's to local leaders' own career concerns. Based on Wang, Zhang, & Zhou (2020), 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, Zhang, & Zhou, local leaders are on a path to promotion, where promotion depends heavily on economic achievement measured by local GDP. However, 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, placing more weight on the welfare of residents. Wang, Zhang, & Zhou 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 .²³

²³ By adding the (calibrated) exogenous component of consumer amenities, Z , to col. (5) in Table 2, we also find that f 's are not significantly correlated with consumer amenities. This is consistent with the notion that f 's mainly reflect city leaders' preferences towards GDP.

Table 2
Regressions for calibrated parameters.

VARIABLES	$\ln A'$	$\ln c$	$\ln G$	f	f
Share of adults (age 19–55) with high school education 2000	4.953*** (0.898)	-1.599*** (0.243)	9.995*** (1.155)	-0.0560 (0.397)	0.0577 (0.413)
Avg. winter temperature, (2014) ^a	0.00232 (0.00258)				
Ln distance to nearest of the 9 major seaports	-0.0178 (0.0175)	0.0120** (0.00525)	-0.0964*** (0.0261)	-0.0268*** (0.00895)	-0.0288*** (0.00927)
Share employment in manufacturing, 2000	0.787*** (0.201)	-0.337*** (0.0588)	2.281*** (0.270)	0.188** (0.0926)	0.165* (0.0954)
Provincial or sub-prov capital	0.232*** (0.0765)	-0.0820*** (0.0227)	0.419*** (0.114)	0.0233 (0.0391)	0.0345 (0.0396)
Ln population 2000 Census	0.215*** (0.0406)	-0.196*** (0.0122)	1.081*** (0.0527)	0.0485*** (0.0181)	0.0528*** (0.0186)
Ln Total FDI, 1996	0.0351** (0.0152)	-0.0160*** (0.00454)			
Avg Age of party secretary [PS] (2000–2010)					0.137* (0.0809)
Ave Age of PS Squared					-0.00137* (0.000811)
Observations	213	213	265	265	265
Adjusted R-squared	0.625	0.839	0.842	0.164	0.167

^a The temperature data are from <https://www.meteomanz.com>.

Table 3
Correlations with producer public goods.

	(1) No controls		(2) Controlling for $\ln(\text{pop}_{2010})$	
	Ln Ave. Inv	Ln cG	Ln Ave. Inv	Ln cG
Ln cG	0.766	1	0.654	1
Ln land revenue	0.769	0.83	0.653	0.684

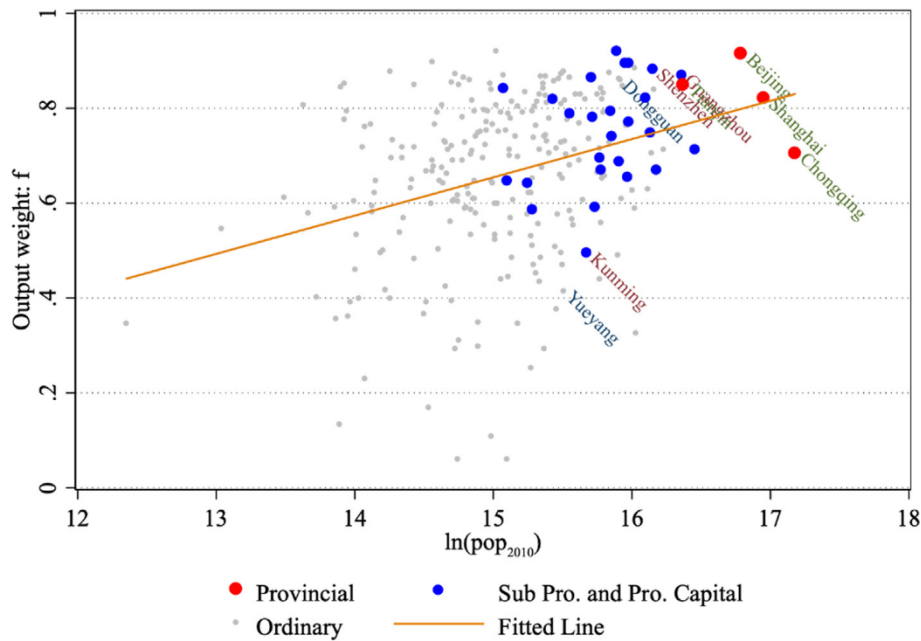


Fig. 4. The calibrated values of the leaders' weight on GDP, f . Notes: The figure plots the inferred vales of f , the weight on GDP in city-leader preferences, against log population in 2010.

There are other equilibrium outcomes that can be backed out of the model, such as housing prices, built area of the city, and trade flows between provinces. 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. Similarly, in Appendix A.2, we look at imports in 2012 from province v by pro-

Table 4
Base results on all counterfactuals relative to benchmark.

	Social welfare Eq. (21) (1)	Total capital income (1000's) (2)	Total G (3)	TFP* (4)	Total effective labor. Eq. (17) (5)	National sum of y (actual production) (6)	Inequality Eq. (23) (7)
Benchmark, equilibrium	1.623	199	44,191	0.0262	3.460e + 09	391,421	0.00684
Counterfactual [CF]1: Equalize <i>r</i>	1.672	204	46,268	0.0265	3.470e + 09	409,811	0.0109
CF 2: Equal <i>r</i> & <i>f</i> = 0.	1.754	204	44,814	0.0265	3.470e + 09	396,931	0.0112
CF 3: Equal <i>r</i> & <i>f</i> = 0 & relaxed public budget.	1.846	204	22,676	0.0254	3.470e + 09	377,932	0.0112

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

vince u for all such pairs and compare them to the model predictions. Figure A2.1 shows that the data and our model predictions correlate well, with an $Rsq.$ of 0.68.

6. Counterfactuals

For counterfactuals, we are primarily interested in three experiments. The main one we call CF-3. There, all restrictions are relaxed: capital prices are set by the market and equalized across cities; f is set to 0 so city leaders maximize just the welfare of residents; and the city budget constraint is relaxed to allow positive or negative taxation of wage income, as well as use of land rents to finance infrastructure. Between the benchmark and CF-3, there are two interim steps. First in CF-1, we ask what happens if we just remove capital market favoritism while keeping the national total capital supply fixed, so the endogenous price of capital is equalized across cities. Then, in CF-2, we can ask what happens if, in addition to freeing capital markets, f 's are set to zero so leaders seek to maximize the welfare of residents in allocating land, but still face the same current type of public budget constraint.²⁴ Finally we move to CF-3, where we additionally relax the public budget constraint to allow worker income taxation.²⁵ These steps allow neat comparisons, where we can ask hypotheticals. For example, if capital markets are already freed up, what are the additional benefits of setting f 's to zero or to relaxing the public budget constraint. The detailed counterfactual solutions and methods are explained in Appendix A1 and involve resolving the model (rather than “hat-algebra”).²⁶

6.1. Basic results

In counterfactuals there are overall national effects given in Table 4. We note two points about these, before we detail results. First, since capital is the numeraire, once capital markets are freed up in CF-1, in all remaining counterfactuals relative to CF-1, capital income is unchanged. Welfare effects in CF-2 and CF-3 are due to changes in consumer welfare. Second, in moving from freed capital markets and $f = 0$ in CF-2 to the final counterfactual, CF-3, where

²⁴ Note we cannot run the counterfactuals on f alone, since this would have capital markets impacts and we do not know how the politically driven prices of capital would then adjust.

²⁵ Note in CF-2 and CF-3 in optimization from the end of Appendix A4 we can fully relax the assumption that leaders see city population as fixed.

²⁶ Hat-algebra involves rewriting the model so that everything is expressed as percentage changes from the baseline equilibrium. This is especially useful if we have detailed true data for the baseline equilibrium, since we can avoid potential modeling errors at the calibration stage. But unfortunately, the data on city-level migration flows and trade flows are not available. Doing hat-algebra in this case is only an alternative way to express the model and does not provide additional new insights. In fact, if we take the baseline equilibrium calibrated in Section 5 as the true data and use hat-algebra in counterfactuals, the results in counterfactuals would be exactly the same as the ones we provide in the text.

the public budget constraint is additionally relaxed, there are no effects on the allocation of population and effective labor across cities (see Appendix A1.3). Intuitively, in (17), in CF-3, the (negative) tax rate on wage income is the same across all cities, so relative utility levels across cities are unaffected in moving from CF-2 to CF-3. The impact of freeing up the budget constraint is to lower infrastructure expenditures and raise consumer consumption and welfare everywhere by the same fraction.

In Table 4, row 1 gives the benchmark numbers for worker welfare, capital income, infrastructure, TFP, effective labor, national output, and the measure of inequality. In row 2 is CF-1, where just capital prices are equalized across cities while the national total capital supply is fixed unchanged. In this, f 's are taken as given and infrastructure is still financed out of land rents. Capital markets clear such that every city faces 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, so there are winners and losers. Overall, for the national economy, going to CF-1 relative to the benchmark increases the returns to capital owners by about 2.25%, as capital is efficiently reallocated. That efficient reallocation helps consumers raising overall consumer welfare by 3.0%, while also modestly raising average TFP, effective labor, national output and total infrastructure investment.

In Table 4 in row 3 for CF-2, we additionally set f 's to zero, so that leaders focus only on the welfare of residents. The effects are intuitive. Cities increase the allocation of land to residential use monotonically in line with the value of initial f 's, correspondingly reducing industrial land usage. Residential land prices decline, and industrial use prices rise in all cities. This lowers housing prices almost everywhere as shown below. This is the main channel in Table 4 leading to national utility gains of 4.9% relative to CF-1 and of 8.1% relative to the benchmark. Average TFP and effective labor are little changed, while output and G decline modestly relative to CF-1.

In row 4, in CF-3 which is the main result, we additionally relax the public budget constraint. Here there are no cities gaining or losing population relative to CF-2 since relative utilities are unaffected. As noted, every city sets its tax rate at the same optimal level, which is the same negative rate of -0.104 in Eq. (17). Allowing a portion of rents to be rebated to consumers lowers the optimizing G nationally by a whopping 49% relative to CF2 and to the benchmark, with modest declines in y and TFP nationally relative to the benchmark.²⁷ Welfare rises because of increased consumption of y , given so much less of y goes into G provision. The result is just over a 5.2% increase in consumer welfare relative to CF-2; and the overall gain in consumer welfare of moving from the benchmark through all phases to CF-3 is 13.7%. These figures are sensitive to γ , the exponent on G in the production function for y , which

²⁷ Having more income from getting a share of land rents means demand for housing and prices increase relative to CF-2, but the changes in all cities are under 2.331%.

reflects the productivity of infrastructure. Our γ of 0.06 was picked prior to results, and based on the relevant empirical literature as noted in Table 1. Raising γ to, say, 0.10, the gain in consumer welfare from going from CF-2 to CF-3 is reduced to 1.03% and the decline in G to 12.8%. That noted, in setting parameters in Table 1, a γ of 0.10 for China would seem implausibly high from the literature. Moreover, to have a positive tax rate on wages would require a γ of over 0.113.²⁸

The final issue concerns inequality in the last column of Table 4. These joint reforms contribute to an increase in national labor inequality, across our heterogeneous labor. Why? Some cities with low capital returns in the benchmark 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 that would result if these heavy industry and subsidized cities had to compete on a level playing field.

6.2. Heterogeneity of impacts across cities

As noted above, relative to the benchmark, in the counterfactuals there are winning and losing cities in terms of population and welfare. In Table 5, in the first 4 rows, we show a basic 4-way comparison at different tails of pairs of r and f values. We show the results of the move from the benchmark to CF-3. In counterfactuals we expect gains to cities which start with either high r 's or high f 's,

Table 5
Population and welfare changes for sample cities.

City	Type	Initial r	Initial f	Pop change, CF-1 vs. Benchmark	Pop Change, CF-2 or CF-3 vs. Benchmark	Welfare change, CF-1 vs. Benchmark	Welfare change, CF-3 vs. Benchmark (Subtract 5.13% everywhere for CF-2)
Beijing	High- f , Low- r	0.694	0.914	-7.73%	-5.39%	-2.37%	3.30%
Dongguan	High- f , High- r	1.366	0.857	10.4%	12.3%	5.10%	10.3%
Kunming	Low- f , Low- r	0.639	0.494	-16.0%	-17.6%	-7.02%	-3.06%
Yueyang	Low- f , High- r	1.490	0.413	14.0%	12.1%	8.35%	12.4%
Tianjin		0.609	0.849	-11.2%	-10.1%	-6.89%	-1.39%
Shanghai		0.927	0.820	-2.23%	-1.82%	1.57%	6.75%
Chongqing		0.975	0.701	-1.72%	-1.90%	2.24%	6.81%
Guangzhou		1	0.870	-4.21%	-2.19%	5.01%	10.2%
Shenzhen		1.484	0.882	12.7%	15.2%	5.14%	10.4%

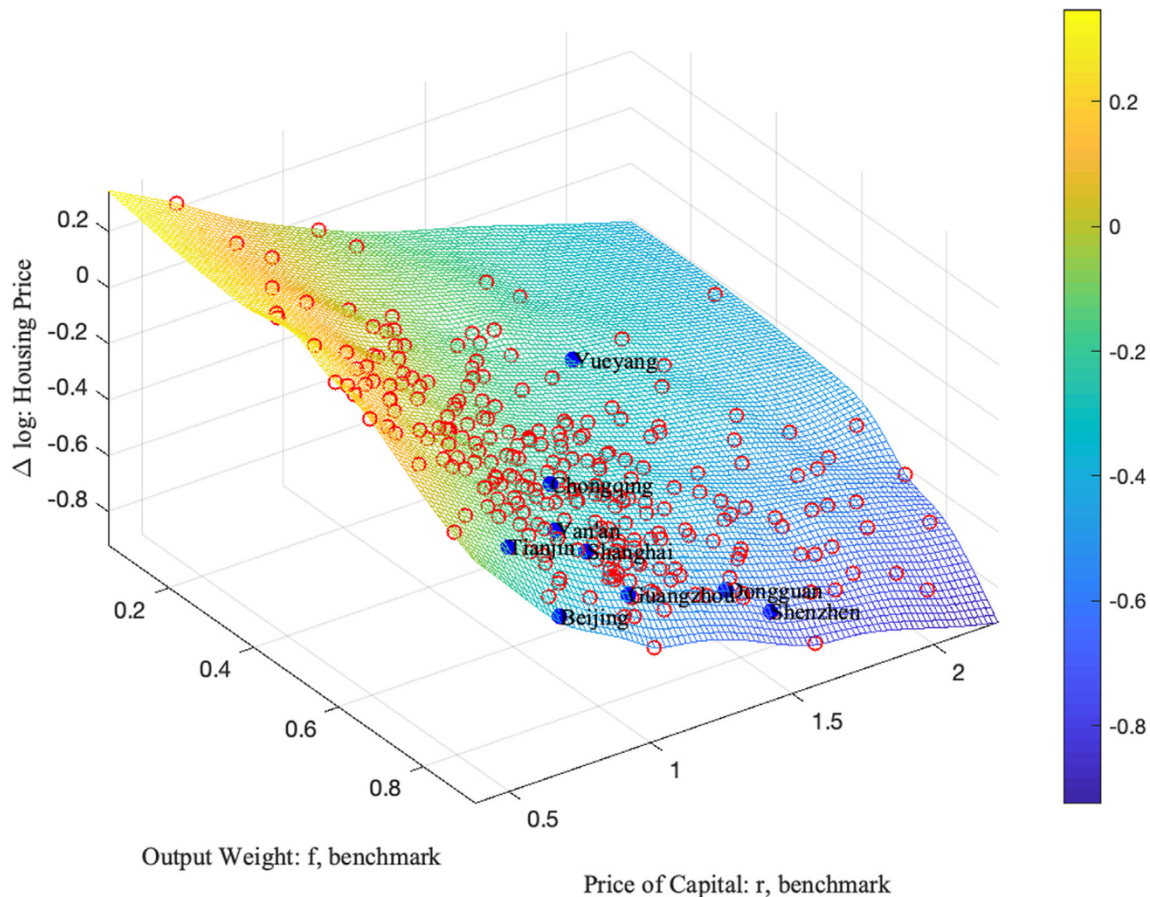


Fig. 5. A 3-D representation of housing price changes. Notes: The two “x”-axes are for the benchmark price of capital and f . The vertical axis is the change in housing prices of CF-3 relative to the benchmark.

because they are rewarded with either lower prices of capital or a greater focus on consumer welfare by local leaders. The 4-way comparison and general expectations as to outcomes are as follows. (i) Cities can start with a high r and a high f . Such cities like Dongguan in going from the benchmark to CF-3 gain population and welfare for two reasons: a lower price of capital and a major switch to enhancing consumer welfare, realized by reallocating more land to residential use. (ii) Cities can start with a high r and low f like Yueyang, in which case under CF-3, they benefit from cheaper capital, but there can be some offset with the more modest change in f , in comparison to some competitors which started with higher f s. However, in the end, Yueyang has strong gains. (iii) Cities can start with a low r and a low f , like Kunming, in which case relative to their competitors, they are likely to lose population and welfare, as they are disadvantaged with both r rising and f declining relatively modestly. (iv) Finally, cities like Beijing start with a low r and high f , so they lose from the rise in r but have some offset from the change in the leader's focus to consumer welfare and lowering of housing prices. Note Beijing's changes are smaller than Kunming where both start with low r but Beijing with a much higher f . Apart from the illustrated cases in the first 4 rows in Table 5, we show gains and losses for 5 other well-known cities for those who are interested including three giant provincial level cities, Shanghai, Tianjin and Chongqing, in addition to two very visible and important cities, Shenzhen and Guangzhou.

Figs. 5-7 compare CF-3 to the benchmark. In Fig. 5, housing prices generally fall because of the reform setting $f = 0$, so that land is allocated more to residential use. Prices fall the most in originally high- r and high- f cities with the decline in capital prices

and the increase in land allocated to residential use. However even in low- r cities where capital costs rise, housing prices decline if f is large. To get the rise in house prices in the handful of cities shown in the figure requires both an initial low r and low f .

In Figs. 6 and 7, we graph the changes in population and welfare of initial residents against initial r s and f s. Relative population and welfare changes mirror each other. We see cities starting with the lowest capital costs generally all lose population regardless of initial f s; and, correspondingly, those with the highest initial capital costs all gain relative to the benchmark regardless of initial f . However, two sets of points are important. First, for cities with capital costs initially more modestly above 1, high- f cities tend to gain population relative to low- f ones. In Table 5, we gave specific examples. Kunming with both low f and low r loses population in going from the benchmark to CF-1 and then again in going from CF-1 to CF-3, as does Chongqing. Second, in many cases for cities with very low initial r s and high f s, like Beijing and Tianjin, the population losses are large in going to CF-1 (-7.7 and -11.2, respectively) as seen in Table 5, while the offset (to -5.4 and -10.1 % net) from lowering f is more modest. Similarly, the gain to high- r Shenzhen is large in going to CF-1 (12.7%), while the further enhancement (going to 15.2%) of lowering f is more modest.

A feature of Figs. 6 and 7 is the peaks and valleys that interrupt smooth changes as we raise or lower r or f , holding the other fixed. An important take-away is that effects are heterogeneous even across cities with similar benchmark r s and f s, based on their province and locations, which drive migration costs and firm and consumer market access. Those in remote or high in-migration cost provinces will have smaller population responses. Note in Fig. 7

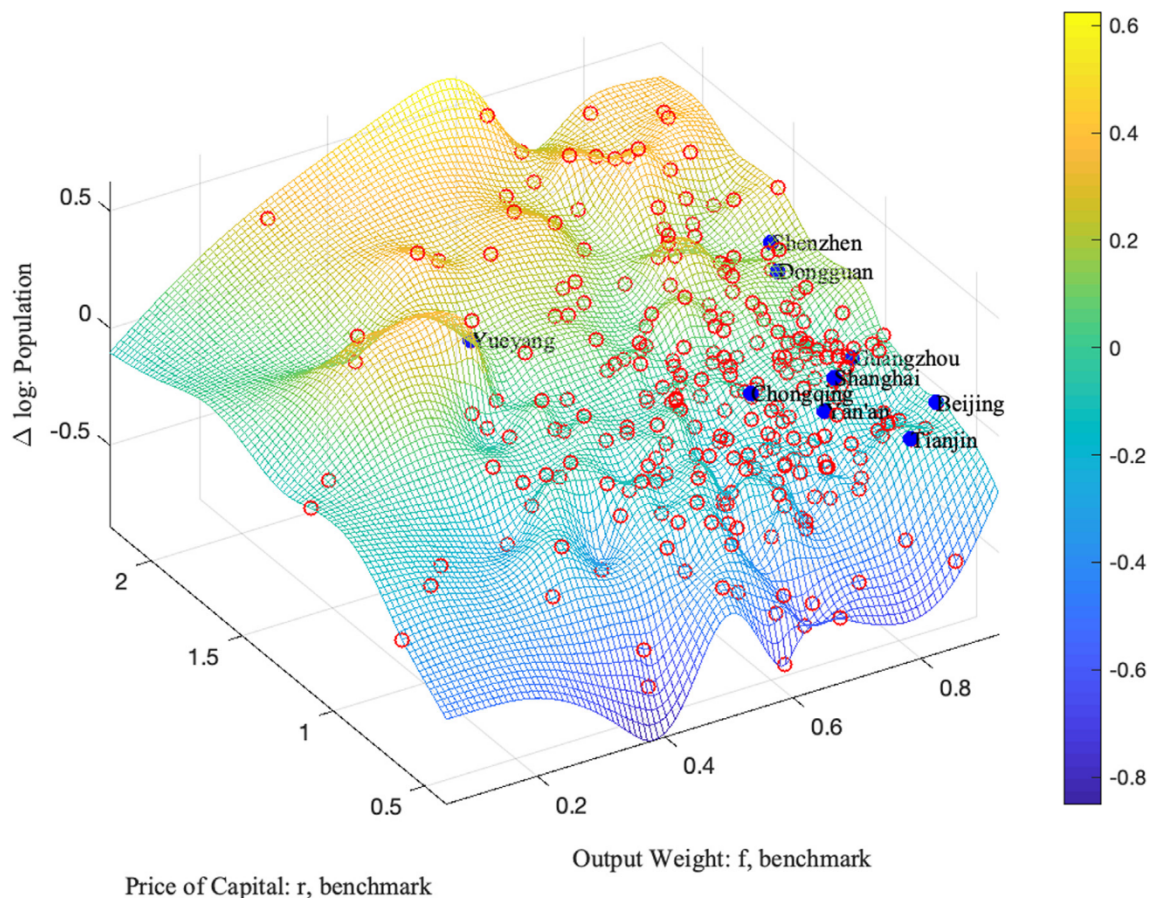


Fig. 6. The 3-D representation of population changes. Notes: The two “x”-axes are for the benchmark price of capital and f . The vertical axis is the percent change in the population of CF-3, relative to the benchmark.

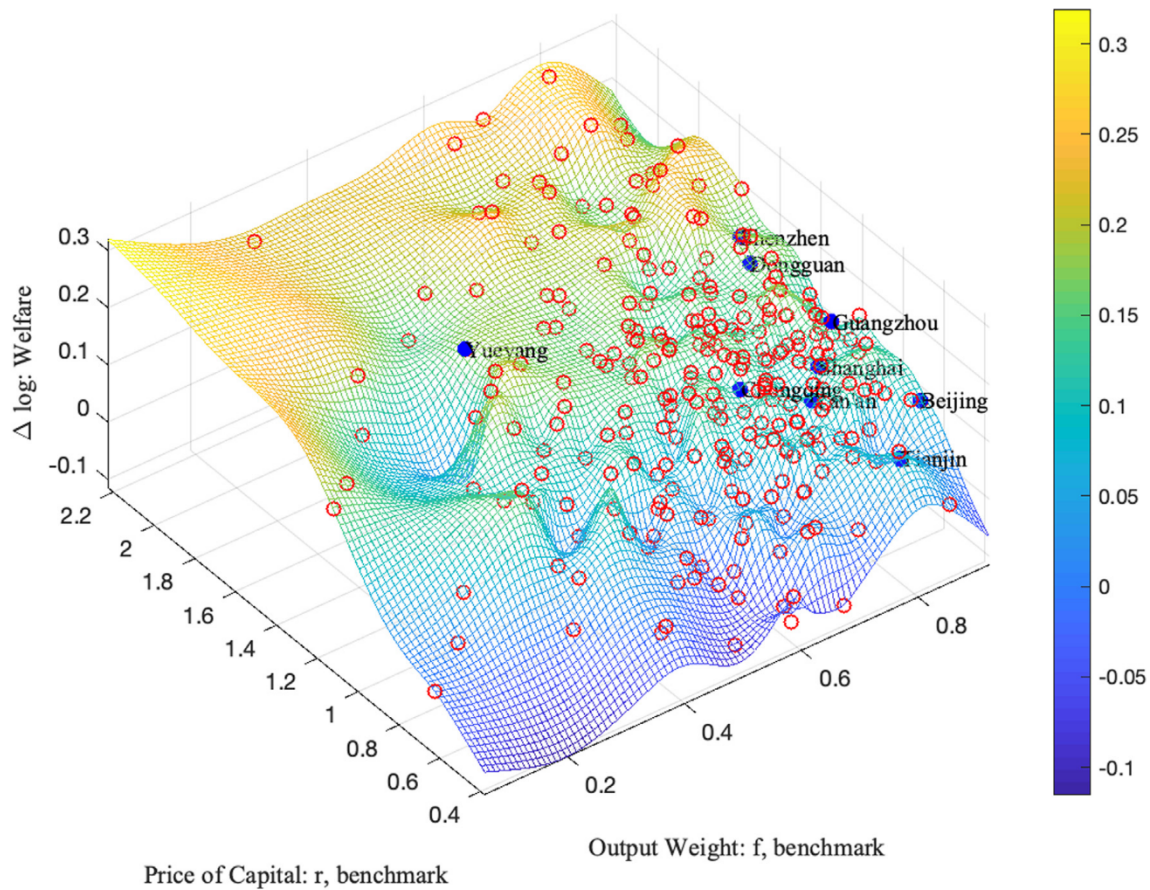


Fig. 7. The 3-D representation of consumer welfare changes. Notes: The two “x”-axes are for the benchmark price of capital and f . The vertical axis is the percent change in the consumer welfare of CF-3, relative to the benchmark.

on welfare almost no cities lose welfare in absolute terms in going from the benchmark to CF-3, because of the consumer gains from the rebate of land revenues. To lose, a city must start with a very low price of capital like Tianjin and Kunming.

6.3. An extension: Lowering the fixed cost of high-cost migration 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 drives the rise in inequality we saw. Relaxing migration barriers would help the residents trapped in poor locations to leave and would lower inequality. As an example, we ask what would happen if we lowered the fixed cost to enter each province by raising the ease of access to 0.34 if the current one is below 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 middle and 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 CF-2 or CF-3 above, there are changes.

In this counterfactual, cities such as Beijing and Shanghai where this experiment does not change migration costs because their provinces have higher ease-of-access than Jiangsu should lose some population to places to which it is easier to migrate. However, the diversion from cities like Beijing and Shanghai is modest. Relative to CF-3, Beijing and Shanghai would lose population by an

additional 3.1 and 2.0 percentage points. These population changes relative to Table 5 are shown in Appendix Table A6.1, for the example cities. A much more profound effect is on national inequality. Relative to CF-3 in Table 4, the inequality measure falls by about 50%, from 0.0165 to 0.00793, given the lowered cost of migration and ability to move to better jobs. Note we do not compare national 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 issued in 2020 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 markets²⁹. While the current literature has studied factor misallocations in China from various perspectives, the focus has been on capital market and migration friction issues. Here we focus more on land market and fiscal reforms, and reforms in the priorities of city leaders as to how much to focus on GDP enhancement versus enhancement of local consumer welfare. Our paper quantifies these differences between cities in priorities and studies reforms in local

²⁹ See the policy directive here: https://www.gov.cn/zhengce/2020-04/09/content_5500622.htm.

governance, land markets and public budgeting in a spatial general equilibrium framework, while at the same time incorporating the effects of correcting capital market misallocations across cities, to evaluate the net gains to be made by key reforms.

Key to understanding the issues is China's characteristic political centralization and fiscal 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 market, so that all cities compete on a level playing field, eliminating favoritism of certain types of cities and firms. A second counterfactual adds a local land market reform by changing priorities of local leaders, so industrial land allocations are not favored over residential ones, and a third adds relaxation on the local budgeting process. Currently, local leaders in striving for promotion are encouraged to enhance GDP by competing for footloose firms. The levers they hold are cheap industrial land and excessive public infrastructure investments. A reform policy which levelled the playing field in capital markets, reallocated land towards residential use, and allowed for (positive or negative) wage taxation as well as use of land rents in financing infrastructure would increase aggregate welfare by 13.7% and raise returns to capital by 2.25%. Reforms would lower the population of the biggest cities like Beijing and Tianjin while other cities like Shenzhen and Dongguan 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 would help people leave low productivity places to go to higher productivity ones or cities with higher quality of life and lower living cost. Then as the extent of migration cost declines rise, cities start to gain population. However, the main impact of this reform is to lower inequality, since people can leave low wage places to go to high wage ones at a lower cost.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jpubeco.2022.104730>.

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